A VIEW ON PERMANENT CLIMATE CHANGE

How the world needs to keep the threat in perspective

BY

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Dedicated to Oliver and Daniel,
my two gifted and cherished grandsons who can expect to have a very interesting, if challenging life ahead of them in a rapidly changing world.

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by

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This document, although comprehensive, is not being presented as a dissertation to be defended or to a science publisher for peer review. It is but one educated person's view of global warming and climate change and of the debate raging throughout the world.
The author has not received any remuneration whatsoever from any source for this work.

"The problem with the world is that fools and fanatics are so certain of themselves, and wise people are full of doubts" Bertrand Russell

"Nothing is stronger than an idea whose time has come. ... Nothing is as powerful as an idea whose time has come." Victor Hugo ["Even if it is doomed to fail like communism". This author]

"One swallow does not a summer make, nor one fine day." Aristotle (384 BCE – 322 BCE). ["Nor does one prolonged drought make for permanent climate change." This author]

"We do not believe any group of men adequate enough or wise enough to operate without scrutiny or without criticism. We know that the only way to avoid error is to detect it, that the only way to detect it is to be free to inquire. We know that in secrecy error undetected will flourish and subvert". J Robert Oppenheimer.

« Pour ce qui est de l'avenir, il ne s'agit pas de le prévoir, mais de le rendre possible. » [As for the future, it is not a case of prediction, but to make it possible.] Antoine de Saint Exupéry, Citadelle, 1948

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He retired from the RAAF as a Group Captain after 28 years of service including 22 years as a maintenance engineering officer, after which he served as a director in the Department of Defence, followed by 16 years as a private consultant in logistic support of major defence-related systems - air, land, sea and communications.
His main disciplines as a consultant were in major capital equipment acquisition; Life Cycle Costing (LCC); cost risk analysis (including development of a cost risk algorithm); Integrated Logistics Support (ILS); systems engineering; and configuration management.
In respect of volunteer work, he served as Treasurer of the governing committee of the Alliance Française de Canberra for 12 years and as Treasurer of the Tuggeranong Community Council for four years.
Since 2014 he has been directly involved in the lobby against light rail in Canberra as a director of Can the Tram Inc and since 2016 as the principal of Smart Canberra Transport, for which he has issued a biweekly newsletter.

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ABSTRACT

So much alarm in the world today from climatologists and followers about the doomsday to come unless all governments take adequate counteraction to minimise harmful greenhouse gas emissions.

Because of the vast array of literature available - the good, the bad and the ugly - average citizens, including politicians, have no real hope of understanding the science and little hope of even knowing where the truth may lie. They are simply asked to "trust the science". Unfortunately, misinformation about the 'science' by powerful vested interests, by some Media, on the Internet and especially in social media, is rife.

This scientific debate concerns the future average global surface temperature (Tw), discussed primarily in terms of the Temperature anomaly (Twi), i.e., the incremental change in surface temperature since pre-industrial revolution times. Notwithstanding a great deal of controversy, it can be concluded that the average temperature is increasing gradually, in part and not exclusively, as a function of greenhouse gas emissions.

Following seminal research around 1980, by a Professor Charney and team of MIT[1], the IPCC [2] of the United Nations identified two values of Twi, being 1.5°C and 2°C, comprising targets later enshrined in the Kyoto Protocol and the Paris Agreement to which most countries subscribe. In 2020, Twi stands at 1.05°C, for a CO2 atmospheric concentration of 413ppm[3] (0.0413%).

A Twi of 1.5°C is seen as tolerable and the most desirable limit endorsed by the protocols. A Twi of 2°C is seen as manageable, although causing possible, greater intensity and damage by climate events, but not permanent climate change. A Twi of 3°C, not specifically identified in IPCC reports as a target, but may be considered as a maximum tolerable threshold before permanent, detrimental climate change could occur. Projections by the IPCC, assuming a 'business-as-usual' scenario[4], show that Twi could reach 1.5°C by 2045, 2°C by 2075 and, by extrapolation, a projected date of 2125 for 3°C.

However, it can be shown that, if the world were able to reduce greenhouse gas emissions by an average across all nations of 1% per annum over the next 30 years and beyond, a Twi of 1.5°C and 2°C would be delayed some years but, most importantly, 3°C would never be reached. Under the protocols, most countries, including Australia, have committed to reducing emissions by around 1% to 1.3% per annum by 2030, based on 2005 levels,

Notwithstanding, industrialised nations like Australia may have to do better than a continual 1% per annum reduction, to compensate for an expected increase in emissions by under-developed nations that have a lot of economic catching-up to do and probably will not be denied their place in the sun, at the expense of further global warming.

A current goal of several countries like the United Kingdom is to achieve 'net zero emissions by 2050'. While success would depend on a raft of minimisation initiatives, it rests primarily on the continued investment in renewable energies. Notwithstanding huge government subsidies in Australia over the past few decades, renewables currently meet only 24% of the electricity demand and 6.5% of its total annual demand for energy. Nevertheless, given that electricity sectors in developed countries account for 30% or less of their total energy demand, a reduction of 30% over the next 30 years could be enough to prevent excessive global warming.

The science-based reasons for global warming and possible climate change comprise an impressive body of work, but too extensive to explain here. It suffices to say that, contrary to what climatologists claim, natural warming could well prove to be the primary 'thermostat' of the Earth's surface temperature, rather than greenhouse gas emissions, although both would contribute. It is also clear that water vapour and clouds together have a far greater effect on surface temperatures than does CO2.

Climatologists, believers and critics alike need to take some basic facts to heart. Australia accounts for only 0.32% of the world population, so how can it be expected to convince the world to repent its energy-guzzling ways? Australia contributes only 1.06% of world greenhouse gas emissions, so small that no matter what it does, it cannot make any significant impact on global warming, let alone on climate change. Australia produces only 7% of world coal production so it

makes zero sense for irrational calls to close down an industry that is the nation's second biggest exporter. As yet, in Australia, renewables account for a mere 6.5% of its total energy demand.

Nor are the claims by climatologists of melting ice-caps, more severe droughts and catastrophic weather events supported by statistical evidence, or that which cannot be explained by natural warming of the planet.

Contrary to the doomsday claims, climate change is not an existential threat to the world, let alone to Australia, as long as reasonable mitigating action is taken. Even the United Nations puts the fighting of climate change well down its list of priorities for humanity in general.

Rather, it would appear that the world is facing a 'perfect storm' over the next 50 years or so, given its ever-growing population, nationalistic threats, religious intolerance, rapidly advancing technology and the perverting effect of social media, let alone the claims of permanent climate change. Above all, the threat of global warming and consequential climate change should be kept well in perspective.

While Australia needs to meet its international obligations as a responsible global citizen, it need not be out there, big-noting itself as the climate change harbinger to the world.

[1] Massachusetts Institute of Technology

[2] Intergovernmental Panel on Climate Change

[3] ppm = parts per million Moles in the atmosphere.

[4] Continued rate of fossil fuel consumption.

EXECUTIVE SUMMARY

Overview

The sensitivity of the Earth's climate to increases in atmospheric greenhouse gases, especially from carbon dioxide (CO2) produced from burning fossil fuels and exacerbated by an ever-increasing world population, sits at the heart of climate science and of the debate about possible permanent climate change that has been raging around the world in recent decades.

There is so much alarm in the world today from climatologists and believers[2] about the doomsday to come unless all governments take adequate counteraction to minimise harmful greenhouse gas emissions,[3] especially carbon dioxide (CO2).

Because of the vast array of literature available - the good, the bad and the ugly - average citizens, including politicians, have no real hope of understanding the science and little hope of knowing where the truth may lie. They are simply asked to "trust the science". Unfortunately, misinformation about the 'science' by powerful vested interests, in the Media, on the Internet and especially in social media, is rife and, given recent protest movements, may be seen to resemble a quasi-religion. So very little of what is claimed as scientific literature on these platforms is seminal, almost all being regurgitation of what others have written.

Scientific debate concerns the future Average global surface temperature (Tw), discussed primarily in terms of the Temperature anomaly (Twi), defined as the increment in average surface temperature since pre-industrial revolution times. Notwithstanding a great deal of often bitter controversy among scientists, it can be concluded from analysis of bona fide literature, that the average temperature is increasing gradually, in part and not exclusively, as a function of greenhouse gas emissions. However, a note of caution: published temperatures are very much averages from surface sensors around the world and satellites and pertain predominantly to the northern hemisphere; they vary quite significantly about the average, depending on region and particularly in latitudes towards the poles. Consequently, Australia needs to be more cognisant of its own temperature records and not be swayed by what may be happening in the northern hemisphere about which the greater majority of literature is written.

Seminal research into global warming, conducted by a Professor Charney and team of MIT[4], has been responsible for most of the scientific research on global warming over the past 40 years. The basic conclusion of the report predicted that Twi would increase by 3±1.5°C (?) for a doubling of CO2 concentrations from 280ppm[5] in pre-industrial times to 560ppm. Subsequent research shows that this relationship would also hold for later periods. In 2020, Twi stands at 1.05°C, for a CO2 atmospheric concentration of 413ppm (0.0413%), which is consistent with the theory.

Following the research by Charney, the IPCC[6] of the United Nations identified two values of Twi, being 1.5°C and 2°C, comprising targets later enshrined in the Kyoto Protocol and the Paris Agreement to which most countries subscribe.

A Twi of 1.5°C is seen as tolerable and the most desirable limit endorsed by the protocols. A Twi of 2°C is seen as manageable and causing possible, greater strength and damage from climate events, but not permanent climate change. A Twi of 3°C, not specifically identified in IPCC reports as a target, may be considered as a maximum tolerable threshold before permanent, detrimental climate change could occur. Projections by the IPCC, assuming a 'business-as-usual'[7] scenario, show that Twi could reach 1.5°C by 2045, 2°C by 2075. Extrapolation of these values gives a projected date of 2125 for 3°C.

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[2] The opposite to 'deniers', 'contrarians', 'sceptics' and other heretics.

[3] 'Emissions' refers to the non-condensable greenhouse gas emissions, ie excluding water vapour.

[4] Massachusetts Institute of Technology

[5] ppm = parts per million Moles in the atmosphere.

[6] Intergovernmental Panel on Climate Change

[7] 'business-as-usual' means continued consumption rates of fossil fuels and consequent emissions of greenhouse gases.

However, it can be shown that if the world was able to reduce emissions by an average across all nations of about 1% per annum, over the next 30 years and beyond, a Twi of 1.5°C and 2°C would be delayed by some years but, most importantly, 3°C would never be reached.

Under the UN protocols, most countries have committed to reduce emissions by about 1% to 1.3% per annum by 2030, based on 2005 levels.[8] Australia has committed to reducing its emissions by 26% to 28% of 2005 levels, by 2030, i.e., about 1% per annum

Most of the countries comprising the United Nations are small emitters and are lobbying for greater effort by industrialised nations to prevent perceived climatic catastrophe in their regions or to subsidise reduction efforts in their countries. The USA (12.1% of world emissions) has threatened to no longer subscribe to the protocols. China, the biggest emitter (24%), like most countries, is committed to a reduction of about 1% per annum through to 2030.[9]

Notwithstanding commitments, industrialised nations like Australia may have to do better than a continual 1°C per annum reduction, to compensate for an expected increase in emissions by under-developed nations that have a lot of economic catching-up to do and probably will not be denied their place in the sun, at the expense of further global warming. In particular, India could be a 'sleeper', even though it has committed to reduce its emissions by 33% to 35% from 2005 levels by 2030.

Some countries like the United Kingdom have even legislated to achieve 'net zero emissions by 2050'[10]. While any success would depend on a raft of minimisation initiatives, it rests primarily on the continued investment in renewable energies. Notwithstanding huge government subsidies in Australia over the past few decades, renewables currently meet a mere 6.5% of total annual energy demand, i.e., 24% of the electricity sector which, in turn, accounts for 27% of total demand. Nevertheless, given that electricity sectors in developed countries account for about 30% or less of total energy demand, a reduction in emissions of 30% over the next 30 years could prove to be enough to prevent excessive global warming.

The average world per-capita emissions in 2020 are 5.6 tonnes per annum. Australia's per capita rate is high at 15.8 tonnes per annum[11], but ranking 14th compared to other countries. However, Australia contributes only 1.06%[12] of world greenhouse gas emissions, which is so small that no matter what it does to minimise these, it can have virtually no impact on global warming, let alone on climate change. In reality, Australia needs only to meet its international obligations and is doing its fair share. Arguments by its critics that Australia should be out there as an example to and leading the world is nothing short of sophistry, even hypocrisy, and more likely motivated by politics than genuine concern for the environment.

Australia is the leading exporter of coal, but only the 5th largest miner of coal at only 7% of world production. It exports only the highest-grades of coal, that being the very reason why other countries need and buy it - no sales no export. It makes zero sense for those anxious about climate change to demand the shutdown of coal mining in Australia, its second biggest export, when buyers would have to source inferior coal elsewhere that would produce greater emissions. If it is to close down, coal mining in Australia should be allowed to do so naturally as world demand and economics dictate.

Australia is also the world's leading exporter of natural gas, which can and does compete with coal because of its lower greenhouse gas emissions per unit of energy produced. Whether availability of natural gas could ever supplant coal completely in Australia would appear feasible, but should occur as un-subsidised economics permit.

In respect of the science, climatologists have long claimed that it is the non-condensable greenhouse gas emissions produced by burning fossil fuels, especially CO2, that control the surface temperature (Tw) and any increment (Twi), by acting as the 'thermostat' of the planet's

[8] Note that these rates of 1% to 1.3% per annum are of the respective levels by country recorded in 2005, and not a progressive (negative exponential) rate.

[9] Actual achievements by countries are something else again. See Annex J, *What can and is being done.*

[10] Net-zero CO2 emissions. See Annex S, *Glossary.*

[11] With good reason, given its small population in a vast continent.

[12] Could vary from 1.03% to 1.1%, average 1.06%, depending on source data.

temperature. They further claim that water vapour and clouds affect temperature only as a positive feedback process, i.e., as the greenhouse gases push up temperature, more water vapour and clouds are produced, so adding to the greenhouse (warming) effect (and higher precipitation somewhere on the planet).

However, water vapour is acknowledged as a much stronger greenhouse gas than CO2 and, after considerable analysis, it is clear that water vapour and clouds together have a far greater effect on surface temperature than does CO2, the latter contributing only around 25%.

Scientific records show that the Earth has gone through many alternating warm-ages and ice-ages over many millions of years and that CO2 atmospheric concentrations have always lagged increasing temperatures. The Earth has now been in another warming period for several hundreds of years, which could well prove to be the primary ‘thermostat’ of the Earth’s surface temperature, or at least a strong contributor.

Climatologists claim proof of climate change due to global warming by citing the retreat of glaciers and ice-caps, more severe droughts, more severe bushfires, bleaching of coral reefs, migration of fish species, and greater frequency and severity of hurricanes/typhoons/cyclones and tornados. They agree that glaciers and ice-caps have been retreating for hundreds of years, since the pre-industrial age, but now claim that global warming due to burning fossil fuels is exacerbating and accelerating the melt.

Although Australia has recently suffered another long drought, there is no statistical evidence that droughts, which are endemic to Australia because of its geographical position and topography, are getting more frequent or longer. Nor is there evidence that the devastating bushfires of 2019 were a consequence of climate change, rather than of the parching effect on vegetation by an extended drought, by the avoidable build-up of the fuel-load in bushland and forests, and the penetration of housing and commercial development into these vulnerable zones.

It can be shown that the climate and prevailing weather patterns in Australia are primarily a function of the combined effects of El Nino/La Nina in the east, the Indian Ocean Dipole in the west, the south-west cold air masses from the Antarctic and by the summer monsoons in the north.

While there has been some evidence of bleaching of coral reefs and migration of fish species due to an increase of ocean temperatures, these were on the planet long before the human race came along and will be here long after humanity disappears. In the meantime, any ill-effect is primarily economic, e.g., the impact on tourism.

Nor is there evidence of increased activity of hurricanes/typhoons/cyclones and tornados around the world. To the contrary, there is statistical evidence of reductions in frequency of all of these. Cyclones are an annual event in Australia but are not increasing in frequency or intensity. The only really devastating cyclone in the past 60 years was Tracy through Darwin in December 1974.

Nor are hurricanes and tornados increasing in frequency in the USA and Caribbean. Obviously, Katrina was a very devastating hurricane, but statistically not unusual.

Given acknowledgement of significant risk of global warming, Australia’s priority should be on proofing itself against consequences like drought and fire and not on excessive subsidies of renewable energy generation, much of which will prove eventually to have been largely a waste of both industry investment and taxpayer funds.

Contrary to the claims by climatologists, genuine believers and irrational protesters like those of “Extinction Rebellion”, climate change is not an ‘existential threat’ to the world, let alone Australia; not like a world nuclear war or some remote planetary calamity would be. Even the United Nations puts the fighting of climate change well down its list of priorities for humanity in general.

Rather, it would appear that the world is facing a ‘perfect storm’ of several possible existential threats over the next 50 years or so, given the pressures of an ever-growing population, nationalistic threats, religious intolerance, rapidly advancing technology and the perverting effect of social media, let alone the risk of permanent climate change. Above all, the threat of global warming and consequential climate change should be kept well in perspective.

For Australia, our greatest threats are much different from, but not immune to, those of humanity in general. Notwithstanding that climatologists say it would have serious impact on countries like

Australia, in suffering more from droughts and limited water resources, permanent climate change poses a relatively small threat for Australia, given its climate history.

In Australia's case, one order of importance of threats to its way of life and wellbeing could be: Chinese expansionism (economic strangulation, a diaspora of over a million already flooding the country with immigrants of doubtful allegiance); sustainable population growth (given Australia's limited fresh water resources and arable land); global competition for limited world resources (leading to mass illegal immigration and possible conflict); artificial intelligence (AI - eventually leading to loss of control by human intellect); nanotechnology (especially combined with future AI); action on climate change; pandemics (from whatever source, even biological warfare); complemented by myriad other problems facing the world that would impact Australia.

Notwithstanding the various sources of serious threats, before the turn of the century the unchecked growth in global population and its natural consequences could yet prove to be the greatest existential threat to humanity in general - with or without global warming.

Principal conclusions and messages

There have been many conclusions drawn and implied recommendations made throughout main document. So, what are considered the principal conclusions and messages for our leaders and their baying critics?

- Australia accounts for only 0.32% of the world population and contributes only 1.06% of world greenhouse gas emissions. Consequently, no matter what Australia does to lower its emissions, it cannot make any significant impact on global warming, let alone on climate change.
- Australia may be the world's largest exporter of coal (all high-quality), but accounts for only 7% of total world coal production. It makes zero sense for irrational calls to close down an industry that is the nation's second biggest exporter. Export of Australia's coal and natural gas should be allowed to change as international demand and economics dictate.
- Renewable energy sources in Australia account for only 6.5% of its annual energy demand. Other than to help meet its international obligations, why should Australia waste further resources on renewable energy, at great expense, with virtually zero effect on climate change?
- The average world surface temperature is gradually increasing, but the claim of climatologists that greenhouse gas emissions, especially of CO2, are the primary cause thereof, is not proved. While there is a well-documented gradual increase in atmospheric CO2 concentrations, the relationship between average temperature and average CO2 concentration is but a correlation and not an established cause and effect relationship. Seasonal dynamics of the Earth's atmosphere are far too complicated to draw such conclusions, even with use of the powerful computers available today.
- Australia's real challenge is, under the precautionary principle[13], to recognise the probable effects of global warming across the country - what, when and how change might occur. Australia can move only to protect itself as best as possible and that means climate proofing this land of 'droughts and flooding rains'.
- Instead of wasting billions of taxpayer funds on reducing greenhouse gas emissions for zero effect, that money should be put into capturing and managing the country's water resources. If we can build gas pipelines across the country, surely dams and water pipelines from the North to the South would also be economically feasible and to great effect.
- Australia is currently just meeting its commitment under the Kyoto Protocol and Paris Agreement at about 1% per annum reduction in emissions. It may have to do better, not so much as to make any difference to global warming, which it cannot, but to meet its moral obligation as a responsible world citizen. However, it need not be shooting itself in both feet or out there, big-noting itself as the climate change harbinger to the world.

[13] Better to prepare than be sorry.

INTRODUCTION

Bibliography [for executive summary and text only]

1. ACS Climate Science Toolkit; ACS Chemistry for Life.
2. Super-power, Ross Garnaut, La Trobe, 2019.
3. Storms of my Grandchildren, James Hansen, Bloomsbury, 2009.
4. Climate Change Primer; www.warmheartworldwide.org/climate-change.
5. Kyoto Protocol to the United Nations Framework Convention on Climate Change, November 1998.
6. Paris Agreement, United Nations, 2015.
7. IPCC Special Report, 2018 "Global Warming of 1.5 ºC".
8. Charney report: Carbon dioxide and climate: a scientific assessment. Report of an ad hoc study group on carbon dioxide and climate, National Academy of Science, Washington DC,1979.
9. Climate stats; Michael Shellenberger; The Austalian, 4-5 July 2020.

Reason for this document

The sensitivity of the Earth's climate to increases in atmospheric greenhouse gases produced from burning fossil fuels sits at the heart of climate science. Potential global warming and consequent climate change have been the subject of a great deal of scientific activity for a long time - sporadic work going back to the 18th century - but with ramped-up intensity over the past 40 years or so.

Yet, so much alarm in the world today about the doomsday to come unless governments around the world take adequate counteraction to minimise greenhouse gas generation.

A quite extensive study of research and analysis has been undertaken by this author over seven months to determine whether global warming and consequent climate change is actually happening and why, at least to put his own doubts to rest.

Because of the vast breadth and depth of the subject, the content of this paper, although quite extensive, is but an overview of the myriad factors involved, with some original work by this author. Getting to the bottom of the science, where the truth may lie, is like peeling the proverbial onion - like the endeavour of all science. It would take a PhD student several years just to review the extensive literature, let alone to add to the knowledge base with original research. Getting to the bottom of the science and sorting the truth from the fiction and political humbuggery is not for the timid.

Like the vast majority of information available on this subject, which only 'churns' the work and comment of others, this paper too is a consolidation of such information, except that is does contain original work in Annexes D, E, F, G, M, and Q.

The paper is but a snapshot in time of where the world and Australia stand in 2020, in respect of this important subject, given the lively, daily debate and ever-increasing volume of available information - the good, the bad and the ugly.

Definitions

Relevant definitions and acronyms, selected from myriad definitions available are listed in Annex S, *Glossary*.

Information sources

Undoubtedly, the subject is diabolically complex to understand in detail. The volume of literature available is immense with a lot of it, unfortunately, biased, misleading and the work of people of doubtful sanity. Most people have neither the time nor inclination to pursue the subject in detail, as important as it is; they are reduced to trusting scientists or maintaining scepticism according to their prejudices and short-term experiences – "*my goodness it is hot today! It must be climate change!"* So, what hope has the person in the street have to genuinely know the facts? Virtually none! Thus, the vast majority of people feel a hotter summer, see the effects of a very long drought, experience and observe what they feel are more intense weather events, and inundated with opinion and propaganda, purporting to be fact, by daily and social Media, simply opt for an emotional response. The perception of climate change becomes a 100 per cent political issue - a battle for hearts over minds.

All sources of information and data cited are listed in bibliographies at the start of this text and of each annex.

Sources for beginners

A few good sources for beginners are:

- Getting Started, ACS Climate Science Toolkit; ACS Chemistry for Life [1]. This is an excellent overview, covering all significant aspects with a comprehensive questions and answer section. ACS accepts that climate change is happening and has a detailed policy in that regard.
- Storms of my Grandchildren; James Hansen; Bloomsbury, 2009 [2]. Hansen is a long-time, well-known, American climate researcher and active promoter of climate change. See Annex H, *Promoters and critics*, for his biography.
- Superpower – Australia's low-carbon opportunity; Ross Garnaut, LaTrobe University Press, 2019 [3]. Professor Garnaut is a well-known Australian promoter of climate change and advisor to government.
- Climate Change Primer [4]. Although this article supports the notion of climate change, it does give a balanced account of the state of play. It includes a precautionary note for readers to keep an open mind and to keep their prejudices under control. (see Box 1).

> **Box 1**
> What does all of this suggest about your becoming a climate change maker?
> Start by embracing three things:
> (1) no one's opinion makes them stupid;
> (2) nothing about the process is or will ever be simple; and
> (3) everyone you confront has really good reasons for doing what they do.
>
> ***If you can't respect the opposition, deal with complexity or recognize that what you want may not be first on everyone's wish list, get out of the business now!***

Global Sources of importance

Some particular sources have been driving the global debate and action by governments:

- Kyoto Protocol,1998 [5]
- Paris Agreement, 2015 [6]
- IPCC Special Report, Global Warming of 1.5 ºC, 2018 [7].

CRITICAL FINDINGS OF THE STUDY

Population

World population has doubled from about 4 to 8 billion in the 40 years from 1980 to 2020, accompanied by a doubling of energy consumption, of which some 95% was provided by fossil fuels. Population could well increase by another 4 billion over the next 80 years, with a corresponding increase, if not a greater increase in energy consumption, most of it still produced by fossil fuels.

Greenhouse gases, especially carbon dioxide (CO2) produced by burning fossil fuels will increase (or decrease) proportionately with consumption of those fuels. The concentration of CO2 in the atmosphere in 2020 is 413ppm and growing at a rate of 2.08ppm per annum, assuming 'business as usual' as far as consumption of energy is concerned.

World Surface temperature

Most of the scientific debate on global warming is about the future average global surface temperature (Tw), but discussed primarily in terms of the Temperature anomaly (Twi), i.e., the incremental change in surface temperature.

The current value of Twi is about 1.05°C, defined as the increment in average surface temperature since pre-industrial revolution times. Records would indicate that Twi has increased from 0.44°C to the present value of 1.05°C over the past 40 years.

It must be noted that values ascribed to Tw and Twi are very much averages of measurements from sensors all around the globe and from satellites, but there is evidence that the temperature varies considerably by latitude, being higher towards the polar regions. There is evidence also that published temperature values are applicable mainly if not wholly to the northern hemisphere, where the density of sensors is much greater than south of the equator. Consequently, claimed values for Tw and Twi need to be treated with caution in the Australian context.

Given that the Twi record and projections for it are fundamental to the question of global warming, these have been the subject of considerable criticism from some climate scientists who have, unfortunately, been branded as deniers, sceptics or contrarians by the righteous majority.[14]

The IPCC of the United Nations has identified two danger points, i.e., critical values of Twi, being 1.5°C and 2°C, comprising targets devolved from the Kyoto Protocol and the Paris Agreement.

A Twi of 1.5°C is seen as tolerable and the most desirable limit endorsed by the protocols. A Twi of 2°C is seen as manageable but possibly causing more frequent and violent changes in climate events, but not permanent climate change. A Twi of 3°C, not specifically identified in IPCC reports as a target, may be considered as a maximum tolerable threshold before permanent, detrimental climate change could (but not for certain) occur.

Projections by the United Nations' Intergovernmental Panel on Climate Change (IPCC) say that Twi could reach 1.5°C by 2045, 2°C by 2075. Extrapolation of these values gives a projected date of 2125 for 3°C. These projections also mirror projected dates for a 'business as usual' regime, being a worst-case scenario, as determined by this author.

It can be shown that if the world is able to reduce greenhouse gas emissions by an average of 1% per annum, over the next 30 years, a Twi of 1.5°C would be reached by 2051; 2°C by 2087; but 3°C would never be reached. Under the protocols, most countries, including China (as the largest emitter at some 24% of total), have committed to reduce emissions by around 30% by 2030, nominally from 2005 levels.[15]

Despite the controversy, there is sufficient evidence that the average surface temperature (Tw) is increasing gradually and that the world would cope well enough with a Twi of 2°C and higher, but 3°C should be seen as a probable 'tipping' point where some permanent climate change may occur. Even if that occurs, the human race, although facing difficult times, would survive. Climate change is not an existential threat as such, not like a world nuclear war or some remote planetary calamity would be.

Notwithstanding this conclusion, none of these earlier dates to reach the IPCC limits of 1.5°C and 2°C is far away - less than 70 years - and indicate that the world needs to continue to reduce consumption of fossil fuels or, at least, to use fossil fuels like natural gas that produces significantly less greenhouse gases than coal.

A world average reduction of 1% per annum for 30 years and beyond could prevent excessive global warming, although a greater reduction would obviously be better. A reduction of this degree is well within the capability of industrialised nations like Australia. But, for developing nations, especially for India, south-east Asian countries and some rapidly growing and large African countries like Nigeria, that is hardly a realistic target. These countries have a lot of economic catching-up to do and probably will not be denied their place in the sun, at the expense of further global warming.

This means that the industrialised nations, including Australia, will have to do better than a continual 1°C per annum reduction, to compensate for increase in emissions by developing nations. How much better is another question not addressed in this paper.

Under the Protocols, China, with 1.4 billion people and growing (22% of the world population) and emitting about 8 tonnes of CO2 per annum (well above the world average), is still treated as a developing nation under the protocols, which of course is a farce. China has a major role to play

[14] Consistent with the 'political correctness' plague pervading the Western world democracies.

[15] 2005 levels of emissions by country have not been researched for this paper.

in controlling future levels of world emissions, but whether it will fulfil that role or forge ahead contrary to what the rest of the world may think, say or do, is another question.

Seminal science

The seminal research by Charney [8] has been responsible for most of the scientific research on global warming over the past 40 years. The basic conclusion of the report predicted that Twi would increase by 3±1.5°C for a doubling of CO2 concentrations from 280ppm in pre-industrial times to 560ppm. Later research shows that this relationship would also hold for current periods. In 2020, the CO2 concentration of 413ppm and Twi of 1.05°C are consistent with the theory, in respect of the short-term warming trend, but considerably less than the figure of 1.5°C that is predicted for the assumed long-term warming trend (due to warming inertia of ocean currents).

CO2 emissions

World CO2 emissions in 2020 are estimated at 36.5 trillion tonnes, based on world consumption of fossil fuels. This may sound a lot but is very small compared to the total weight of CO2 in the atmosphere.

The average per-capita world emissions are 5.6 tonnes per annum. Australia's per capita emissions are 15.8 tonnes per annum but ranking 14th compared to other counties. Australia contributes only 1.06%[16] of world emissions, so small, no matter what Australia does to combat global warming, it can make no real impact on world emissions.

Renewable energy in Australia

Net zero emissions by 2050, for any country, will be a very difficult, expensive task and of doubtful need, given that renewable energy is currently producing less than 10%[17] of the world's fossil fuel consumption. Several Australian states have signed up to this target but not federally. Notwithstanding the huge investment and government subsidies in Australia over the past few decades, renewable energy sources produce only 24% of electricity sector demand, which comprises 27% of total energy demand. Thus, renewables in Australia currently produce only 6.5% of its total annual energy demand. There is a long way to go yet.

Given the little progress with renewables to date, at considerable expense, albeit manifested in some of the world's highest energy prices, achieving net zero emissions by 2050 would appear to be a pipedream in Australia, if reliant on renewable sources. Note that 'net zero emissions by 2050' expects renewable sources to replace all fossil fuel use, not just for the electricity sector.

It is also very doubtful, despite claims by the industry, that renewables could even supplant fossil fuel use for the electricity sector alone. Given its miniscule contributions to world greenhouse gas emissions which are of negligible effect on global warming, let alone climate change, Australia could easily and should continue to use fossil fuel-fired power plants, to minimise electricity prices. In the long-term, given abundant resources of uranium, nuclear energy should always be an option to meet the growing demand for electricity in Australia.

The proposition put forth by Professor Garnaut and associates [2] that hydrogen, as a universal emission-free fuel, could be a saviour of the planet, while technically possible, is yet to be proven to be economically feasible. It should be noted that, while not the only technology available to produce hydrogen, the principal means by electrolysis, because of poor process efficiency, would require the colocation of the plant with huge renewable energy farms and sources of fresh, pure water, most probably in remote locations well away for consumers.

Fossil fuels

Australia is the leading exporter of coal but only the 5th largest miner of coal. Annually, China produces and burns seven times more tonnage of coal than produced by Australia. Australia exports the highest-grades of coal, that being the very reason why it is the major exporter - other countries need and buy our coal - no sales no export. It makes zero sense for those anxious about climate change to demand the shutdown of coal mining in Australia, its second biggest export, when buyers would have to source inferior coal elsewhere that produces greater emissions. If it is

[16] Could vary from 1.03% to 1.1%, average 1.06%.

[17] Varies by country.

to close down, coal mining in Australia should be allowed to occur naturally as world demand and economics dictate.

Australia is also the world's leading exporter of natural gas, which can and does compete with coal because of its lower greenhouse gas emissions per unit of energy produced. Whether availability of natural gas could ever supplant coal completely in Australia would appear feasible, but should occur as un-subsidised economics permit.

Causes of global warming

Climatologists have long claimed that it is the greenhouse gas emissions produced by burning fossil fuels, especially CO2, that control the surface temperature (Tw) and any increment (Twi), by acting as the 'thermostat' of the planet's climate. They further claim that water vapour and clouds affect temperature as only a positive feedback process, i.e., as the greenhouse gases push up temperature, more water vapour and clouds are produced, so adding to the greenhouse (warming) effect (and higher precipitation somewhere on the planet).

Water vapour is recognised as a much stronger greenhouse gas than CO2 and, after considerable analysis, it is clear that water vapour and clouds together have a far greater effect on surface temperature than does CO2, the latter contributing only around 25%.

Nevertheless, this conclusion does not necessarily in itself negate a primary claim of climatologists that the non-condensable greenhouse gases comprise the only 'thermostat' of the surface temperature, but validity of that claim needs irrefutable, experimental proof to be provided by climatologists.

Palaeontological records show that the Earth has gone through many alternating warm-ages and ice-ages over the past millions of years and that CO2 atmospheric concentrations have always lagged increasing temperatures. The Earth has now been in another warming period for several hundreds of years. Climatologists acknowledge this, but claim that increasing greenhouse gas concentrations since the industrial revolution now lead surface temperature. The validity of that claim is strongly contested by critics. The current warm-age could well prove to be the primary 'thermostat' of the Earth.

Consequences of Population growth

World population has doubled from about 4 to 8 billion in the 40 years 1980 to 2020 and is expected to peak somewhere between 10.5 billion to 12.5 billion over the next 80 years.

Climate change or no climate change, another 3 to 4 billion people, a possible increase of 50%, poses major threats to humanity in its own right, because of increased competition for scarce planetary resources, particularly arable land and fresh water. Illegal migration has been occurring for at least 50 years already and can be expected to become worse, due to probable famine, disease and perhaps even armed conflict over scarce resources. However, there is some hope; researchers like Shellenberger [9] would argue that technology could solve the most serious problems, e.g., a 40% improvement in crop yields in the sub-Saharan regions.

Permanent climate change – weather events

Climatologists claim proof of climate change due to global warming by citing the retreat of glaciers and ice-caps, more severe droughts, more severe bushfires, bleaching of coral reefs, migration of fish species, and greater frequency and severity of hurricanes/typhoons/cyclones and tornados.

They agree that glaciers and ice-caps have been retreating for hundreds of years, since the pre-industrial age, but now claim that global warming due to burning fossil fuels is exacerbating and accelerating the melt.

Although Australia has recently suffered another long drought, there is no statistical evidence that droughts, which are endemic to Australia because of its geographical position and topography, are getting more frequent or longer. It can be shown that the climate and prevailing weather patterns in Australia are primarily a function of the combined effects of El Nino/La Nina in the Pacific Ocean, the Indian Ocean Dipole in the Indian Ocean, the south-western cold air masses from the Antarctic and by the summer monsoons in the north. This situation can be expected to prevail for many decades, even many centuries into the future, depending on how the heat of the oceans is distributed around the planet by prevailing currents, at different depths and timeframes, even as long as 1,000 years for the deepest currents.

Notwithstanding the undoubtedly severe bushfires in Australia during the summer of 2019-20, again there is little if any evidence that these were a consequence of climate change, rather than of the parching effect on vegetation by an extended drought, by the avoidable build-up of the fuel-load in bushland and forests, and housing and commercial development encroaching upon and even penetrating within these vulnerable zones.

There is evidence of some bleaching of coral reefs and migration of fish species due to an increase of ocean temperatures. However, reefs and fish were here on the planet long before the human race came along and will be here long after humanity disappears. In the meantime, ill effects are primarily economic, e.g., tourism, and not long-term environmental.

Nor is there evidence of increased activity of hurricanes/typhoons/cyclones and tornados around the world. To the contrary, there is statistical evidence of reductions in frequency of all of these. In Australia, tornados are very rare; there have been only two of any intensity and doing significant damage in in the past 60 years. Cyclones are an annual event in Australia, but are not increasing in frequency or intensity. The only really devastating cyclone in the past 60 years was Tracy through Darwin in December 1974.

Nor are hurricanes and tornados increasing in frequency in the USA and Caribbean. Obviously, Katrina was a very devastating hurricane, but statistically not unusual.

Climatologists claim that global warming is already changing the climate in respect of precipitation patterns. They say that, although atmospheric water vapour, clouds and consequent precipitation are increasing because of human-induced global warming, precipitation patterns themselves are changing. Specifically, they say that more moisture is being carried away from the tropics towards the poles, by natural, prevailing air currents (Hadley cells[18]), so starving tropical regions of precipitation and increasing it in northern and southern latitudes. This has yet to be proven.

What is being done

Following international endorsement of the Kyoto Protocol and the Paris Agreement, many countries have taken action to reduce greenhouse gas emissions. Some like the United Kingdom have even legislated to achieve net zero emissions by 2050. Most of the countries comprising the United Nations are small emitters and are lobbying for greater effort by industrialised nations to prevent perceived climatic catastrophe in their regions or to subsidise reduction efforts in their countries. The USA (12.1% of world emissions) has threatened to no longer subscribe to the protocols. China, the biggest emitter (24%), like most countries, is committed to a reduction of about 1% per annum through to 2050.

Under the protocols, Australia is committed to and is reducing its emissions by at least 1% per annum. Notwithstanding its record, it would seem that Australia is being unfairly targeted in the UN, aided and abetted by ‘progressive’ bodies and much of the left-leaning Media in Australia, accusing it of ‘rorts’ in claiming past credits to meet its commitment. In reality, Australia is doing its fair share.

Given that it produces only 1.06% of world greenhouse gas emissions and cannot affect global warming in any way, Australia needs only to meet its international obligations. Arguments by critics that Australia should be out there as an example to and leading the world is nothing short of sophistry, even hypocrisy, motivated more by politics rather than genuine concern for the environment.

On one hand, as mentioned earlier, Australia will have to do more as an industrialised nation to compensate for slacking by other countries, if an average reduction of at least 1% is to be achieved. On the other hand, Australia should not be wasting billions of dollars on subsidising renewable sources of energy, more than is needed to meet its international obligations. They

[18] The Hadley cell is a closed circulation loop which begins at the equator. There, moist air is warmed by the Earth's surface, decreases in density and rises. A similar air mass rising on the other side of the equator forces those rising air masses to move poleward. [https://en.wikipedia.org/wiki/Atmospheric_circulation]

should be forced to compete with other sources, given that Australia has many potential sources of energy and can have virtually zero effect on global warming anyway.

Given acknowledgement (sans panique) of global warming, Australia's priority should be on proofing itself against consequences like drought and fire and not on subsidising renewables, much of which will prove eventually to have been largely a waste of both industry investment and government subsidies.

Existential threats

If one is to believe the often-strident claims of climatologists and fellow alarmists, global warming and permanent climate change is well on the way and comprises the number one existential threat to humanity. The truth is far from that. Even the United Nations puts the fighting of climate change well down its list of priorities for humanity in general.

It would appear that the world is facing a 'perfect storm' over the next 50 years or so, given its growing population, nationalistic threats, religious intolerance, rapidly advancing technology and general pollution of the atmosphere and waterways, let alone the claims of permanent climate change.

In respect of existential threats to humanity this century, as may be expected, opinions vary widely according to source, vested interest and politics. Above all, it must be noted that threats are peculiar to each nation, depending on its natural climate, resources and economic status. Existential threats are quite different for every nation - one suit does not fit all, even if all are in the same planetary boat.

For Australia, our greatest existential threats are much different from, but not immune to, those of humanity in general. Global warming and climate change are relatively small existential threats for Australia even though the country could suffer even more from droughts and limited water resources.

In Australia's case, one order of importance of existential threats could be: Chinese expansionism, economic strangulation, a diaspora flooding of this country with immigrants of doubtful allegiance (well over 1 million already); sustainable population growth, given Australia's limited water resources and arable land; global competition for limited world resources, both leading to illegal immigration and conflict; artificial intelligence (AI), eventually leading to loss of control by human intellect; nanotechnology (especially combined with future AI); action on climate change; pandemics - from whatever source, even biological warfare; complemented by myriad other problems facing the world that would impact Australia's way of life and wellbeing.

Notwithstanding sources of existential threats, before the turn of the century, the unchecked growth in global population and its natural consequences could yet prove to be the greatest existential threat to humanity in general - with or without global warming.

While potentially very serious, in the long-term, global warming and consequential climate change should be kept well in perspective.

A FEW GENERAL COMMENTS

Very few people have any hope of understanding the science of global warming or knowing where the truth lies. They are simply asked to "trust the science", as they are expected to trust other specialists. As a result, virtually everybody will fall back to their held political beliefs, ignoring what they do not want to hear, see or read, with political parties and supporting Media gladly feeding them the party-line, albeit with a grain of truth, but more likely gilded as far as credibility and law suits may tolerate.

In this regard, the COVID-19 epidemic in the first half of 2020 provides a good object lesson. For almost six months, people around the world largely obeyed their governments in respect of precautions against spreading the virus, based on the expert advice of the health professions and science. Yet, when it comes to global warming and climate change, notwithstanding protest marches and continual, often strident comment in the Media, governments and the public have not reacted to advice of climatologists in the same way. Why the difference?

It is almost certainly due to two reasons, namely: the timeframes involved and the relative lack of misinformation being disseminated by whomever.

The COVID-19 threat has been recognised as an immediate threat, whereas that of climate change is still in the never-never for most of the world's population. Among the 8 billion people on this planet, the greater majority remain ignorant of the potential threat, because of illiteracy, apathy or preoccupation with sheer survival. Although, the reaction to and consequences of the virus have varied widely by country, which may be put down to many physical, economic and social factors differently affecting each country, misinformation has been minimal, albeit evident in some countries to some extent.

For all those Australians worried about climate change, let's be straight! Australia, let alone the Federal Government, has not caused global warming, consequent climate change or more intense droughts or weather events. Australia's influence on the climate has been and will remain negligible, no matter what it does. Unfortunately, global warming and climate change are being blamed too, illogically, for the disastrous bushfires of 2019. It has been argued by commentators that more could have been done collectively, particularly at the State and local government levels, to have prevented the severity of the fires, had it not been for certain political pressures that allowed the risk to increase to dangerous levels.

Promoters of climate change are not really about 'saving the planet', as often couched in arguments, it is about saving humanity and, specifically, about preservation of their bloodline. It is also the developed and wealthy nations, having created much of an increasing greenhouse effect, that are now making most noise. The reality is that most of the human race is more concerned about where its next meal is coming from, or climbing the economic ladder, rather than how to limit any climate change.

If readers have seen the film documentary 'An Inconvenient Truth' (2008), one should recognise the political context in which it was made, the sensationalism that it encompassed, the doubtful veracity it purveyed and, above all, the fact that it dragged in some US$50 million in revenue for its producers and front-men. A sense of the sensationalism may be gained by noting what was claimed then and what has not come true over the 12 years since. Nor does the sequel 'An Inconvenient Truth II' correct the sensationalism by publicising, among other things, achievements in the renewable energy field which, although significant, affect only the demand for electricity, which accounts for roughly 30% of total energy consumption by industrialised nations.

SUMMARIES OF ANNEXES

[See annexes for bibliography references]

Annex A – Introduction to global warming

About the annex

Annex A introduces the subject of global warming. Climatologists and promoters of climate change say that anthropological[19] activity, which is increasing with world population, is warming the planet and engendering dangerous and life-threatening climate change.

It introduces the concept of an 'enhanced' greenhouse effect, the basic cause and effect chain; the claims of climatologists; questions most often posed by critics and public alike; the assumptions underlying the scientific case for global warming; tenets complementing assumptions; probable causes, main factors at work and definition of what constitutes greenhouse gases. Each of these subjects are discussed in detail in annexes that follow.

'Enhanced' greenhouse effect

Use of the term 'enhanced' greenhouse effect is deliberate throughout the paper, given that the Earth has always been subject to a greenhouse effect, essential to life on the planet. The Earth's atmosphere has always acted like a garden greenhouse[20] that captures heat[21] from the Sun, ensuring temperatures, according to the seasons and latitudes, that have permitted the emergence

[19] human

[20] Use of the term 'greenhouse effect' is an analogy only; the atmosphere actually insulates the Earth in a different way.

[21] The word 'heat' is very commonly used interchangeably with 'thermal energy', whereas 'heat' is technically defined as the 'transfer of thermal energy'.

and sustenance of all life forms on Earth, including humans. Without the greenhouse effect of our atmosphere, the earth would be a very cold, uninhabitable place indeed.

Basic cause and effect chain

The basic argument of climatologists - those who research and promote global warming and climate change - goes like this, each subject being treated in some detail at the annexes of this paper, as indicated:

- It started with the industrial revolution (Annex P);
- causing exponential technological growth (Annex P);
- causing world population growth (Annex G);
- causing ever-increasing consumptions of the earth's resources for food, housing and mobility (Annex G);
- causing ever-increasing demand for energy, particularly for industry, transport and electricity (Annexes F, G, Q);
- causing an enhanced greenhouse effect (Annexes B, C, D, E, F);
- caused by global temperature change (Annex D);
- causing global warming (Annexes D, E, M);
- causing permanent climate change (Annex I);
- causing unprecedented consequences for humankind (Annexes G, I);
- causing the world to react (Annex J).

The claims of climatologists

The fundamental claims of climatologists are that:

- the average world surface temperature (Tw) and incremental changes thereto, referred to as the Temperature anomaly (Twi), are caused by and controlled only by the presence and concentrations of non-condensable greenhouse gases in the atmosphere, in particular carbon dioxide (CO2), i.e., Tw and Twi = Function (CO2 ppm[22]).
- CO2 ppm and CO2e[23] is caused primarily by the increase in world consumption of fossil fuels caused by world population growth;

  Note: *CO2 occurs also for natural reasons.*

  Note: *As the most important of the non-condensable greenhouse gases, CO2 is used here as a proxy for the effect of all non-condensable greenhouse gases, i.e., excluding water vapour.*
- Atmospheric water vapour (H2O) increases as a function of Tw, through increased evaporation of terrestrial waters, virtually all from the oceans.
- Water vapour, is excluded as a driver of Tw and Twi because it is condensable into clouds and its concentration in the atmosphere is due only to the surface temperature controlled by the non-condensable greenhouse gases.
- Water vapour is recognised as a greenhouse gas and more absorbent of infra-red radiation (IRR) than CO2, but seen by climatologists only as a positive feedback phenomenon to global warming rather than a cause of surface temperature change, due its presence at lower altitudes and to its short life-time.

  Note: *This author refutes these last two arguments. (see Annex E, Temperature change - possible causes*).
- CO2 concentration controls Tw and, thus, the level of water vapour in the atmosphere.

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[22] 'ppm' is parts per million moles in atmosphere. Moles comprise all identified atomic particles existing in the atmosphere.

[23] CO2e is a weighted effect of all greenhouse gases, but CO2 is the most important.

Note: *Any relationship between CO2ppm and Tw is a correlation only, i.e., a direct cause-and-effect relationship is in theory only has not been established in fact*[24].

Probing Questions

Several questions have been posed by scientific critics and the public alike:

- Given that CO2 concentration is only 0.04% (1/40,000) of the atmosphere, how can it be such a strong IRR absorbent and the cause of global warming?
- What is the validity of the claim that only CO2 (with some help from other non-condensable greenhouse gases) determines the Earth's surface temperature (Tw) and the Temperature anomaly (Twi), and that water vapour does not?
- Is there a direct cause-and-effect relationship between CO2 concentration and change in global surface temperature or is there a correlation only?
- Given acceptance that the concentration of water vapour and clouds increases with surface temperature and are both strong absorbents of IRR, what is the predominant cause of global warming, water vapour, clouds and aerosols[25] or the non-condensable gases, particularly CO2?

These questions are addressed and answered at Annex D, *Temperature change - fact of fiction?* and Annex E, *Temperature change – possible causes.*

Assumptions underlying the scientific case for global warming

Of necessity, several simplifying assumptions are made by climatologists to support the case for CO2 as the main villain:

- The world surface temperature and Temperature anomaly (Tw and Twi) are averages from sensors from around the world and from satellites and are presumed **accurate** measures of the effect of climate change. **Considered not valid**. In fact, reports say that variations at higher latitudes could be from 2 to 5°C above the world average. This assumption is subject to heavy criticism by critical climatologists and some evidence of data tampering[26].
- The Earth's energy balance is predominantly due to radiation into and out of the Earth System[27], with minor roles assigned to the other sources of thermal energy, namely thermal flux (heat) emanating from the Earth's interior and massive amounts of 'new' thermal energy created by burning fossil fuels and electricity production by nuclear power plants. **Mostly valid.**
- All IRR reflected downward from the atmosphere to heat the land and oceans is from greenhouse gases (excluding water vapour and clouds). **Considered not valid**. IRR from water vapour and clouds is in fact very substantial.
- Clouds play no significant part in global warming. **Considered not valid**. Even the primary literature, in which the UN promotes global warming and climate change, acknowledges that the science of clouds and their effect is still very poorly understood and is the weak link in argument for global warming.
- A basic tenet of radiation theory is that whatever infra-red is captured by gases or water vapour is also emitted by the same amount. **Valid**.
- The Earth is considered as a black-body emitter, i.e., emitting the same radiation power as it absorbs. **Considered not quite valid**. The Emissivity of the Earth (0.96) is assumed to be unity but is of no significant consequence.
- There is a direct cause-and-effect relationship between CO2 (and other non-condensable greenhouse gases) and global warming. **Considered not valid**. While climatologists say that Tw and Twi are a function of CO2ppm, whatever relationship they claim exists is

[24] As far as this author has been able to determine in his research.

[25] Aerosols comprise particulate matter like soot, dust and ash, as well as gases like fluorocarbons.

[26] Discussed in Annex E, *Temperature change-fact or fiction?*

[27] See annex K, *The Earth system* for description of basic facts about the Earth.

purely a correlation, i.e., there has not been a cause-and-effect relationship established[28]. Therefore, ppm could just as well be a function of Tw, which science has shown to be the case in every past ice-age the Earth has experienced [1, Fig 3, p37].

Tenets

In complementing the several assumptions, the scientific case rests upon certain tenets:

- The Earth's energy budget must be in equilibrium, i.e., the warming power of all incoming un-reflected short-wave solar radiation (in watts per square metre W/m^2) must equal the power of long-wave IRR out into space[29]. (See Annex C, *Radiation and concept of forcing*).
- All bodies of matter absorb and re-emit radiation energy according to their emissivity properties.
- CO2 is a strong absorbent of IRR in three narrow bands of wavelengths - 2.7, 4.3 and 15 µm[30]. This means that most of the heat producing radiation escapes the CO2. Only 8% of the available black body radiation is picked up by these "fingerprint" frequencies of CO2. [2]
- Water vapour is a stronger absorbent of IRR than CO2, at most wavelengths of the IRR spectrum, mostly on either side of the CO2 bands, and the two overlapping around the 18µm wavelength.

  Note: *The infra-red spectrum is quite large, extending from the nominal red edge of the visible spectrum at 0.70 µm to 1,000 µm. This range of wavelengths corresponds to a frequency range of approximately 430 THz down to 300 GHz. Water vapour is an active absorbent of IRR across much of the spectrum.*

Annex B - Genesis and theory

About the annex

Annex B is intended only as an overview of the genesis of the world-wide debate and the theories expounded by scientists about the projected change in the average surface temperature, referred to as the Temperature anomaly (Twi), epitomising global warming underlying the debate. It also gives an insight into the complexity of the problem in identifying the myriad scientific disciplines and technologies necessarily involved.

It discusses the seminal Charney Report; the theories involved; climate sensitivity; the theoretical effect of doubling CO2 atmospheric concentration from pre-industrial revolution levels (280 ppm)[31]; and conclusions.

In particular, it involves the sciences (theoretical and applied) dealing with radiation (solar, earth and atmospheric), atomic physics, atmospherics, meteorology, oceanography, palaeontology, geology, glaciology, anthropology, biospherics, climatology and others to perhaps a lesser extent. Each of these sciences, in turn, depends on a large range of general and specific-to discipline technologies, developed from the knowledge of physics (including thermodynamics), chemistry, engineering, advanced mathematics, systems theory and computer modelling, as well as hardware like microscopes, spectrometers, computers, a large range of sensors and probes and satellites.

Global warming is not a novel idea. Scientists have been addressing parts of the presumed problem for the past two centuries, one way or another. For over 100 years, scientists have theorised that the atmosphere acts like a blanket to keep the Earth at liveable temperatures and speculated upon the existence of greenhouse gases and CO2 as the main culprit.

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[28] There are claims that some laboratory simulation has been undertaken to establish a cause-and-effect relationship between ppm and Tw.

[29] Note that all energy returned to space is in the form of IRR, given that conduction and convection cannot occur in the outer edges of the atmosphere where there is no physical matter.

[30] μm = micro-metre = one millionth of a metre

[31] CO2 is 413 ppm in 2020, still a long way from 560 (2 x 280).

Source of climate science

Notable early pioneers were: Jean-Baptiste Joseph Fourier [1768-1830]; John Tyndall [1820-1893]; Nils Gustaf Ekholm (1848-1923); and Svante August Arrhenius (1859-1927).

In more recent times there has been: Hubert Horace Lamb [1913-1997]; Jule Gregory Charney [1917-1981]; Edward Norton Lorenz [1917-2008] and James Hansen [1941-].

Charney Report

Although there has been a great deal of activity by the scientific community throughout the 20th century, it was not until President Carter of the USA, in 1978, commissioned Professor Jule Charney of MIT to head a scientific group to prepare a report on global warming.

As taken from the Charney Report: [15]:

"*Specifically, our charge was:*

- *To identify the principal premises on which our current understanding of the question is based,*
- *To assess quantitatively the adequacy and uncertainty of our knowledge of these factors and processes, and*
- *To summarize in concise and objective terms our best present understanding of the CO2/climate issue for the benefit of policymakers."*

The Report (reviewed in detail by this author and summarised in Table B1-1, Appendix 1) seems to have several contradictions in respect of a final decision on radiance forcing. However, the fundamental conclusion by the report [15, p2] is the second and main conclusion that: "*We estimate the most probable global warming for a doubling of CO2 to be near 3°C with a probable error of ± 1.5°C".*

Note: *The said range 3°C ± 1.5°C is quite wide. The current (2020) value for Twi is said to be 1.05°C. 'Doubling of CO2' means from the pre-industrial age concentration of 280ppm to 560ppm. CO2 concentration in 2020 is 413ppm and increasing at a rate of 2.05ppm per annum. See Annexes D and E for detail.*

This predicted range for Twi is sacrosanct among the climatologists who see it as the foundation of the modern science of global warming and climate change.

The Report is the fundamental source document for subsequent work by climatologists, extensive work by IPCC Working Groups, endorsement by the United Nations and world-wide promotion of global warming ever since by vested interests - sadly, much of which is quite misleading and pure sensationalism.

Although there have been advances in computer modelling and other techniques, the range for Twi of 3°C ± 1.5°C, as estimated by the Charney Report, has remained essentially unchallenged. As late as 2013, IPCC Fifth Assessment Report [16] upheld the range with high confidence.

Primarily, the conclusion on the probable range of the Twi, was based almost exclusively on the most advanced computer modelling (at the time) performed by three groups of research scientists, particularly the work by Manabe and Wetherald [17].

The Manabe/Wetherald technical report is the only one reviewed by Charney's group that is in the public domain and available on the Internet. Unfortunately, that paper (and probably the others from GCM modelling as well) gives no insight or information on modelling assumptions (there would be many simplifying assumptions of necessity), equations used or data plugged in to the models. Therefore, the validity of this fundamental modelling is buried <u>deep</u> within the research community, probably never to be examinable by other scientists, let alone the public.

In its conclusions, the Manabe/Wetherald report [17 p13] says, inter alia:

- *"In this study, an attempt is made to analyse the effect of doubling the CO2 concentration [as tasked by Charney] in a highly simplified three-dimensional general circulation model."*
- *"Because of the various simplifications of the model described above, it is not advisable to take too seriously the quantitative aspect of the results obtained in the study."*

The Theories

In particular, the theories underlying the foregoing conclusion by Charney relied on some notable basic science, namely: radiation theory; Planck's law; Stefan–Boltzmann equation; and Einstein's famous equation for mass and energy.

Conclusions

Getting to the bottom of the relevant science is like peeling the proverbial onion. Unfortunately, the lowest layers of the onion are buried deep within the scientific world, never to see the light of day for all except the very few scientists performing the research.

Climate sensitivity (ΔForcing/ΔTemperature, i.e., F W/m^2/ Twi°C) due to concentrations of greenhouse gases and natural terrestrial causes sits at the heart of theoretical climate science. What the climatologists are really trying to answer is whether the average surface temperature of the Earth is actually increasing and, if so, at what rate and what is causing it.

A more efficient approach might have been to concentrate first on getting the temperature record straight and agreed, with science in parallel to explain how and primary causes. On the latter point, a great deal of effort has gone into proving that non-condensable greenhouse gases are the primary culprits.

In fact, the cause is a combination of both greenhouse gases and natural terrestrial causes, although the former is the hot favourite. Climatologists and supporters claim that the effect of increasing greenhouse gases far outweighs natural causes and discount the latter, such as Earth/Sun dynamics and the current warm-age (interglacial period).

While there seems to be general consensus on the validity of the science, the literature is all over the place, often confusing and even contradictory in estimates and explanations.

There would appear to be consensus among climatologists on the following aspects that:

- doubling of CO2[32] concentration (nominally from the pre-industrial age estimate of 280 ppm and primarily from burning fossil fuels), would, in the long-term, cause a Forcing of about 4 W/m^2;
- which, produces a Climate Sensitivity of about 0.75°C/W/m^2; and
- Temperature anomaly (Twi) of 3±1.5°C for a doubling of CO2 concentration.

In respect of where the world stands in 2020, with a CO2 concentration of 413ppm, theoretical research to date gives that the average Temperature anomaly (Twi) would be just on 1.05°C since about 1750. This figure agrees with some published records from observations from surface sensors and satellites.

However, given that the temperature record has been under severe dispute, there needs to be a lot more work to be done to achieve consensus before proof of causes can be determined and validated.

Annex C - Radiation and concept of forcing

About the annex

Annex C is intended as a basic primer on the nature of solar radiation reaching the Earth, infra-red radiation (IRR) leaving the Earth and the difference referred to in the scientific world as 'forcing'.

It deals with the aspects of radiative forcing, the global energy budget, climate sensitivity, solar irradiance and its spectrum, emitted long-wave IRR; and radiation absorption bands of CO2 and other emission gases, as well as for water vapour.

The greenhouse gases, including water vapour, are said to absorb radiation, including IRR, because of their three-atom molecular structure, whereas nitrogen and oxygen because of their two-atom structure are said to be transparent to radiation. Absorption is explained technically at the atomic level of physics by the excitation of the atoms of molecules by EMR and how kinetic energy is stored within atoms (at least temporarily) by rotation and vibration of component particles.

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[32] Note that CO2 is used as a proxy for all non-condensable greenhouse gases, ie excluding water vapour which is also a powerful greenhouse gas.

It is clear from the IRR absorption graphs that H2O (water vapour and in clouds) is a much greater absorbent of IRR than CO2, the latter being in relatively few and narrow bands, mainly about the wavelength of 15 µm, whereas H2O absorbs over a much wider range of the IRR spectrum, which is quite wide in terms of frequency/wavelength, with the two overlapping around the 18µm wavelength.

While H2O may be the preponderant absorbent of IRR, this fact does not necessarily deny the claim of climatologists that only the concentrations of CO2 and other non-condensable greenhouse gases control surface temperature and that atmospheric H2O affects temperature by 'feedback' alone. However, the claims by climatologists that 'ample physical evidence' exists that only the greenhouse gases, as the Earth's 'thermostat', control global warming is disputed by some scientists (and by this author too) as 'not proven'.

Annex D - Temperature change – Fact or fiction

About the annex

Annex D addresses whether the average world surface temperature (Tw) and its increment the Temperature anomaly (Twi) is increasing, by how much and at what rate.

The annex discusses in detail and draws conclusions from several aspects, namely: the temperature anomaly data sources; global temperature change; causes of global warming; danger points of temperature; tipping Point; runaway; and conclusions.

Appendix D1, *Temperature anomaly-CO2 relationship*, addresses: derivations from recorded values of Tw; derivations from both CO2ppm and Twi records; date projections for four cases; effect of increasing world population; net zero emissions by 2050; data tables; a summary and conclusions.

It is arguably the most important of the annexes in that it addresses the fundamental question of the global warming debate. What is causing any temperature change is a secondary but no less important question. Answers to both questions need to be known and agreed upon, so that remedial action, if proven to be needed, can be devised and acted upon by those in authority through policy initiatives and funding, especially by the developed nations. Possible and probable reasons are addressed in Annex E, *Temperature change-possible causes*.

Annexes D and E comprise the essential arguments for and against whether the planet is warming at an unacceptable rate and why. Together they may be considered the most important of all 17 related annexes which treat relevant parts of the puzzle.

This annex contains original work by this author on formulation of emission reduction policies and the effect they would have on probable dates for the Temperature anomaly (Twi) to reach IPCC targets of 1.5°C and 2°C, as well as getting to the danger point of 3°C. Of note, this work reaches virtually the same results from two essentially independent directions, namely from direct observations of surface temperature, by whatever means, and by derivation from recorded world consumption of fossil fuels and resultant greenhouse gas emissions.

Danger points of Temperature anomaly (Twi) changes

The Average surface temperature of Earth (Tw) is said by climatologists to be increasing since the start of the industrial revolution (taken as 1750) to the present day, especially what has happened over the past 40 years (1980-2020) with doubling of world population and corresponding demand for energy, some 95% provided by fossil fuels.

It is claimed that human-induced warming reached approximately 1.05°C in 2020, above pre-industrial levels and, at the present rate, global temperatures would reach 1.5 degrees Celsius around 2045, according to NASA.

IPCC[33] reports of the United Nations (UN) and international protocols define an average[34] increase of 1.5°C as the maximum desirable and an increase of 2°C as the maximum allowable, without causing serious, detrimental changes to the climate.

A change to 1.5°C is said to be controllable but causing significant changes to regional climates in terms of increasing average temperatures and changing precipitation patterns, the latter causing

[33] IPCC — Intergovernmental Panel on Climate Change (United Nations).

[34] Temperature readings are taken from sensors all around the globe, in all seasons in both hemispheres and averaged out.

extended droughts in some regions (like Australia) and higher levels of precipitation elsewhere. International protocols are based on 1.5°C as a maximum sustainable temperature.

A change of 2°C and above are said to cause excessive disruption to the world populations as a result of mass starvation and illegal immigration due to famine, increased disease due to warming, especially mosquito-borne diseases, as well as the risk of higher methane and mercury emissions from thawing tundra and perennial burning of drying peat beds.

A change of 3°C is said to approach a tipping point, causing irreversible, detrimental climate change, with catastrophic consequences for humanity.

The IPCC AR5 report [13] defines a tipping point as that Twi at which there would be irreversible change in the climate system. While the literature is largely silent on a global temperature when the tipping point could be reached, given acceptance of the 'precautionary principle' by the IPCC, a possible tipping point could be about 3°C, a temperature that could be reached early in the next century, at current rates of increase in CO2ppm. A tipping point should not be considered as a particular temperature, but as a range above which conditions on Earth become progressively and irreversibly worse for humanity.

Although the impacts of possibly reaching a 'tipping point' are serious enough, having reached it does not mean the total disaster of a 'runaway' climate. The world is a long way off that occurring, if ever.

Controversy

While there may be general agreement on how greenhouse gases have increased and where atmospheric concentrations may go in the future, the same cannot be said for any resultant world temperature change. The science has been the subject of considerable criticism by other scientists. See Annex H, *Promoters and critics.*

Although climatologists claim that there is general scientific consensus[35] about the range of world surface temperature increase above pre-industrial levels, these ranges do vary considerably and the temperature record is heavily criticised by critics (contrarians[36]) as having been tampered with to prove Twi is increasing as a function of greenhouse gas concentrations in the atmosphere.

Nor is data created by some climatologists freely available to other scientists let alone the public. Critics have been silenced, sued and their data 'lost'. Such manipulation of common source data can be biased to whatever objectives the originating agency may have. The history of Temperature anomaly determination is rife with accusations of manipulation, omissions and additions to data to serve political agendas[37].

Douglass and Christy [1] point out an important aspect of temperature anomalies that those derived from surface measurements are not a suitable proxy for that variable and that there are additional reasons for not using the surface temperature data that include non-uniform coverage of the globe.

Data sources

Through palaeontology, scientists have used various techniques, including study of ice-cores, ocean sediment cores and tree-ring records, to establish periods of global warming and ice-ages over the millennia, to establish past relationships between temperature and CO2 concentrations and as a reference for comparison with temperatures and CO2 that have been recorded (or estimated) since the start of the industrial revolution.

General scientific agreement says that the Temperature anomaly index (Twi) in 2020 stands at about 1.05°C[38], i.e., above average pre-industrial temperatures.

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[35] Some 97% of scientists no less, although the sample has never been identified.

[36] An epithet coined by Hansen for 'sceptics'.

[37] Readers should note that virtually all climatologists work for one institution or another; very few, if any, have the means to conduct independent research. Therefore, climatologists are constrained by the mind-set, politics and agendas of their respective institutions, to toe the 'party line'. Thus, the results of good or bad research reach the light of day only through the filter of the institution's agenda. Even the institutions themselves are beholden to the agendas of the powers that provide the funds for research.

[38] Degrees Celsius

Fundamental data are those recorded from original sources (land, ocean atmospheric and satellite sensors). The raw data are massaged and even added to, calculated by computer models using the same source data or from correlated data, e.g., CO2 levels.

Given that sensor readings vary according to prevailing regional conditions (seasons, latitude, etc and the time-base used), various techniques are used to determine average temperatures, moving averages and max/min bands. Gaps and apparently anomalous bumps up or down in the data may be 'smoothed out' by educated guessing. Also, according to critics, it has not been beyond the wit of some climatologists to invent data and to manipulate the graph axes to exaggerate changes, especially for projections into the future. *"Lies, damned lies, and statistics"*[39].

It should be clearly understood that the world surface temperature and changes thereto (Tw and Twi) are averages from sensors from around the world, as well as from satellites in more recent years, and should be accurate measures of the effect of climate change. Actual temperature and variation thereof can vary substantially by hemisphere, region and season, especially in higher latitudes. Although there is also monitoring of ocean temperatures, most surface instrumented sensors are located in the industrial areas of the northern hemisphere.

The annex shows several graphs of the Temperature anomaly (Twi), from various sources, each purporting to show growth in Twi and even correlation with greenhouse gas atmospheric concentrations.

One set of graphs presented in the annex (Box D10) is very interesting in that it compares the average temperature anomalies (Twi) for the two hemispheres and globally (around a base date of 1960). These are quite different, showing Twi in 2020 in the northern hemisphere at twice that of the southern hemisphere, i.e., 1°C compared to 0.5°C (from a 1960 base date). Consequently, most literature should be read as pertaining only to the northern hemisphere, even though climatologists rarely, if ever, make this clear.

Higher average temperature changes at higher latitudes, especially in the northern hemisphere, could be important due to the potential melting effect on glaciers, ice-caps and sheet-ice although such melting would be primarily a function of slowly-increasing ocean temperatures rather than by the temperature of air masses. In fact, the elevated temperatures recorded in the Arctic are due rather to convection of warm air from the tropics and the temperatures are higher there than in the Antarctic because of the preponderance of land masses in the north and of oceans in the south.

Net zero emissions by 2050

The IPCC Glossary [19] defines Net zero emissions as *"Conditions in which any remaining anthropogenic carbon dioxide (CO2) emissions are balanced globally by anthropogenic CO2 removals. Net-zero CO2 emissions are also referred to as carbon neutrality."*

Many countries (and some Australian states, but not federally, have signed-up and made a commitment under the United Nations' Kyoto Protocol and Paris Agreement to achieving Net zero emissions by 2050 (only 30 years away). But is such a target really feasible or just an objective? How do these countries - rich or poor - plan to get there and pay for it without damaging their economies?

Net zero emissions by 2050 means that a subscribing country will need to reduce its net emissions by 100% within 30 years, i.e., an average of 3.33% per annum. Under the Paris Agreement, most countries have signed up to reduce their emissions by about 1% per annum, from 2005 levels. While a reduction of 1% per annum has been shown to be feasible, tripling this rate would be a very difficult and expensive task for any country. The financial burden on countries like India ($42.4 trillion[40]) could be crippling.

Countries like Australia are counting on renewable energy sources to meet its reduction commitments. However, renewables currently produce only about 10% of world fossil fuel

[39] *"Lies, damned lies, and statistics"* is a phrase describing the persuasive power of numbers, particularly the use of statistics to bolster weak arguments. It is also sometimes colloquially used to doubt statistics used to prove an opponent's point, mistakenly attributed by Mark Twain to Benjamin Disraeli, Prime Minister of England.

[40] www.carbonbrief.org/paris-2015-tracking-country-climate-pledges

consumption and about 27% of the electricity market[41]. Australia currently meets only 6.5% of its energy needs by renewable sources.

Nevertheless, some countries, e.g., the United Kingdom (UK), have even legislated a zero emissions commitment.

This subject is addressed in Annex J, *What can and is being done*.

Summary and conclusions

Table D1-8 (copied below) consolidates the data in other tables of Appendix D1 to show the most probable impact of four cases of world emissions growth on when the critical Temperature anomalies of 1.5, 2 and 3°C could be reached.

Case 1 - assumes one growth policy (defined in Appendix D1 and Table D1-5), set for each country, that could be met. However, given world population trends, increased emissions would be worse than for the current Cases 2 and 3 - not sustainable, i.e., action to curtail emissions is needed.

Case 2 - derived from actual and predicted CO2 emissions data - assumes that current emission rates will continue through to 2100 - not sustainable.

Case 3 - the basic case based on NASA/Mauna Loa data - assumes that current emission rates will continue through to 2100 - not sustainable.

Case 4 - assumes one possible reduction policy for all countries of an average of at least 1% per annum over the next 30 years and beyond. Note that this is only one of many possible reduction policies, or ‘paths’ as often referred to in the literature[42]. Its effect can be seen to be only marginally better for Temperature anomaly of 1.5 and 2°C but, importantly, indicates that a Temperature anomaly of 3°C may be avoided, i.e., never reached. This policy would be consistent with eliminating fossil-fuelled generation of electricity which, in most developed countries, currently produces some 25% to 35% of all CO2 emissions.

Under the Kyoto Protocol and Paris Agreement, Australia is committed to reducing its emissions by 26 to 28 per cent from 2005 levels by 2030, i.e., about 1% per annum. An Australian Department of Energy Emissions Report, as reported in The Australian, 29 May 2020. [18], says that Greenhouse gas emissions fell 0.9 per cent last year to 532.5 million tonnes, i.e., about 1% per annum.

Under ‘business-as-usual’ regimes, the worst-case scenario is that a Twi of 1.5°C would be reached by about 2045; 2°C by 2073; and 3°C by 2125. This situation would not be sustainable and action is needed by all countries to curtail emissions.

Under a Case 4 regime, a Twi of 1.5°C would be reached by about 2051; 2°C by 2087; and 3°C never. This could be a sustainable scenario.

In all probability, the world could cope well enough with a Twi of 2°C and even up to 3°C although with some difficulty. Beyond 3°C permanent climate change could be expected.

These point estimates would have error bands on either side, but most likely on the outward side because, while the estimates assume ‘business-as-usual’ consumption rates of fossil fuels, there are reports that such consumption and the CO2 produced therefrom is starting to decline. If so, the projected dates would be delayed but not by much of any real consequence.

Notwithstanding these conclusions, none of the earlier dates is far away - less than 70 years - and indicate that the world needs to continue to reduce emissions from consumption of fossil fuels by at least a world average 1% per annum for at least 30 years. However, given that this is a world average, the industrialised nations, including China, would have to reduce emissions by more than 1% per annum to compensate for developing countries that can be expected to increase emissions. Australia will have to do better too.

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[41] www.c2es.org

[42] This paper has not evaluated the various ‘paths’ enunciated in the literature but they are generally demanding a much more severe reduction in emissions than 1% per annum.

Table D1-8

Twi predictions for reduced and increaseed emissions

Case	TCO2 pa Change	x 10^9 TCO2 pa	ppm	% Δ ppm	Year to reach Twi 1.5 °C	2 °C	3 °C	Notes
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	
1	1.1	36.9	417.65	0.5416%	2045	2073	2125	[8] [8A]
2	1.03	36.7	415.40	0.5172%	2049	2081	2147	]9]
3	1	36.5	413	0.5157%	2046	2074	2131	
4	0.7	25.7	[10]	-1.0000%	2051	2087	never	[11]

Notes:

1. Reduced/increased level from 100% (Year zero)
2. Billions of tonnes of CO2 released by fossil fuels pa.
3. CO2ppm.
4. %Change in CO2ppm.
5. Year to reach Twi= 1.5 °C.
6. Year to reach Twi= 2.0 °C.
7. Year to reach Twi= 3.0 °C.
8. If countries consume fossil energy at a probable increased per capita rate.

8A. Expected increase is from 36.7 in 2020 to 52.6 Billion Tonnes in 2100.

9. If countries continue to consume fossil energy at 2020 per capita rate.
10. CO2ppm reducing 4.15ppm pa over 30 years (max).
11. Assumes CO2 emissions reduced by 1% pa over 30 years (max).

General Comments:

Very difficult to decrease use of fossil fuels and therefore future is bleak.

30% reduction is feasible given electricity generation consume about 30%.

Future may need a hydrogen power generated by renewable sources.

Annex E – Temperature change – possible causes

About the Annex

Annex E poses and provides answers to the fundamental question of why a change in the average World surface temperature, i.e., the Temperature anomaly (Twi), may be increasing at an unacceptable rate, if indeed proven to be the case.

It and Annex D *Temperature change – fact or fiction?* together comprise the essential arguments for and against whether the planet is warming and why.

The Annex discusses in detail and draws conclusions from several aspects, namely: a few basic facts (in 2020) (atmosphere, CO2, and water vapour); world surface temperature; causes of global warming (the theory, assumptions underlying the scientific case for global warming, tenets); questions (CO2 concentration is only 0.04%, CO2 as Earth's thermostat); cause and effect; causes of global warming (fundamental causes, new heat, natural warming, feedback warming and cooling, overall warming, leading or lagging - the Temperature anomaly/CO2 relationship).

Appendices E1 and E2 address more detailed aspects.

The Annex contains original work by this author to establish the dominance of water vapour and clouds over non-condensable greenhouse gases specially CO2, as the primary cause of prevailing surface temperature.

Background

Global warming is said by climatologists to be driven primarily as a function of the concentrations and radiation absorbing properties of the greenhouse gases (GHG) in the atmosphere, where global warming means an increase in the average surface temperature of the Earth. Any consequent climate change would be how prevailing weather patterns for regions and seasons respond to the stimulus of any increase in surface temperature.

Although there are several greenhouse gases, the most important ones are water vapour (H2O) (condensable), active in the troposphere (up to12 km altitude); carbon dioxide (CO2), methane (CH4) and sulphur dioxide (SO2) (non-condensable), active up through the troposphere and stratosphere; and ozone (O3), active in the stratosphere. The mesosphere and above layers (55 km to outer space) are not of any significant consequence to global warming except, perhaps, for the negative effects of cirrus clouds.

While methane and sulphur dioxide, which are strong infra-red radiation absorbents, contribute significantly as greenhouse gases, their relative effect is small because of their very low concentrations and relatively low half-lives.

There has been and still is controversy as to what is the predominant force on the average world surface temperature and global warming, CO2 or water vapour, aerosols and clouds. This Annex deals only with the relative effects of these agents.

Discussion

In its discussion on the causes of global warming, i.e., an increase in the Temperature anomaly (Twi), this Annex makes a distinction between fundamental causes, being due to all greenhouse gases, including water vapour, and the secondary effects of what is referred to in the literature as 'positive/negative feedback'. Both contribute to global warming as such.

There are essentially four basic arguments made by climatologists for what could be causing fundamental global warming, namely: a) increasing volumes of CO2 (and other non-condensable greenhouse gas) emissions produced by burning fossil fuels that are absorbed and retained by the atmosphere; b) atmospheric water vapour and clouds; c) natural causes; or d) some combination of the foregoing four.

Of these four, CO2 (and other non-condensable greenhouse gas), and natural causes could be sources only of increases in Twi, whereas water vapour and clouds are contributors to both fundamental and feedback warming.

Climatologists, the IPCC, the UN and promoters blame the greenhouse gases (excluding water vapour) and dismiss the possibility of natural causes. However, given the very strong effect of water vapour and clouds, the argument by climatologists that non-condensable greenhouse gases, particularly CO2, comprise the 'thermostat' of Earth and thus are the only controllers of the Temperature anomaly (Twi), cannot be sustained without conclusive, experimental proof[43].

The basic argument by climatologists goes something like this. Only the non-condensable greenhouse gases act as a 'thermostat' and thus control surface temperatures around the globe. The presence of water vapour (and clouds) in the atmosphere is a function of surface (ocean) temperatures and so constitutes only a positive 'feedback' to the surface temperature and global warming. Note, however, that water vapour is a much more powerful absorbent of infra-red radiation than CO2, with at some 10 times the atmospheric concentration (0.4% compared to 0.04% for CO2).

Climatologists offer a 'proof' to the foregoing by saying that, if burning fossil fuels stopped tomorrow and the atmospheric and ocean temperatures were to stabilise - as they were in pre-industrial times[44] - evaporation from the oceans and subsequent cloud formation would be also stable and not be able to cause global warming. While this may seem a reasonable, logical argument, it discounts completely the extremely important effects on climate and weather of the ocean currents, particularly the fundamental effects of El Nino/La Nina (ENSO)[45] and the Indian Ocean Dipole (IOD). In fact, Hansen [2, p4] dismisses the ENSO (and by implication the IOD) as 'one big slow sloshing on the Earth' of no effect on global warming (in the northern hemisphere that is).

In respect of natural causes, the argument by climatologists is quite weak when analysed in some detail. The basic argument for natural causes is that it can be shown that the Earth has been in a warm-age for hundreds of years, with temperatures still rising. Some if not all climatologists acknowledge this but now claim that the effect of greenhouse gases has overwhelmed natural causes, starting with the industrial revolution and particularly in the past 40-50 years with the doubling of world population and fossil fuel use. That claim has been heavily criticised by some scientists.

Annex E, Appendix 1 – Earth's energy balance

Discussion of the Earth's energy budget complements the theory behind climate global warming and change discussed in Annex B, *Genesis and theory*. Like the work in Annex B, this subject is

[43] Scientific proof (not logical deduction) needs to be established.

[44] A somewhat debatable point in itself.

[45] El Niño–Southern Oscillation (ENSO)

part of the theoretical approach climatologists have taken to global warming, in contrast to the empirical approach by recording of the world surface temperature (Tw) and any increments thereto, namely the Temperature anomaly (Twi), by way of instrumented observations at the near surface and from satellites.

It examines the work of two leading authorities on the subject of the Earth's energy budget, namely NASA [8] and by the scientist M.L. Salby [9]. While the two sources differ in a few details, their overall data and analyses are in close agreement.

It is clear from analysis that both water vapour and CO_2 are strong absorbents and radiators of IRR but that water vapour and clouds together have a far greater effect on surface temperature than does CO_2, the latter contributing only around 25%.

Annex E, Appendix 2 - Cases for and against CO2 as the earth's thermostat

This appendix comments on several of the references, in the context of the claim of climatologists that only CO_2 (as well as other non-condensable greenhouse gases) acts as a 'thermostat' to determine the Earth's surface temperature (Tw) and increase thereof (Twi).

It was written after review of additional technical papers provided by Dr Howard Brady, Author of the book 'Mirrors and Mazes', after discussions with him. Dr Brady is a noted Australian scientist and disagrees with the conclusions of the IPCC on global warming and climate change.

The papers discussed in this appendix are probably as good as the published science gets.

There appears to be sound proof, at least theoretically, that 2xCO_2 concentrations would produce a Radiation Forcing (F) of 3 W/m^2, a Climate sensitivity of 2.3°C and a Specific Climate Sensitivity of 0.77 °C/W/m^2, as predicted by scientists for decades.

However, a few serious anomalies remain. There are still valid questions to be answered in respect of the true relationship between CO_2 ppm and temperature Tw, namely:

- How can similar rates of increase in temperature Tw be the result of quite different rates of change in CO_2 ppm, for the periods 1910-1940 and 1970-2000?
- What is the scientific explanation for the distinct cooling period from 1940 to 1980 which has not been convincingly explained by climatologists? It is a serious anomaly in the argument by climatologists that needs to be explained.
- What is the true role of cosmic and solar weather on global warming, if any?
- What is the true role of water vapour and cloud behaviour around the planet? "we are dealing with a coupled chaotic nonlinear system and therefore the prediction of future climate states is not possible.' IPCC Report 2001 (14.2.2.2).

The second crucial claim that "the essential and only cause of temperature change is the change in concentration of non-condensable greenhouse gases in the atmosphere, particularly CO_2" is still not proved.

Annex E – General conclusions

Fundamental global warming is caused by natural earthly phenomena, especially the relationship between the Earth and Sun, as well as by the greenhouse gases, including water vapour. However, respective contributions are very difficult to determine, given the preponderance of literature that promotes greenhouse gases as the primary cause.

The question of whether greenhouse gas levels determine temperature change or vice-versa is a fundamental question. Geological evidence of temperature leading greenhouse gas levels cannot be denied, especially given the severe criticism of the Temperature anomaly (Twi) records presented by some climatologists. The current warm-age could well be the dominant cause of any global warming.

The average world surface temperature is gradually increasing, but the claim of climatologists that greenhouse gas emissions, especially of CO_2, are the primary cause thereof, is not proved. While there is a well-documented gradual increase in atmospheric CO_2 concentrations, the relationship between average temperature and average CO_2 concentration is but a correlation and not an established cause-and-effect relationship. Seasonal dynamics of the Earth's atmosphere are far too complicated to draw such conclusions, even with use of the powerful computers available today.

After considerable research and analysis for this document, it is clear that both water vapour and CO2 are strong absorbents/radiators of IRR but that water vapour and clouds together have a far greater effect on surface temperature than does CO2, the latter contributing only around 25%.

On balance, until proven otherwise conclusively by climatologists, a natural warm-age is believed to be the predominant 'thermostat' of the Earth, and not the non-condensable greenhouse gases.

This conclusion does not necessarily in itself negate a primary claim of climatologists that greenhouse gases comprise the only 'thermostat' of the surface temperature, but validity of that claim needs irrefutable, experimental proof to be provided by climatologists.

Annex F – Demand for energy and emission

About this Annex

Annex F addresses the production and consumption of energy across the world in general and in Australia in particular; world and Australian coal production; renewable energy sources; and greenhouse gas emissions from these anthropological activities. Most importantly, it puts into perspective Australia's almost negligible role in any global warming, let alone climate change.

The Annex discusses in detail and draws conclusions from several aspects, namely: energy sources; world production and consumption of energy; Australian production and consumption of energy; world coal production and reserves; world greenhouse gas emissions; emissions per capita; several data tables; a summary and conclusions.

Appendix F1 is dedicated to renewable energy in Australia, comprising sections on: Australian energy lobby groups; types of 'renewables'; Australian production of renewables; subsidies of renewables in Australia; energy from fuel cells; and a Noddy's guide to hydrogen.

The annex contains original work by this author on the projections for world demand for energy and consequent CO2 emissions.

Summary

Primary sources of energy for use by humanity are as listed below, all of which, with the exception of nuclear, owe their existence to radiation from the sun, received over millions of years and every day:

- Fossil fuels comprising:
  - the various grades of petroleum, black coal, brown coal, peat and natural gas; and
  - old growth forests[46].
- Renewable energy: solar; wind; hydro; geo-thermal; bioenergy/biomass, marine (wave and tidal action); and energy storage (batteries and pumped-hydro). This is the currently accepted scope of 'renewables' but see the following discussion.
- Nuclear [none in Australia].

Pertinent content of the Annex is summarised in Table F18, copied here. It also poses several questions that Australian climatologists should be pressed to answer in a rational manner.

[46] Old growth forests are not normally included as a fossil fuel but in fact they are just that. Trees 300 years old can hardly be considered as renewable sources.

Table F18

Energy - Australia - 2020 Fact Sheet
Facts for 2020
Population
The world population is currently 7.8 billion, going to 10.9 billion by 2100.
The world population is currently growing at 36 million a year.
Australia has only 25 million, ie 0.32% of the world population (25M/7.B.)
Coal production
China is the world's biggest coal producer at 50% of total.
Australia is 5th and produces only 7% of world production.
Australia has third highest high-quality coal reserves at 14% of total.
Australia is the leading world exporter of coal.
Australia exports its high-quality coal only because other countries want to buy it.
Australia does not export GHG emissions.
Energy production
The world produces a total of at least 10.236 billion tonnes of oil equivalent per annum
The world produces a total of at least 12.762 billion tonnes of coal equivalent per annum
The world per capita consumption is 2,674 KWh pa.
Australia per capita consumption 9,742 KWh pa, but 9th in world.
CO2 Emissions
The world produced a total of 36.5 billion tonnes of CO2 per annum
World per capita production of CO2 was 5.16 tonnes.
Per capita consumption in one country was as high as 64.9 tonnes
Australia per capita production of CO2 was 16.8 tonnes; ranked 14th in world.
But Australia produces only 1.06% of world emissions.
Renewable energy in Australia
Electricity accounts for 27% of energy consumed in Australia.
Renewables account for 23% of electricity generated in Australia
Therefore, renewables account for only 6.3% (0.27*0.23) of energy used in Australia.
Global warming and climate change
Australia is having virtually zero effect on global warming or climate change.
Australia is wasting resources investing billions in renewable energy.
Australia should invest to protect itself against detrimental climate change.
Questions Australian climatologists should answer
Why should Australia waste resources on renewable energy when we have zero effect on climate change?
Why damage ourselves economically by banning coal when other countries would buy dirtier coal?
Why should Australia do more to reduce GHG emissions than required to meet international obligations?
Why should Australia not be investing in climate-proofing itself rather than subsidising renewables?
Why should Australia continue to subsidise renewables at great cost with little result?

Conclusions

This annex covers the subjects of world energy consumption, the sources of that energy (fossil fuels and renewables) and resulting greenhouse gas emissions[47] , as well Australia's place in respect of each of these aspects.

Australian climatologists, aided and abetted by a large part of the Media, vested interests, rent-seekers and citizen supporters, have been agitating loudly for the Federal Government to do more to prevent global warming and any consequent climate change. In particular they want to shut down the coal industry, the country's second biggest export earner, and more subsidies for renewable energy. Although well intentioned, in their eyes Australia should do whatever it takes, at whatever cost to reduce greenhouse gas emissions. That is not practicable, as virtually conceded by the Australian Leader of the Opposition in The Australian, 25 June 2020, in his proposal for a "bipartisan" energy policy with the governing Coalition.

Yet the reality is that whatever Australia does, it will have virtually zero effect on global warming and climate change. Our contributions to world emissions are miniscule now, so why waste billions of dollars more to have even less effect?

[47] CO2 is used as a proxy for all greenhouse gases.

China is and will remain by far the world's biggest consumer of energy (and thus producer of emissions). It is by far the biggest coal producer in producing 50% of the world's coal, about seven times more than Australia in fifth place, and thus, the biggest emitter of greenhouse gases.

While Australia may be the world's leading exporter of highest-quality coal and natural gas, it does not export greenhouse gas emissions; it exports coal and gas only because other countries need and want these products, without which they would use inferior coal and so produce greater levels of emissions. No buy - no export!

While coal is seen as the 'bad boy', world consumption of liquid petroleum products and natural gas are each larger or about the same as for coal. So, where are the complaints about petroleum and gas usage from the environmentalists still driving fossil-fuelled vehicles and happy to fly around the world? Is there not a bit of hypocrisy here?

India is currently a giant 'sleeper', which, with 1.4 billion people and from a low consumption/emissions base, can be expected to consume increasing levels per capita of energy over the rest of the century, and with consequent greenhouse gas emissions. How can the industrialised nations morally deny developing nations the right to a better standard of living without the use of coal as the cheapest source of energy?[48]

Nevertheless, the climatologists, especially in Australia, are relatively quiet when it comes to China and India.

One often hears in the Media that Australia's per capita consumption of energy and emissions are relatively high. That is so, but with good reason, given its geography and demographics. It is also modest compared to many other countries, Australia being 9th and 14th respectively on these measures. Every country is different and has unique challenges as to its energy needs and solutions. One cannot (should not) compare Australia with say the United Kingdom, which is tackling global warming seriously, politically, if not achieving targets in practice. The UK is 67 million people in an area the size of Victoria, with much of its transportation sector electrified and much of the electricity generated by nuclear plants and hydro-power. Australia occupies a vast, very dry continent with only 25 million people, who are heavily dependent on road and air transport and fossil fuels to power it. The same comparison can be made with European countries.

China, the USA and Europe consume over 50% of the world's energy production, some 90% or more of which comes from fossil fuels. At about 1.06% of global emissions, Australia cannot in any way affect global warming let alone climate change - it has not and cannot. This does not mean that we do nothing, but we do need only to do our share as a responsible world citizen. We do not have to shoot ourselves in the foot trying to big-note ourselves to the other small emitting countries that tend to dominate votes in the United Nations.

While pursuit of renewable energy sources is considered a good thing, there is a very, very long way to go. Australia may be the per-capita world leader in renewable energy, yet it accounts for only about 6.5% of the total energy it consumes itself.

It is wrong for climatologists, the Media and supporters, let alone the vested interests and rent-seekers to imply that the Australian Coalition Government is not doing enough about climate change. It is doing as much as it needs to do to meet its international obligations. Why should it do more at considerable cost for no effect? Australia could disappear off the map tomorrow and it would make no difference to global warming or climate change. See Annex J, *What can and is being done*, for details on what Australia is doing and achieving.

And arguments one hears from proponents, that Australia should be out there leading an example to the world, when its contribution to world greenhouse gas emissions is a negligible 1.06%, is specious, fatuous, grandiose and is sophistry if not hypocrisy as well:

- *"Australia should be out there leading the world!"* What, with 1.06% of global emissions? Australia could disappear off the map tomorrow and it would make no difference to global warming or climate change.
- *"Even with its small contributions to emissions, Australia should be rallying all small emitters to band together to force the big emitters to do more to reduce overall*

[48] One should not be taken in by the claims that renewables are cheaper than coal/gas fired generators.

emissions." Fair enough but what are the small nations doing in the UN? Blaming Australia for not doing enough and accusing it of 'rorts' in claiming past credits.

- *"Australia claiming past emission credits is a 'rort'* [The Australian, 25 June 2020]. Why? It is no different to students claiming credits for subjects passed in previous years or at other institutions.
- *"Shut down coal now."* Why? For countries needing coal to buy dirtier coal from other countries and cause more emissions?
- *"We must trust our scientists. 97% of scientists cannot be wrong!"* Why? It is of no consequence if 1,000 or even 100,000 scientists have signed a petition in belief of climate change. It is only the valid findings of the few who are doing the 'hard yards' in research who count. All the rest are expressing an opinion no more valid than the man and woman in the street.

Our real challenge is to recognise the probable effects of climate change on Australia (not good), what, when and how they might occur and how we as a nation might best respond. Australia can move only to protect itself, climate-proof itself, as best it can against any changing climate such as extended droughts and bushfire disasters. That is where Australia's investment should go and not be wasted on chasing ineffectual reductions in greenhouse gas emissions.

For example, climate-proofing could include projects to capture the billions of tonnes of monsoonal rain running off into the sea each year; better arid-area farming and irrigation techniques; better education on water usage, to name a possible few.

In his essay 'Of vainglory' in The Essays [22, p217] Sir Francis Bacon wrote *"**A fly sat on the axle-tree of a chariot wheel and said, 'What a dust do I raise?'**"*[49] Is that our Australian climatologists speaking?

Annex G – World population growth and consequences

About the Annex

Annex G addresses the question of the world's population, how it has grown to date, more rapidly in more years, and to what level it may reach and level out, if at all. It then looks at the repercussions on humanity itself from in eating itself out of house and home. However, the real problem, in the minds of climatologists, is that population is pushing greater demand for energy and, so, greater levels of greenhouse gas emissions into the atmosphere so accelerating global warming and possible permanent climate change to the detriment of humanity.

The relationship between population growth and energy demand is not quite a simple matter of proportionality, as may be seen when discussed in Annex F, *Demand for energy and emissions*.

The Annex contains original work by this author on the analysis of projections for world population growth, particularly by regions, development of a possible emissions reduction policy, and how future greenhouse gas emissions may grow.

Discussion

The Annex discusses and draws conclusions about the consequences of world population, in respect of: overall world population growth; consequences of overpopulation; and existential threats from a world and Australian perspectives.

Population growth since early times, especially in the past 150 years, is well documented. It has been growing at an exponential rate, having doubled in the 40 years since 1980, to about 7.8 billion in 2020.[1] Official projections expect world population to level out at about 9.8 billion, but with positive error bands, this could be out to perhaps 12.5 billion. That is an average of about 25 million per annum over 80 years but some regions in Africa and Asia are accounting for a short-term rate of about 39 million a year.

Population projections are given by regions. These numbers are very important because projections for energy consumption and consequent greenhouse gas emissions will not necessarily follow the overall population curve. Industrialised nations in the west have flattened out and even decreased their greenhouse gas emissions, whereas the developing nations, even China which is well advanced

[49] Incorrectly attributed to Aesop but was said by Lorenzo Bevilaqua [Note 1, The Essays, p217].

on others[50], have a long way to go to catch up with the western nations. The big sleepers are India (the most populous nation by 2100) and Nigeria, both currently with a very low energy consumption per capita but high potential for demand.

The relationship between population and energy demand is not a simple matter, as may be seen from the discussion in Annex F, *Demand for energy and emissions*.

There is no doubt about population growth causing ever-increasing consumption of the earth's resources and fouling the environment in the process, especially by:

- the demand for arable land, water, minerals and vegetation;
- increasing production of food, consumer goods and infrastructure;
- increased production and consumption of energy in all its forms;
- destruction of greenery, especially the jungles of the Amazon, central Africa and Indonesia to create arable and grazing land;
- the increased use of synthesised fertilisers for enhanced food production and to compensate for exhausted arable land; and
- ever-increasing pollution of our water resources with enormous volumes of plastic waste – complete products like bottles and bags, as well as pulverised and degraded particles – killing ocean mammals and detectable in fish species and even in the deepest recesses of the oceans.

Population growth at its current exponential rate, if not checked, could lead to disaster for humanity, eating themselves out of house and home, no different to the lemmings, <u>with or without any effect on global warming</u>.

In particular, availability of fresh water resources could well prove to be a principal limiting factor on population growth, and with dire consequences. Yet, there are several ways that some (but not all) nations could supplement fresh water resources from use of sea water:

- Massive desalination plants already exist but are expensive to build and can consume masses of electricity, still largely dependent on generation from fossil fuels, which would simply add to global warming.
- These could be and are being powered from neutral-renewable energy sources (see definition at Annex L, *Energy*) but still require huge investment in both the plant and power and with substantial ongoing maintenance costs.
- Solar stills can also produce fresh water, given space and investment, but are probably not economic on a large scale.
- Water is even being extracted from the air in some places, but almost certainly not an economic proposition on a large scale.

Notwithstanding the strong but often irrational debate about anthropological (human-induced) climate change, it is extremely important to note that population growth would continue upwards until checked naturally, even if the global temperature were perfectly stable. Any human induced global warming would simply hasten the process. This means, as often spoken about by Dr Lomborg, (who does not deny that global warming is occurring) that the trillions of dollars being wasted in trying to combat climate change, with virtually zero effect, would be much better invested in saving humanity from itself. The greatest existential threat to mankind could well be mankind itself - its need to breath, eat, drink and powerful instincts to procreate.

In respect of existential threats to humanity within the next 60 to 100 years, to this point, this paper has identified two, namely the effects of permanent climate change and unchecked population growth. There are others that must be considered. As may be expected, opinions vary widely according to source, vested interest and politics and, above all, in the context of each nation's geographical and economic position in the world.

The Annex canvasses several sources on opinions of most pressing existential threats to mankind. If one were to believe the climatologists, climate change is Public Enemy #1. Two of these sources place climate change as Number 1, but others place it well down the list. Notably, even the UN places action on climate change as number 13 in its list of priorities for the world.

[50] There is considerable angst about China still sheltering as a 'developing' nation, when, in fact, it is very advanced technologically and economically.

Notwithstanding that ‘we are all in this together’, it must be remembered that all countries are different. They have different problems, different social structures, different geography, different locations on the planet, different climates and different national interests to protect or project.

Consequently, existential threats to Australia must be seen and considered as quite different from every other nation. In the opinion of this author, they are, in order of risk[51], within this century:

1. Chinese expansionism, economic strangulation and the Chinese diaspora flooding of this country with immigrants of doubtful allegiance *[well over 1 million already]*; [*high probability within 30 years + very high consequences]*.
2. Competition for limited world resources, exacerbated by religious fanaticism, leading to mass, illegal migration and conflict (even nuclear war); [*high probability over next 50 years + very high consequences].*
3. For Australia, sustainable population growth, given its limited water resources and arable land; [*high probability over next 50 years + high consequences]*.
4. Artificial Intelligence (AI), eventually leading to loss of control by human intellect; *[Scary stuff and very few people know where it is heading.*] [*high probability within 30 years + high consequences].*
5. Nanotechnology; *[Scarier stuff, especially combined with future AI and very few people know of the problem, let alone appreciate the danger.]* [*high probability within 30 years + high consequences]*.
6. Permanent climate change; [*high probability within 80 years + high consequences]*
7. Pandemics - from whatever source, even biological warfare; [*medium probability within 80 years + high consequences].*
8. Myriad other problems facing the world that would impact Australia’s way of life and wellbeing. [*of varying probability within 80 years + variable consequences].*

Conclusions

Although the future never seems to turn out as expected, the world could well be heading for a ‘perfect storm’ in as little as 30 to 50 years, given its growing population, nationalistic threats, religious intolerance, advancing technology and general pollution of the atmosphere and waterways, let alone the strident claims of permanent climate change. Global warming and climate change could well turn out to be the least of the existential threats to the world and to Australia in particular.

World population doubled from 4 to 8 billion in the past 40 years with few signs yet of abatement. Growth could be to around 10 to 12 billion through the year 2100, unless checked by government controls, natural causes or serious conflict, one needs to recognise also that population-induced global warming and possible permanent climate change would exacerbate the other threats.

Nevertheless, while having captured the attention of governments and people around the world, global warming and permanent climate change, although possibly coming to pass within this century, should be kept well in perspective, compared to other existential threats within the same timeframe. The often- strident claims of Australian climatologists, rent-seekers and much of the Media are doing little to actually minimise global warming, but a lot to misinform and to panic unnecessarily the population.

Annex H - Promoters and critics

About the Annex

This annex identifies institutions and climatologists that profess to be principal supporters or critics of global warming and climate change, as well as some of the myriad websites and blogs pushing or pulling according to their vested interests, and presents credentials and essential arguments of those entities.

It covers the following aspects: what is in dispute; authoritative research institutions and scientists; other promoters; critics and what they say; critical websites and blogs; and conclusions.

What is in dispute?

The fundamental variables of claimed global warming and consequential climate change are said by scientists to be: world population growth as the driving factor, causing the concentration of

[51] Risk is defined here as the probability of the event times the detrimental severity of the event.

greenhouse gases, especially carbon dioxide (CO2), in the atmosphere to increase, so causing the average world surface temperature to increase, with detrimental effects on mankind.

Fundamentals in dispute are:

- the claimed increase in the average world surface temperature, i.e., the Temperature anomaly (Twi);
- the claimed (or implied) cause and effect relation between atmospheric concentrations of non-condensable greenhouse gases[52], mainly CO2 and the Temperature anomaly (Twi);

  Note: *CO2 is used herein after as a proxy for all non-renewable greenhouse gases.*
- the claim that CO2 is the 'thermostat' of the Earth's climate, i.e., that it is the concentration of CO2 and not water vapour that determines atmospheric temperatures around the globe;
- that apparent, more severe weather events are evidence of permanent climate change; and
- that the climate, however defined, could be changing permanently.

These aspects are defined more precisely and discussed in detail in the several Annexes hereto.

Conclusions

Essentially, the critics do not accept that the average global temperature[53] is increasing, let alone being the result of the increase of atmospheric CO2 and, thus, not contributing to climate change. They claim that vested interests have been manipulating temperature data and performing invalid modelling to show increases.

The planet has been in another warm cycle for hundreds, maybe thousands of years.

Glaciers have been retreating and sea levels have been on the rise since the early 1800s, before the industrial age and massive increase in world population.

Contrary to common belief, storm events have increased in violence, but not in frequency.

Increased levels of CO2 have increased the Earth's vegetation and ability to feed itself.

There is no proof of a cause-and-effect relationship between CO2 concentration and global warming or climate change.

Annex I, Permanent climate change

About the Annex

Annex I discusses what constitutes a climate, how that may change permanently and the consequences of permanent change.

In so doing it addresses several aspects, namely: what is climate and climate change; greenhouse gases; what is weather; clouds and climate change; what is permanent climate change and consequences; severe weather events and damage, including precipitation, hurricanes/typhoons/cyclones, droughts, Indian Ocean Dipole (IOD), El Nino, la Nina, bushfires, the reef, melting glaciers, icecaps and sea-level rise, thawing tundra, mercury, disease, water, food shortages and mass migration.

Conclusions

While there is some evidence of hurricanes/typhoons and tornados becoming more violent, contrary to some expert reports, the frequencies of these are not increasing.

The combined effect of the Indian Ocean Dipole (IOD), El Nino and La Nina, is considered by this author to be the predominant determinant of precipitation across Australia. These ocean events are, in turn, heavily influenced by the prevailing conditions in each of the oceans, namely the trade winds, water temperature, currents, salinity and seal-levels. How these phenomena may be influenced in the long-term by increasing surface temperature is somewhat difficult to say, they being up to a thousand years away, given the varying inertia of the ocean currents at all depths.

[52] Excludes water vapour (H2O).

[53] A flat global average does not preclude increases at different latitudes or climatic regions.

While there have been many reports of the Great Barrier Reef dying off, permanently or for significant durations, given rising ocean temperatures, the reef can be expected to migrate progressively south and will be here a long time after humanity has disappeared from the planet. In the meantime, however, there could be serious economic damage due to loss of tourist dollars and possible damage to commercial fish stocks, if the reef is severely impacted by global warming.

In respect of retreating glaciers, melting icecaps and sheet ice as evidence of global warming and sea-level rises, critics point out that such effects on ice have been going on for hundreds if not thousands of years, given that the Earth is in a natural warming cycle. This is not in fact disputed by climatologists but who say that anthropologically-induced global warming is accelerating the melting.

Scientists report that there are very significant levels of CO2, methane and mercury currently trapped in the arctic permafrost that with warming could escape into the atmosphere, so exacerbating the global greenhouse effect as well as the very poisonous mercury vapour posing a health threat.

In addition, the masses of additional stagnant water from melting ice and thawing tundra would cause massive increase in insect populations, especially vectors of disease like mosquitos.

Given population induced global warming, droughts and more concentrated regions of precipitation away from tropical latitudes, one may see how fresh water and arable land for food production could become in short supply, especially in Australia. Under that scenario, there could be devastating consequences of famine, mass migration of races if not whole nations, which would inevitably lead to violence and war over resources needed for survival.

Annex J - What can and is being done

About this Annex

Annex J addresses the important matter of what can be done and what is being done, in response to the challenge of possible permanent climate change, but in an economically responsible way and recognising that, while ‘we are all in this together’, on planet Earth, what the world institutions like the United Nations (UN) might expect to occur as a whole, is not necessarily in the best interests of any given nation, especially one like Australia.

The annex discusses and draws conclusions in respect of: what can be done; criteria for policy development; international protocols and obligations; Australian Government’s position and emissions target; what the critics of the Government are saying; what Australia is doing to reduce emissions; what the world is doing; net zero emissions by 2050; and what else Australia could do.

Discussion

Climate change due to rising levels of non-condensable greenhouse gases like CO2 in the atmosphere is either real, as promoters claim, not happening, as critics claim, or somewhere in between and controllable with reasonable investment.

Given an objective statement “*To reduce national greenhouse emissions and pollution, subject to reasonable cost”*, and Australia’s international obligations under the Kyoto protocol of 2005 (see Definitions) and the Paris Agreement of 2015, there are many things that Australia can do to reduce emissions. *Running around like “Chicken Littles” or acting like the “Extinction Rebellion” protesters are not two of them!*

Policies and initiatives have been under way for many years already by Australian governments and industry, to reduce greenhouse gases retained in the atmosphere, in tacit if not explicit recognition that these are the primary causes of global warming and any consequent <u>permanent</u> climate change.

There are many and varied ways that greenhouse gas levels in the atmosphere, especially of CO2, can be decreased. All have a place to contribute but, hopefully, each in an economically responsible way (for each country) according to each’s ability to decrease emissions.

There is so much hyperbole and misinformation being generated about climate change by vested interests, rent-seekers the Media that governments are being unreasonably pressured by popularism to adopt inappropriate solutions to the reduction of greenhouse gas production.

Clearly, governments need to establish firm criteria for the development of policies to meet international obligations for reduction of greenhouse gases. One suggested set of criteria could be as follows:

- consistency with their national interests;
- economically responsible;
- consistency with their national resource capability;
- market led initiatives with minimal subsidies;
- based on science and technology;
- morally responsible; pulling one's weight; and
- keeping all issues in perspective.

There is no real place for emotional popularism; the matter is too important to be corrupted by politics.

Under the Kyoto Protocol and the Paris Agreement, in 2016, Australia joined more than 170 countries in signing-up to a global deal that seeks to combat climate change by reducing greenhouse gas emissions.

Australia is committed to reduce emissions to 26-28 per cent on 2005 levels by 2030. This target would represent a 50-52 per cent reduction in emissions per capita and a 64-65 per cent reduction in the emissions intensity of the economy between 2005 and 2030. [2]

In spite of its genuine efforts, critics are giving the Federal Government a hard time about its emissions reduction programs and, unfortunately, undermining the Government's efforts and generating mistrust. Political motives cannot be discounted. Climate change is very much a political football in Australia, if not the world.

There are at least 10 Federal Government initiatives in progress and several others under consideration. Unfortunately, nuclear power generation of electricity is not one of them despite its obvious potential.

Conclusions

The world is working on the problem and investing trillions of dollars in trying to reduce greenhouse gas emissions in an attempt to limit global warming to the targets of 1.5°C and maximum of 2°C, recommended by the IPCC and enshrined in the Kyoto Protocol and the Paris Agreement.

Despite the often-harsh criticism by vested interests, Australian Governments - Federal, state and, territory - are not resting on their arms reversed or on their laurels. A great deal of positive work is being done, despite the sometimes-vicious criticism. Australia will meet its obligation to reduce its greenhouse gas emissions by 26-28 per cent on 2005 levels by 2030.

Use by the Australian Government of carbon credits, obtained in past years, may be unethical in the eyes of her critics but, until banned under the Paris Agreement, use of credits is legitimate practice.

When the ABC, The Guardian and other critics of what Australia is doing about climate change start to address what the really big polluters are doing, they may achieve some credibility in the eyes of rational Australians but, until they are simply on narcissistic joyrides, mostly at taxpayer expense.

Several significant Australian companies are progressively changing internal operational policies to reflect changing, personal attitudes to climate change. Such action has not been without controversy, often being seen as 'virtue signalling' by Board members and CEOs and neglect of their primary duty to shareholders.

The really big emitters are China, USA, India and Europe, which between them account for some 60-70% of all annual CO2 emissions and related pollutants.

We must never lose sight of the fact that Australia accounted for only about 1.06% of global emissions in 2020. Whatever Australia does, its effect on global emissions, let alone climate change and global warming, would be negligible. Climate changers cannot argue with the truth of this statement but attempt, with arguments of sheer sophistry, that Australia with its 25 million citizens (0.3% only) should be showing 'leadership' to the world of 8 billion people.

Australia only needs to demonstrate to the world that it is meeting its international obligations and doing it best to reduce its emissions. It does not have to do more, let alone trying to big-note itself as a world paragon to lead the world to lower emissions. Readers here and Australians need to note that there is no one silver bullet to reducing emissions and that it will take decades to make even modest inroads against excessive emissions. Whether it can be done without wrecking the Australian economy in the process is another but very legitimate question. There are too many climate changers ignorant of the economic damage that their agendas would do. *"Softly, softly, catchee monkey"*, should be a guide.

Annex K - The Earth system

About the Annex

Annex K is an introduction to what constitutes that referred to in the literature as the Earth System. It is descriptive only and meant only to give the setting for global warming and to complement the information in other annexes.

Discussion

The concept of 'the Earth System' is fundamental to the subject of global warming and climate change. For the purposes of this paper, it is defined here as: *"The physical combination of all land, all water (in oceans and fresh on land) and the atmosphere, as well as the dynamic activity on and within these components,"*

The Earth System obeys all of the known laws of physics; its behaviour is described as the most important case of chaos theory, the state of which, at any time in the future, is virtually impossible to predict, notwithstanding recognisable general trends. Super computers are needed to model it but, in the opinion of some scientists, computer modelling still cannot yet predict with valid accuracy.

Note that there is considerable controversy about the progressive disappearance of glaciers and ice-caps. Critics of global warming agree with climatologists that glaciers and icecaps are retreating, except that it has been happening for a very long time, due to a natural long-term warm cycle the Earth is now experiencing, rather than to global warming. Climatologists also agree that they have been melting for a long time but say that they are now melting at an accelerated rate because of global warming.

While all principal components of the Earth System are important to global warming, it is the physics of the oceans that is absolutely fundamental to continental and regional climates and weather systems that prevail around the world, on a daily and seasonal basis. The oceans comprise a gigantic heat sink and reservoir of absorbed minerals and gases, especially carbon dioxide (CO_2). There are huge, powerful currents - warm and cold - moving within, shifting heat around the globe in never-ending cycles which, depending on depth and location, can take from months near the surface to possibly 1,000 years for the deepest currents. It is the delayed effect of the deeper currents that climatologists refer to as thermal 'inertia'. [2, pp 72, 73, 251]

In respect of the essential need for fresh water to all life on land and in the air, it becomes a more precious commodity every day, with the relentless and exponential growth in world population and other detrimental factors at work such as droughts, release of molten ice water into the oceans and pollution in general. Availability of fresh water is seen by some scientists as a probable limiting factor on the ever-increasing population of the planet, to the point of competition (even war) over this scarce resource.

Annex L - Energy

About the Annex

Annex L discusses the nature of the various forms of energy and their relevance to the debate on global warming and climate change. It is meant to be descriptive only and in no way quantitative in how it affects global warming or climates. Other annexes between them cover specific information on this subject.

It covers several aspects including: the nature of energy; forms of energy; new heat into atmosphere from fossil fuels; and Earth's thermal energy.

Discussion

The Annex describes the many forms of energy, namely: electro-magnetic, kinetic, thermal, potential, gravitational, electrical, mechanical, chemical, nuclear (atomic), tidal, earthquakes and sound. Except for earthquakes and sound, all of the various forms are relevant in some way to global warming, particularly in the context of electricity generation.

Other than the bona fide 'renewable' sources, thermal energy (heat) is the most common source of electricity, using fossil fuels. In popular language, thermal energy is almost always referred to as 'heat' but, technically, heat is defined as the transfer of thermal energy. Thus, heat is not energy in itself as such.

The 'renewable' sources, particularly wind and solar, do not consume or produce net energy, but take energy temporarily from the Earth System, convert it into electricity which does work, with the energy content being returned to the Earth System as heat,

In the case of wind, turbines use the kinetic energy contained in the masses of moving air, namely the wind. In the case of solar, panels convert solar radiation directly into electricity using the photovoltaic effect. However, there are other means of capturing the power of solar radiation not using the photovoltaic effect.

A detailed discussion of 'renewable' sources and generation in Australia is given at Appendix 1 of Annex F, *Demand for energy and emissions.*

Annex M - The nature of carbon dioxide (CO2)

About the Annex

Annex M describes the properties and nature of Carbon dioxide (CO2), considered as the primary antagonist in the global warming and climate change debate, so that a better understanding may be obtained by readers as to its real place in the scheme of things.

The annex covers off several aspects about CO2, namely: sources of CO2 emissions; contentious issues; recorded CO2 atmospheric concentrations; CO2 from burning fossil fuels; a brief on world population; a brief on whether CO2 is the principal cause of global warming; thermal properties of CO2 compared to other gases; and the relevance of longevity of CO2 in the atmosphere.

More detailed information and data about the nature, prevalence and attributed effects of CO2 are presented and discussed at Appendix 1 to the Annex, concerning: concentration of CO2 in the atmosphere; the natural cycle of CO2; CO2 in the oceans; basic CO2 facts; and CO2 increase in atmosphere in 2020.

The Annex contains original work by this author on estimates of the tonnage of CO2 entering the atmosphere each year and how that independently and accurately correlated with the CO2 concentrations being recorded by Mauna Loa Observatory.

Discussion

The threat of permanent climate change because of global warming is a major issue under discussion in the world today, and climatologists[54] have fingered an increasing concentration of non-condensable[55] greenhouse gases in the Earth's atmosphere, especially CO2, as the primary antagonists in the global warming and climate change debate.

Excluding water vapour (H2O), CO2 is undoubtedly the principal of the several greenhouse gases, including methane and nitrous oxide, which scientists say are causing global warming through an enhanced greenhouse effect.

It is further stated by climatologists that the increase in greenhouse gas concentrations is due to the increase in world population (anthropological causes) and consequent demand for energy, the greater majority of which is generated by burning fossil fuels. This position has been determined by the Intergovernmental Panel on Climate Change (IPCC) of the United Nations, which promotes it through its international forums. [1]

In respect of contentious issues, climatologists claim and that they can prove the following phenomena concerning the role of CO2 in global warming, that:

[54] Climatologists comprise those scientists concerned primarily with research and analysis of data ascribed to global warming, climate change and consequences.

[55] Although water vapour is also classed as a greenhouse gas, it is 'condensable' and dismissed by climatologists as the primary cause of global warming.

- although only 0.0413% of the atmosphere[56] in 2020, CO_2 is the principal greenhouse gas and the 'thermostat' of the planet;
- because of its 'longevity' in the atmosphere, CO_2 is the principal cause of global warming;
- since the start of the industrial revolution, concentration of CO_2 in the atmosphere has risen by some 42% to the 2020 level of 413 parts per million (ppm);
- the increase in CO_2 has been caused mainly by the increased burning of fossil fuels, which has been caused by a continuing increase in world population;
- global warming is manifested by the Average world surface temperature (Tw) and its increment, referred to as the Temperature anomaly (Twi), which has risen by about 1.05°C above the pre-industrial levels and continues to rise gradually;
- CO_2 is the primary driver of Twi, i.e., that Twi is a function of ppm (Twi = f(ppm);
- water vapour is not the primary driver of global warming, even though the latter is recognised also as a powerful greenhouse gas;
- cloud behaviour is not a primary cause of global warming;
- global warming is causing 'permanent' climate change;
- Desirable limits of Twi above 1.5°C and 2°C have been set by the IPCC [1]. The upper limit of 2°C should be considered as the maximum value permissible before unacceptable and irreversible changes to and consequences of climate change occur.

Significant debate still exists within the scientific community as to the validity of the foregoing claims. So, where does the truth lie?

All of these questions are addressed in detail in Annex E, *Temperature change-possible causes*, Annex D, *Temperature change - fact or fiction*? Annex F, *Demand for energy and emissions* and Annex G, *World population growth and consequences.*

Of all carbon released initially into the atmosphere from all sources, mainly from burning fossil fuels, some 26% has been absorbed by the oceans, about 28% used by vegetation, with 46% remaining in the atmosphere.

It is very important, in this discussion, to realise that the CO_2 level in the atmosphere is varied continuously as a function of the temperature of the ocean and atmospheric pressure thereon, i.e., the ocean is continuously absorbing CO_2 from and releasing it into the atmosphere. It is not all due to burning fossil fuels.

Over the past 40 years, both world population and demand for energy have increased exponentially by 100%, 95% of the energy being generated by burning fossil fuels. Correlation between the two variables is almost 100%. In the same period, there has been an almost linear growth of CO_2 concentration in the atmosphere of 22.2%[57], but is currently curving upwards slightly at 0.505% per annum (Mauna Loa data). These changes are well documented and are not really in dispute.

The following table from Appendix M1, gives estimates from three different sources for tonnes of CO_2 generated in the world for 2020. All are in reasonable agreement, but with 36.5 billion tonnes per annum being the most probable and all within an error band of ± 7%. The differences do illustrate, again, the variation in data for various sources.

[56] Assumes equal distribution throughout the atmosphere, although it is obvious that local levels will be higher or lower. CO_2 levels in building often measure between 1000 and 2000 ppm.

[57] The difference (22% vs 100%) is explained by the fact that only 46% of CO_2 released into atmosphere is absorbed and that that is only a fraction of the total content of CO_2 in the atmosphere.

Table M1-4

World CO2 Emissions (2020)	
Tonnes CO2 10^9	Source
36.5	Actual total world CO2 emissions in 2020 [see emissions table Annex E]
40.00	https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions
41.57	https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data

The fundamental claim by climatologists that the increasing CO_2 concentration (ppm), as the claimed 'thermostat' of the planet, is the sole driver of global warming and consequent climate change may be correct, but is not yet proven. See annex E. *Temperature change– possible causes.*

Notwithstanding the more important effect of water vapour on global warming, CO_2 production from burning fossil fuels is still a major problem as far as the consequences of warming and acidification of the oceans are concerned, so needs to be minimised.

Annex N - Methane

Annex N is a brief introduction to the subject of methane, a powerful non-condensable greenhouse gas in its own right, but of very small concentration in the atmosphere compared to CO_2.

Although not a significant threat yet, it could become so due to potential thawing of northern hemisphere tundra.

Methane is a colourless, odourless gas that occurs abundantly in nature and as a product of certain human activities. It is a molecule of carbon and hydrogen atoms with the chemical formula CH_4 and is among the most potent of the greenhouse gases.

The main sources of atmospheric methane are: emissions from anaerobic decomposition in natural wetlands and paddy rice fields; emission from livestock production systems (including intrinsic fermentation and animal waste); and biomass burning (including forest fires, charcoal combustion, and firewood) and, potentially from thawing of the northern hemisphere tundra and arctic permafrost. [1]

Methane is roughly 30 times more potent than CO_2 as a heat-trapping gas [3]. However, its concentration in the atmosphere in 2020 is only about 2 ppm compared to 413 for CO_2 and has an atmospheric lifetime (before total dissipation) of about 10 years compared to 50-1,000 years for CO_2. [4]

Some references suggest that the contribution by CH_4 relative to that of CO_2 will decrease substantially, from 35% in 1992 to 15% in 2050 [5]. However, this reference would be assuming no further increase in the Temperature anomaly (Twi).

Although not a significant threat yet, it is thought that thawing of the arctic permafrost could exacerbate global warming by releasing methane and other hydrocarbons now trapped therein, which would contribute further to global warming. See Annex I, *Permanent climate change* for more detail on the threat of thawing of the tundra and Arctic permafrost.

Annex O - Aerosols and other pollutants

Annex O addresses harmful matter in the atmosphere, other than non-condensable greenhouse gases, that have some influence on global warming, namely aerosols. It also makes reference to non-atmospheric pollutants plaguing the planet because of human activity. It is intended only as a primer, given that the subject matter is vast and the object of a great deal of research and government attention.

Aerosols are "*particles of matter, solid or liquid, larger than a molecule but small enough to remain suspended in the atmosphere. Natural sources include salt particles from sea spray and clay particles as a result of weathering of rocks, both of which are carried upward by the wind. Aerosols can also originate as a result of human activities, e.g., the burning of fossil fuels and in this case are often considered pollutants. The most important contribution is SO_2. Aerosols have a significant cooling effect with strong regional variation which is not fully understood.*" [1]

'Aerosol' may be seen as a general term embracing both particulate matter and numerous chemical particles, including ions of various elements.

It is important to note that aerosols and particulate matter are important if not essential to cloud formation as nuclei for condensation of water vapour in to water droplets.

While rare, huge volcanic eruptions can cause significant disruption, at least locally, the ill effects of which could last for months if not years, their overall effect on long-term global warming is considered very small. Nevertheless, it may be noted, without further comment, that volcanic ash has in the past caused extended ill-effects on climate in some regions (droughts)[58] and can exist for many years in the atmosphere, even to the highest levels of the stratosphere where it has some effect on solar radiation reaching the Earth.

Since the start of the industrial revolution, there have been many types of pollutants ejected into and detrimentally affecting the environment. In particular, one could include sewerage dumped into waterways and oceans, dumping chemical waste into waterways and simply over the land, mountains of excreted waste from intensive animal farming and domestic waste, but especially plastic products.

Except in under-developed countries, sewerage is generally under control. After much publicity, scandal, court cases and legislation, chemical pollution is largely but not totally under control. Excreted waste from animal farming does not have to be wasted or allowed to pollute, being profitably recyclable into fertilisers and used to generate methane for power.

However, plastic pollution is a growing and deeply concerning problem. Plastic waste is seriously polluting waterways, especially in Asia, and is causing serious issues for fish species and marine mammals. There are huge floating masses of plastic rubbish in various parts of the world's oceans, carried and brought together by the currents. Marine birds are dying from being trapped by, or by consuming plastics. Fish caught for human consumption are found to have plastics in stomach contents and even nano-particles in the flesh. Plastic items and trash have been found on the ocean floors even at great depths.

Pollution, whether atmospheric, on land or in our waterways and oceans, is man-made; solutions too have to be man-made. That requires strong legislation and a balancing act between utility and cost, in all its forms (economic, social and environmental - often referred to as the 'triple-bottom line' so dear to the hearts of environmentalists).

Annex P - Industrial revolution

Annex P gives a brief introduction to the industrial revolution, as the presumed start and cause of the threat today of global warming and possible permanent climate change.

The presumed problem of global warming today is believed to have started with the industrial revolution, starting about 1760 but not gathering speed until the early 1800's, powered by recently developed steam engines. Steam powered production and mass transportation were the driving forces, but needed masses of coal. Despite its current label by environmentalist as a pariah, the world could not have been where it is today without coal. With its many grades of quality, it has been essential also to other major activities, notably steel-making, chemical derivatives and heating of commercial, industrial and domestic premises[59]. Except for electricity generation and steel manufacture, coal has long since relinquished its crown to petroleum and gas products.

The industrial revolution then engendered progressive scientific research, invention and continual, remarkable technological progress, mainly in the United Kingdom and Western Europe but, later, to be eclipsed by development in North America. In particular, medical and agricultural science has led to an exponential increase in world population to today's figure of some eight (8) billion souls.

The concentration of CO_2 in the atmosphere is believed to have increased from about 280 ppm in 1760 to the recorded 413 ppm in 2020.

[58] For example, the devastation caused by the explosion of Santorini about 1600 BC, the 'dark ages', after about 600 AD (which some pundits have blamed on volcanic activity) and the drought in Egypt in 44-41 BC.

[59] Note that coal has for many years been able to be synthesised into gas and petrol, even though the latter has not been necessary while adequate supplies of petroleum are available.

Annex Q - Electric vehicles

Annex Q looks at the situation in Australia in respect of the adoption of electric vehicles (EV) and how this sits with the probable availability of renewable energy, throughout the country.

It addresses various aspects concerning EVs, namely: the relative efficiencies of EVs versus internal-combustion vehicles (ICV); the possibility of renewable energy in Australia meeting the probable demand from EVs; the lifetime carbon footprint of EVs; batteries or fuel cells; and a brief on hydrogen.

There is a great deal of chat at present (2019-20) in Australia about EVs, with pundits, electioneering politicians and climate watchers waxing lyrically about their future, and with virtually all major car manufacturers in a race for potential market share. Although these cars are still relatively expensive, early adopters of EVs will undoubtedly have a good run for some years yet with running costs, but only until the market takes off and the reality of electricity distribution and consumption costs and inevitable government charges start to bite.

A big unknown at present is whether electricity from renewable sources will ever be able to keep up with traditional demands for power (domestic and industry), as well as replacing the consumption of petrol and diesel by ICV[60]. The full potential of EVs will not be realised unless they are powered by renewable energy, and we are a long way off that position, given that renewables in 2020 account for only 6.5% of Australia's annual energy demand in 2020, the rest still being provided by fossil fuels. However, even if powered off a fossil-fuelled grid, EVs can result in significantly lower greenhouse gas and aerosol production than ICVs, because of relative efficiencies.

The two viable energy sources for EVs are batteries, charged from home or grid resources, and hydrogen fuel cells. While battery driven EVs have certain advantages, their future is limited unless recharged by renewable energy. Battery powered EVs can be expected to predominate in the city, but elsewhere, limitations on range and availability of charging facilities could well limit their usefulness.

The opportunity for hydrogen fuel cells to compete favourably on a cost basis for EVs in local applications such as transport and remote area power systems is within reach based on potential cost reductions in coming years. In the eyes of some pundits, the development of a hydrogen export industry represents a significant opportunity for Australia and a potential 'game changer' for the local industry and the broader energy sector due to associated increases in scale. However, while a proponent of hydrogen production, Professor Garnaut, in his latest book [5], does not believe that Australia could export hydrogen economically.

So, what does all this mean for the future of EVs in Australia?

EVs are a reality and adoption will increase at an increasing pace, as economics, subsidies and government policy permit. The brightest future for EVs is obviously in cities where short, daily running is predominant, recharging networks relatively cheaper to install and where roof-top solar is prevalent for overnight charging of vehicles. However, adoption of EVs in Australia can never be hoped to match what is occurring in densely populated countries, or those with cheap renewable power like Norway. ICVs will always be a necessity in Australia.

The CSIRO predicts that Australia's entire car fleet could be fully electric by 2050, but that assumes achievement of a zero-emissions baseline by 2050, which is a very big ask for Australia and one unlikely to be met.

Growth in renewable electricity generation will not only have to cope with adoption of EVs, but also will have to cope with the increase in domestic, commercial and industrial demand. Nevertheless, EV demand for electricity from renewable sources is expected to be accommodated, eventually, if at considerable cost.

A most important conclusion though, is that the adoption of EVs in Australia should be as economic development and productivity gains permit. Contrary to what is being said politically, there is absolutely no imperative to push adoption of EVs through subsidies or law. After all, the

[60] An article in The Australian (5Apr19) discusses whether the EV roll-out is a 'threat to the power grid'.

reality is that whatever Australia does with EVs, it will have negligible effect on world climate change.

Annex R – Letters to editors

This annex contains letters written by this author to editors of the Canberra Times, Canberra City News, The Australian and to certain journalists, on the subjects of global warming and climate change. Letters are annotated as published or not.

Annex S – Glossary

This annex is a comprehensive list of definitions relating to global warming and climate change. The main reference has been sr15_glossary.pdf [IPCC].

ORIGINAL WORK BY THIS AUTHOR

Analysis

Admittedly, like the greater majority of articles found in the literature and on the Internet, this paper is largely a consolidation of material written by others, so as to gain a realistic appreciation of the global warming debate. Notwithstanding, it does contain original work, not in the sense of experimental research but in analysis of available data and projections and conclusions therefrom.

Annex D, *Temperature change - fact or fiction*, contains original work on formulation of emission reduction policies and the effect they would have on probable dates for the Temperature anomaly (Twi) to reach IPCC targets of 1.5°C and 2°C, as well as getting to the danger point of 3°C.

Annex E, *Temperature change – possible causes*, contains original work to establish the dominance of water vapour and clouds over non-condensable greenhouse gases specially CO2, as the primary cause of prevailing surface temperature. However, this work was unable to negate the argument of climatologists that the non-condensable greenhouse gases operate as the ‘thermostat’ of Earth’s surface temperature, but nor was it able to establish the scientific proof of this claim.

Annex F, *Demand for energy and emissions*, contains original work on the projections for world demand for energy and consequent CO2 emissions.

Annex G, *World population growth and consequences*, contains original work on the analysis of projections for world population growth, particularly by regions, development of a possible emissions reduction policy, and how future greenhouse gas emissions may grow.

Annex M, *Carbon dioxide (CO2)*, contains original work on estimates of the tonnage of CO2 entering the atmosphere each year and how that independently and accurately correlated with the CO2 concentrations being recorded by Mauna Loa Observatory.

Annex Q, *Electric vehicles*, contains original calculations for comparison of electric vehicles (EV) and internal-combustion vehicles (ICV), in respect of respective efficiencies, as well as projections for growth of EVs in Australia.

Annex R, *Letters to editors*, by its nature, is original work by this author.

Caveat: *Although this work is being claimed by this author as original work, it does not preclude the possibility that the same or similar work may exist somewhere in the vast array of information in the literature and on the Internet. Time has precluded exhaustive search of bona fide information therein.*

A word in defence of the Internet

The Internet is often maligned as a poor source of authentic research information. There is obviously a lot of garbage therein which is difficult to sort out. However, most sites of interest will have copious, valid references from which content is drawn and it is to these that researchers should always refer to verify authenticity.

A. Introduction to global warming
B. Genesis and theory
C. Radiation and concept of forcing
D. Temperature change – fact or fiction?
E. Temperature change – possible causes
F. Demand for energy and emissions
G. World population growth and consequences
H. Promoters and critics
I. Permanent climate change
J. What can and is being done
K. The Earth System
L. Energy
M. Carbon dioxide (CO2)
N. Methane
O. Aerosols and other pollutants
P. Industrial revolution
Q. Electric vehicles
R. Letters to editors
S. Glossary

Australian Logistics Study Centre

Canberra, 24 July 2020

Addendum 1, 22 March 2021:

- Added summaries of Annexes R and S
- Added summary of Annex E, Appendix 1
- Amendment of Executive summary to reflect final conclusions.

INTRODUCTION TO GLOBAL WARMING

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About this annex

This annex introduces the subject of global warming and climate change. Climatologists[61] and promoters[62] of climate change say that anthropological[63] activity, which is increasing with world population, is warming the planet and engendering permanent and life-threatening climate change.

Greenhouse effect

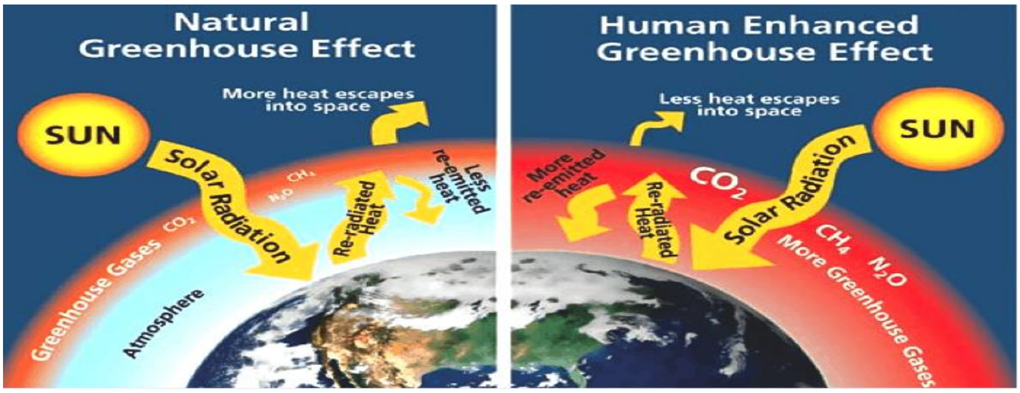
The Earth's atmosphere has always acted like a garden greenhouse[64] that captures heat[65] from the Sun, ensuring temperatures, according to the seasons and latitudes, that have permitted the emergence and sustenance of all life forms on Earth. Without its atmosphere, the earth would be a very cold, uninhabitable place. So, the global warming debate is really about whether an 'enhanced' greenhouse effect is occurring, at what rate, the causes and the consequences.

Box A1 – Greenhouse Effect [1]

"The greenhouse effect is a natural process that warms the Earth's surface. When the Sun's energy reaches the Earth's atmosphere, some of it is reflected back to space and the rest is absorbed and re-radiated by greenhouse gases. The absorbed energy warms the atmosphere and the surface of the Earth. This process maintains the Earth's temperature at around 33 degrees Celsius warmer than it would otherwise be, allowing life on Earth to exist. The problem we now face is that human activities – particularly burning fossil fuels (coal, oil and natural gas), agriculture and land clearing – are increasing the concentrations of greenhouse gases. This is the enhanced greenhouse effect, which is contributing to warming of the Earth." [https://www.environment.gov.au/climate-change/climate-science-data/climate-science/greenhouse-effect]

The diagrams in Box A2 illustrate the natural and enhanced greenhouse effect. These basic diagrams are elaborated on in Annex E, *Temperature change - possible causes.*

Box A2 [2]



https://climatechange.lta.org/get-started/learn/co2-methane-greenhouse-effect/

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[61] The term 'climatologists' is used throughout this paper as a common term for scientists active in research into global warming and climate change and scientists qualified to do peer reviews of research papers.

[62] The term 'promoters' is used throughout this paper as a common term for vested interests, Media, and Internet sites and platforms that promote the dangers of global warming and climate change, fairly or with hyperbole.

[63] human

[64] Use of the term 'greenhouse effect' is an analogy only; the atmosphere actually insulates the Earth in a different way.

[65] The word 'heat' is very commonly used interchangeably with 'thermal energy', whereas 'heat' is technically defined as the 'transfer of thermal energy'.

Basic cause and effect chain

The basic argument of climatologists - those who research and promote global warming and climate change - goes like this, each subject being treated in some detail at the annexes of this paper, as indicated:

- It started with the industrial revolution (Annex P);
- causing exponential technological growth (Annex P);
- causing world population growth (Annex G);
- causing ever-increasing consumptions of the earth's resources for food, housing and mobility (Annex G);
- causing ever-increasing demand for energy, particularly for industry, transport and electricity (Annexes F, L, Q);
- causing an enhanced greenhouse effect (Annexes A, B, C, F);
- caused by global temperature change (Annex D);
- causing global warming (Annexes D, E, M);
- causing permanent climate change (Annex I);
- causing unprecedented consequences for humankind (Annexes G, I); and
- causing the world to react (Annex J).

The claims of climatologists

The fundamental claims of climatologists are as follows:

- The average world surface temperature (Tw) and incremental changes thereto, referred to as the Temperature anomaly (Twi), defined as the change since the beginning of the industrial revolution, are caused by and controlled only by the presence and concentrations of non-condensable greenhouse gases in the atmosphere, in particular carbon dioxide (CO2), i.e., acting as the Earth's 'thermostat' (Tw = Function (CO2 ppm[66]).
- CO2 ppm and CO2e[67] is caused primarily by the increase in world consumption of fossil fuels caused by world population growth.

  Note: *CO2 occurs also for natural reasons.*
- Water vapour (H2O) is recognised as a greenhouse gas and more powerful than CO2 in absorbing infra-red radiation (IRR), but seen by climatologists only as a positive feedback process to global warming rather than a primary cause of surface temperature change, because it is condensable into clouds, present only at lower altitudes and has a short life-span.
- Atmospheric water vapour increases as a function of Tw, through increased evaporation of terrestrial waters, virtually all from the oceans.
- The CO2 concentration controls Tw and, thus, the level of water vapour (%Wv) in the atmosphere, i.e., that %Wv = f (CO2 ppm).

  Note: *Any relationship between CO2ppm and Tw is a correlation only, i.e., a direct cause-and-effect relationship is in theory only has not been established in fact*[68].

[66] 'ppm' is parts per million moles in atmosphere. Moles comprise all identified atomic particles existing in the atmosphere.

[67] CO2e is a weighted effect of all greenhouse gases, but CO2, as the most important, is used throughout this paper as a proxy for the effect of all non-condensable greenhouse gases, ie excluding water vapour.

[68] As far as this author has been able to determine in his research.

Common questions posed by critics and public

Several questions have been posed by qualified critics and the public alike:

- Given that CO2 concentration is only 0.04% (1/40,000) of the atmosphere, how can it be such a strong IRR absorbent and the cause of global warming?
- What is the validity of the claim that only CO2 (with some help from other non-condensable greenhouse gases) determines the Earth's surface temperature (Tw) and the Temperature anomaly (Twi), and that water vapour does not?
- Is there a direct cause-and-effect relationship between CO2 concentration and change in global surface temperature or is there a correlation only?
- Given acceptance that the concentration of water vapour and clouds increases with surface temperature and are both strong absorbers of IRR, what is the predominant cause of global warming, water vapour, clouds and aerosols[69] or the non-condensable gases, particularly CO2?

These questions are addressed and answered at Annex D, *Temperature change - fact or fiction?* and Annex E, *Temperature change – causes.*

Assumptions underlying the scientific case for global warming

Of necessity, several simplifying assumptions are made by climatologists to support the case for CO2 as the main villain:

- The world surface temperature and Temperature anomaly (Tw and Twi) are averages from sensors from around the world and from satellites and are presumed **accurate** measures of the effect of climate change. **Considered not valid**. In fact, reports say that variations at higher latitudes could be from 2 to 5°C above the world average. This assumption is subject to heavy criticism by sceptical climatologists and some evidence of data tampering.[70]
- The Earth's energy balance is predominantly due to radiation into and out of the Earth System,[71] with minor roles assigned to the other sources of thermal energy, namely thermal flux (heat) emanating from the Earth's interior and massive amounts of 'new' thermal energy created by burning fossil fuels and electricity production by nuclear power plants. **Mostly valid.**
- All IRR reflected downward from the atmosphere to heat the land and oceans is from greenhouse gases (excluding water vapour and clouds). **Considered not valid**. IRR from water vapour and clouds is in fact substantial.
- Clouds play no significant part in global warming. **Considered not valid**. Even the primary literature, in which the UN promotes global warming and climate change, acknowledges that the science of clouds and their effect are (or at least were) very poorly understood and the weak link in argument for global warming
- A basic tenet of radiation theory is that whatever infra-red is captured by gases or water vapour is also emitted by the same amount. **Valid**.
- The Earth is considered as a black-body emitter, i.e., emitting almost the same radiation power as it absorbs. **Considered not quite valid**. The Emissivity of the Earth (0.96) is assumed to be unity, but is of no significant consequence.
- There is a direct cause-and-effect relationship between CO2 (and other non-condensable greenhouse gases) and global warming. **Considered not valid**. While 97%[72] of scientists are said to agree that Tw and Twi are functions of greenhouse gas concentrations,

[69] Aerosols comprise particulate matter like soot, dust and ash, as well as gases like fluorocarbons.

[70] Discussed in Annex D, *Temperature change-fact or fiction?*

[71] See Annex K, *The Earth system* for description of basic facts about the Earth.

[72] This claimed 97% of scientists is of an unspecified sample and is seriously questioned by critics.

whatever relationship they claim exists is purely a correlation, i.e., there has not been a true cause and effect relationship established.[73] Therefore, concentrations could just as well be a function of Tw, which science has shown to be the case in every past ice-age that the Earth has experienced. [3, Fig 3, p37]

Tenets

In complementing the several assumptions, the scientific case rests upon certain tenets:

- The Earth's energy budget must be in equilibrium, i.e., the warming power of all incoming un-reflected short-wave solar radiation (in watts per square metre W/m^2) must equal the power of long-wave IRR out into space[74]. (See Annex C, *Radiation and concept of forcing*)
- All bodies of matter absorb and re-emit radiation energy according to their emissivity properties.
- CO2 is a strong absorbent of IRR in only three narrow bands of wavelengths - 2.7, 4.3 and 15 µm.[75] This means that most of the radiation from Earth escapes the CO2. Only 8% of the available black body radiation is picked up by these "fingerprint" frequencies of CO2. [4]
- Water vapour is a stronger absorbent of IRR than CO2, at most wavelengths of the IRR spectrum, mostly on either side of the CO2 bands but the two overlapping around the 18µm wavelength.

  Note: *The infra-red spectrum is quite large, extending from the nominal red edge of the visible spectrum at 0.70 µm through to 1,000 µm. This range of wavelengths corresponds to a frequency range of approximately 430 THz*[76] *down to 300 GHz. Water vapour is an active absorbent of IRR across much of the spectrum.*

Probable Causes

Excessive amounts of CO2 and other non-condensable greenhouse gases in the atmosphere are getting the blame for global warming but there is more to it than that.

Main factors at work:

- levels of CO2 in the atmosphere;
- levels of noxious greenhouse gases in the atmosphere, e.g., methane and nitrous oxide (N02);
- levels of water vapour as a greenhouse gas in the atmosphere and the heating/cooling effect of clouds;
- presence of aerosols, including particulate matter, in the atmosphere from many sources:
  - incomplete combustion of fossil fuels by modes of transport (soot),
  - smoke from home fires and bushfires, and
  - smoke and ash from volcanoes.
- increasing world population growth and its detrimental effects:
  - increasing consumption of world resources, especially arable land, fresh water and forests,
  - increasing production of food, consumer goods and infrastructure,
  - destruction of greenery, especially the jungles of the Amazon and central Africa, and

[73] There are claims that some laboratory simulation has been undertaken to establish a cause-and-effect relationship between ppm and Tw.

[74] Note that all energy returned to space is in the form of IRR, given that conduction and convection cannot occur in the outer edges of the atmosphere where there is no physical matter.

[75] µm = micro-metre (1 millionth of a metre).

[76] THz = TeraHertz = a frequency of 10^12 cycles per second (cps). Ghz = GigaHertz = a frequency of 10^9 cps.

- increasing production and consumption of energy in all its forms.

Box A3 [5]
"Different specialists describe the particles based on shape, size, and chemical composition. Toxicologists refer to aerosols as ultrafine, fine, or coarse matter. Regulatory agencies, as well as meteorologists, typically call them particulate matter—PM2.5 or PM10, depending on their size. In some fields of engineering, they're called nanoparticles. The media often uses everyday terms that hint at aerosol sources, such as smoke, ash, and soot. Climatologists typically use another set of labels that speak to the chemical composition. Key aerosol groups include sulphates, organic carbon, black carbon, nitrates, mineral dust, and sea salt. In practice, many of these terms are imperfect, as aerosols often clump together to form complex mixtures. It's common, for example, for particles of black carbon from soot or smoke to mix with nitrates and sulphates, or to coat the surfaces of dust, creating hybrid particles." [https://earthobservatory.nasa.gov/features/Aerosols]

World demand for energy has been increasing in direct proportion to population growth, both doubling in the past 40 years, with 95 per cent of demand being met by burning fossil fuels. Besides pollutants, this produces massive amounts of new heat that must be absorbed by the atmosphere, oceans and, to a lesser extent, the land. However, whether its net effect is significant or not has to be considered in the context of all heat sources affecting the surface temperature of the planet, particular solar radiation.

Earth is a massive sphere of iron and rock, much of it in a molten state containing an unimaginable amount of heat, enveloped by a relatively thin layer of solid material, mostly water and rock. Internal thermal energy is continuously transferred as heat to the atmosphere by conduction and some radiation. Again, like new heat, its net effect has to be considered in the context of all heat sources affecting the surface temperature of the planet, albeit relatively small per square metre of the Earth's surface.

Greenhouse gases

"*A greenhouse gas is a gas that absorbs and emits radiant energy within the thermal infrared range. Greenhouse gases cause the greenhouse effect on planets. The primary greenhouse gases in Earth's atmosphere are water vapor, carbon dioxide, methane, nitrous oxide, and ozone." [Wikipedia]*

In more detail and in order of importance, the greenhouse gases in Earth's atmosphere are:

- Water vapor (H2O) (also condensed vapour in clouds);
- Carbon dioxide (CO2);
- Methane (CH2);
- Nitrous oxide (N2O) ;
- Ozone (O2) ;
- Chlorofluorocarbons (CFCs); and
- Hydrofluorocarbons (includes HCFCs and HFCs).

With the exception of H2O, all of these gases are considered non-condensable.

Subsequent Annexes B through Q of this paper deal progressively with all aspects of global warming and climate change, from genesis and theory, through fact and fiction of temperature change, the real role of CO2 to possible climate changes and effects, as well as reference to what leading promoters and critics are saying.

Australian Logistics Study Centre (ALSC)
Canberra 24 July 2020

ANNEX B TO
A view on permanent climate change

GENESIS AND THEORY

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17. The missing climate forcing, J. Hansen, M. Sato, A. Lacis, R. Ruedy, NASA Goddard Institute for Space Studies, The Royal Society, 1997.
18. www.www.carbonbrief.org/explainer-how-scientists-estimate-climate-sensitivity
19. www.en.wikipedia.org/wiki/Climate_sensitivity
20. www.skepticalscience.com/why-global-warming-can-accelerate.html

About this Annex

This Annex is intended only as an overview of the genesis of the world-wide debate and the theories expounded by scientists about the projected change in the average world surface temperature, referred to as the Temperature anomaly (Twi), epitomising global warming underlying the debate. It also gives an insight into the complexity of the problem in identifying the myriad scientific disciplines and technologies necessarily involved.

As readers may imagine, available literature is vast, whether it be of basic research, valid reporting by reputable authorities or all forms of Media published by vested interests.

Introduction

So much alarm in the world today about ‘global warming’ and ‘climate change’ and the doomsday to come unless governments around the world take adequate counteraction. How has it come to this? What is the genesis and theory put forth by the climatologists to create such alarm?
While there is a preponderance of scientists (of all disciples – not just climatologists) who believe

[77] Reference 1 was followed by “Physics of the atmosphere and climate”, M.L. Salby, Cambridge University press, **2012** [available on Amazon]**,** which is believed to be an updated version of Reference 1 and is assumed to have the same emission figures as used in this Annex, although they could have been updated for atmospheric changes in the following six years between publication.

that global warming and consequent climate change is happening, there are also eminent scientists[78] who refute the published findings of the relatively few scientists doing the research.

Based on some early work by pioneers in the field, serious research to identify the real causes, extent and potential ramifications within the scientific community have been underway since the 1960s, with efforts ramping up significantly since the 1980s, so much so, that the available literature - the good, the bad and the ugly – is indeed massive.

Sorting the scientific fact from fiction and political humbuggery is not for the timid. It has taken untold hours to unravel the science underlying global warming; like peeling the proverbial onion.

Definitions

Annex S, *Glossary*, contains definitions and acronyms relevant to the contents of this Annex. Although there are myriad definitions for some entities, only one will be provided but, while suitable, may not be the clearest of those available in the vast literature.

Sciences and technologies

The problem of global warming and climate change, attributed to the 'greenhouse effect' is extremely complex, involving the coordination of most scientific disciplines and exploitation of most technologies. In particular, it involves the sciences (theoretical and applied) dealing with radiation (solar, earth and atmospheric), atomic physics, atmospherics, meteorology, oceanography, palaeontology, geology, glaciology, anthropology, biospherics, climatology and others to perhaps a lesser extent. Each of these sciences, in turn, depend on a large range of general and specific-to-discipline technologies, developed from the knowledge of physics (including thermodynamics), chemistry, engineering, advanced mathematics, systems theory and computer modelling, as well as hardware like microscopes, spectrometers, computers, a large range of sensors, probes and satellites.

Radiation. The Earth's energy balance has been treated mostly as one of balancing the electro-magnetic radiation (EMR) onto, into and out from the Earth, but with some mention of sensible and latent heat. See Annex C, *Radiation and concept of forcing* and Annex E, *Temperature change - possible causes* for detailed discussion. Earth's energy (radiation) balance is considered by climatologists as the basic science used to explain how the Earth has maintained a relatively stable liveable temperature range for millennia by the so-called 'greenhouse effect' and how that temperature range is now threatened by an 'enhanced' greenhouse effect caused by activities of an increasing world population and consequent energy consumption, mainly from burning fossil fuels.

Atomic physics. Atomic physics is used to explain how molecules with three or more atoms, e.g., greenhouse gases and water vapour, absorb and emit radiation and why molecules of two atoms or only one, especially nitrogen (N2) and oxygen (O2) which together comprise some 99% of the atmosphere, do not. Any number of sites are available on the Internet that describe the theory of how molecules possess kinetic energy, absorb and emit radiation energy because of the continuous motion, rotation and vibration modes of themselves and component atoms. A comprehensive description may be found at *www.en.wikipedia.org/wiki/Carbon_dioxide* . [1]

Atmospherics. The most detailed knowledge of atmospherics is essential and deals with how a chaotic atmosphere actually works and influences world temperatures and the climate. Excellent and comprehensive references are the books by Professor H.B. Salby [2]. See also Annex E, *Temperature change - possible causes*.

Meteorology. Meteorology had its origin in weather forecasting but, from about 1945, there has been a great deal scientific development which has essentially metamorphosised into atmospherics and advanced computer modelling of the atmosphere and oceans. It has also given rise to the chaos theory, developed by Edward Lorenz (see Box B8), which has seen special application in atmospherics, to explain a prime example of a natural chaotic system.

Oceanography. Oceanography is the study of the Earth's oceans, in particular the identification and behaviour of their many cold and warm currents, as influenced by the natural dynamics of the planet, surface temperatures, the absorption and release of CO2, the source of all water vapour and

[78] Often referred to as 'climate deniers' by promoters or by the more refined term 'contrarians' by the educated elite of climatologists.

clouds through evaporation, the effects of their heat transfer around the planet and its effect on regional climates. It should be noted that oceanography, although recognised now as very important to part of the science of global warming, was largely ignored in earlier modelling, e.g., that underlying the Charney Report (see Appendix B1, Table B1-1). The Charney Report, Hansen and other literature make mention of the inertial effects of ocean currents within the nominal three layers of the ocean and their eventual effect on global warming. Currents are relatively fast (months to years) within the top layer down to about 200 metres, but up to 1,000 years for some at the greatest depths. Charney and others warn, therefore, that estimates made to date for surface temperatures due to the greenhouse effect may be understated due to delayed effects of thermal inertia of currents.

Palaeontology. "*Palaeontology is the study of the forms of life existing in former geological periods, as represented by fossil animals and plants.*"[79] Scientists use ice-cores and tree-ring records to establish periods of global warming and ice-ages over the millennia as well as the existence of CO2 and its concentrations in respect of surface temperatures. This aspect is very important because, for past warm/ice ages, until the current warm age (inter-glacial) era, the concentrations of CO2 lagged temperature by centuries. However, for the modern era, climatologists are now claiming that CO2 levels are leading and even the primary cause of surface temperature change. This is a topic hotly disputed by some scientists. See discussion on the controversy surrounding the so-called 'hockey stick' graph of surface temperature change (see Annex D, *Temperature change - fact of fiction?* for discussion).

Geology. Geology is the study of the land masses of the planet and is one of the so-called earth sciences. It is important because of how land forms - location and topography of continents/islands, movement of the tectonic plates, internal thermal energy and volcanic activity - affect the Earth's climate.

- While volcanic activity is ever present around the 'ring of fire', the effect of the millions of tonnes of matter blasted into the troposphere by eruptions is discounted by climatologists as irrelevant to global warming because of their short-term nature. However, it is known that volcanic particles can exist in the stratosphere for long periods and, initially upon very large eruptions, that 'nuclear winters' lasting for years have ensued, causing catastrophic damage to societies, mainly through famine induced by crop failure. One example is the eruption about 1,600 BC of Kira (Santorini) that wiped out the Minoan society on Crete and caused havoc all around the Mediterranean Sea. Other catastrophic cases have also been recorded, one being attributed to severe famine in Egypt in 45-42 BC and as the cause of the 'dark ages' in Europe from about 600 AD. Nevertheless, in the long-term, volcanic action may be considered to have little insignificant effect on global warming. See also Annex O, *Aerosols and other pollutants* and Annex K, *The Earth System*.

- Because it contains trillions of tonnes of molten iron, towards its centre, and molten rock in the mantle and crust, the internal thermal energy of the Earth is hard to imagine and does cause massive heat transfer through the crust (about 8 km thick) to the surface, primarily by conduction. This thermal 'flux' has been estimated by scientists but is quite small when averaged over the surface of the Earth and of little consequence to global warming. See Annex L, *Energy*.

Glaciology. Glaciology is the study of glaciers, ice sheets and other natural phenomena involving ice. This science features strongly in climate change literature as evidence of global warming. Glaciologists believe global warming is causing glaciers to retreat and sheet ice on Greenland and the Antarctic to melt, so causing sea-levels to rise and to threaten communities and even countries. While some climatologists admit that such reduction in ice has been occurring for centuries (in the current warm age), they now say the global warming is 'accelerating' the melt. There is no shortage of literature, blogs or sheer sensationalism in the Media and cinemas about this phenomenon, attributed to global warming because of increasing CO2 levels in the atmosphere. Other scientists attribute the melt to the natural warm age being experienced by the Earth.

[79] Macquarie Australian dictionary.

Anthropology. Anthropology, in this context, addresses the exponential growth in world population, if and when it may stabilise in the future, its corresponding demand for energy and resources and how populations react to the ill effects of climate change. See discussion in Annex G, *World population growth and consequences*.

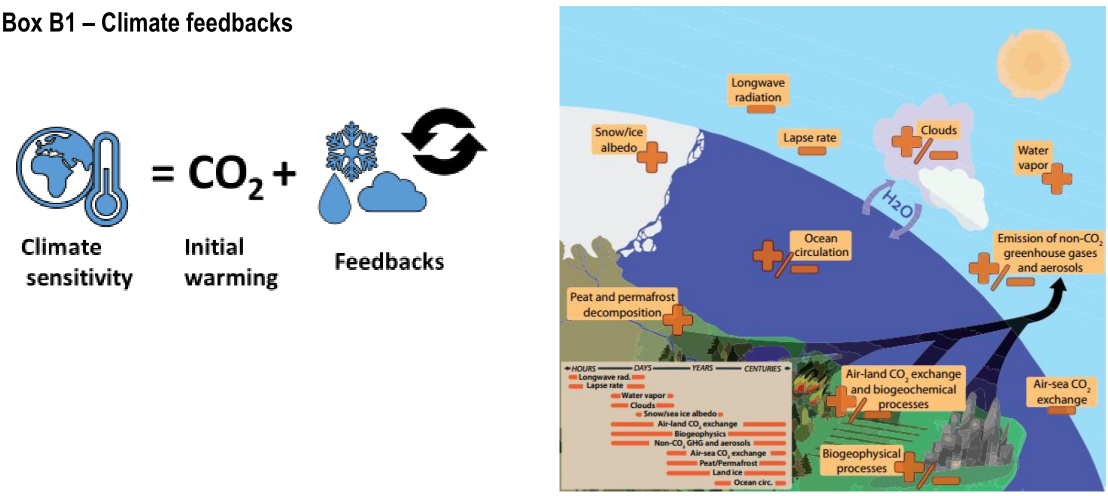
Biospherics. Biospherics is the study of all living things comprising the Earth's biosphere, i.e., on land, in the oceans, in fresh waters and in the air. The biosphere, also known as the ecosphere, is the worldwide sum of all ecosystems. It is important because of how vegetation and ocean resources are affecting and being affected by CO2 levels and global warming, e.g., deforestation by burning, warming of the oceans and consequent bleaching of coral reefs, although some countries are making significant progress in 're-greening' by reforestation. Controversy exists about the real impact on coral reefs. It should be realised that the need for reefs to exist in pristine condition is rather an economic argument and does not threaten life of the human race. Reefs have been on the planet for millions of years and will be on the planet long after the human race has managed to extinguished itself.

Climatology. Climatology is at the heart of the problem being discussed and the alarm being generated by certain quarters. In the stricter sense, climatologists study the regional climates of the planet and prevailing weather patterns and how these maybe permanently changing with any global warming. In practice, a climatologist is likely to have evolved from one of the afore-mentioned disciplines. Climatologists, qualified or not, comprise most of the world-wide lobbying against fossil fuels, particularly coal, even though this mineral is extremely important to world economies and, in fact, comprises only about of 33% of the world fossil fuel use. On the other hand, where is the same volume of noise about oil and natural gas? Although burning coal produces much CO2 and significantly more than oil or gas, the arguments against coal are essentially emotional and irrational. See Annex F, *Demand for energy and emissions*, for fossil fuel data and discussion.

Support sciences. Virtually all of the theoretical sciences - particularly physics, chemistry, materials and mathematics - and their application to engineering, systems theory and computer modelling are essential to understanding and measuring the variables and setting parameters of global warming.

Box B1 may help to put the foregoing into perspective

Box B1 – Climate feedbacks



Early Historical development

Global warming is not a novel idea. Scientists have been addressing parts of the presumed problem for the past two centuries, one way or another. For over 100 years, scientists have theorised that the atmosphere acts like a blanket to keep the Earth at liveable temperatures and speculated upon the existence of greenhouse gases and CO2 as the main culprit.

Early experimentation was done by the French mathematician and physicist Joseph Fourier. [Box B2]

Box B2 - Jean-Baptiste Joseph Fourier [1768-1830] [3]
Discovery of the greenhouse effect
Jean-Baptiste Joseph Fourier, French mathematician and physicist [1768-1830]. He is best known for the mathematical techniques that he developed in his analytical theory of heat transfer. Over the past two centuries, his methods have evolved into a major subject, harmonic analysis, with widespread applications in number theory, signal processing, quantum mechanics, weather prediction and a broad range of other fields.
[www.www.irishtimes.com/news/science/how-joseph-fourier-discovered-the-greenhouse-effect]

Fourier was the first person to study the Earth's temperature from a mathematical perspective. He examined variations in temperature between day and night, and between summer and winter, and concluded that the planet was much warmer than a simple analysis might suggest. He calculated that it would be much colder than it is if the incoming radiation from the sun were the only warming effect. His idea that the Earth's atmosphere acts like an insulator is the first formulation of what we now call the greenhouse effect. However, he did not use that term, which first appeared in the work of Swedish meteorologist Nils Gustaf Ekholm around 1900.
[www.www.irishtimes.com/news/science/]

Important work followed by the Irish scientist John Tyndall in the 1850s. [Box B3]

Box B3 -John Tyndall [1820-1893] [4]
Tyndall … conducted a series of experiments in the 1850s [1859] to measure precisely how infra-red radiation is absorbed by gases. He tested several gases and vapours, and found that while pure elements such as oxygen and nitrogen have little effect, more complex molecules are strong heat absorbers.

Tyndall showed that water vapour, carbon dioxide and ozone are strong absorbers of heat radiation. He speculated how changes in water vapour and carbon dioxide are related to climate change. This is what we now call the enhanced greenhouse effect. He realised that the strongest effect was from water vapour, without which "the Earth's surface would be held fast in the iron grip of frost". *[www.www.irishtimes.com/news/science/]*

Two important Swedish global warming pioneers were Nils Gustaf Ekholm and Svante August Arrhenius. The latter is often cited by other scientists even today. [Boxes B4 and B5]

Box B4 - Nils Gustaf Ekholm [1848-1923] [5]
Ekholm was a Swedish meteorologist … regarded as the founder of the Swedish storm warning system, …. The system began in 1905 with 27 storm warning stations on the Swedish west coast, and expanded over the following years until it finally covered the entire Swedish coastline from 1913.
Publication: Nils Ekholm, "On the variations of the climate of the geological and historical past and their causes." Quarterly Journal of the Royal Meteorological Society, January 1901.
[www.en.wikipedia.org/wiki/Nils_Gustaf_Ekholm]

Box B5 - Svante August Arrhenius [1859 –1927] [6]
Arrhenius was … originally a physicist, but often referred to as a chemist, Arrhenius was one of the founders of the science of physical chemistry. He received the Nobel Prize for Chemistry in 1903, becoming the first Swedish Nobel laureate.
In 1896, Arrhenius was the first to use basic principles of physical chemistry to calculate estimates of the extent to which increases in atmospheric carbon dioxide (CO2) will increase Earth's surface temperature through the greenhouse effect. These calculations led him to conclude that human-caused CO2 emissions, from fossil-fuel burning and other combustion processes, are large enough to cause global warming. This conclusion has been extensively tested, winning a place at the core of modern climate science.
He formulated what he referred to as a 'rule' … that is still in use today: $\Delta F=\alpha*\ln(C/C_0)$, where C_0 is the concentration of CO2 at the beginning (time-zero) of the period being studied (if the same concentration unit is used for both C and C_0, then it doesn't matter which concentration unit is used); C is the CO2 concentration at end of the period being studied; ln is the natural logarithm (=$\log_e$); and ΔF is the augmentation of the temperature, in other words the change in the rate of heating Earth's surface (radiative forcing), which is measured in Watts per square metre. Derivations from atmospheric radiative transfer models have found that α (alpha) for CO2 is 5.35[80] (± 10%) W/m^2 for Earth's atmosphere.
In his calculations, Arrhenius included the feedback from changes in water vapour as well as latitudinal effects, but he omitted clouds, convection of heat upward in the atmosphere, and other essential factors. His work is currently seen less as an accurate quantification of global warming than as the first demonstration that increases in

[80] This figure is disputed by some climatologists

atmospheric CO_2 will cause global warming, everything else being equal.[81] .
At this time, the accepted consensus explanation is that, historically, orbital forcing has set the timing for ice ages, with CO_2 acting as an essential amplifying feedback. However, CO_2 releases since the industrial revolution have increased CO_2 to a level not found since 10 to 15 million years ago, when the global average surface temperature was up to 11 °F (6°C) warmer than now and almost all ice had melted, raising world sea-levels to about 100 feet higher than today's.
Arrhenius estimated, based on the CO_2 levels at his time, that reducing levels by 0.62–0.55 would decrease temperatures by 4–5°C (Celsius) and an increase of 2.5 to 3 times of CO_2 would cause a temperature rise of 8–9°C in the Arctic.
Note: *These figures were good guestimates for the 19th century but have not stood the test of time*.

In the 1960s, David Keeling demonstrated that human-caused carbon dioxide emissions are large enough to cause global warming.

Note: *This statement about Keeling is not correct. Keeling certainly established the 'Keeling Curve' for the growth in CO_2 concentration in the atmosphere based on continuous measurements taken at the Mauna Loa Observatory on the island of Hawaii from 1958 to the present day, but did not demonstrate 'that human-caused carbon dioxide emissions are large enough to cause global warming'*.

Publication: Arrhenius, Svante (1897). "On the Influence of Carbonic Acid in the Air Upon the Temperature of the Ground". Publications of the Astronomical Society of the Pacific.
www.en.wikipedia.org/wiki/Svante_Arrhenius]

A noted climatologist from England was H. H. Lamb who founded the Climatic Research Unit in 1972 in the School of Environmental Sciences at the University of East Anglia. (Box B6)

Box B6 - Hubert Horace Lamb [1913 - 1997] [7]
Lamb's 1977 book 'Climatic History and the Future', described studies of fossil pollen showing an abrupt change from a glacial era of pinewoods to oak trees, pointing to "great rapidity of climate change". He discussed research on the complex effects of human caused pollution, and suggested that "On balance, the effects of increased carbon dioxide on climate are almost certainly in the direction of warming but is probably much smaller than the estimates which have commonly been accepted."
Note: *In a later book [8], he acknowledged that global warming could have serious effects within the 21st century.*

Charney and Lorenz (Boxes B7, B8)

Two giants in the world of climatology were MIT professors Jule Charney and Ed Lorenz. Although never having actually worked together, the work of each strongly influenced that of the other and both profoundly shaped the field of meteorology during their lifetimes. Their legacy is essentially the basis of research into global warming and climate change ever since.

Box B7 - Jule Gregory Charney [1917- 1981] [9]
Jule Charney was an American meteorologist at MIT[82] who played an important role in developing numerical weather prediction and increasing understanding of the general circulation of the atmosphere by devising a series of increasingly sophisticated mathematical models of the atmosphere. He is considered the father of modern dynamical meteorology. His work also influenced that of his close colleague Edward Lorenz, who explored the limitations of predictability and was a pioneer of the field of chaos theory.

Jule Gregory Charney, was the leading world figure in meteorology ever since he and John von Neumann first introduced the electronic computer into weather prediction in 1950.
[www.history.computer.org/pioneers/charney.html]

Lorenz changed our conception of weather from deterministic phenomena to chaos, though the development of ground-breaking research into the chaotic behaviour of the atmosphere. Among other things, his work gave rise to what has been called 'The butterfly effect'.

Box B8- Edward Norton Lorenz [1917 - 2008] [10]
Ed Lorenz was an American mathematician and meteorologist at MIT who established the theoretical basis of weather and climate predictability, as well as the basis for computer-aided atmospheric physics and meteorology. He is best known as the founder of modern chaos theory, a branch of mathematics focusing on the behaviour of

[81] A third scientist, Knut Ångström, famous for other work, is said to have erroneously criticised the work of Arrhenius in 1900.

[82] Massachusetts Institute of Technology

dynamical systems that are highly sensitive to initial conditions.
His discovery of deterministic chaos "profoundly influenced a wide range of basic sciences and brought about one of the most dramatic changes in mankind's view of nature since Sir Isaac Newton", according to the committee that awarded him the 1991 Kyoto Prize for basic sciences in the field of earth and planetary sciences.
www.en.wikipedia.org/wiki/Edward_Norton_Lorenz

James Hansen (Box B9) is a well-qualified climate scientist and is often cited in scientific papers related to climate change. He is best known for his book 'Storms of my grandchildren'. [11]

At the time of contributing to the Charney report, he was working with the NASA Goddard Institute for Space Studies (1967–2013). Nevertheless, he has claimed that NASA had tried at times to silence his views.

Although much of his book is based on his own research work, as input to the Charney report, his fundamental conclusions about the importance of CO2 to climate change is largely based on the work of Charney and other scientists.

He implies that CO2 is the primary cause of global warming and rather dismisses the role of water vapour which is a stronger IRR absorbent. He goes so far as to say that CO2 concentration drives the world land-ocean temperature and that water vapour is a result of that. That is, he implies that water vapour content of the atmosphere, at some 4% compared to 0.04% by CO2, is a function of CO2 ppm which, at best, is a correlation only and not proven cause and effect.

He dismisses the effect of El Nino and La Nina as 'sloshings', and of no long-term effect on climate change. While that may be so, El Nino, La Nina and the Indian Ocean Dipole (IOD) have a profound effect on weather cycles in Australia. See Annex I, *Permanent climate change.*

Several of his facts and figures cited in his book appear to be out of date if not in error. Several of his graphs constructed from ice-core samples, for the past 400,000 years show the occurrence of several ice-ages which, in every case, show CO2 concentrations lagging temperature by several centuries. Yet he claims that, since the industrial revolution, CO2 ppm is leading and driving the change in temperature.

His book seems to be somewhat sensational and a quest in the same vein as the film "An inconvenient truth" to influence the masses. His work has not been without severe criticism. See Annex H, *Promoters and critics.*

Box B9 – James Hansen [1941 -] [12]
James Edward Hansen, is an American best known for his research in climatology, his 1988 Congressional testimony on climate change that helped raise broad awareness of global warming, and his advocacy of action to avoid dangerous climate change. In recent years he has become a climate activist to mitigate the effects of global warming, on a few occasions leading to his arrest. *[www.en.wikipedia.org/wiki/James_Hansen]*

Charney Report

Although there has been a great deal of activity by the scientific community throughout the 20th century, it was not until President Carter of the USA, in 1978, commissioned Professor Jule Charney of MIT to head a scientific group to prepare a report on global warming. (Box B10)

Box B10 – Jule Gregory Charney [13]
In 1979, Charney chaired an "ad hoc study group on carbon dioxide and climate" for the National Research Council. The resulting 22-page report, "Carbon dioxide and climate: A scientific assessment" [12], is one of the earliest modern scientific assessments about global warming. Its main conclusion can be found on page 2: "We estimate the most probable global warming for a doubling of CO2 to be near 3°C with a probable error of ± 1.5°C." This estimate of climate sensitivity has been essentially unchanged for over three decades, e.g., the IPCC Fourth Assessment Report (2007) says that "equilibrium climate sensitivity is likely to be in the range 2°C to 4.5°C, with a best estimate value of about 3°C. It is very unlikely to be less than 1.5°C. Values substantially higher than 4.5°C cannot be excluded, but agreement with observations is not as good for those values."
[www.en.wikipedia.org/wiki/Jule_Gregory_Charney]

According to Hansen [11, p41], Charney chose to keep the objective of his review very simple. Charney posited: *"How much will global temperature increase if the CO2 concentration instantly doubled, ceteris paribus".*

From the Charney Report: [14] "*Specifically, our charge was:*

- *To identify the principal premises on which our current understanding of the question is based,*
- *To assess quantitatively the adequacy and uncertainty of our knowledge of these factors and processes, and*
- *To summarize in concise and objective terms our best present understanding of the CO2/climate issue for the benefit of policymakers.*"

The Report (reviewed in detail by this author and summarised in Table B1-1 of Appendix 1 hereto, seems to have several contradictions in respect of a final decision on radiance forcing. However, the fundamental conclusion by the report [14, p2] is the second and main conclusion that: *"We estimate the most probable global warming for a doubling of CO2 to be near 3°C with a probable error of ± 1.5°C".*

The Charney Committee, comprised of many experts from around the world, did not do research in its own right but, rather, reviewed critically and collated the work of other climatologists. In particular, it reviewed the work done by several researchers using General Circulation Models (GCM), including work by James Hansen who, at the time was working for NASA's Goddard Institute. Not surprisingly, the Report was fully supported by Hansen in his book [1].

The Report is the fundamental source document for subsequent work by climatologists, extensive work by IPCC Working Groups, endorsement by the United Nations and world-wide promotion of global warming ever since by vested interests, much of which, sadly, is quite misleading and pure sensationalism.

Although there have since been advances in modelling and other techniques, the range for Twi of 3°C±1.5°C, estimated by the Report, has remained essentially unchallenged. As late as 2013, IPCC Fifth Assessment Report [15] has upheld the range with high confidence.

Primarily the conclusion on the probable range of the Temperature anomaly (Twi), was based almost exclusively on the most advanced computer modelling performed by three groups, particularly the work by Manabe and Wetherald. [16]

The Manabe/Wetherald technical report is the only one reviewed by Charney's group that is in the public domain and available on the Internet. Unfortunately, that paper (and probably the others from GCM modelling) gives no insight or information on modelling assumptions (there would be many simplifying assumptions of necessity) or equations used. Therefore, the validity of modelling is buried deep within the research community, probably never to be examinable by other scientists, let alone the public.

In its conclusions, the Manabe/Wetherald report [16 p13] says, inter alia:

- *"In this study, an attempt is made to analyse the effect of doubling the CO2 concentration [as tasked by Charney] in a highly simplified three-dimensional general circulation model."*
- *"Because of the various simplifications of the model described above, it is not advisable to take too seriously the quantitative aspect of the results obtained in the study."*

The Theories

Radiation

Short-wave, solar radiation is the source of all renewable and stored energy on Earth and essential to sustenance of all life on the planet. Knowing how it does this is obviously important.

Solar radiation reaching the Earth has been measured at about 1,370 W/m^2,[83] a figure generally accepted by the scientific community. Of that, actually radiating the Earth at the top of the atmosphere (TOA), a figure of 340 to 345 W/m^2 is generally agreed also. Of this, after albedo reflection and absorption by the atmosphere, some 165-170 W/m^2 reaches and is absorbed by the Earth, mostly by the oceans.[17]

[83] W/m^2 = Watts per square metre of the Earth's surface.

Given the scientific tenet that the Earth's energy budget must be in equilibrium, the incoming short-wave solar radiation must equal the power of long-wave IRR out into space, as determined at the TOA. Annex E compares two sources (Salby and NASA) describing the 'Earth's energy balance', and quantifies the component radiations in and out. An imbalance between the rates of incoming and outgoing radiation energy is called 'radiative forcing'.

Planck's Law

Planck's radiation law is fundamental to radiation science. It explains the spectral-energy distribution of radiation emitted by a blackbody (a hypothetical body that completely absorbs all radiant energy falling upon it, reaches some equilibrium temperature, and then re-emits that energy as quickly as it absorbs it). Planck assumed the change from a state of energy E1 to a state of lower energy E2, the discrete amount of energy E1- E2, or quantum of radiation, is equal to the product of the frequency of the radiation, symbolised by **γ** and a constant *h*, now called Planck's constant, that he determined from blackbody radiation data; i.e, E1-E2 = *h*γ.

Planck's law for the energy Eλ radiated per unit volume by a cavity of a blackbody in the wavelength interval λ to λ + Δλ (Δλ denotes an increment of wavelength) can be written in terms of Planck's constant (*h*), the speed of light (*c*), the Boltzmann constant (*k*), and the absolute temperature (T):

$$E_\lambda = \frac{8\pi hc}{\lambda^5} \times \frac{1}{\exp(hc/kT\lambda) - 1}.$$

This equation is used to derive the Stefan–Boltzmann equation by integration of the IRR spectrum to give:

P = εσAT^4 = power emitted in Watts, where:
ε = Emissivity = 1 for black body
σ = Stefan-Boltzmann constant
A = area of emitting surface
T = absolute temperature °K = 273 +°C

E=P/A W/m^2 = radiative power per area, derived by integration of IRR spectrum using Planck's equation, gives the basic version of the Stefan–Boltzmann equation, applicable to radiation from a black body, i.e., E = σT^4 W/m^3 (sometimes stated as φ = σ*T^4).

Stefan–Boltzmann Equation

Given the tenet that all bodies absorb and remit equal amounts of radiation, scientists have calculated the average level of energy being radiated by the Earth, a major component that must be balanced within the energy system. The Stefan-Boltzmann equation describes the rate of transfer of radiant energy and is used to make this calculation, under certain assumptions.

The formula for an object in a vacuum is *[some symbols changed from previous section]*:

φ = ε*F*σ*T^4, where: (B-1)
φ = heat flux (radiation) W/m^2
ε = is the Emissivity (unity for a black body, in this case =1),
F = View factor[84] (in this case =1),
σ = Stefan–Boltzmann constant,5.670374419 × 10−8 W/m^2 per K^4.
T = Absolute temperature Kelvin = 273 + t°C

W/m^2 = Watts per square metre
K = absolute temperature in degrees Kelvin (273 + t°C)
K^4 = (273 + t°C) to the fourth power.

Given Emissivity and View factor are assumed to be unity, the equation is simplified to **φ = σ*T^4** W/m^2[85]. Salby [4] assumes an average surface temperature (Tw) of 15°C (288 °K) which, using the formula, gives a figure 390 W/m^2 being emitted by the Earth. The NASA derived value is 398.2 W/m^2 which may have assumed a Tw of 16.5°C. For details of how these

[84] In radiative heat transfer, a view factor is the proportion of the radiation which leaves surface A that strikes surface B. In a complex 'scene' there can be any number of different objects, which can be divided in turn into even more surfaces and surface segments.

[85] ΔQ = 4 W/m^2 is used in Charney report.

similar figures are used, see Annex D, *Temperature change-fact or fiction?* and Annex E, *Temperature change-possible causes*.

Climate sensitivity

Climate sensitivity of the Earth's climate to increases in atmospheric CO2 concentration is a question that sits at the heart of climate science. See Box B11 for definitions.

Box B11 – Climate sensitivity [18]

For many years, estimates have put climate sensitivity somewhere between 1.5C and 4.5C of warming for a doubling of pre-industrial CO2 levels. This range has remained stubbornly wide, despite many individual studies claiming to narrow it.

Here, Carbon Brief examines studies of climate sensitivity published over the past two decades. These studies use climate models, recent observations and paleoclimate data from the Earth's more distant past to estimate climate sensitivity.

There appears to be no evidence that recent studies show a substantially different range of sensitivity than in the past, though some approaches generally result in lower or higher sensitivity than others.

[www.www.carbonbrief.org/explainer-how-scientists-estimate-climate-sensitivity]

Climate sensitivity is a measure of how much the Earth's climate will cool or warm after a change in the climate system, for instance, [in particular] how much it will warm for doubling of carbon dioxide (CO2) concentrations. In technical terms, climate sensitivity is the average change in the Earth's surface temperature in response to changes in radiative forcing, the difference between incoming and outgoing energy on Earth. Climate sensitivity is a key measure in climate science and a focus area for climatologists, who want to understand the ultimate consequences of anthropogenic climate change.

Climate sensitivity is typically estimated in three ways; using direct observations of temperature and levels of greenhouse gases taken during the industrial age; using indirectly estimated temperature and other measurements from the Earth's more distant past; and modelling the various aspects of the climate system with computers.

The two most used definitions of climate sensitivity specify the climate state: ECS and TCR are defined for a doubling with respect to the CO2 levels in the pre-industrial era. Because of potential changes in climate sensitivity, the climate system may warm by a different amount after a second doubling of CO2 than after a first doubling. The effect of any change in climate sensitivity is expected to be small or negligible in the first century after additional CO2 is released into the atmosphere. *[Wikipedia]*

Charney set his committee the task of quantifying climate sensitivity for a doubling of CO2 concentration in the atmosphere.

The first step was to determine the reduction in heat radiation from Earth into space due to absorption by the atmosphere. His answer was 4 W/m^2 [11, p41], a value which has long-standing acceptance in the scientific community.

Note: *Some references put the figure at 3.7 W/m^2, using the formula Forcing F = 5.35*ln(C/C_0), for C/C_o= 2 (doubled). [www.skepticalscience.com, attributed to IPCC [1990] Table 2.2]* [15]

But, where does this long-standing figure of 4 W/m^2 *come* from; what is the source?

First, it is a figure determined for a doubling of the CO2 concentration from the start of the industrial revolution (1750), at which time the CO2 is estimated at 280 ppm, i.e., to 560 ppm (several decades into the future yet, given the 2020 level of 413ppm).

Hansen came up with an estimate for climate sensitivity of 0.75°C per Wm^2 forcing (3°C for 4 W/m^2) on several occasions, originally in 1979 [11, p46], again in 2019 [19], based on studies of paleoclimate radiative forcing and probably several other papers authored or co-authored.[86]

Hansen attributes virtually all of the 4 W/m^2 to greenhouse gases and atmospheric feedbacks over the past 270 years, given quite small values for natural forcing, e.g., solar forcing at 0.2 W/m^2 and 'wobbling' of the Earth of similar small effect.

The next step for Charney was to determine the effect on surface temperature, the Temperature anomaly (Twi), for a forcing of 4 W/m^2.

"*These processes will influence the feedback parameter λ in the expression $\Delta T = \Delta Q/\lambda$. For the simplest case in which only the temperature change is considered, and the earth is assumed to be*

[86] Too many to research and list here.

effectively a blackbody, the value of λ = 4δT^3 is readily computed to be about 4 W/m^2/ K. For such a case, doubled CO2 produces a temperature increase of 1°C" [14, p8].

Note: *The formula λ = 4σT^3 is not explained in the report and is misleading in the way presented. In this case, λ = Forcing (F)/ ΔT_{2xCO2}, thus λ = 4σT^3 W/m^2 /°C, Assuming T=255 °K (-18°C) and λ= 4 W/m^2, ΔT_{2xCO2} can be shown to have a value of 1.06°C (presumed to be the same derivation by Charney). [Notes in en.wikipedia.org/wiki/Climate sensitivity].*

Note: *The figure T=255°K is the temperature at the TOA, determined by the Stefan-Boltzmann equation but ignoring its atmosphere and effect thereof. Salby [2, p44] states that "T = 255°K corresponds to the middle troposphere, above most of the water vapour and where clouds are abundant."* The mid-troposphere range is said to be 7-8 km.

But, where does this formula λ = 4σT^{3} and T = (λ/4σ)$^{(1/3)}$ come from?

This calculation gives us an effective temperature of the Earth of 255 K (-18°C). However, the average temperature of the Earth is 288 K (15°C). The main reason for the difference between the two values of 33°C is due to the greenhouse effect (not due only to CO2 and other non-condensable greenhouse gases), which increases the average temperature of the Earth's surface. How this figure of 33°C is derived may be seen in Table B1 (shows 34°C, due to rounding), which calculates the temperatures for respective radiations at surface and TOA, according to Salby and NASA.

Table B1

Surface radiation Using Stefan-Boltzmann equation				273	[1]	
		Case 1 - Radiation at surface [2]		Case 2 - Radiation at MOT [3]		
Variable	Unit	Salby	NASA	Salby	NASA	Notes
Temperature (Twi)	°C	15	16	- 19	- 18	[4] [5]
Temperature (Twi)	T °K	287.99	289.49	254.27	255.04	
Twi^4	T^4	6,878,307,195	7,022,926,736	4,179,899,770	4,231,035,056	
Radiation (Black body)	W/m^2	390.0	398.2	237.0	239.9	
			ΔT °C	34	34	[6]
Notes:						
1. Absolute temperature -273 °K						
2. IRR from Earth's surface						
3. Mid-Troposphere (MOT) is set at 8km altitude in the troposphere.						
4. Average Twi for Case 1.						
5. Average Twi for Case 2.						
6. ΔT (Surface; TOA) = 34 °C being gross effect of global warming.						

The Stefan-Boltzmann equation φ = σ*T^4 W/m^2 is the radiation from a black body plane. However, just as the incoming radiation from the sun of 1372 W/m^2 is divided by 4 to obtain a figure of 343 W/m^2 at the defined top of the Earth's spherical atmosphere (TOA) [Salby, 2], the area ratio of the Earth as a spherical emitter for an average of 12 hours a day, is 1/4 (0.25).

The Stefan-Boltzmann equation φ = σ*T^4 then becomes λ/4 = σ*T^4, λ = 4σ*T^4 and λ/T = 4σ*T^3 W/m^2/°C.

Note: *There seems to be a disconnect here between the two formulae. The Stefan-Boltzmann equation φ = σ*T^4 is used by Salby and NASA to calculate the radiation from Earth at 15°C, assuming a flat black-body plane, whereas T^4, in λ = 4σ*T^4, assumes emittance from a spherical body for half the day. Which is correct?*

The value for the Temperature anomaly (Twi) of 3°C ± 1.5°C, producing a forcing of 4 W/m^2, determined by Charney, was based on several assumptions: that the Earth is a perfect black-body (which it is not, having an Emissivity of about 0.96[87]) and a nominal value of 255°K at the middle troposphere, thus ignoring the existence of various important feedbacks. By the time Charney's modellers accounted for feedbacks within the lower atmosphere, i.e., below the defined TOA, particularly of those created by water vapour, ice-albedo effects as well as the nature and chaotic behaviour of the many types of clouds, the estimate went to the final estimate of Twi of 3°C±1.5°C for a doubling of CO2 concentration, at the Earth's surface.

[87] Source is Wikipedia

Doubling the CO2 concentration

The formula $\lambda = 4\sigma T^3$ perΔT_{2xCO2} applies to the case of 2xCO2 industrial era (1750) concentrations. Doubling of CO2 in later centuries is expected to have a similar effect due to the logarithmic relationship of 2xCO2 to Twi.

So, what does that mean for the current time, especially for the past 40 years during which population and energy consumption have both doubled. Although burning fossil fuels and CO2 pumped into the atmosphere may have doubled in this period, CO2 concentration in the atmosphere has not. Only about 46% of CO2 so produced and absorbed remains in the atmosphere. The still very low concentration of 413ppm in 2020 is increasing at 2.08ppm per annum, i.e., 0.505% per annum.

A basic conclusion of the Charney report predicted that Twi would increase by 3±1.5°C for a doubling of CO2 concentrations from 280ppm in pre-industrial times to 560ppm. That is a sensitivity range of 0.00536°C/ppm (1.5°C/280), through a mean 0.0107°C/ppm (3°C/280) to a maximum of 0.016°C/ppm (4.5°C/280).

Given a CO2ppm of 413, an increase of 133ppm from 280ppm should result in a Twi range of 0.7°C through a mean of 1.4°C to a maximum of 2.1 °C. Thus, the actual Twi of 1.05°C is well below mean value predicted by the Charney formula. However, as maybe seen in Figure B1, while this result is consistent with the short-term warming trend, it is below 1.4°C that would be expected with the long-term trend.

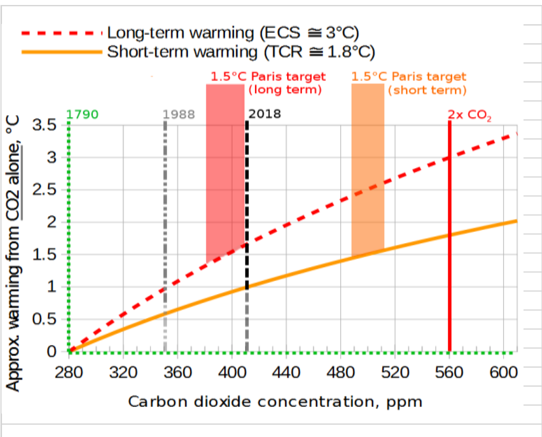
A common formula found in references for radiative forcing due to increasing CO2 concentration is: Forcing (F) = $5.35 * \ln(C/C_0)$, for $C/C_o = 2$ (doubled), which gives the value 3.7 W/m^2 (almost the same as the 4 W/m^2 used by Charney). Both these figures produce a Twi of about 1°C as determined by Charney, which becomes 3°C after accounting for feedbacks within the atmosphere. Therefore, this gives a climate sensitivity of 0.75°C per W/m^2 of forcing.

"Depending on the time scale, there are two main ways to define climate sensitivity: the short-term Transient Climate Response (TCR) and the long-term Equilibrium Climate Sensitivity (ECS). CO2 increases is measured in the amount of temperature change for doubling in the atmospheric CO2 concentration." [19] *[www.en.wikipedia.org/wiki/Climate_sensitivity]*

Both models incorporate the warming from exacerbating feedback loops. TCR modelling ignores the long-term heating inertia of the ocean currents and their effects on glaciers and ice-sheets, which may not manifest themselves for centuries, whereas ECS modelling takes these into account.

One diagram illustrating the relationship of both TRC and ECS is shown in Figure B1. According to this chart, at a ppm of 413 in 2020, the TCR prediction says we have incurred a Twi of 1.0°C and climbing. But taking the ECS figures, we have already sustained a change of 1.5°C, which is the current limit recommended by the IPCC and the UN. In addition, this graph accounts only for the increase in CO2 whereas other greenhouse gases, especially methane, would raise both curves shown.

Figure B1 – CO2 vs Twi°C



[20]

Figure 9: Warming from various CO2 levels based on a typical TCR estimate of 1.8°C and the most commonly-cited estimate of ECS, 3°C. Various scientific groups have produced a range of TCR and ECS estimates; the precise concentration of CO2 that corresponds to 1.5°C is unknown (the bars marked "Paris target" are drawn wide to represent the uncertainty, but are not scientifically accurate error bars). And of course, this graph is just a first-order approximation. The real climate will be warmed further by other greenhouse gases, and the real climate has additional variability and unpredictability, as do all computer models of it. *[www.www.skepticalscience.com/why-global-warming-can-accelerate.html]*

Note: *This graph is the first reference found by this author that clarifies that a Twi of 3°C for a forcing of 4 W/m^2 actually refers to the* long term *ECS value determined for doubling CO2 ppm.*

According to the chart, a doubling of the pre-industrial concentration of 280 ppm to 560 ppm would give an increase in Twi of from 1.5 to 3°C. At present rates of fossil fuel consumption (2.08ppm per annum), a CO2 concentration of 560 would not be reached until perhaps 2090 to 2100 ((2020+(560-413)/2).

Table B2 tabulates and agrees with the values on the graph in Figure B1, particularly of interest being the Twi values for the current CO2 ppm of 413. The Case 2 - Short-term Twi = 1.01°C agrees with at least some of the published records of Twi.

Table B2

Predicted Twi for CO2 ppm increases						
		Case 1 - CO2 Doubling ppm		Case 2 - CO2 ppm (1750-2020)		
Variable	Unit	Short-Term	Long-term	Short-Term	Long-term	Notes
Formula & constants	Const*ln (C/C0)	3.46	5.35	3.46	5.35	[1] [2]
Temperature (Future)	°K	560	560	413	413	[3] [4]
Temperature (1750)	°K	280	280	280	280	
Forcing	W/m^2	2.40	4.00	1.34	2.08	[5]
Climate sensitivity	°C /W/m^2	0.75	0.75	0.75	0.75	
Temperature Change (Twi)	°C	1.80	3.00	1.01	1.56	[6] [7]

Notes:

1. Long-term constant of 5.35 is from literature
2. Short-term constant of 3.46 is derived using 'Goal Seek' using Twi = 1.8 °C.
3. Case 1 - ppm of 560 not likely to happen before 2070. Present rate of increase is 2.08 ppm/annum.
4. Case 2 - CO2 ppm in 2020 is 413
5. Case 1- Long-term forcing of 4 W/m^2 used by Charney is actually 3.7 using the formula 5.35*ln (C/C0).
6. Case 2 - Short-term Twi = 1.01 °C agrees with graph in Figure B1 and at least some of the published records of Twi.
7. Case 2 - Long-term Twi = 1.56 °C agrees with graph in Figure B1.

The foregoing discussion has been all about the theories and scientific effort to predict the increase in surface temperature, the Temperature anomaly (Twi), as expected by the climatologists, for a doubling of CO2 concentrations. Atmospheric modellers claim that they have validated their models by running them in reverse to see if they indeed reproduce data that agrees with recorded, historical values for Twi.

However, the temperature record is heavily criticised by some scientists as having been tampered with to prove Twi is increasing as a function of greenhouse gas concentrations in the atmosphere.

The beleaguered question of temperature is discussed at Annex D, *Temperature change – fact or fiction?*

Conclusion

It has taken untold hours to unravel the science underlying global warming. Getting to the bottom of the relevant science is like peeling the proverbial onion. Unfortunately, the lowest layers of the onion are buried deep within the scientific world, never to see the light of day for all except the very few scientists performing the research. Sorting the fact from fiction and political humbuggery is not for the timid.

Climate sensitivity (ΔForcing/ΔTemperature, ie F W/m^2/ Twi°C) due to concentrations of greenhouse gases and natural terrestrial causes sits at the heart of theoretical climate science. What the climatologists are really trying to answer is whether the average surface temperature of the Earth is actually increasing and, if so, at what rate and what is causing it.

A far less expensive approach could have been to concentrate on first getting the temperature record straight and agreed, then using science to explain how and the primary causes. Of course, on the latter point, a great deal of effort has gone into proving that greenhouse gases are the primary culprits.

In fact, the cause is a combination of both greenhouse gases and natural terrestrial causes, albeit the former being the hot favourite. Climatologists and supporters claim that the effect of increasing greenhouse gases far outweigh natural causes and discount the latter, such as Earth/sun dynamics and the current warm-age (interglacial period).

It should be noted that the surface temperature record is heavily questioned by critics as having been tampered with to prove Twi is increasing as a function of greenhouse gas concentrations in the atmosphere. See Annex D, *Temperature change – fact or fiction?* for detailed discussion.

While there seems to be general consensus on the validity of the science outlined in this Annex, the literature is all over the place, often confusing and even contradictory in estimates and explanations.

There would appear to be consensus on the following aspects that:

- doubling of CO_2[88] concentration (nominally from the pre-industrial level of 280 ppm and primarily from burning fossil fuels), would, in the long-term, cause a Forcing of about 4 W/m^2;
- which, produces a Climate Sensitivity of about 0.75°C/W/m^2; and
- Temperature anomaly (Twi) of 3°C ± 1.5°C for a doubling of CO2 concentration.

In respect of where the world stands in 2020, with a CO2 concentration of 413ppm, theoretical research to date gives that the average Temperature anomaly (Twi) would be just on 1.05°C since pre-industrial times. This figure agrees with some published records from observations from surface sensors and satellites.

However, given that the temperature record is under severe dispute, there needs to be a lot more work to be done to achieve consensus before proof of causes can be determined and validated.

Appendix: B1 Summary of Charney report

Australian Logistics Study Centre
Canberra, 24 July 2020

[88] Note that CO2 is used as a proxy for all non-condensable greenhouse gases, i.e., excluding water vapour which is also a powerful greenhouse gas.

APPENDIX B1

SUMMARY OF CHARNEY REPORT

Table B1-1
Summary of Charney Report - selected extracts

Page	Statement	Comment
1	The primary effect of an increase of CO_2 is to cause more absorption of thermal radiation from the earth's surface and thus to increase the air temperature in the troposphere. A strong positive feedback mechanism is the accompanying increase of moisture, which is an even more powerful absorber of terrestrial radiation.	
2	We estimate the most probable global warming for a doubling of CO_2 to be near 3°C with a probable error of ± I.S °C.	Current (2020) Twi is 1.05 °C Current (2020) CO_2 ppm = 413 Double (2020) ppm = 826 occurs about the year 2112 (business as usual - burning fossil fuels)
2	Our estimate is based primarily on our review of a series of calculations with three-dimensional models of the global atmospheric circulation.	
5	Our limited knowledge of the basic features of the carbon cycle means that projections of future increases of CO_2 in the atmosphere as a result of fossil-fuel emissions are uncertain. It has been customary to assume to begin with that about 50 percent of the emissions will stay in the atmosphere.	Most references say 46% retained in atmosphere
6	There are considerable uncertainties about the future changes of atmospheric CO_2 concentrations due to burning of fossil fuels.	
7	For a doubling of atmospheric CO_2, the resulting change in net heating of the troposphere, oceans, and land (which is equivalent to a change in the net radiative flux at the tropopause) would amount to a global average of about $\Delta Q = 4\ W/m^2$ if all other properties of the atmosphere remained unchanged.	This value of $\Delta Q = 4\ W/m^2$ has long-standing acceptance in the scientific community.
8	Greater uncertainties arise in estimates of the resulting change in global mean surface temperature, ΔT, for this quantity is influenced by various feedback processes that will increase or decrease the heating rate from its direct value. These processes will influence the feedback parameter λ in the expression $\Delta T = \Delta Q/\lambda$. For the simplest case in which only the temperature change is considered, and the earth is assumed to be effectively a blackbody, the value of $\lambda = 4\sigma T^3$ is readily computed to be about $4\ W/m^2/K$. For such a case, doubled CO_2 produces a temperature increase of 1°C	The formula $\lambda = 4\sigma T^3$ is not explained in the report and is misleading in the way presented. The correct formula is $\lambda = 4\sigma T^3/\Delta T(2x\ CO_2)$ *[https://en.wikipedia.org/wiki/Climate_sensitivity],* ie for the case of 2 x CO_2 industrial era (1750) concentration. Doubling of CO_2 in later centuries has a lesser effect due to the logarithmic relationship of 2xCO_2 to Twi. Assuming T=255 °K (-18 °C) and $\lambda = 4\ W/m^2$, $\Delta T(2x\ CO_2)$ has a value of 1.06 °C
9	Most clouds are efficient reflectors of solar radiation and at the same time efficient absorbers (and emitters) of terrestrial infrared radiation. Clouds thus produce two opposite effects: as cloud amount and hence reflection increase, the solar radiation available to heat the system decreases, but the decreased upward infrared radiation at the tropopause and downward radiation from the base of the clouds raises the temperature of the earth's surface and troposphere.	
9	How important the overall cloud effects are is, however, an extremely difficult question to answer. The cloud distribution is a product of the entire climate system, in which many other feedbacks are involved.	
10	It must thus be emphasized that the modelling of clouds is one of the weakest links in the general circulation modelling efforts.	This is an admission in most literature dealing with modelling the atmosphere.
10	Existing numerical models of the atmosphere, which treat the ocean as having no meridional heat transports of its own, may give somewhat improper accounts of the CO_2 impact.	This is an admission in most literature dealing with modelling ocean behaviour.
13	We proceed now to a discussion of the three-dimensional model simulations on which our conclusions are primarily based. Some of the existing general circulation models have been used to predict the climate for doubled or quadrupled CO_2 concentration. The results of several such predictions were available to us: three by S. Manabe and his colleagues at the NOAA Geophysical Fluid Dynamics Laboratory (hereafter identified as Ml, M2, and M3) and two by J. Hansen and his colleagues at the NASA Goddard Institute for Space Studies (hereafter identified as HI and H2).	
16	The existing general circulation models produce time-averaged mean values rainfall, whose climate is reasonably accurate in global or zonal mean. Their inaccuracies are revealed much more in their regional climates.	
17	It is for this reason that we do not consider the existing models to be at all reliable in their predictions of regional climatic changes due to changes in CO_2 concentration.	
17	If the CO_2 concentration of the atmosphere is indeed doubled and remains so long enough for the atmosphere and the intermediate layers of the ocean to attain approximate thermal equilibrium, our best estimate is that changes in global temperature of the order of 3° C will occur and that these will be accompanied by significant changes in regional climatic patterns.	

ANNEX C TO
A view on permanent climate change

RADIATION AND THE CONCEPT OF FORCING

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About this Annex

This Annex is intended as a basic primer on the nature of solar radiation reaching the Earth, infra-red radiation leaving the Earth and the difference referred to in the scientific world as ‘forcing’.

What follows is an overview only. As readers may be aware, like any aspect of the subject of global warming and climate change, the literature is vast, whether it be of basic research, valid reporting by reputable authorities or all forms of Media published by vested interests.

Annex B, *Genesis and Theory* and Annex E**,** *Temperature change- possible causes,* elaborate further on these subjects.

Concept of Forcing

The following extracts in Boxes C1 and C2 summarise the concept of ‘radiative forcing’. Although not mentioned, the unit of measurement for these radiation fluxes is Watts per square metre (w/m^2).

Box C1- Radiative Forcing [1]

Box 8.1 - Definition of Radiative Forcing and Effective Radiative Forcing

The two most commonly used measures of radiative forcing in this chapter are the radiative forcing (RF) and the effective radiative forcing (ERF). RF is defined as …the change in net downward radiative flux at the tropopause after allowing for stratospheric temperatures to readjust to radiative equilibrium, while holding surface and tropospheric temperatures and state variables such as water vapour and cloud cover fixed at the unperturbed values.

ERF is the change in net Top of Atmosphere (TOA) downward radiative flux after allowing for atmospheric temperatures, water vapour and clouds to adjust, but with surface temperature or a portion of surface conditions unchanged. Although there are multiple methods to calculate ERF, we take ERF to mean the method in which sea surface temperatures and sea ice cover are fixed at climatological values unless otherwise specified. Land surface properties (temperature, snow and ice cover and vegetation) are allowed to adjust in this method. Hence ERF includes both the effects of the forcing agent itself and the rapid adjustments to that agent (as does RF, though stratospheric temperature is the only adjustment for the latter). In the case of aerosols, the rapid adjustments of clouds encompass effects that have been referred to as indirect or semi-direct forcings (see Figure 7.3 and Section 7.5), with some of these same cloud responses also taking place for other forcing agents (see Section 7.2).

Calculation of ERF requires longer simulations with more complex models than calculation of RF, but the inclusion of the additional rapid adjustments makes ERF a better indicator of the eventual global mean temperature response, especially for aerosols. When forcing is attributed to emissions or used for calculation of emission metrics, additional responses including atmospheric chemistry and the carbon cycle are also included in both RF and ERF (see Section 8.1.2). The general term forcing is used to refer to both RF and ERF.
https://www.ipcc.ch/site/assets/uploads/2018/02/WG1AR5_Chapter08_FINAL.pdf

Box C2
Incoming Energy – Outgoing Energy = Radiative Forcing [2]
In accordance with the basic laws of thermodynamics, as Earth absorbs energy from the sun, it must eventually emit an equal amount of energy to space. The difference between incoming and outgoing radiation is known as a planet's radiative forcing (RF). In the same way as applying a pushing force to a physical object will cause it to become unbalanced and move, a climate forcing factor will change the climate system. When forcings result in incoming energy being greater than outgoing energy, the planet will warm (positive RF). Conversely, if outgoing energy is greater than incoming energy, the planet will cool. *https://www.climate.gov/maps-data/primer/climate-forcing*

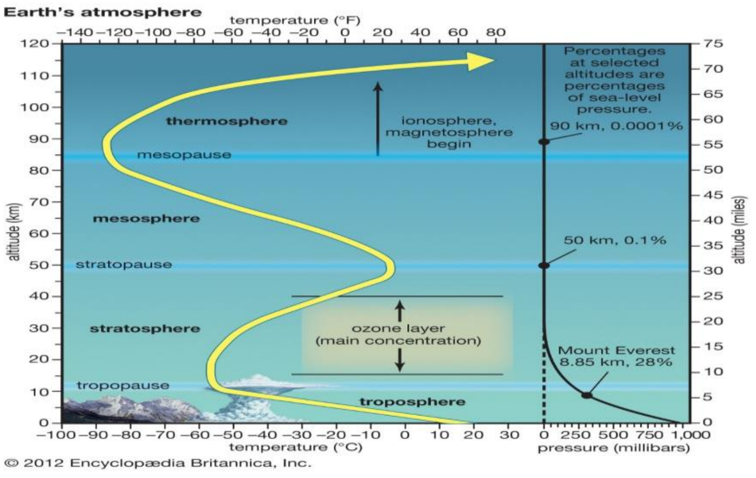
Box C3 - Effective Radiative Forcing (ERF)

1.4 The Global Energy Budget. [Salby, 3, p41]

Because it follows from a simple energy balance, the equivalent blackbody temperature provides some insight into where LW radiation is ultimately emitted to space. The value T e = 255 K corresponds to the middle troposphere, above most of the water vapour and where clouds are abundant. Most of the energy received by the atmosphere is supplied from the earth's surface, where SW radiation is absorbed. Transfers of energy from the surface constitute a heat source for the atmosphere, whereas IR cooling to space in the middle troposphere constitutes a heat sink for the atmosphere. These energy transfers drive the atmosphere and make its circulation behave as a global heat engine in the energy budget of the earth.

While Salby [3] does not actually mention Effective Radiative Forcing (ERF) as such, he does define the baseline for analysis as the 'middle troposphere', and precisely where the absolute temperature is 255 °K (-18°C). NASA [4] also uses this baseline. This temperature occurs at an altitude of about 5 km (16,500 feet), being about the middle of the troposphere said to be below an altitude of around 11 km (this level does vary with latitude). One may see in the following chart that a temperature of 255 °K (-18°C) occurs around 5 km altitude. See Annex E, *Temperature change - causes*, for how Salby and NASA use this baseline.

Figure C1 [5]



Climate sensitivity

Climate sensitivity is the change in globally averaged surface temperature (Twi) in response to changes in radiative forcing, which can occur, for instance, due to increased levels of carbon dioxide (CO_2)[89].

"Earth's energy balance is the best indication of where global temperature is headed and how much global forcings must be altered to stabilise climate." [6, p102]

"…climate sensitivity is about 0.75°C per W/m^2, or 3°C for doubled CO2 …" [twice the concentration in the atmosphere] [6, p105]. The reference [6, p107] says further that an *"annual increase of carbon dioxide today [at year 2000] is about 2 ppm, … an annual increase of about 0.3 W/m^2"*. In fact, the increase in CO2 concentration in 2020 (413ppm) is increasing at 2.08ppm per annum. See also Annex B, *Genesis and theory* and Annex D, *Temperature change-fact of fiction?* for further discussion.

Box C4 gives a general statement about climate sensitivity.

> **Box C4 - Climate sensitivity** [7]
> Although the term climate sensitivity is normally used in the context of radiative forcing by CO2, it is thought of as a general property of the climate system: the change in surface air temperature following a unit change in radiative forcing, and the climate sensitivity parameter … is therefore expressed in units of °C/(W/m2). The measure is approximately independent of the nature of the forcing (e.g. from greenhouse gases or solar variation). When climate sensitivity is expressed for a doubling of CO2, its units are degrees Celsius (°C).
> *[https://en.wikipedia.org/wiki/Climate_sensitivity]*

Without comment, Box C5 is a recent statement on climate sensitivity by an Australian National University (ANU) specialist in climate change. It starts by citing the 2013 statement by the IPCC that a doubling of CO2 in the atmosphere was likely to produce warming within the range of 1.5 to 4.5°C, which is consistent with a long-standing prediction within the climate change community (See Charney Report, Annex B), i.e., an expected value of 3+-1.5°C. Now, early reports from the latest climate modelling are predicting that a doubling of CO2 may in fact produce between 2.8 and 5.8°C of warming, i.e., an expected value of 4.3°C. *These latter figures need to be considered with circumspection.*

Note: *The validity of such models needs always to be verified. Irrespective of how sophisticated they may be in detail and how powerful the computer used, they are always dependent on the accuracy of formulae, algorithms and the effect of essential, simplifying assumptions that comprise these models, as well as the validity of data used for each variable. The problem being addressed is one of the most complex possible with myriad variables to consider. The potential combinatorial problem is daunting, thus the need for simplifying assumptions.*

> **Box C5 - Climate sensitivity** [8]
> When the IPCC's fifth assessment report was published in 2013, it estimated that such a doubling of CO2 was likely to produce warming within the range of 1.5 to 4.5°C as the Earth reaches a new equilibrium. However, preliminary estimates calculated from the latest global climate models (being used in the current IPCC assessment, due out in 2021) are far higher than with the previous generation of models. Early reports are predicting that a doubling of CO2 may in fact produce between 2.8 and 5.8°C of warming. Incredibly, at least eight of the latest models produced by leading research centres in the United States, the United Kingdom, Canada and France are showing climate sensitivity of 5°C or warmer. *The terrible truth of climate change", Joëlle Gergis, ANU, August 2019*

Solar irradiance[90]

The source of all energy within the Earth System is irradiance from the Sun, in the form of high-frequency electro-magnetic (EMR), mostly in the visible and ultra-violet light bands of the EMR spectrum. Boxes C6 and C7 describe solar irradiance.

[89] CO2 is used in this paper as a proxy for all non-condensable greenhouse gases.

[90] 'Radiance' and 'irradiance' are often used interchangeably but they differ. Radiance is the phenomenon of emission of light. Irradiance is the intensity of the radiance from objects like the Sun and Earth.

Box C6 - Solar irradiance 1 [9] [10]
The solar irradiance is the output of light energy from the entire disk of the Sun, measured at the Earth. It is looking at the Sun as we would a star rather than as an image. The solar spectral irradiance is a measure of the brightness of the entire Sun at a wavelength of light. [www.nasa.gov › mission_pages › sdo › science › Solar Irradiance]

The atmosphere scatters and absorbs some of the Sun's energy that is incident on the Earth's surface. Roughly half of the radiation that is scattered is lost to outer space, the remaining half is directed towards the Earth's surface from all directions as diffuse radiation. ***[https://www.itacanet.org/the-sun-as-a-source-of-energy/]***

Box C7 - Solar irradiance 2 [10] [11]
Solar irradiance is the EMR power per unit area (watt per square metre, W/m^2), received from the Sun. Solar irradiance is often averaged over a given time period. A yearly average value is thus taken and the solar constant equals 1367 W/m^2. This figure may vary with variations in the actual output of the sun at a given time, e.g., due to sun spot cycles*. **[https://www.itacanet.org/the-sun-as-a-source-of-energy/],***

Average annual solar radiation arriving at the top of the Earth's atmosphere is roughly 1361 W/m^2. The Sun's rays are attenuated as they pass through the atmosphere, leaving maximum normal surface irradiance at approximately 1000 W /m2 at sea level on a clear day. When 1361 W/m2 is arriving above the atmosphere (when the sun is at the zenith in a cloudless sky), direct sun is about 1050 W/m2, and global radiation on a horizontal surface at ground level is about 1120 W/m2. The latter figure includes radiation scattered or re-emitted by atmosphere and surroundings. The actual figure varies with the Sun's angle and atmospheric circumstances. Ignoring clouds, the daily average insolation for the Earth is approximately 6 kWh/m2. ***[https://en.wikipedia.org/wiki/Solar_irradiance]***

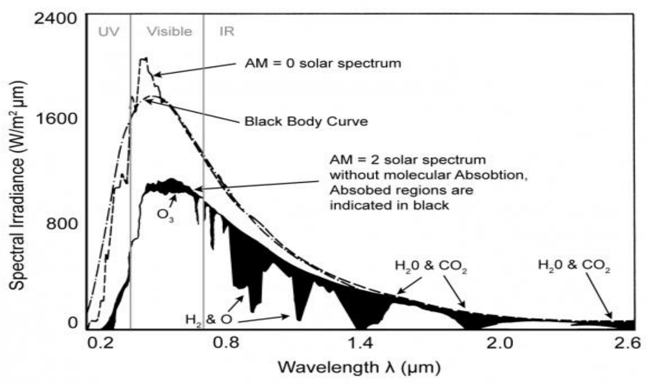
[This statement in Wikipedia is somewhat incomplete and misleading. The figures mentioned of 1000, 1050 and 1120 W/m^2 (why the three?) assume the same basis as the 1,361 W/m^2 arriving at the atmosphere from the Sun, i.e., assuming a flat surface. In fact, these numbers need to be divided by 4 (see Annexes B and E for explanation), giving an actual figure at the surface of about 250 W/m^2.

According to Salby [3] (and NASA [4]), the Average daily irradiation (Effective Radiative Forcing (ERF)) is in fact about 340 W/m^2, of which 100 W/m^2 is reflected, leaving 240 W/m^2 absorbed by the atmosphere (77 W/m^2) and by the oceans and land (163 W)m^2). This figure of 240 W/m^2 converts to 5.76 KWh/m^2 per day, which is equivalent to the 6kWh/m^2 for an irradiance of 250 W/m^2 cited in the reference.]

To put things in perspective, the average downwards radiation of 240 W/m^2 (direct to Erath and from the clouds)[91] is like having one 1,000 Watt bar radiator for every four m^2, heating the atmosphere.

Box C8 shows one graph (of many available from myriad sources) of the spectrum of solar radiation. While 98% of the atmosphere (N2 and O2) is said to be transparent to solar radiation, water vapour (H2O), carbon dioxide (CO2) and Ozone (O3) are seen to absorb at certain frequencies, about 23% of the radiation at the top of the atmosphere (77/340).

Box C8 – Solar irradiance spectrum [10]



The extra-terrestrial solar spectrum (AM = 0), the theoretical black body curve and the solar spectrum at the Earth's surface for AM = 2 and the absorbed regions shown in black. ***[https://www.itacanet.org/the-sun-as-a-source-of-energy/]***

[91] One can still get sunburnt from UVR on an overcast day.

Visible light falls in the range of the EM spectrum between infrared (IR) and ultraviolet (UV). It has frequencies of about 4×10^{14} to 8×10^{14} cycles per second and wavelengths of about 740 nano-metres (nm).

This radiation is used by growing vegetation through photosynthesis or converted to kinetic, potential and radiant energy contained by molecules of the atmosphere, oceans and land.

Ultra-violet radiation (UV) falls in the range between visible light and X-rays. It has frequencies of about 8×10^{14} to 3×10^{16} cycles per second and wavelengths of about 10 nm to 400 nm.

UV is known to damage genetic material in animals (DNA[92]) and can sterilise surfaces with which it comes into contact. For humans, suntan and sunburn are familiar effects of exposure of the skin to UV light, along with an increased risk of skin cancer. The amount of UV light produced by the Sun means that the Earth would not be able to sustain life on dry land if most of that light were not filtered out by the atmosphere.

Emitted long-wave IRR

What comes down must go up, i.e., there needs to be a balance (equilibrium) between the incoming solar radiation and outgoing radiation in the form of infra-red radiation (IRR, being long-wave EMR). This is referred to as the 'Earth's energy balance' and is explored in detail in Annex B, *Genesis and theory* and Annex D, *Temperature change-fact or fiction?*

About 70% of IRR outgoing from the surface of the Earth is eventually emitted up through the atmosphere to space, with the remaining 30% being the net radiative forcing at the surface of the Earth. [3] and Annex D, *Temperature change-fact or fiction?*].

The greenhouse gases, including water vapour, are often said to 'trap' outgoing IRR but this is a somewhat misleading choice of words. In fact, these gases absorb IRR at specific frequency bands of the IRR spectrum (Boxes C9, C10, C11), but re-emit it also in all directions, with about 50% going outwards to space. However, enough thermal energy is retained in the atmosphere as the proverbial 'blanket' to insulate the earth from freezing at a nominal temperature of -18°C.

Box C9 - Absorption bands [12]
Radiation can be absorbed by carbon dioxide, water vapour and other emission gases in different bands or ranges of wavelength. Absorption bands of carbon dioxide are centred at 15, 4.3, 2.7, and 2 μm. There exists a window between 8 and 14 μm for absorption bands of water vapour.
[https://www.ncbi.nlm.nih.gov › pmc › articles › PMC6174548]

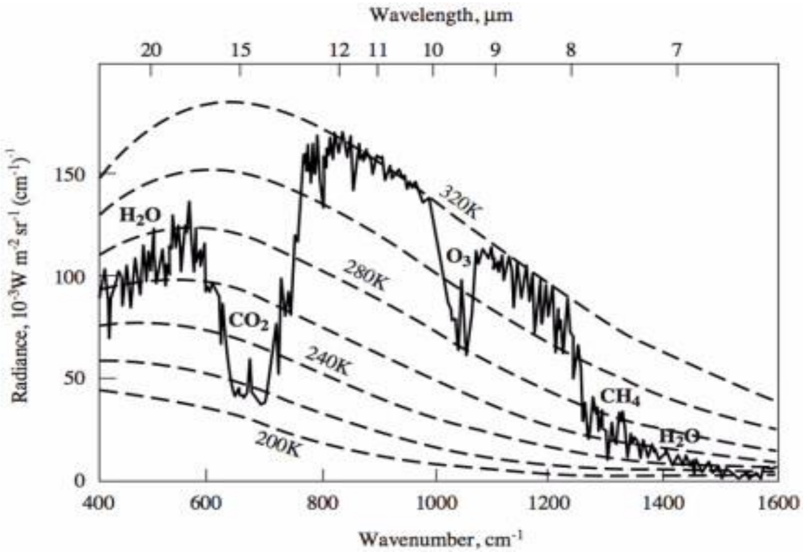
The greenhouse gases, including water vapour, are said to absorb radiation, including IRR, because of their three-atom molecular structure, whereas nitrogen and oxygen because of their two-atom structure are said to be transparent to radiation. Absorption is explained technically at the atomic level of physics by the excitation of the atoms of molecules by EMR and how kinetic energy is stored within atoms (at least temporarily) by rotation and vibration of component particles.

Some weather satellites measure the energy being radiated into space from the surface and atmosphere. The example in Box C10 shows clearly the relative absorption of IRR by CO2 and H20.

It is important to note that the absorption by CO2 in relatively few and narrow bands, mainly about the wavelength of 15 μm, whereas H2O absorbs over a much wider range of the IRR spectrum, which is quite wide in terms of frequency/wavelength. The two sources can also overlap as shown in the figure at Box C11. This accounts for why H20 is a much greater absorbent of IRR than CO2.

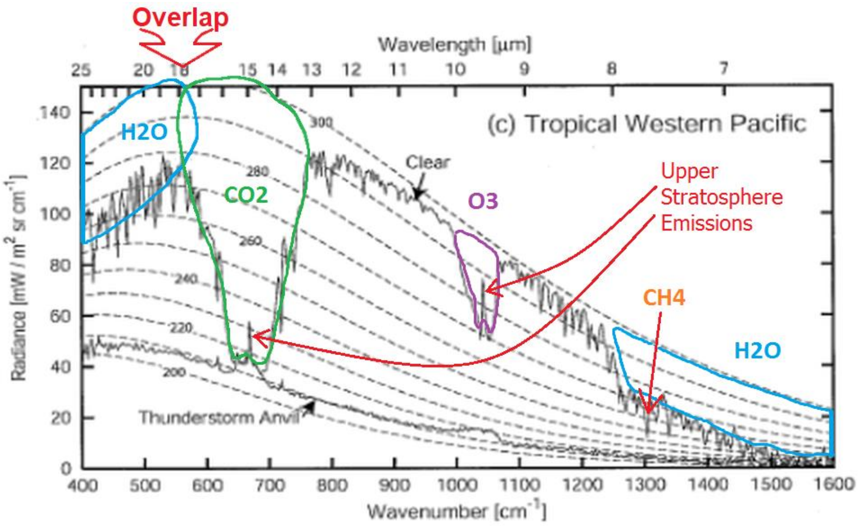
[92] Deoxyribonucleic acid

Box C10 – Outgoing IRR absorption [13]



Credit: Data from R. A. Hanel, et al., J. Geophys. Res., 1972, 77, 2829-2841
https://www.acs.org/content/acs/en/climatescience/atmosphericwarming.html

Box C11 – Outgoing IRR absorption – CO2 and H2O overlap [13]



Earth's emission spectrum, measured by satellite over the tropical western Pacific

The claimed role of CO2

CO2 is said by the climatologists to be the single most important climate-relevant greenhouse gas in Earth's atmosphere. Although it is responsible for only 25% of the greenhouse effect, it is said also to be the sole controller of surface temperature change, i.e., that it is the Earth's 'thermostat'. See Boxes C12 and C13.

Box C12 [14]
Atmospheric CO2: Principal Control Knob Governing Earth's Temperature
Abstract
Ample physical evidence shows that carbon dioxide (CO2) is the single most important climate-relevant greenhouse gas in Earth's atmosphere. This is because CO2, like ozone, N2O, CH4, and chlorofluorocarbons, does not condense and precipitate from the atmosphere at current climate temperatures, whereas water vapour can and does. Noncondensing greenhouse gases, which account for 25% of the total terrestrial greenhouse effect, thus serve to provide the stable temperature structure that sustains the current levels of atmospheric water vapour and clouds via feedback processes that account for the remaining 75% of the greenhouse effect. Without the radiative forcing supplied by CO2 and the other noncondensing greenhouse gases, the terrestrial greenhouse would collapse, plunging the global climate into an icebound Earth state.
Andrew A. Lacis, Gavin A. Schmidt, David Rind, Reto A. Ruedy, Science 15 Oct 2010*

Box C13 [15] [16]
This ability to absorb and re-emit infrared energy is what makes CO_2 an effective heat-trapping greenhouse gas. Not all gas molecules are able to absorb IR radiation. For example, nitrogen (N_2) and oxygen (O_2), which make up more than 90% of Earth's atmosphere, do not absorb infrared photons.
[***Carbon Dioxide*** Absorbs and Re-emits Infrared Radiation | UCAR; https://scied.ucar.edu]

Carbon dioxide controls the amount of water vapour in the atmosphere and thus the size of the greenhouse effect. This means that Earth's temperature will increase at least another 0.6 degrees Celsius (1 degree Fahrenheit) because of carbon dioxide already in the atmosphere. *[https://earthobservatory.nasa.gov › features › CarbonCycle]*

Box C14 – Water vapour [17]
Water vapour is a greenhouse gas in the Earth's atmosphere, responsible for 70% of the known absorption of incoming sunlight, particularly in the infrared region, and about 60% of the atmospheric absorption of thermal radiation by the Earth known as the greenhouse effect.
[https://en.wikipedia.org › wiki › Electromagnetic absorption by water]

Although water vapour and clouds cause the remaining 75% of the greenhouse effect, they are said to not 'control' the surface temperature but contribute only to global warming as a positive feedback – the oceans get warmer because of greenhouse gases (excluding water vapour), the higher temperature causes more evaporation and water vapour into the atmosphere which, with clouds forming therefrom, absorb IRR and so heat the surface further.

Contrary to the so-called opinion of most scientists[93], the role of CO_2 and other non-condensable greenhouse gases is contested by other scientists. See Boxes C15 and C16. The claims in Boxes C12 and C13 that 'ample physical evidence' exists that only the greenhouse gases control global warming is also disputed by this author. See Annex E, *Temperature change-causes.*

Box C15 [18]
On the influence of changes in the CO_2 concentration in air on the radiation balance of the Earth's surface and on the climate, F. Möller; 1 July 1963
Abstract
The numerical value of a temperature change under the influence of a CO_2 changes as calculated by Plass is valid only for a dry atmosphere. Overlapping of the absorption bands of CO_2 and H_2O in the range around 15 μ essentially diminishes the temperature changes. New calculations give $\Delta T = + 1.5°$ when the CO_2 content increases from 300 to 600 ppm. Cloudiness diminishes the radiation effects but not the temperature changes, because under cloudy skies larger temperature changes are needed in order to compensate for an equal change in the downward long-wave radiation. The increase in the water vapour content of the atmosphere with rising temperature causes a self-amplification effect which results in almost arbitrary temperature changes, e.g., for constant relative humidity $\Delta T = +10°$ in the above-mentioned case. It is shown, however, that the changed radiation conditions are not necessarily compensated for by a temperature change. The effect of an increase in CO_2 from 300 to 330 ppm can be compensated for completely by a change in the water vapour content of 3 per cent or by a change in the cloudiness of 1 per cent of its value without the occurrence of temperature changes at all. *Thus, the theory that climatic variations are affected by variations in the CO_2 content becomes very questionable.*

Box C16 [19]
Absorption coefficient of carbon dioxide across atmospheric troposphere layer.
Peng-Sheng Wei,∗ Yin-Chih Hsieh, Hsuan-Han Chiu, Da-Lun Yen, Chieh Lee, Yi-Cheng Tsai, and Te-Chuan Ting, 2018
Abstract
Absorption coefficient affected by carbon dioxide concentration and optical path length responsible for temperature or global warming across the troposphere layer, which is less than the altitude of 10 km in the atmosphere, is systematically presented in this work. Solar irradiation within a short wavelength range can be absorbed, scattered and transmitted by the atmosphere, and absorbed and reflected by the Earth's surface. Radiative emission in high wavelength ranges from the Earth's surface at low temperature can be absorbed by atmospheric water vapour, carbon dioxide and other gases. Unbalance of radiation thus results in the atmosphere to act as the glass of a greenhouse and increase atmospheric temperature. Even though global warming strongly affects the life of the human being, the cause of global warming is still controversial.
This work thus proposes a fundamental and systematic unsteady one-dimensional heat conduction-radiation model together with exponential wide band model to predict absorption coefficients affected by concentration, temperature,

[93] Some 97% of scientists no less, claimed by some promoters of global warming, but 97% of which group of competent scientists has not been clarified by sources.

optical path lengths and radiation correlated parameters in different bands centred at 15, 4.3, 2.7, and 2 μm of carbon dioxide across the troposphere layer. It shows that absorption coefficient required for calculating heat transfer is strongly affected by carbon dioxide concentration and optical path length across the troposphere. Relevant values of the latter should be greater than 5,000 m. Absorption coefficients in the band centred at 4.3 μm subject to a chosen optical path length of 104 m increase from 0.04 m−1 and 0.165 m−1at the tropopause to 0.11 m−1 and 0.44 m−1 at the Earth's surface for carbon dioxide concentrations of 100 and 400 ppm, respectively. A more relevant and detailed temperature profile across the troposphere is presented.

It should be noted here that, while heat transfer throughout the atmosphere is both kinetic (by collision of molecules) and electronic (IRR), all heat eventually transferred to space (about 240 W/m^2) is in the form of infra-red radiation, there being, at the top of the atmosphere, virtually no physical matter to transfer kinetic energy. Greenhouse gases (and no water vapour) are the only vehicles at that altitude able to emit radiation to space.

Absorbing power of CO2 – an analogy

This author has conducted a small experiment to test, by analogy, the absorbing power of CO2. With a concentration is only 0.04%.

To simulate the current concentration of CO2 in the atmosphere (0.04%), four (4) millilitres (0.04%) of dark red beetroot juice was mixed with one litre of water (1,000,000 mm^3). This mixture significantly changed the colour. A test paper in red letters from 14 to 48 size units was placed underneath. The letters, while dimmer, could be read easily.

To simulate the effect of the thickness of the atmosphere (decreased emissivity), averaging a density of 21% of that at sea-level and thus a measure of the average concentration of CO2 in the atmosphere, 85 ml (0.85%) of beetroot juice was mixed with a litre of water. Even at this apparently small concentration, none of the red letters were visible, having been completely absorbed by the reddened water.

This simple experiment was able to demonstrate the absorption power of even a quite small concentration of suspended coloured particles (think soot and other particles, if not CO2).

Thus, the claim by climatologists that even the small concentration of CO2 is a powerful absorbent of infra-red radiation and responsible for absorption of a large percentage of the 390[94] W/m^2 of infra-red radiation from the Earth could be viable

Caution: *This experiment showed the effect of absorbing red visible light, whereas the argument about CO2 is about absorbing infra-red radiation. It is an analogy only.*

Conclusion

It is clear from the IRR absorption graphs in Boxes C10 and C11 that H2O (water vapour and in clouds) is a much greater absorbent of IRR than CO2. Absorption by CO2 is in relatively few and narrow bands, mainly about the wavelength of 15 μm, whereas H2O absorbs over a much wider range of the IRR spectrum, which is quite wide in terms of frequency/wavelength.

While H2O may be the preponderant absorbent of IRR, this fact does not necessarily deny the claim of climatologists that only the concentrations of CO2 and other non-condensable greenhouse gases control surface temperature and that atmospheric H2O affects temperature by 'feedback' alone.

However, the claims by climatologists that 'ample physical evidence' exists that only the greenhouse gases act as the Earth's 'thermostat' to control global warming is disputed by some scientists (and by this author too) as 'not %'.

See Annex E, *Temperature change-causes*, for detailed discussion on this fundamental aspect.
Australian Logistics Study Centre
Canberra, 24 July 2020

[94] See Tables Y1 through Y4

TEMPERATURE CHANGE – FACT OR FICTION

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About this Annex

This Annex addresses whether the average World surface temperature (Tw) is increasing, by how much and at what rate. This is the fundamental question of the global warming debate and any consequent climate change. What is causing it is a secondary but no less important question. Answers to both questions need to be known and agreed upon, so that remedial action, if proved to be needed, can be devised and acted upon by those in authority through policy initiatives and funding, especially by the developed nations. Possible and probable reasons are addressed in Annex E, *Temperature change-possible causes*.

Introduction

The Average surface temperature of Earth (Tw) is said to be increasing since the start of the industrial revolution (taken as 1750) to the present day, especially what has happened over the past 40 years (1980-2020) with doubling of world population and corresponding demand for energy, some 95% provided by fossil fuels.

Through palaeontology[95], scientists have used various techniques, including study of ice-cores, ocean sediment cores and tree-ring records, to establish periods of global warming and ice-ages over the millennia, to establish past relationships between temperature and CO2 concentrations, and as a reference for comparison with temperatures and CO2 that have been recorded (or estimated) since the start of the industrial revolution.

General scientific agreement says that the Temperature anomaly index (Twi) in 2020 stands at about 1.05°C[96], i.e., above average pre-industrial temperatures. However, some eminent climate scientists have questioned the accuracy and validity of this figure and claim a lesser change. See Annex H, *Promoters and critics.*

It should be clearly understood that the world surface temperature and changes thereto (Tw and Twi) are averages from sensors from around the world, as well as from satellites in more recent years, and should be accurate measures of the effect of climate change. Actual temperature and variation

[95] Palaeontology is the study of the forms of life existing in former geological periods, as represented by fossil animals and plants [Macquarie Australian dictionary].

[96] Degrees Celsius

thereof can vary substantially by hemisphere, region and season, especially in higher latitudes. Although there is also monitoring of ocean temperatures, most surface instrumented sensors are located in the industrial areas of the northern hemisphere. Consequently, most literature should be read as pertaining to the northern hemisphere, even though climatologists do not often make this clear.

Higher average temperature changes are known to prevail at higher latitudes, especially in the northern hemisphere, could be important due to the potential melting effect on glaciers, ice-caps and sheet-ice although such melting would be primarily a function of slowly-increasing ocean temperatures rather than by the temperature of air masses. In fact, the elevated temperatures recorded in the Arctic, rather than being due to an average change in world surface temperature, are due to massive convection of warm air from the tropics up through the atmosphere to fall and cool at the poles. Although subject to the same transfer of tropical heat, temperatures are higher in the Arctic than in the Antarctic because of the preponderance of land masses in the north and of oceans in the south.

Although climatologists claim that there is general scientific consensus about the range of world surface temperature increase above pre-industrial levels, these ranges do vary considerably and the temperature record is heavily questioned by absorbents (contrarians) as having been tampered with to prove Twi is increasing as a function of greenhouse gas concentrations in the atmosphere.

Terminology

While the term ‘Average world surface temperature (Tw)’ is generally used throughout this paper, for actual temperatures, in respect to the incremental change thereto (Twi), climatologists may use several terms, the most common being: ‘Global temperature change’; ‘Temperature anomaly’; Calculated temperature anomaly’. Temperature anomaly (Twi) is used throughout this paper.

Note: *When looking at the many temperature diagrams in the literature, one should always be alert to the stated base date or range, not only 1750, i.e., the presumed start of the industrial revolution. If the base date (or range) is not stated on the diagram, its accuracy should be considered as suspect.*

Data sources

Data used in the diagrams that follow are based on recorded data from the same original sources (land, ocean atmospheric and satellite sensors): raw, massaged and even added to, calculated by computer models using the same source data or from correlated data, e.g., CO2 levels.

Given that sensor readings vary according to prevailing regional conditions (seasons, latitude, etc. and the time-base used), various averaging techniques are used to determine average temperatures, moving averages and max/min bands. Gaps and apparently anomalous bumps up or down in the data may be ‘smoothed out’ by educated guessing. Also, it has not been beyond the wit of some climatologists to invent data and to manipulate the graph axes to exaggerate changes, especially for projections into the future. *"Lies, damned lies, and statistics"*[97]

Nor is data created by some climatologists freely available to other scientists let alone the public. Critics have been silenced, sued and their data ‘lost’. Such manipulation of common source data can be biased to whatever objectives the originating agency may have. The history of Temperature anomaly determination is rife with accusations of manipulation, omissions and additions to data to serve political agendas.[98]

Douglass and Christy [1] (Box D1) point out an important aspect of temperature anomalies that those derived from surface measurements are not a suitable proxy for that variable and that there are additional reasons for not using the surface temperature data that include non-uniform coverage of the globe.

[97] *"Lies, damned lies, and statistics"* is a phrase describing the persuasive power of numbers, particularly the use of statistics to bolster weak arguments. It is also sometimes colloquially used to doubt statistics used to prove an opponent's point, mistakably attributed by Mark Twain to Benjamin Disraeli, Prime Minister of England.

[98] Readers should note that virtually all climatologists work for one institution or another. Very few, if any, have the means to conduct independent research. Therefore, climatologists are constrained by the mindset, politics and agendas of their respective institutions, to toe the ‘party line’. Thus, the results of good or bad research reach the light of day only through the filter of the institution’s agenda. Even the institutions themselves are beholden to the agendas of the powers that provide the funds for research. Even today in Australia there has been a case of scientists being fired because they contested the ‘conventional wisdom’ on global warming and climate change.

The Characteristic Emission Layer (CEL) referred to in Box D1, at an altitude of around 7-8 km, is in fact the mid-tropospheric layer at which radiative forcing is calculated (e.g., by Hansen [2], NASA [3] and Salby [4]) and at which satellite data is measured. See discussion in Annex B, *Genesis and theory*, Annex C, *Radiation and concept of forcing* and Annex E, *Temperature change-possible causes*.

Thus, we have an apparent disconnect in the derivation of the temperature anomaly from suspect source data. Theoretical derivation of global temperature changes from an irradiation basis is thus at odds with that observed by sensors. Have climatologists been comparing apples and oranges?

Box D1 - Definition of temperature anomaly [1]

It is necessary to define temperature 'T' and other quantities describing the climate system of Earth. The radiative-convective equilibrium concept in climate modelling is discussed in a recent National Research Council report [NRC 2005]. In this report, the radiation forcing, the heat content, and the changes in temperature ΔT are all referenced to the tropopause. Note that the reference is not Earth's surface. Pielke et al. [2007] have pointed out that in this context the ΔT in the energy balance equations is a "…thermodynamic proxy for the thermodynamic state of the Earth system". They then make the point that the surface temperature anomalies are not a good proxy for ΔT because the measurements are made within the surface boundary layer (SBL) which can in many cases contain effects which result in a decoupling from ΔTs higher in the troposphere. … This characteristic emission layer (CEL) is above the boundary layer and is typically at an altitude of 7-8km …

For these reasons, temperature anomalies derived from surface measurements are not a suitable proxy (see also Christy et al. 2006). There are additional reasons for not using the surface temperature data that include non-uniform coverage of the globe. [***Limits on CO2 Climate Forcing from Recent Temperature Data of Earth; David H. Douglass and John R. Christy, Energy and Environment, Aug 2008]***

Global Temperature Change

It is claimed that human-induced warming reached approximately 1.0°C in 2017 (1.05°C in 2020) above pre-industrial levels and, at the present rate, global temperatures would reach 1.5 degrees Celsius around 2040, according to NASA. See Box D2 and later discussion in this paper of the probable range for future dates to reach stated benchmark temperatures.

The IPCC[99] of the United Nations (UN) says that an average[100] increase of 1.5°C is a danger point for warming and consequent climate change and that an increase of 2°C could cause serious and detrimental changes to the climate. See later discussion under 'Danger points' for warming.

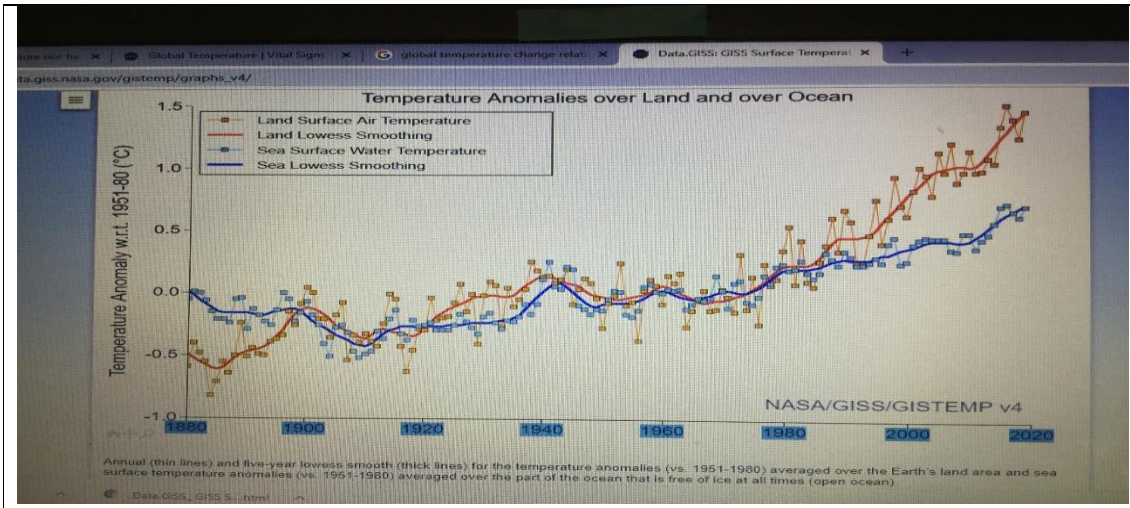
Boxes D2 and D3 give the NASA/GISS version of global temperature change for the surface and the average temperature change in the oceans.

Box D2 - Global Temperature [see following graph Box D4] [5]
The graph below illustrates the change in global surface temperature relative to 1951-1980 average temperatures. Eighteen of the 19 warmest years all have occurred since 2001, with the exception of 1998. The year 2016 ranks as the warmest on record. (Source: NASA/GISS). This research is broadly consistent with similar constructions prepared by the Climatic Research Unit and the National Oceanic and Atmospheric Administration.
The time series below shows the five-year average variation of global surface temperatures. Dark blue indicates areas cooler than average. Dark red indicates areas warmer than average.
Human-induced warming reached approximately 1 degree Celsius (1.8 degrees Fahrenheit) above pre-industrial levels in 2017. At the present rate, global temperatures would reach 1.5 degrees Celsius (2.7 degrees Fahrenheit) around 2040. The green section of the diagram represents the range of uncertainty in how much global temperature would continue to rise before levelling off, assuming that reductions in carbon dioxide emissions were to begin immediately and reach zero by 2055. *[IPCC Global Land-Ocean Temperature Index; NASA's Goddard Institute for Space Studies (GISS).]*

Box D3

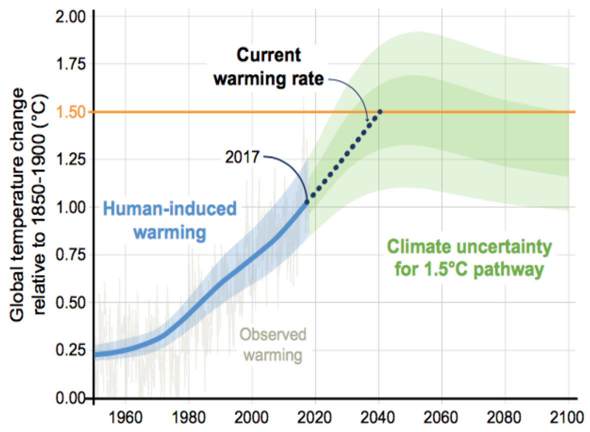
[99] IPCC — Intergovernmental Panel on Climate Change (United Nations).

[100] Temperature readings are taken from sensors all around the globe, in all seasons in both hemispheres and averaged out.



Box D4 is another graph from the IPCC, also showing that, at the present rate, global temperatures would reach 1.5°C around 2040 (could be 2045).

Box D4



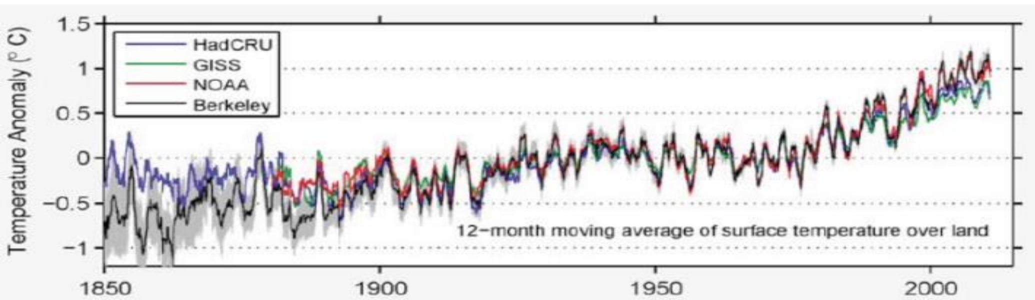
Human-induced warming reached approximately 1 degree Celsius (1.8 degrees Fahrenheit) above pre-industrial levels in 2017. At the present rate, global temperatures would reach 1.5 degrees Celsius (2.7 degrees Fahrenheit) around 2040. The green section of the diagram represents the range of uncertainty in how much global temperature would continue to rise before levelling off, assuming that reductions in carbon dioxide emissions were to begin immediately and reach zero by 2055. [Credit: IPCC]

Note: This diagram has already concluded that the change in temperature is "human-induced", while a likely thing, there is correlation only, not established cause and effect.

The following diagrams in Boxes D5 and E6 are taken from the article '*Taking the Earth's Temperature*'. [6]

Box D5 offers a graph which has used four sources of basic and calculated data.[6] This diagram too shows a Temperature Anomaly (Twi) in 2020 of about 1°C, not surprisingly given the source data.

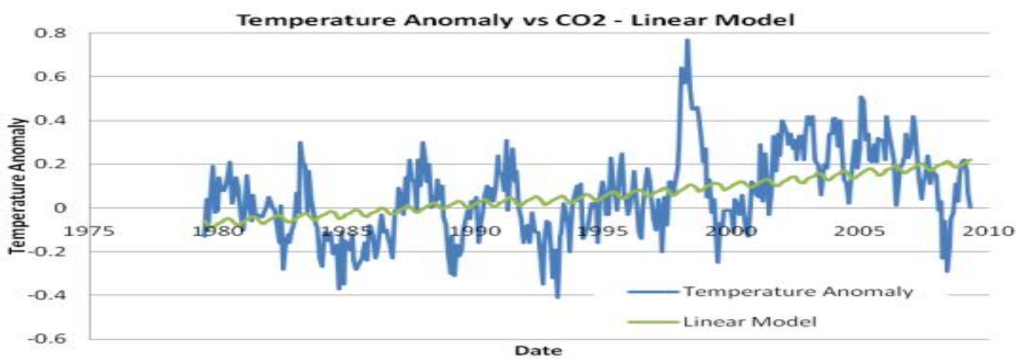
Box D5



"These reconstructions have consistently shown a slow long-term cooling trend changing into relatively rapid warming in the 20th century, with the instrumental temperature record by 2000 exceeding earlier temperatures.[https://www.acs.org/content/acs/en/climatescience/energybalance/earthtemperature.html]

Box D6 gives a temperature graph superimposed on the linear graph for CO_2 concentration. [6] Notice the huge spike in Twi in 1998 and the large negative spike in 2008-09, both ignored in some literature as anomalies in themselves.

Box D6



https://www.acs.org/content/acs/en/climatescience/energybalance/earthtemperature.html

Box D7 is a graph for Twi determined by Mauna Loa (Hawaii), presumably from the Mauna Loa CO2 record, using theoretical climate sensitivity formulae. A paper by Malamud et al [7] discussing Mauna Loa temperature data says that there was a constant trend in Twi of 0.021°C per annum, for the period 1977-2006. This figure actually agrees closely with the NASA/GISS Twi record for the year 2020, at which the increase in Twi (ΔTwi°C) is 0.022% per annum, except that NASA/GISS figure is a slightly <u>increasing rate</u> every year, whereas the Mauna Loa data gives a <u>constant</u> trend in Twi of 0.021°C per annum. See Appendix D1 for further discussion.

Box D7

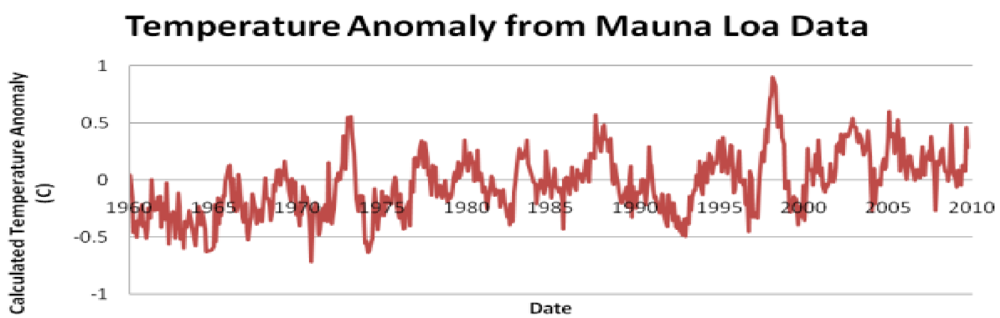


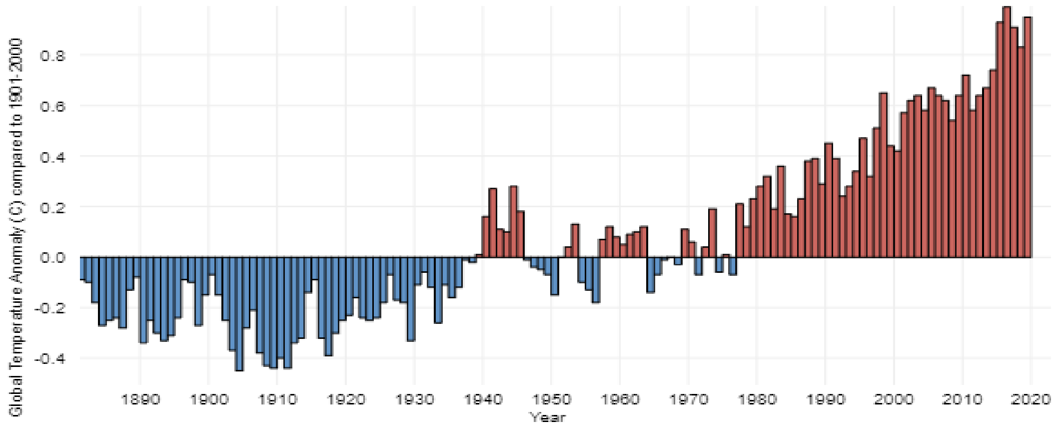
Figure 4: Calculated Temperature Anomaly from MLO CO2 data
https://www.acs.org/content/acs/en/climatescience/energybalance/earthtemperature.html

Box D8 is an interesting histogram [8] showing Twi from 1880 to 2020. However, like most of such graphs presented in the literature, one does not necessarily know the source of data used and interpreted. Readers could note, a correlation with world population growth (and corresponding demand for energy) that has doubled (100%) from 1980 to 2020.
Assuming a baseline for Tw of 15°C, in the same 40 years, Twi (as indicated but not necessarily true) has increased by only 5.3% (0.8/15°C). That is at a rate of 0.02°C per annum, under business-as-usual[101] energy consumption. CO2 increase in 2020 is 2.08ppm, giving a climate sensitivity of 0.0095 Twi°C/CO2ppm. Elsewhere (Table D1-2), a value of 0.00803 is derived for the climate sensitivity ratio.

At 0.02°C per annum, to raise from 1°C to the IPCC safety benchmark of 1.5°C, would take 25 years, to 2045 (similar to the 2040 prediction by NASA and the IPCC).

[101] 'Business-as-usual' means the rate of the present fossil fuel consumption continues.

Box D8



[https://www.climate.gov/news-features/understanding-climate/climate-change-global-temperature]

Without comment, Box D9 shows two early (2009) graphs prepared by Hansen and team. [9]
Note: *The base date is not shown but is presumed by inspection to be around 1960.*

Box D9

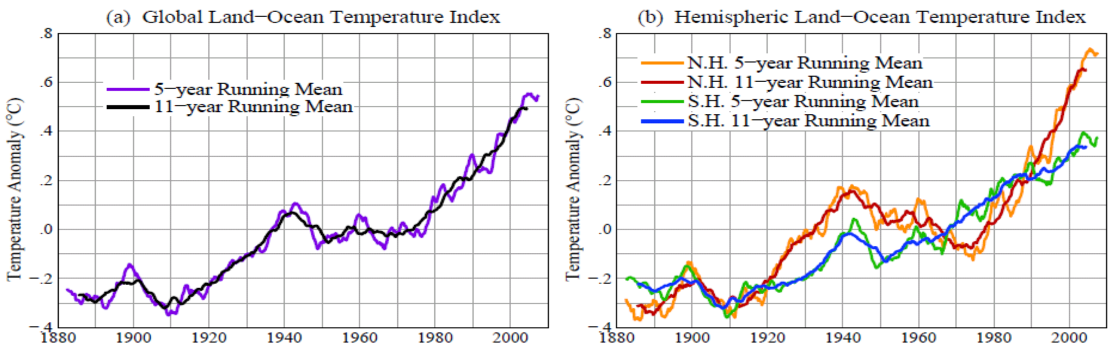
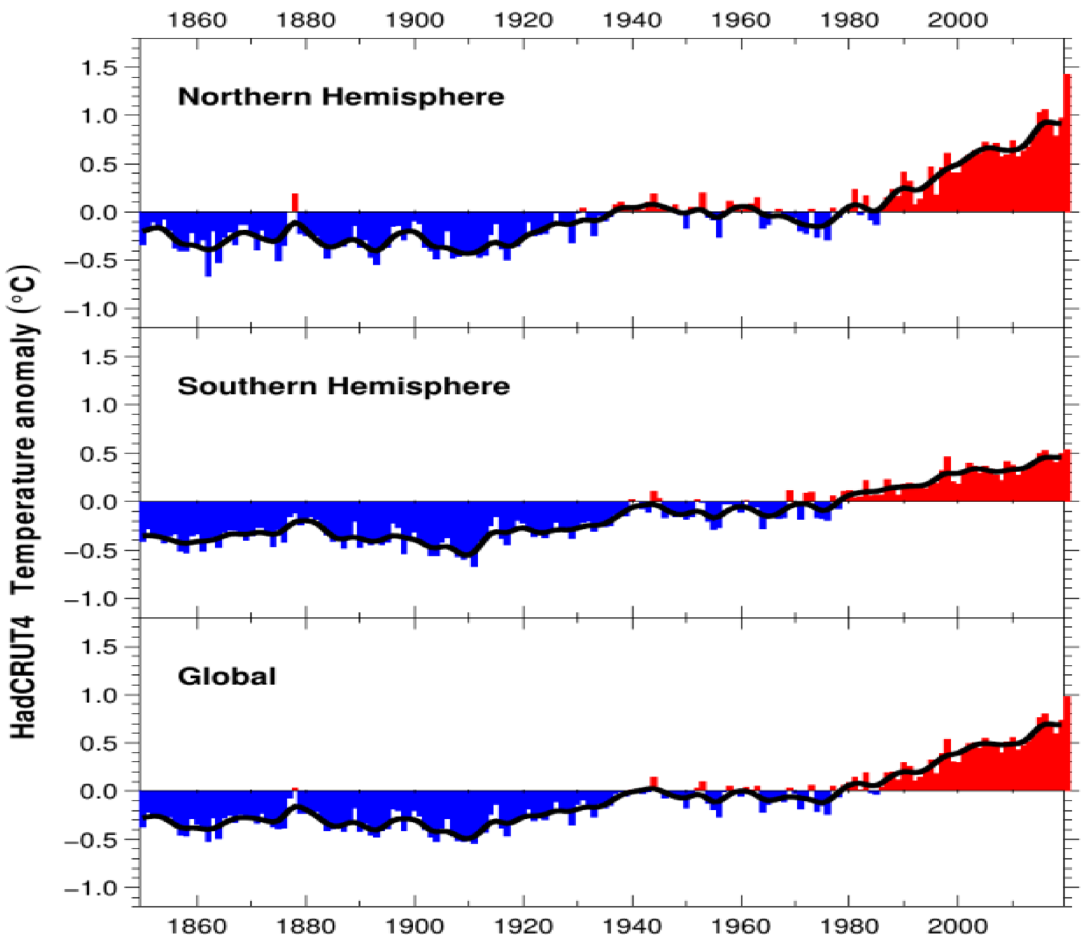


Figure 2. 60-month (5-year) and 132 month (11-year) running mean temperatures in the GISS analysis of (a) global and (b) hemispheric surface temperature change. (Base period is 1951-1980.)
[James Hansen, Reto Ruedy, Makiko Sato, Ken Lo 2009. Http://www.columbia.edu/~jeh1/mailings/2010/20100115_Temperature2009.pdf]

The graphs in Box D10 [10] are also interesting in that they compare the average temperature anomalies (Twi) for the two hemispheres. These are quite different, showing Twi in 2020 in the northern hemisphere at twice that of the southern hemisphere, i.e., 1°C compared to 0.5°C. It also implies that when the IPCC and the UN issue warning temperatures of 1.5 and 2°C, these are **only for** the northern hemisphere.

Box D10



[https://crudata.uea.ac.uk/cru/data/temperature]

Hockey stick graph

The so-called ‘hockey stick’ graph (Box D11) claims to show the temperature anomaly record for the years 1000 to 2000 (based on climate proxy records)[102]. The term "hockey stick graph" was coined to describe the pattern shown by the Mann, Bradley & Hughes, 1999. [11]

This graph was presented by Co-chair of the IPCC Working Group (WG1) at a climate conference in 2005. It has been severely criticised on several grounds by other climate experts, particularly the red-line section purporting to show values from the mid-1980s). Let alone the sharp increase shown, climate scientists promoting the curve have never been able to explain the cooling period shown on the graph from about 1980-1990. Some later attempts at this graph have ignored this period as if it did not happen. Critics say that the red section on the graph has been deliberately constructed with manufactured data to meet the narrative of global warming promoted by climate scientists and other vested interests.

In particular, the work of climatologist Keith Briffa of the Climatic Research Unit, University of East Anglia, Norwich, UK, concerning evidence of the temperature anomaly through history, deduced from study of tree-ring records, was effectively dismissed by the IPCC in favour of the same type of research done by its appointed expert, Michael E. Mann.

So much controversy has arisen about the ‘hockey stick’ that Michael Mann has sued at least one publishing firm and another climatologist, a Dr Ball of Canada, for false criticism of his work. The first of these suits drew an apology; the second was dismissed by a Canadian court.

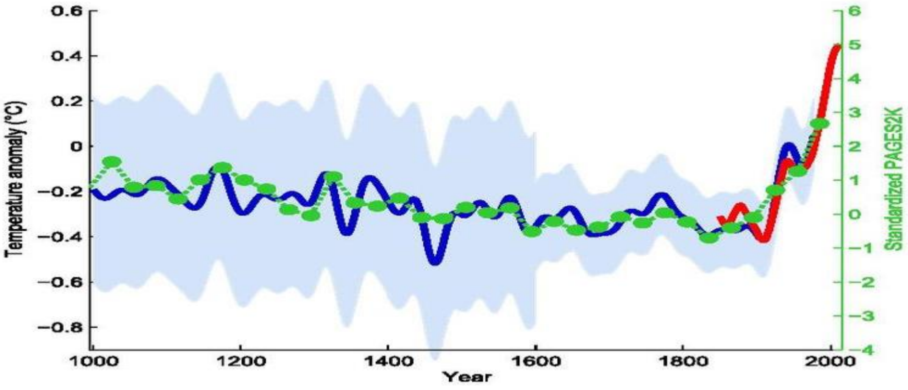
An interview, in which Dr Ball explains why he is a climate change absorbent, may be seen in the Youtube article *“The climate change hoax*”. *[https://www.youtube.com/watch?v=ksMYjzWSlI4]*

[102] Derived from proxies of ice core and tree-ring records.

Note: *In any case, the graph seems to be in error (or way out of date), seeing that the temperature anomaly Twi in 2020 is probably about 1°C, whereas the best the graph can show is 0.05°C in 2000. However, the zero °C reference year is not known. What is meant by the right vertical axis of 'Standardized PAGES2K' is not known.*

Consequently, the validity of the curve and the case for CO2 being the cause of global warming, let alone climate change, is in serious doubt, which is extremely important, given that the real long-term increase in surface temperature is what the whole climate change argument is about.

Box D11 – 'Hockey stick' Graph of Temperature Anomaly



Hockey stick graphs present the global or hemispherical mean temperature record of the past 500 to 2000 years as shown by quantitative climate reconstructions based on climate proxy records. These reconstructions have consistently shown a slow long term cooling trend changing into relatively rapid warming in the 20th century, with the instrumental temperature record by 2000 exceeding earlier temperatures.
The term "hockey stick graph" was popularised by the climatologist Jerry Mahlman, to describe the pattern shown by the Mann, Bradley & Hughes 1999 (MBH99) reconstruction, envisaging a graph that is relatively flat with a downward trend to 1900 as forming an ice hockey stick's "shaft" followed by a sharp, steady increase corresponding to the "blade" portion.[1][2] The reconstructions have featured in Intergovernmental Panel on Climate Change (IPCC) reports as evidence of global warming.
[https://en.wikipedia.org/wiki/Hockey_stick_graph]

Causes of global warming

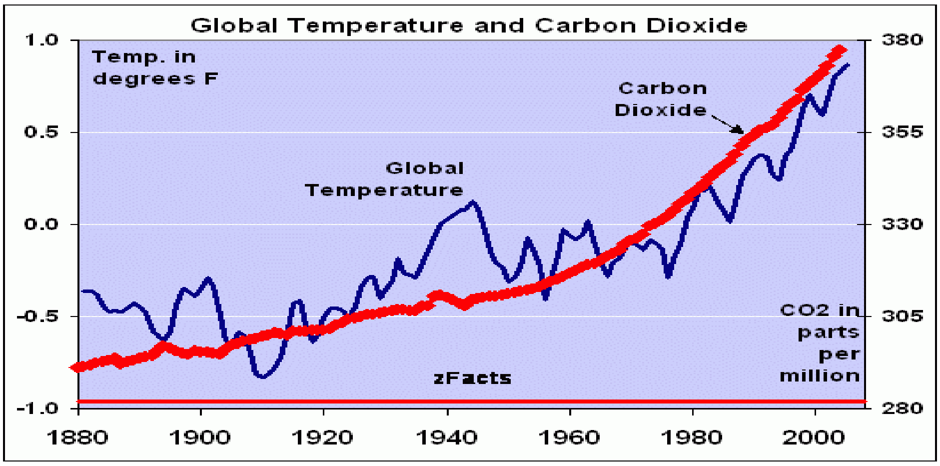
There are essentially four basic causes cited by climatologists for fundamental global warming, namely: a) increasing volumes of CO2 (and other greenhouse gases) emissions produced by burning fossil fuels and absorbed by the atmosphere; b) atmospheric water vapour; c) natural causes; or d) some combination of these.

Of these four, CO2 and natural causes could be sources only of increases in Twi, whereas water vapour is a contributor to both fundamental and feedback warming. See Annex E, *Temperature change- possible causes* for details.

A major point of dissention in the scientific camp is whether the concentration of non-condensable greenhouse gases is leading and controlling the Temperature Anomaly (acting as the Earth's thermostat) or the other way around. Historically, over past millennia, temperature has always led CO2 concentrations by many years (centuries). However, now climatologists like Hansen say that, since the start of the industrial revolution, CO2 levels have increased so much that they now lead and control the temperature. See Appendix D1 for further discussion.

The *wattsupwiththat.com* website, is one of the dissidents and publishes the graph in Box D12 as proof. However, it shows CO2 leading from about 1970, which is what the climatologists are saying. Nevertheless, the contention that CO2 controls the Temperature Anomaly is challenged at Annex E, *Temperature change-possible causes.*

Box D12



https://wattsupwiththat.com/2010/06/09/a-study-the-temperature-rise-has-caused-the-co2-increase-not-the-other-way-around/

Danger points of temperature

Climate change literature, IPCC reports and international protocols state that a temperature change of 1.5°C is the maximum that the world should allow and that a change of 2°C would have serious consequences for the world. In 2020, the change is at 1.05°C.

A change to 1.5°C is said to be controllable but causing significant changes to regional climates in terms of increasing average temperatures and changing precipitation patterns, the latter causing extended droughts in some regions (like Australia) and higher levels of precipitation elsewhere. International protocols are based on 1.5°C as a maximum sustainable temperature.

A change of 2°C and above are said to cause excessive disruption to the world populations as a result of mass starvation and illegal immigration due to famine, increased disease due to warming, especially mosquito-borne diseases, as well as the risk of higher methane and mercury emissions from thawing tundra and perennial burning of drying peat beds.

That said, except for an extended period of drought, more violent (but less frequent) storms like hurricanes/cyclones and tornados, greater flooding in certain regions, literature is still very light on evidence that the world is not in fact in the warming part of a natural Earth cycle. See discussion at Annex I, *Permanent climate change*.

In May 2020, the Australian Government initiated a Bushfire Royal Commission, in respect of the disastrous bushfires of 2019-20. An early witness was Dr Helen Cleugh, Chief Research Scientist at the CSIRO who is reported as saying, among other things, that *"2019 was both the hottest and driest year on record"; "Australia's hottest year on record will be mild by comparison if the country's emissions continue to rise at the current rate"; "Australia's temperature had warmed by 1.5°C over the last 100 years"*. [12] *Canberra Times, 26 May 2010.*

This statement is typical of climatologists pushing the 'party line'. It erroneously implies **that Australia**, in minimising greenhouse gas emissions, could influence Australia's climate let alone world emissions that pose the threat. Australia's emissions are only 1.05% of the world total in 2020 and cannot affect global warming or climate change one iota.

Tipping Point

The IPCC AR5 report [13] defines a tipping point (in global temperature increase) as an irreversible change in the climate system. However, the literature is largely silent on a global temperature when the tipping point could be reached.

Box D13 - Tipping Point
The IPCC AR5 report defines a tipping point (in global temperature increase) as an irreversible change in the climate system. It states that the precise levels of climate change sufficient to trigger a tipping point remain uncertain, but that the risk associated with crossing multiple tipping points increases with rising temperature.
[en.wikipedia.org › wiki › Tipping_points_in_the_climate_system]

A tipping point in the climate system is a threshold that, when exceeded, can lead to large changes in the state of the system. Potential tipping points have been identified in the physical climate system, in impacted ecosystems, and sometimes in both. For instance, feedback from the global carbon cycle is a driver for the transition between glacial and interglacial periods, with orbital forcing providing the initial trigger. Earth's geologic temperature record includes many more examples of geologically rapid transitions between different climate states.
[https://en.wikipedia.org/wiki/Tipping_points_in_the_climate_system]

The IPCC is warning that 2°C should be the allowed maximum. Given acceptance of the ‘precautionary principle’ by the IPCC, a possible tipping point could be about 3°C, a temperature that could be reached early in the next century, at current rates of increase in CO2 ppm.

A tipping point should not be considered as a particular temperature, but as a range above a temperature where conditions on Earth become progressively and irreversibly worse for humanity. The IPCC says that that is above 2°C and would be well on the way if 3°C is ever allowed to be reached.

One may see the progressive ‘Key impacts from temperature rise’, of up to 6°C from the following diagram [14] produced from https://c2sm.ethz.ch/ (Figure D1). In particular, many detrimental effects, e.g., coral bleaching, are claimed to be already apparent.

Note: Box D14 and Figure D1 and others like it, essentially assume that the world population continues to grow at its present exponential rate and keep producing greenhouse gases in proportion. World population growth is said by some experts [15] to peak at 11, maybe 12 billion over the next 80 years or so. That is 50% more than now that the planet has to sustain.

Warning: Box D14 and Figure D1 should be considered as suspect promotion by climate change promoters.

World population has increased from 4 to 8 billion over the past 40 years from 1980 to 2020. During that period, given validity of the NASA temperature record, the surface temperature increase Twi has gone from 0.441 to 1.05. At the same rate, a population of 11 or 12 billion would add another 0.56°C to a level of 1.61°C, well within the range of 1.5 to 2°C set by the IPCC and UN. Therefore, if world population peaks at about 11 or 12 billion, there should not be excessive global warming or detrimental climate change.

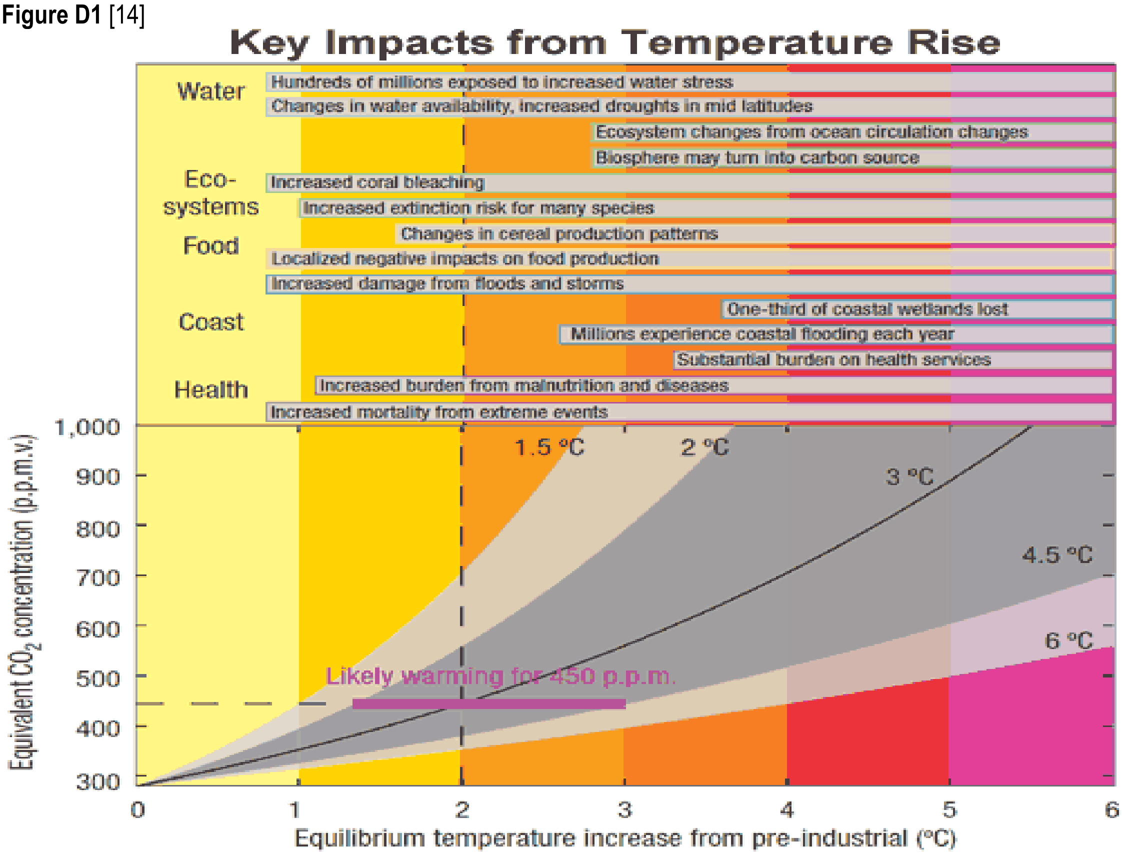
However, this does not mean that a population of 11-12 billion would not be a catastrophe in itself, given the demand for and increased competition, even war over limited resources of the planet. See discussion at Annex G, *World population growth and consequences* and Annex F, *Demand for energy and greenhouse emissions*, as to how energy consumption and generation of greenhouse gases may increase with changing population - not necessarily as at present.

Box D14

Figure E1: Relation between atmospheric CO2 concentration and key impacts associated with equilibrium global temperature increase. The most likely warming is indicated for climate sensitivity 3°C (black solid). The likely range (dark grey) is for the climate sensitivity range 2 to 4.5°C. Selected key impacts (some delayed) for several sectors and different temperatures are indicated in the top part of the figure [Knutti and Hegerl 2008, https://c2sm.ethz.ch]

If we manage to stabilize CO2 levels at 450 ppm (the atmospheric CO2 concentration as of 2010 is about 390 ppm), according to the best estimate, we have a probability of less than 50% of meeting the 2°C target. The key impacts associated with 2°C warming can be seen at the top of Figure 6. The tight constraint on the lower limit of climate sensitivity indicates we're looking down the barrel of significant warming in future decades.
There are many positive and negative feedbacks to global temperatures and the carbon cycle that have been identified. The IPCC reports that feedbacks to increased temperatures are net positive for the remainder of this century, with the impact of cloud cover the largest uncertainty. IPCC carbon cycle models show higher ocean uptake of carbon corresponding to higher concentration pathways, but land carbon uptake is uncertain due to the combined effect of climate change and land use changes.

Figure D1 [14]



Possible key impacts from Temperature Rise

Runaway

Although the impacts of reaching a 'tipping point' are serious enough, having reached it does not mean the total disaster of a 'runaway' climate. The world is a long way off that occurring, if ever. See Box D15.

Box 15 [13]
The runaway greenhouse effect is used in astronomical circles to refer to a greenhouse effect that is so extreme that oceans boil away and render a planet uninhabitable, an irreversible climate state that happened on Venus. The IPCC Fifth Assessment Report states that "a 'runaway greenhouse effect' —analogous to Venus— appears to have virtually no chance of being induced by anthropogenic activities." Venus-like conditions on the Earth require a large long-term forcing that is unlikely to occur until the sun brightens by a few tens of percent, which will take a few billion years.

Several references reporting on computer simulations of cloud activity as a function of CO2 concentration seem to agree that a concentration of 1200 ppm would cause total break-up of the cloud cover and cause runaway of the climate, leading to a 'Venus syndrome'. [3, Chapter 10]. Assuming a climate sensitivity of 3°C for doubling CO2 concentration, Figure E1 would seem to indicate that a level of 1200 ppm could cause about 6°C of global warming.

One reference ['*Earth may be 140 years away from reaching carbon levels not seen in 56 million years*' [16] states that, given evidence from a Southern Ocean sediment core, that the earth had suffered a warming event about 56 million years ago, when massive quantities of carbon dioxide were released into Earth's atmosphere, rapidly spiking global temperatures by 5 to 8 degrees Celsius, without causing a 'runaway' of the climate. Neither this nor other references reviewed contained any evidence or even speculate on how the Earth had obviously recovered from that catastrophic event. In geological terms, it was not long after the meteor crash that wiped out the dinosaurs around 65 million years ago.

Appendix: D1 - Temperature Anomaly - CO2 Relationship

Australian Logistics Study Centre
Canberra, 24 July 2020

APPENDIX D1

TEMPERATURE ANOMALY - CO2 RELATIONSHIP

Assumption: *In Tables D1-1 through D1-3, the temperature anomaly figures taken from graphs published by authorities (NASA And IPCC) are assumed to be valid and will continue their trend, noting, however, that the validity of various temperature anomaly records have been seriously questioned.*

Caution: *Most of the research into global warming and recording of temperature anomalies has concerned the northern hemisphere. Consequently, the figures cited herein for temperature anomaly Twi are considered applicable only to the northern hemisphere. Twi for the southern hemisphere is on about half that for the north.*

Derivation from recorded Temperature anomalies (Twi)

The purpose of Table D1-1 is to derive the most appropriate value for climate sensitivity to plug into the Table D1-2, to extrapolate changes in Temperature anomaly (Twi). The 40-year period from 1980 to 2020 is considered the most relevant, it being that during which the world population, energy consumption and CO2 released initially into the atmosphere can be shown to have doubled. Thus, a value for climate sensitivity of 0.00816°C/CO2 ppm is established using the NASA/GISS Twi record and the Mauna Loa CO2 ppm record.

If only the Mauna Loa data for both CO2 ppm and Twi are used, a value of 0.01 is derived for climate sensitivity. See Table D1-3 for how this value alters the predicted dates to reach the limits of 1.5°C and 2°C.

Table D1-1

Climate sensitivity [NASA/GISS data]							
Year	CO2 ppm [1]	ΔT °C [2]	Δ [1]	1984-2009 [3]	2009-2010 [4]	1980-2020 [5]	Notes
1980	337	0.440	**ΔT °C**	0.33	0.25	0.62	
1984	**343**	0.480	**Δ ppm**	45	25	76	
1997	364	0.628	**ΔT/Δ ppm**	0.00738	0.00992	**0.00816**	[6]
2009	**388**	0.812					[7]
2020	**413**	1.060					
Notes:							
1	CO2 ppm	from Mauna Loa CO2 ppm record					
2000-2020	ΔT °C	NASA/GISS From Table D1-2					
3	1984-2009	Hansen period 0.33 °C change in 25 years					
4	2009-2010	Since Hansen period					
5	1980-2020	40 years of doubled world population and energy consumption					
6	**0.00816**	ΔT °C/Δ ppm	Used in Table D1-2, as most appropriate figure				
7	**This table in fact combines Mauna Loa CO2 ppm and NASA Twi records**						

Derivation from both CO2 ppm and Twi records

In Table D1-2 (Column 9), the values for Twi (Δ°C) of 0.44 in 1980 and 1.06°C in 2020, are taken from the graph in Box D4. 1.06°C is used in the extrapolation of values of Twi from 2020 through to 2139.

Note: *Data points for observed Twi have been adjusted between the start and finish point for 1980 to 2020, to obtain a smooth, upwards curve and better determination of the exponential index to use for extrapolation.*

The purpose of Table D1-2 is to show estimates of climate sensitivity for the future period of 2020 to 2150, given an estimate of 0.5157% per annum for the rate of change in CO2 ppm, over the period, i.e., a change of 2.125 ppm per annum[103]. This figure of 0.5157% for Δ% ppm per annum is the escalation index derived from the world population and CO2 emissions data for years 2020 to 2100.

It shows that the critical Temperature anomalies, assuming current CO2 emission rates of 1.5, 2 and 3°C would be reached by 2046, 2074 and 2131 respectively.

[103] Elsewhere in this paper, a figure of 2.08 ppm is derived for annual increase in CO2 ppm concentration.

Assumption: *The figures determined in Tables D1-1 to D1-3, for the period after 2020, assume 'business as usual' as far as consumption of fossil fuels is concerned.*

Caution: *Although there is a strong correlation by year between CO_2 ppm and the published average change in world temperature (with respect of 1880-1950 baseline), as scientists and academics know, a correlation does NOT mean also a cause-and-effect relationship between these variables.*

Table D1-2

Growth - CO_2 and Temperature Anomaly Twi — Amended 2Jan21

Year	CO_2 [1] [1A] ppm [1]	CO_2 Δ %ppm pa	Period (5Y)	Period Change %ppm	Period Ave pa (5Y) %ppm	T Change/ CO_2 ppm change: Change Δ ppm	Change Δ °C	Cum Δ°C	Notes
1975	330								
1980	337	**0.424%**	1980-2020	22.55%	0.56%	7.0	0.057	0.44	[2] [3] [4]
1985	343	0.356%				6.0	0.049	0.49	
1990	353	0.583%	1990-2020	17.00%	0.57%	10.0	0.082	0.57	
1995	360	0.397%				7.0	0.057	0.63	
2000	369	**0.500%**	2000-2020	11.92%	0.60%	9.0	0.073	0.70	
2005	377	0.434%				8.0	0.065	0.77	
2010	390	**0.690%**	2010-2020	5.90%	0.59%	13.0	0.106	0.87	
2015	400	0.513%	2015-2020	3.25%	0.65%	10.0	0.082	0.95	
2020	*413*	**0.650%**				13.0	0.106	1.06	
2025	423.63	.@ Δ%ppmpa)				10.63	0.087	1.15	
2030	434.25	"				10.63	0.087	1.23	
2035	444.88	"				10.63	0.087	1.32	
2040	455.50	"				10.63	0.087	1.41	
2045	466.13	"	**2046**	**1.5 °C**		10.63	0.087	1.49	[5]
2050	476.75	"				10.63	0.087	1.58	
2055	487.38	"				10.63	0.087	1.67	
2060	498.00	"				10.63	0.087	1.75	
2065	508.63	"				10.63	0.087	1.84	
2070	519.25	"				10.63	0.087	1.93	
2075	529.88	"	**2074**	**2 °C**		10.63	0.087	2.01	[6]
2080	540.50	"				10.63	0.087	2.10	
2085	551.13	"				10.63	0.087	2.19	
2090	561.75	"	Double pre-industrial level of 280			10.63	0.087	2.27	**[7]**
2091	572.38	"				10.63	0.087	2.36	
2100	583.00	"				10.63	0.087	**2.45**	
2105	593.63	"				10.63	0.087	2.53	
2110	604.25	"				10.63	0.087	2.62	
2115	614.88	"				10.63	0.087	2.71	
2120	625.50	"				10.63	0.087	2.79	
2125	636.13	"				10.63	0.087	2.88	
2130	646.75	"	**2131**	**3 °C**		10.63	0.087	2.97	[8]
2135	657.38	"				10.63	0.087	3.05	
2140	668.00	"				10.63	0.087	3.14	
2145	678.63	"				10.63	0.087	3.23	
2150	689.25	"				10.63	0.087	3.31	
Δ%ppm(5y)	2.573%	[10]							
Δ%ppm(1y)	0.5145%	[11]	2.125 Δppm (2020) [12]				ΔT/Δ ppm	0.00816	[9]

Notes:

No.	Note
1	CO_2ppm data Years 1980-2015 https://www.esrl.noaa.gov/gmd/ [Muana Loa data]
1A	CO_2ppm data Years 2025-2150 based on 1980-2020 data.
2	ppm change 1980-2020 = 1.9 ppm per annum average but at increasing rate of assumed 2.125.
3	Population and energy usage both up 100% 1980-2020
4	CO_2ppm up by 22.55% (not 100%) 1980-2020 due to small percentge in atmosphere
5	Year to reach 1.5 °C 2046
6	Year to reach 2 °C 2074
7	Twi = 560 (2 x 280, pre-ind level) in 2095; Twi is 2.28 °C (in range predicted by Garney of 3+-1.5 °C)
8	Year to reach 3 °C 2131
9	0.00816 ΔT/Δ ppm = Average climate sensitivity. From Table D1-1 Temperature record.
10	Δ%ppm(5y) = 2.570% per 5 yrs; escalation index derived from known CO_2ppm from 1975 t0 2020
11	Δ%ppm(1y) = 0.515% per annum; escalation index derived from known CO_2ppm from 1975 t0 2020.
12	Δppm (2020-2150) is assumed 2.125 ppm per annum, based on 1980-2020 average of 1.9 ppm per annum.

Date projections for four cases

Table D1-3 compares the estimates for four cases. Case 1 is based only on the NASA Twi record. Case 2 is based only on the Mauna Loa CO2 record. Case 3 uses a combination of both the NASA Twi and Mauna Loa CO2 data. Case 4 uses the world CO2 emissions data.

There is close concurrence in the results between Cases 3 and 4, given the different data sources - Case 3 based on an observed CO2 ppm and temperature records and Case 4 derived on reported emissions data. Cases 1 and 2 are only some 5 years earlier, but may be considered the same within an error band.

In respect of Case 3, Box D7 has a graph for Twi calculated from Mauna Loa CO2 data, presumably using theoretical climate sensitivity formulae. A paper discussing Mauna Loa temperature data [7] says that there was a constant trend in Twi of 0.021°C per annum, for the period 1977-2006. This figure actually agrees closely with the NASA/GISS Twi record for the year 2020, at which the increase in Twi (ΔTwi°C) is 0.022°C per annum ((1.06 - 0.95)/5.

Assuming that the Mauna Loa temperature record is valid, the limit of 1.5°C would be reached in 21 years ((1.5-1.05)/0.021), i.e., in 2041, and the 2°C limit in 45 years, i.e., in 2065 (as indeed shown in Table D1-3).

Table D1-3

Year projections for Twi = 1.5 °C, 2 °C and 3 °C							
Case		ppm	ΔT/Δ ppm	Year reached			
No	Description	2020	[5]	1.5 °C	2 °C	3 °C	Notes
1	NASA Twi only	413.00		2040	2063	2107	[1]
2	Mauna Loa CO2 data only	413.00		2041	2065	2112	[2]
3	NASA Twi & Mauna Loa CO2	413.00	0.0100	2046	2074	2131	[3]
4	World emissions data (2020)	415.40	0.0100	2049	2081	2147	[4]
Notes:							
1. Unlikely due to contested record		based on 0.22 °C per annum					
2. Possible but unlikely		based on 0.21 °C per annum					
3. Very probable							
4. Most probable		Using current (2020) world CO2 emission data.					
5. ΔT/Δ ppm = 0.01 from Mauna Loa Twi data							

For further discussion, see Annex M, *Carbon dioxide (CO2)* and Annex E, *Temperature change-possible causes.*

Effect of increasing world population

The previous cases assume ‘business-as-usual, as far as fossil fuel consumption is concerned. But the consequences of CO2 emissions affect the future under increased world population, changing energy consumption per capita by countries and policies adopted by each country and the world as a whole to contain increased CO2 levels.

According to UN Probabilistic Population Projections, August 2019 [17], world population will grow from 7,794,799 in 2020 to 10,875,394 in 2100 (Table D1-6), comprising the respective population of over 200 individual countries. Each of these is consuming fossil fuel generated energy and, in the process, producing CO2 emissions. Table D1-4 lists the 2020 emissions data per capita for selected countries. *

Australia has a relatively high per capita rate of 16.8 tonnes per annum, but nationally comprises only about 1.06%[104] of the world’s emissions. Several countries (see Note 8 of table) have been included in Table D1-4 because of their potential for growth in CO2 emissions over the next 80 years - referred to here as ‘sleepers’- either because of their potential for increased energy consumption, e.g., India, or for their huge population growth, e.g., Nigeria.

[104] Depending on source data, estimates for this figure can vary from 1.03% to 1.12%.

Table D1-4

CO2 emissions per capita (Epc)			
Sample Countries	EPc TCO2 pa	Rank	Notes
Max	64.90		
Average	5.16	of 223	[1]
Median	2.60	countries	
Min	0.10	listed	
Australia	16.80	14	[2] [2A]
Canada	16.10	16	[2]
United States	16.10	17	[2]
Japan	9.40	32	[2]
Norway	9.40	33	[2]
Germany	9.10	36	[2]
China	8.00	44	[3]
New Zealand	7.70	50	[4]
United Kingdom	5.60	69	[5]
France	5.00	75	[6]
Sweden	4.50	84	[7]
Egypt	2.70	113	[8]
Brazil	2.40	116	[8]
Indonesia	2.10	120	[8]
India	1.90	136	[8]
Pakistan	1.00	156	[8]
Nigeria	0.60	172	[8]
Notes:			
1. Unlikely to be reached by all countries			
2. Needs to come down			
2A. Australia: only 1.17 % of world CO2 emissions			
3. Should not increase but will			
4. OK			
5. On average: 25% nuclear power			
6. On average: 70% nuclear power			
7. High % renewales and nuclear			
8. Sleepers - high population growth			
9. *en.wikipedia.org/... by countries CO2 emissions*			

Table D1-5 gives details of <u>one</u> possible world policy for recognition of inevitable growth by third-world countries and deliberate reduction in rates for developed countries.

For the developing countries (Emissions in tonnes of CO2 per capita (Epc) of 0-6), escalation factors assume what respective economies could be expected to achieve through to 2100. For developed countries (Epc of 10 plus) would be expected to decrease emissions by at least 13% from current levels.

By way of general comment, China has an Epc of 8 Tonnes per annum, up from a base of about 2 in just 40 years, i.e., at a rate of 3.5% per annum, which is very fast but consistent with China's growth in GDP[105] for the same period of 6-8% per annum.

India, with a population of 1.4 billion people and capacity for considerable economic growth is the big sleeper. It could achieve perhaps 1.5% per annum over the 80 years (x 3.3), but its rate has been set at a conservative 2.5 times its current rate.

Note: *The policy given in this table is <u>only one of many</u> possible policies. It is illustrative only but indicative of the potential problem for temperature increase and global warming*.

[105] Gross Domestic Product

Table D1-5

CO2 Emmissions-per capita (Epc)					
Targets - 2020-2100					
Range in 2021		80	Years	Policy	
Epc	[1]	Growth pa		[2]	
From	To	Ratio	%	Times	Notes
0	2	1.0138	1.383%	3	[3]
2	4	1.0115	1.152%	2.5	[3]
4	6	1.0051	0.508%	1.5	[3]
6	8	1.0000	0.000%	1	[3]
8	10	1.0000	0.000%	1	[3]
10	12	-1.008702	-0.870%	0.67	[4]
12	14	-1.008702	-0.870%	0.71	[4]
14	16	-1.008702	-0.870%	0.75	[4]
16	18	-1.008702	-0.870%	0.78	[4]
18	20	-1.008702	-0.870%	0.80	[4]
20	100	-1.0563033	-5.630%	0.90	[4]
Notes:					
1. *en.wikipedia.org/... by countries CO2 emissions*					
2. Only one of many possible policies.					
3. Assumes what economies of countries could achieve.					
4. Assumes what countries could decrease to in 80 Yrs					
General Comments					
1. Average Emissions per capita(Epc) (2020) is 5.117					
2. China has achieved an Epc of 8 in 40 years					
3. Assumption: China's Epc in 1980 was 2.0					
4. China's rate of development has been (2 t0 8 in 40 years)					
ie, 3.5% pa (very fast).					
5. Other developing nations could not achieve the same rate.					
6. India big sleeper. Could achieve perhaps 1.5% pa					
in 80 yrs (x 3.3), but set at 2.5.					

Table D1-6 shows the growth in world CO2 emissions from 2020 to 2100, based on population projections and the set policy for growth by individual countries.

If countries maintained their current rates, world emissions would increase from the current 36,705,000 to about 37,726,000 billion tonnes per annum.

If countries met the set policy rates, world emissions could increase to about 52,622,000 billion tonnes per annum. This represents a growth in world emissions of about 0.041% per annum. While this is a small percentage, it would not be sustainable in respect of changes in the Temperature anomaly (Twi).

If all countries decreased or increased rates to the current per capita average of 5.6 tonnes per annum, world emissions could increase to about 56,168,632 billion tonnes per annum. This is not seen as feasible.

This aspect is treated further in Annex J, *What can and is being done.*

Table D1-6

CO2 emissions - Growth			
Parameter	2020	2100	Notes
	Billions	Billions	
Population-world	7.795	10.875	[1]
CO2 Emissions World	Billions Tonnes pa		
At current rate by country	36.705	37.726	[2] [3]
At policy reduction rate		52.622	[4]
All achieving average emissions		56.169	[5]
Notes:			
1. Source: UN Probabilistic Population Projections - Aug19			
2. 2020 world CO2 emissions			
3. 2100 world CO2 emissions - at current emissions per capita.			
4. 2100 world CO2 emissions - at Policy reduction targets.			
0.041% growth pa - Not much but unsustainable			
5. 2100 world CO2 emissions - at average emissions per capita.			

In respect of Australia, to put things into perspective, Table D1-7 shows how Australia contributes a miniscule 1.12%[106] of global CO2 emissions and, while a relatively high emitter per capita (with good reason, due mainly to its geography), is still only 14th in the world.

Table D1-7

CO2 Emissions - World/Australia comparison					
	2020				
Parameter	**World**	**Australia**	**%**	**Rank**	**Notes**
Population [millions]	7,795	25.0	0.32%		[1]
CO2 Emissions [billions tonnes pa]	36.705	0.413	1.12%		[2] [3]
CO2 Emissions per capita [tonnes pa]	5.43	16.50	3.04	14th	[4] [5]
Notes:					
1. Australia's population could double by 2100					
2. Australia's emissions are negligible on a world scale.					
3. 1.12% is maximum, based on high emissions of coal. Overall the figure is more like 1.06%					
3. High but due mainly to Australia's relative transport costs.					
4. High per capita but still only 14 highest in world					
en.wikipedia.org/... by countries CO2 emissions					

Net zero emissions by 2050

The IPCC Glossary [19] defines Net zero emissions as *"Conditions in which any remaining anthropogenic carbon dioxide (CO2) emissions are balanced globally by anthropogenic CO2 removals. Net-zero CO2 emissions are also referred to as carbon neutrality."*

Many countries (and Australian states) have signed-up and made a commitment under the United Nations' Kyoto Protocol and Paris Agreement to achieving Net zero emissions by 2050 (only 30 years away). But is such a target really feasible or just an objective? How do these countries – rich or poor - plan to get there and pay for it without damaging their economies? Some countries, e.g., the United Kingdom (UK), have even legislated its commitment.

This subject is addressed in Annex J, *What can and is being done*.

Summary and conclusions

Table D1-8 below consolidates the data in other tables of this appendix to show the most probable impact of four cases of world emissions growth on when the critical Temperature anomalies of 1.5, 2 and 3°C could be reached.

Case 1 - assumes one growth policy (defined herein and at Table D1-5), set for each country, that could be met. However, given world population trends, increased emissions would be worse than for the current Cases 2 and 3 - not sustainable, i.e., action to curtail emissions is needed.

Case 2 - derived from actual and predicted CO2 emissions data - assumes that current emission rates will continue through to 2100 - not sustainable.

Case 3 - the basic case based on NASA/Mauna Loa data - assumes that current emission rates will continue through to 2100 - not sustainable**.**

Case 4 - assumes one possible reduction policy for all countries of an average of at least 1% per annum over the next 30 years and beyond. Note that this is <u>only one of many</u> possible reduction policies, or 'paths' as often referred to in the literature[107]. Its effect can be seen to be only marginally better for Temperature anomaly of 1.5 and 2°C but, importantly, indicates that a Temperature anomaly of 3°C may be avoided, i.e., ever reached. This policy would be consistent with eliminating fossil-fuelled generation of electricity which, in most developed countries, currently produces some 25% to 35% of all CO2 emissions.

[106] 1.12% is maximum, based on high emissions of coal. Some references put the figure as low as 1.03%. Overall a figure of 1.06% is used in this paper as the most probable value of percentage of world emissions by Australia.

[107] This paper has not evaluated the various 'paths' enunciated in the literature but they are generally demanding a much more severe reduction in emissions than 1% per annum.

Under the Kyoto Protocol and Paris Agreement, Australia is committed to reducing its emissions by 26 to 28 per cent from 2005 levels by 2030, i.e., about 1% per annum. An Australian Department of Energy Emissions Report, as reported in *The Australian*, 29 May 2020. [18], says that Greenhouse gas emissions fell 0.9 per cent last year to 532.5 million tonnes, i.e., about 1% per annum.

Under 'business as usual' regimes, the worst-case scenario is that a Twi of 1.5°C would be reached by about 2045; 2°C by 2073; and 3°C by 2125.

Under a Case 4 regime, a Twi of 1.5°C would be reached by about 2051; 2°C by 2087; and 3°C never.

In all probability, the world could cope well enough with a Twi of 2°C and even up to 3°C although with some difficulty. Beyond 3°C permanent climate change could be expected.

These point estimates would have error bands on either side, but most likely on the outward side because, while the estimates assume 'business-as-usual' consumption rates of fossil fuels, there are reports that such consumption and the CO2 produced therefrom is starting to decline. If so, the projected dates would be delayed.

Notwithstanding these conclusions, none of the earlier dates is far away - less than 70 years - and indicate that the world needs to continue to reduce emissions from consumption of fossil fuels by at least a world average 1% per annum for at least 30 years. However, given that this is a world average (by nations), the industrialised nations, including China, would have to reduce emissions by more than 1% per annum to compensate for developing countries that can be expected to increase emissions. Australia will have to do better too.

Table D1-8

Twi predictions for reduced and increaseed emissions

Case	TCO2 pa Change	x 10^9 TCO2 pa	ppm	% Δ ppm	Year to reach Twi 1.5 °C	2 °C	3 °C	Notes
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	
1	1.1	36.9	417.65	0.5416%	2045	2073	2125	[8] [8A]
2	1.03	36.7	415.40	0.5172%	2049	2081	2147	]9]
3	1	36.5	413	0.5157%	2046	2074	2131	
4	0.7	25.7	[10]	-1.0000%	2051	2087	never	[11]

Notes:
1. Reduced/increased level from 100% (Year zero)
2. Billions of tonnes of CO2 released by fossil fuels pa.
3. CO2ppm.
4. %Change in CO2ppm.
5. Year to reach Twi= 1.5 °C.
6. Year to reach Twi= 2.0 °C.
7. Year to reach Twi= 3.0 °C.
8. If countries consume fossil energy at a probable increased per capita rate.
8A. Expected increase is from 36.7 in 2020 to 52.6 Billion Tonnes in 2100.
9. If countries continue to consume fossil energy at 2020 per capita rate.
10. CO2ppm reducing 4.15ppm pa over 30 years (max).
11. Assumes CO2 emissions reduced by 1% pa over 30 years (max).

General Comments:
Very difficult to decrease use of fossil fuels and therefore future is bleak.
30% reduction is feasible given electricity generation consume about 30%.
Future may need a hydrogen power generated by renewable sources.

Australian Logistics Study Centre
Canberra, 24 July 2020

ANNEX E TO
A view on permanent climate change

TEMPERATURE CHANGE – POSSIBLE CAUSES

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About this Annex

This Annex poses and provides answers to the fundamental question of why a change in the average World surface temperature (Twi) and the incremental Temperature anomaly (Twi), may be increasing at an unacceptable rate, if indeed proven to be the case.

Introduction

Global warming is said by climatologists to be driven primarily as a function of the concentrations and radiation absorbing properties of the greenhouse gases (GHG) in the atmosphere, where global warming means an increase in the average surface temperature of the Earth. Any consequent climate change would be how prevailing weather patterns for regions and seasons respond to the stimulus of any increase in surface temperature.

Although there are several greenhouse gases, the most important ones are water vapour (H2O) (condensable), active in the troposphere up to12 km altitude; the non-condensable gases - carbon dioxide (CO2), methane (CH4) and sulphur dioxide (SO2), which are active up through the troposphere and stratosphere; and ozone (O3) active in the stratosphere. The mesosphere and above layers (55 km to outer space) are not of any significant consequence to global warming except, perhaps, for the negative effects of cirrus clouds.

While methane and sulphur dioxide, which are strong infra-red radiation absorbents, contribute significantly as greenhouse gases, their relative effect is small because of their very low concentrations and relatively low half-lives.

There has been and still is controversy as to what is the predominant force on the Temperature anomaly (Twi) and global warming, CO2 or water vapour, aerosols and clouds. This Annex deals only with the relative effects of these agents.

Note: *To minimise repetition of terminology in the following discussion, CO2, as the most important, may be used herein as a proxy for all non-condensable greenhouse gases and refers also to its concentration in parts per million (ppm) in the atmosphere.*

A few Basic facts (in 2020)

Atmosphere

The atmosphere is the body of gases surrounding Earth and, because it has mass, is held in place by gravity. It is divided technically into five main layers (bottom to top): the troposphere, stratosphere, mesosphere, thermosphere and exosphere. Density thins out asymptotically up through the layers until the gases dissipate in space.

While all layers have properties that affect the Earth in some way, it is what happens in the troposphere that matters most where life on Earth is concerned.

[108] Reference 1 was followed by "Physics of the atmosphere and climate", M.L. Salby, Cambridge University press, 2012 [available on Amazon], which is believed to be an updated version of Reference 1 and is assumed to have the same emission values as used in this Annex, although they could have been updated for atmospheric changes in the following six years between publication.

The atmosphere, but primarily the troposphere, is comprised of dry air, water vapour and clouds. Dry air comprises 78% nitrogen, 21% oxygen and other gases including 0.04% carbon dioxide; water vapor content is 0.1% to 0.4%. Components of the troposphere are essentially uniform by parts per million (ppm) but decreasing in density as a function of temperature with altitude and latitude.

The troposphere occupies the atmosphere to an average altitude of about 12 km but varying from 18 km in the tropics to 6 km in the polar regions in winter.

At 12 km, air density has reduced to about 25% of the normal sea-level pressure of 1013 millibars, i.e., contains 75% of all gases in the atmosphere. Within the troposphere, temperature decreases with altitude on an average of 6.5°C per kilometre[109], from an average of 15°C at sea-level to about -57°C at 12 km. As will be read herein and Appendix E1, the mid-troposphere at 6-8km is important as a basis of calculations concerning absorption of infra-red radiation (IRR).

The troposphere is essential to all life on the planet, in many distinct and related ways, through the oxygen we and other animals breathe, through carbon dioxide for vegetation, the warmth it provides and the distribution of precipitation around the planet according to regional climate and the seasons. Protection from harmful solar radiation is provided by the upper layers of the atmosphere.

The troposphere is very complex in composition and dynamic behaviour, being the principal part of the Earth's Energy System and, while obeying the laws of physics, it is essentially chaotic in nature, i.e., unpredictable in detail although predictable in general patterns. All weather of any consequence takes place within the troposphere and its behaviour is manifested by regional climates, prevailing weather patterns and the daily weather.

On the natural downside, the weather is not always benign and can cause catastrophic damage from time to time, with floods, droughts, strong, unsettled weather fronts, hurricanes/cyclones/ typhoons (around several regions) and tornados (mostly un the USA). Climatologists say and promoters believe that global warming will exacerbate bad weather events.

On the induced downside, industrialisation and rapid growth in world population over the past 160 years or so has been progressively polluting the atmosphere with additional greenhouse gases, particulate matter and aerosols which threaten the natural behaviour of the atmosphere and are potentially detrimental to life, mostly caused by the burning of fossil fuels to meet a soaring demand for energy. See Annex F, *Demand for energy and emissions*, Annex G, *World population growth and consequences* and Annex L, *Energy*.

The source of water vapour is from evaporation of terrestrial waters, virtually all from the oceans, which contain 97% of all water on the planet[110]. Given that temperature of the troposphere decreases with altitude and latitude and that saturation water vapour pressure decreases strongly as temperature drops, the amount of water vapour that can exist in the atmosphere decreases strongly with altitude. Virtually all water vapour is normally contained within the lower 3 km, above which it condenses and forms clouds. With a few exceptions (cirrus clouds), all cloud types are confined to the troposphere with some types reaching heights to the top of the troposphere.

CO2

CO2 may be described by the following facts:

- **Concentration in atmosphere**: 0.0413% (413 parts per million)[111] in 2020 and increasing by about 0.505%, i.e., 2.08 ppm per annum.
- **CO2 and life**: CO2 is essential to all animal life and for growth of vegetation. While the atmosphere currently contains about 413ppm of CO2, humans often tolerate levels of 2,000 or more indoors. However, excessive levels that minimise the level of oxygen available, can be fatal.

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[109] Referred to technically as the temperature lapse rate.

[110] Ice-caps contain 2% of global water (fresh) while rivers, lakes and dams account for only 1% (fresh) to sustain 8 billion people.

[111] Note that ppm means parts per million of what are defined as 'moles' comprising the air and NOT of molecules of air, although moles may be a function of the number of molecules.

- **Half-life of molecules in atmosphere**[112]: 30 years, i.e., concentration reduces by 50% in 40 years.
- **Production**: CO2 released into the atmosphere is increasing at a rate of 2.86 kg for every tonne of coal[113] burnt and some 10% less for oil and 20% less for natural gas, per unit of energy produced.
- **Percentage absorbed by atmosphere**: About 46% of CO2 generated by fossil fuels and natural release from the oceans, land and animals, is said to be retained by the atmosphere, the remainder being absorbed by the oceans and vegetation.
- **Presence in altitude**: CO2 occurs through all levels of the atmosphere, reducing proportionately with altitude. Some 75% is contained within the troposphere.
- **Effective (optical) density**: If the density of the atmosphere were assumed the same at all altitudes, the average density of the air and CO2 through all levels (to 40 km) would be about 21.5%. This is an important value, given that CO2 absorbed at sea-level diffuses up and absorbs and re-emits infra-red radiation through all layers of the atmosphere.
- **Condensation**: CO2 and other greenhouse gases, except water vapour, are non-condensable and concentrations remain in the atmosphere at reducing levels, according to life-expectancy.
- **Absorption of IRR**: CO2 absorbs effectively in the range 13-15-18 μm[114] frequency band of infra-red radiation, through all layers of the atmosphere. [1, p101]

Water vapour

Water vapour may be described by the following facts:

- **Concentration in atmosphere**: 0.1% to 0.42% (assumed average 0.20%), i.e., 1,000 to 4,000 ppm and average of 2,000 ppm (up to 10 times that of CO2).
- **Water and life**: It really goes without saying that water, along with air (oxygen) and food, is absolutely fundamental to all life on Earth.
- **Half-life of molecules in atmosphere**: Days to weeks only.
- **Production**: water vapour is produced by the evaporation of terrestrial waters (virtually all from the oceans), as a function of the surface and ocean temperatures. The capacity of the atmosphere to carry water vapour has always been and is still limited by the physics of water vapour pressure and atmospheric temperature with altitude.
- **Presence in altitude**: 99% of water vapour is contained within the troposphere (below 12 km).
- **Effective (optical) density**: If the density of the troposphere were assumed the same at all altitudes, the average density of water vapour through all levels (to 17 km) would be about 0.093. This is an important value, to be compared with 0.21 for CO2 (see Table E1-4).
- **Condensation**: Above altitudes where temperature reaches a dew-point (varies from zero upwards but most below 12 km), water vapour, condenses into water droplets, leading to formation of clouds and precipitation. The formation of the many types of clouds, their respective behaviours and effects on global warming have been for decades and are still posing major uncertainty as to the real causes of global warming and climate change. Clouds normally cover about 50% of the Earth at any one time, obviously varying by region, latitude, season and even time of day.
- **Absorption of IRR**: Water vapour is a major absorbent of infra-red radiation over a large part of the very broad IRR spectrum, in two main bands: 6-8 μm and 17-25 μm (partially overlapping CO2) [1]. H2O absorbs about 1,000 times more infra-red radiation (per

[112] Half-life here means the time it takes for new molecules of a gas in the atmosphere to reduce its concentration by 50 per cent, given that the concentration/time curve is negatively exponential.

[113] Of a certain grade/quality.

[114] μm means micrometre (1 millionth of a metre).

volume of air) than CO_2. However, climatologists say that the relatively long lifespan of CO_2 and its presence at higher altitudes than water vapour outweigh the effect of water vapour (yet to be proven, see later discussion).

World Surface Temperature

The Average world surface temperature (Tw) is said to be increasing at an accelerating rate since the start of the industrial revolution and especially over the past 40 years with a doubling of both world population and demand for energy, some 95% provided by fossil fuels. See Box E1 for one version (there are others - discussed fully in Annex D, *Temperature change - fact or fiction?*).

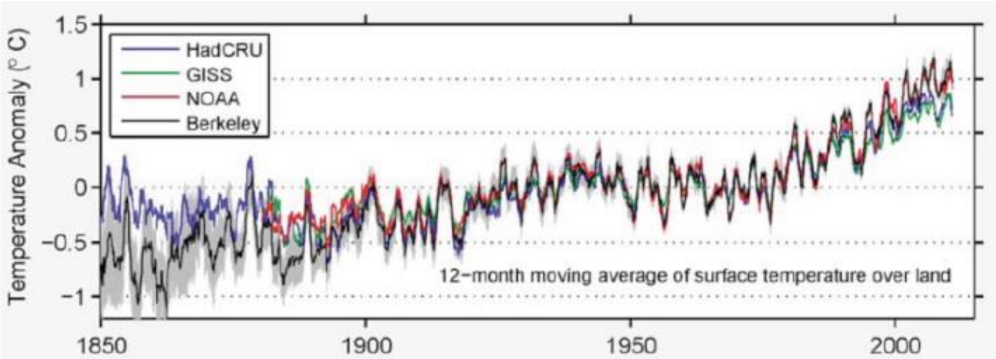
The change in average surface temperature, is also referred to as the 'Global land-Ocean Temperature Index' and 'Temperature anomaly' (Twi), depending on reference. The latter term is generally used in this paper and Annexes.

General scientific agreement says that the Temperature anomaly (Twi) in 2020 stands at about 1.05°C, i.e., above average pre-industrial temperatures. However, some eminent climatologists have questioned the accuracy and validity of this graph, as often depicted in the literature, like the chart in Box E1, and claim a lesser change [2].

Note: *It should be clearly understood that the literature is talking about* *averages* *of surface temperature and temperature change, around the globe, but predominantly in the industrial countries of the northern hemisphere. Actual temperature and variations thereto can vary substantially by region, season and hemisphere, especially in higher latitudes. Some references record temperature changes in Canada as much as 2°C and in the Arctic as much as 5°C above the average, mainly by movement of warm air from the tropics. Average Temperature anomalies in the northern hemisphere can be twice that of the southern hemisphere*.

Any higher average temperature changes at higher latitudes could be important due to the potential melting effect on ice-caps, sheet-ice and sea-ice, although such melting would be primarily a function of slowly-increasing ocean temperatures rather than by the temperature of short-term prevailing air masses.

Box E1



"These reconstructions have consistently shown a slow long-term cooling trend changing into relatively rapid warming in the 20th century, with the instrumental temperature record by 2000 exceeding earlier temperatures."

https://www.acs.org/content/acs/en/climatescience/energybalance/earthtemperature.html

Causes of global warming

The Theory

Climatologists claim the following, in theory:

- Only CO_2 (as well as other non-condensable greenhouse gases) acts as a 'thermostat' to determine the Earth's surface temperature (Tw) and increase thereof (Twi).
- Atmospheric water vapour increases with surface temperature, through increased evaporation of terrestrial waters.
- Water vapour and clouds do not determine the Earth's surface temperature but are functions of the surface temperature and 'feedback' phenomena controlled by the CO_2 concentration.

- Water vapour absorbs a great deal of infra-red radiation, so heating and warming the atmosphere, but seen only as a positive feedback to global warming rather than a cause of surface temperature change.

Assumptions underlying the scientific case for global warming

Of necessity, several simplifying assumptions are made by climatologists in their case for CO2 as the villain:

- The world surface temperature and changes thereto (Tw and Twi) are averages from thousands of sensors from around the world and from satellites and are presumed accurate measures of global warming. **Not Proven**. This assumption is subject to heavy criticism by some climatologists. See Annex D *Temperature change - fact or fiction*? and Annex H, *Promoters and critics*.

- Clouds play <u>no significant part</u> in global warming. **Not Proven**. Even the primary literature upon which the UN promotes global warming and climate change acknowledges that the science of clouds and their effect is still very poorly understood and, according to the Charney Report, *"It must thus be emphasised that the modelling of clouds is one of the weakest links in the general circulation modelling efforts*". [3, p10][115]

- There is a direct cause-and-effect relationship between CO2 (and other non-condensable greenhouse gases) and global warming. **Not Proven.**

Tenets

In complementing the several assumptions, the scientific case rests upon certain tenets:

- The Earth's energy budget must be in equilibrium, i.e., the warming power of all incoming <u>un-reflected</u> short-wave solar radiation (in watts per square metre W/m^2) must equal the power of long-wave IRR up through the atmosphere into space[116]. (See discussion at Appendix E1)
- All bodies of matter absorb and re-emit radiation energy according to their emissivity properties.
- CO2 is a strong absorbent of IR in three narrow bands of wavelengths - 2.7, 4.3 and 15 µm. This means that most of the heat producing radiation escapes being 'trapped' by CO2, up through the atmosphere to space.
- Water vapour is a much stronger absorbent of IRR than CO2, at several wavelengths of the IRR spectrum, mostly on either side of the CO2 bands but the two overlapping around the 18µm wavelength.

> **Note**: *The infra-red spectrum is quite large, extending from the nominal red edge of the visible spectrum at 0.70 µm to 1,000 µm. This range of wavelengths corresponds to a frequency range of approximately 430 THz down to 300 GHz. Water vapour is an active absorbent of IRR across much of the spectrum.*

Questions

Several important questions have been posed by climate science critics and the public alike, in respect of the CO2 concentration being only 0.04%; the claim of CO2 as the Earth's 'thermostat'; cause-and-effect; and the real causes of temperature change and global warming.

CO2 concentration is only 0.04%

Given that CO2 concentration is only 0.04% (1/40,000) of the atmosphere, how can it be such a strong infra-red radiation absorbent and the primary cause of global warming? This is an important question that climatologists have failed to justify, in the opinion of this author.

This author has conducted a small experiment to test, by analogy, the possible absorbing power of CO2. See Box E2.

Caution: *The experiment described in Box E2 shows the effect of absorbing red visible light, whereas the argument about CO2 is about absorbing infra-red radiation. It is an analogy only.*

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[115] Admittedly, the science has advanced some way since the Charney report.

[116] Except for solar radiation immediately reflected, all energy returned to space is in the form if IRR, given that conduction and convection cannot occur in the outer edges of the atmosphere where there is no physical matter.

Box E2 – An experiment [*Original work*]

To simulate the current concentration of CO2 in the atmosphere (0.04%), four (4) millilitres (0.04%) of dark red beetroot juice[117] was mixed with one litre of water (1,000,000 mm^3). This mixture significantly changed the colour. A test paper in red letters from 14 to 48 size units was placed underneath. The letters, while dimmer, could be read easily.

To simulate the effect of the thickness of the atmosphere (decreased emissivity), averaging a density of 21% of that at sea-level and thus a measure of the average concentration of CO2 in the atmosphere, 85 ml (0.85%) of beetroot juice was mixed with a litre of water. Even at this apparently small concentration, none of the red letters was visible, having been completely absorbed by the reddened water.

This simple experiment was able to demonstrate the absorption power of even a quite small concentration of suspended coloured particles (think soot and other particles, if not CO2).

Thus, the claim by climatologists that even the small concentration of CO2 is a powerful absorbent of infra-red radiation and responsible for absorption of a significant percentage of the 390 W/m^2 of infra-red radiation from the Earth could be viable.

Notwithstanding this little experiment, "*Despite its small concentration in the atmosphere, CO2 is responsible for nearly a quarter of the total greenhouse trapping of radiation in the current atmosphere under clear-sky conditions."* [1, p102]. This implies that water vapour, as the other major absorbent of IRR, has a much greater trapping capability than CO2, which it does.

It should be noted that heat transfer throughout the troposphere is mainly by convection but with all heat eventually transferred to space (about 240 W/m^2) being in the form of infra-red radiation, there being, at the top of the atmosphere, virtually no physical matter to transfer kinetic energy. Greenhouse gases (excluding water vapour) are the only vehicles at that altitude able to emit radiation to space.

CO2 as Earth's thermostat?

What is the validity of the claim that only CO2 (with some help from other non-condensable greenhouse gases) comprises a 'thermostat' that determines the Earth's surface temperature (Tw) and the Temperature anomaly (Twi), and that water vapour does not?

Climatologists claim such by arguing that:

- "… if there had been no increase in the amounts of non-condensable greenhouse gases (like carbon dioxide), the amount of water vapour in the atmosphere would not have changed with all other variables remaining the same. …" (Box E3);
- "…this is because the temperature of the surrounding atmosphere limits the maximum amount of water vapour the atmosphere can contain. ..." (Box E3);
- this would be the case if CO2 levels were stable, as they were for thousands of years before the industrial revolution[118].

This author sees these arguments as unconvincing. While the statements cited can be considered accurate in themselves, they are hardly any argument that CO2 is the only determinant and controller of TW and Twi. Experimental proof is needed. See later discussion under 'Fundamental global warming'.

Box E3

It's true that water vapour is the largest contributor to the Earth's greenhouse effect. On average, it probably accounts for about 60% of the warming effect. However, water vapour does not control the Earth's temperature, but is instead controlled by the temperature. This is because the temperature of the surrounding atmosphere limits the maximum amount of water vapour the atmosphere can contain. If a volume of air contains its maximum amount of water vapour and the temperature is decreased, some of the water vapour will condense to form liquid water. This is why clouds form as warm air containing water vapour rises and cools at higher altitudes where the water condenses to the tiny droplets that make up clouds.
https://www.acs.org/content/acs/en/climatescience/climatesciencenarratives/its-water-vapor-not-the-co2.html

... water vapour is the largest contributor to the Earth's greenhouse effect. However, water vapour does not control the Earth's temperature, but is instead controlled by the temperature. If there had been no increase in the amounts

[117] Red wine would have had the same effect as a medium.

[118] Note that in past ice ages, CO2 levels have always lagged temperature changes - down and up – except now, scientists say that CO2 forcing has overwhelmed the natural forcing of the current global warming period (Holocene is the current geological epoch - 11,650 years before present).

of non-condensable greenhouse gases (like carbon dioxide), the amount of water vapour in the atmosphere would not have changed with all other variables remaining the same. The addition of the non-condensable gases causes the temperature to increase and this leads to an increase in water vapour that further increases the temperature. This is an example of a positive feedback effect. The warming due to increasing non-condensable gases causes more water vapour to enter the atmosphere, which adds to the effect of the non-condensables.
https://www.forbes.com/sites/marshallshepherd/2016/06/20/water-vapor-vs-carbon-dioxide-which-wins-in-climate-warming

Cause and effect

Is there a direct cause-and-effect relationship between CO2 concentration and change in global surface temperature or is there a correlation only?

While a consensus[119] among scientists (97% no less[120]) is that Tw and Twi are functions of non-condensable greenhouse gas concentrations, whatever relationship they claim exists is purely a correlation, i.e., there has not been a direct cause and effect relationship established.[121] Therefore, greenhouse gas concentrations could just as well be a function of Tw, which science has been shown to be the case in every past ice-age the Earth has experienced [4, Fig 3, p37].

Note: *Although it may exist somewhere in the literature, this author has not found a reference that addresses specifically this aspect. There is a presumption by climatologists that there is a direct cause-and-effect relationship, i.e., Twi = f(CO2ppm). Some scientists make the point, given that they are talking about the whole planet, that it is not possible to conduct experiments to prove the relationship.*

Causes of global warming

First, a distinction needs to be made between the causes of global warming and any resultant climate change. This annex concerns only what may be causing global warming. Climate change itself, as a probable consequence, is discussed at Annex I, *Permanent climate change*.

While, as may be seen from discussion in Annex D, *Temperature change - fact or fiction?*, there would appear to be general agreement that temperatures are increasing gradually, and presuming the questionable validity of the published surface temperature records, especially that they are increasing, the fundamental question of the global warming debate is what is causing it. Is it only the non-condensable greenhouse gases like CO2, as claimed by climatologists, water vapour and clouds, or natural causes? There is still considerable argument on this issue.

A distinction needs to be made between fundamental causes of global warming, i.e., increase in the Temperature anomaly (Twi), being due to all greenhouse gases, including water vapour, and the secondary effects of what is referred to in the literature as 'positive/negative feedback'. Both contribute to global warming as such.

In this vein, when discussing the respective trapping (absorption) capability of greenhouse gases, some literature also makes a distinction between 'clear sky' calculations and otherwise. Cloud cover of the Earth is said to average about 50% of the time. Of course, cloud cover varies greatly by region, season and latitude and, even to this day, climatologists have not fully explained the role and impact of clouds on global warming.

Fundamental causes

Fundamental causes are those that control changes to the Temperature anomaly (Twi).

There are essentially four basic arguments made by climatologists for what could be causing fundamental global warming, namely: a) increasing volumes of CO2 (and other greenhouse gases) emissions produced by burning fossil fuels and absorbed by the atmosphere; b) atmospheric water vapour; c) natural causes; or d) some combination of these.

[119] "Consensus is not science", Dr Ball, Canada.

[120] This statement is very misleading and its use in literature and the Media is unethical, given that the sampled group is not defined and is believed to be relatively small. Also, the opinion of so many scientists are of no more value than that of laymen. Only the basic climate researchers know what may be happening.

[121] There are claims that some laboratory simulation has been undertaken to establish a cause-and-effect relationship between ppm and Tw.

Of these four, CO_2 and natural causes could be sources only of increases in Twi, whereas water vapour is a contributor to both fundamental and feedback warming.

Climatologists, the IPCC, the UN and believers blame the increase on CO_2 only, dismiss the possibility of natural causes as being too small and relegate the effect of water vapour and clouds on global warming as only a 'positive feedback'. As may be seen from the discussion at Appendix E1, the argument for CO_2 is not considered valid, given the far greater effect of water vapour. Zhong and Haigh [1, p102] say *"…despite having a concentration of less than 0.04%, CO_2 is responsible for nearly a quarter of the total greenhouse trapping of radiation in the current atmosphere under clear-sky conditions."* This implies that water vapour, as the other major absorbent of IRR, has a much greater trapping capability than CO_2, which in fact it does.

Zhong and Haigh [1, p102] also say that *"…at the extremes of the wavelength range, indicating greenhouse trapping by H_2O."* and *"…the impact of the individual gases* [H_2O and CO_2] *on downward radiation incident at the surface. This component is dominated by H_2O due to the very strong emission of radiation by the near-surface atmosphere through the H_2O continuum …".*

Appendix E1 addresses the fundamental causes from the perspective of the Earth's energy (radiation) balance, at mid-troposphere (7-8 km altitude), deliberately chosen for being above most cloud activity and their ability to absorb and reflect radiation.

The sensitivity of the Earth's climate to increases in atmospheric CO_2 concentration is a question that sits at the heart of climate science. Given dismissal of natural causes, the basic argument by climatologists goes something like that which follows.

Climatologists claim that only CO_2 acts as the Earth's 'thermostat' and controls surface temperatures around the globe. The presence of water vapour (and clouds) in the atmosphere is a function only of surface (ocean) temperatures and so constitutes a positive 'feedback' to the surface temperature and global warming. Note however, that water vapour is a more powerful absorbent of the broad infra-red radiation spectrum than CO_2, with at least 10 times the atmospheric concentration (0.4% compared to 0.04% for CO_2). See also Annex C, *Radiation and concept of forcing.*

One proof to their case, offered by climatologists, is that if burning fossil fuels stopped tomorrow and the atmospheric and ocean temperatures were to stabilise - as they were in pre-industrial times[122]- evaporation from the oceans and subsequent cloud formation would stabilise also; i.e., not increase, and not be able to cause global warming. While this may seem a logical argument, it discounts completely the extremely important effects on climate and weather of the ocean currents, particularly the fundamental effects of El Nino/La Nina (ENSO)[123] and the Indian Ocean Dipole (IOD). In fact, Hansen [4 p4] dismisses the ENSO (and by implication the IOD) as 'one big slow sloshing on the Earth' of no long-term effect on global warming. This is disputed by other climatologists like Professor R. S. Lindzen (Annex H, *Promoters and critics*) and Lamb. [5]

Another argument used by climatologists, prevalent in the literature, is that the life of water vapour molecules is only a matter of hours or days before it condenses into clouds and precipitates, implying that the greenhouse effect of water vapour is transient and of no consequence. However, this argument ignores the fact that water vapour is being renewed by evaporation all of the time.

It is the presence (density) of IRR absorbing molecules in the air that contribute to the greenhouse effect and not how long an individual water (or other) molecule might exist in the atmosphere.

Although decreasing therein, CO_2 exists and is presumed to be well-mixed at all altitudes of the atmosphere with some 75% being within the troposphere. In contrast, most water vapour exists only up to where the reduced temperature causes condensation into clouds. Note that there are generally three main types of clouds: high-level clouds (5-13 km) - cirrocumulus, cirrus, and cirrostratus; mid-level clouds (2-7 km) - altocumulus, altostratus, and nimbostratus; and low-level clouds (0-2 km) - stratus, cumulus, cumulonimbus, and stratocumulus. Nevertheless, the average concentration of water vapour (0.4%) at more than ten times that of CO_2, and its greater IRR absorption, outweigh the effect of CO_2.

[122] A somewhat debatable point in itself.

[123] El Niño–Southern Oscillation (ENSO)

Another claim by climatologists for the dominance of CO_2 is that it lasts for many years in the atmosphere and so keeps on absorbing IRR. In the case of CO_2 itself, it is said for a small percentage to last up to 1,000 years or more, but the concentration of any CO_2 added to the atmosphere decreases exponentially due to absorption by the oceans and chemical reactions, with a half-life of about 30 years. [6]

It is not as if the molecules of CO_2 absorb IRR and 'store' it for the rest of their lives. All capable molecules, including water vapour, continuously absorb and emit IRR. They do not take 'stored' energy with them when precipitated, absorbed by the oceans/land or chemically transformed. Again, it is the number of IRR absorbing molecules in the air that contribute to the greenhouse effect, and not how long an individual CO_2 molecule might exist in the atmosphere.

There is little doubt that CO_2 atmospheric concentration is steadily increasing (as recorded by Mauna Loa, see Annex M, *Carbon dioxide (CO_2)*, Figure M1), the major cause (but not the only one) being the burning of fossil fuels. Concentration has increased from 280ppm in pre-industrial times to 413ppm in 2020, an increase of 133ppm in some say 150 years, i.e., an average of 0.9ppm per annum. However, from 1975 to 2020, CO_2 concentration has increased from 330ppm to 413ppm, and increasing at 1.84 ppm per annum. The curve is not far off being linear, in 2020 swinging upward slightly at a rate of 0.0505% (2.08ppm) per annum, under the 'business-as-usual' scenario.[124]

Note: *There is a presumption here that the greenhouse gases are causing all of the temperature anomaly increase, which has yet to be proven.*

While the Mauna Loa Observatory record of CO_2ppm is not in doubt, it is, after all, applicable to only one point on the planet and at 3,000 metres altitude. Therefore, there has to be an assumption by climatologists that this record applies all over the planet. This is similar to the argument that the average Temperature anomaly (Twi) of 1.05% in 2020, is the same all over the planet, which is far from the truth. See Annex D, *Temperature change - fact or fiction?*

From the foregoing and discussion at Appendix E1, the argument by climatologists that CO_2 is the 'thermostat' of Earth and thus the only controller of the Temperature anomaly (Twi) cannot be sustained. At best, it is a major contributor but is actually outweighed by the effect of water vapour. The argument by climatologists may be reasonable and logical, but substantiation by proven experimentation appears yet to occur.

New Heat

New heat is defined here as that produced from burning fossil fuels or from uranium by conversion of chemical energy into thermal energy. It is used to generate electricity and to power transport and industry. Whatever the temporary forms of energy, e.g., electricity, kinetic, etc., all energy generated is eventually dissipated as thermal energy (heat) and IRR that is absorbed by the oceans, land and atmosphere.[125]

Note that the so-called 'renewable' energies, particularly wind and solar, do not generate new heat. Instead, they extract energy from the Earth's natural energy system and convert it into electricity which, after doing useful work, returns it to the Earth system as thermal energy (heat).

See Annex L, *Energy* for detailed discussion.

Much of the new heat is generated in power houses (some 33%) and is released initially into the atmosphere with flue gases, but also directly into water resources through heat exchangers. New heat generated by transport and industry is also eventually dissipated into the oceans, land and atmosphere.

World-wide, the burning of fossil fuels generates billions of BThu[126] per annum. While initially new heat may cause temporary temperature increases locally, it is presumed to eventually dissipate uniformly within the atmosphere and oceans. Despite the massive new heat generated and given the surface area of the Earth, it can be shown that the power emitted per square metre is quite

[124] 'Business-as-usual' means continued world energy consumption patterns and sources of energy, given current emission reduction regimes currently in place.

[125] First law of thermodynamics, "Energy is neither created nor destroyed, it simply takes one form or another".

[126] British Thermal Unit [Imperial system of measurement]

small compared to the 390 W/m^2 said to be emitted by the Earth naturally and is ignored as far as its effect on global warming is concerned.

Natural warming

Natural warming of the Earth is due mostly to its dynamic relationship with the sun and that due to its internal, molten components.

In respect of its natural relationship with the sun being a fundamental cause of global warming, arguments by climatologists against this are quite weak when analysed in some detail. While it can be accepted that the effects of periodic 'wobbling' of the Earth and solar radiation (sunspot) cycles are minimal and of little consequence, the fact that the Earth is now in another warm-age cannot be discounted.

It can be shown from geological records that the Earth has been in a warm-age for hundreds of years, with temperatures still rising. Some, if not all, climatologists acknowledge this but now claim that the effect of the non-condensable greenhouse gases has overwhelmed natural causes, starting with the industrial revolution and particularly in the past 40-50 years with the doubling of world population and fossil fuel use, and are causing accelerated warming.

The question of whether greenhouse gas levels determine temperature change or vice-versa is a fundamental question. Geological evidence of temp leading greenhouse gas levels cannot be denied, especially given the severe criticism of the Temperature anomaly (Twi) claimed records presented by some climatologists. The current warm-age could well be the dominant cause of any global warming.

In respect of heat coming from the internal molten and hot solid components of the Earth, by both conduction and IRR, often referred to as comprising the 'sensible' heat going into the atmosphere, its power can be shown to be in the order of only 0.03% of Earth's total energy budget at the surface [7], given the surface area of the Earth, and can be ignored as far as global warming is concerned.

Feedback warming and cooling

Water vapour concentration increases through evaporation from the oceans, being a function of many factors, not the least of which being ocean temperatures - varying considerably over the vast expanses of the oceans due to the effects of currents and winds. Evaporation actually extracts energy from the ocean in the form of latent heat, but the effect on ocean temperatures is negligible given their vastness. Evaporation does two main things. While its increased concentration causes increased absorption of IRR and re-emittance downwards, so warming the surface, condensation of a percentage of the total mass of water vapour into clouds returns that latent heat to the atmosphere so heating it. Clouds themselves, depending on type and time of day, may cause positive or negative feedback; the science on their net effect is still unclear but is accepted by climatologists as 'positive feedback'.

Overall warming

The truth is that all these causes would be contributing to global warming, but which one is predominant, given proof that Twi is in fact increasing and at what rate?

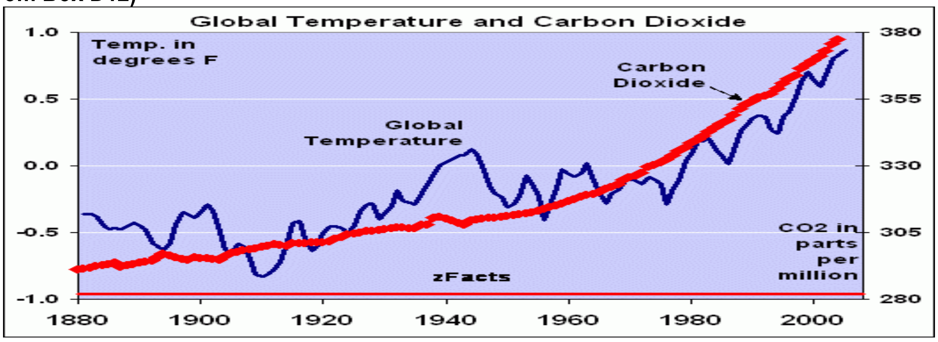
Fundamental global warming is caused by natural earthly phenomena as well as by greenhouse gases, including water vapour. However, respective contributions are very difficult to determine, given the preponderance of literature that promotes greenhouse gases as the only cause.

Leading or lagging - the Temperature Anomaly - CO2 Relationship

A major point of dissention in the scientific camp is whether the concentration of non-condensable greenhouse gases is leading and controlling the Temperature Anomaly (acting as the Earth's thermostat) or the other way around. Historically, over past millennia, temperature has always led CO2 concentrations by many years (centuries). However, now climatologists like Hansen say that, since the start of the industrial revolution, CO2 levels have increased so much that they now lead and control the temperature.

The *wattsupwiththat.com* website, is one of the dissidents and publishes the graph in Box E4 (from Box D12) as proof. However, it shows CO2 leading from about 1970, which is what the climatologists are saying. Nevertheless, the contention that CO2 controls the Temperature Anomaly is as challenged in this Annex.

Box E4 (from Box D12)



https://wattsupwiththat.com/2010/06/09/a-study-the-temperature-rise-has-caused-the-co2-increase-not-the-other-way-around/

Conclusion

In a discussion on the causes of global warming, i.e., an increase in the Temperature anomaly (Twi), a distinction needs to be made between fundamental causes, being due to all greenhouse gases, including water vapour, and the secondary effects of what is referred to in the literature as 'positive/negative feedback'. Both contribute to global warming as such.

There are essentially four basic arguments made by climatologists for what could be causing fundamental global warming, namely: a) increasing volumes of CO2 (and other non-condensable greenhouse gas) emissions produced by burning fossil fuels that are absorbed and retained by the atmosphere; b) atmospheric water vapour and clouds; c) natural causes; or d) some combination of the foregoing four.

Of these four, CO2 (and other non-condensable greenhouse gas), and natural causes could be sources only of increases in Twi, whereas water vapour and clouds are contributors to both fundamental and feedback warming.

Climatologists, the IPCC, the UN and other promoters blame the greenhouse gases (excluding water vapour) and dismiss the possibility of natural causes. However, given the very strong effect of water vapour and clouds, the argument by climatologists that non-condensable greenhouse gases, particularly CO2, comprise the 'thermostat' of the Earth and thus are the only controllers of the Temperature anomaly (Twi), cannot be sustained without conclusive, experimental proof[127].

The basic argument by climatologists goes something like this. Only the non-condensable greenhouse gases act as a 'thermostat' and thus control surface temperatures around the globe. The presence of water vapour (and clouds) in the atmosphere is a function of surface (ocean) temperatures and so constitutes only a positive 'feedback' to the surface temperature and global warming. Note however, that water vapour is a much more powerful absorbent of infra-red radiation than CO2, with at some 10 times the atmospheric concentration (0.4% compared to 0.04% for CO2).

Climatologists offer a 'proof' to the foregoing by saying that, if burning fossil fuels stopped tomorrow and the atmospheric and ocean temperatures were to stabilise - as they were in pre-industrial times[128] - evaporation from the oceans and subsequent cloud formation would be also stable and not be able to cause global warming. While this may seem a reasonable, logical argument, it discounts completely the extremely important effects on climate and weather of the ocean currents, particularly the fundamental effects of El Nino/La Nina (ENSO)[129] and the Indian Ocean Dipole (IOD). In fact, Hansen [2, p4] dismisses the ENSO (and by implication the IOD) as 'one big slow sloshing on the Earth' of no effect on global warming (in the northern hemisphere that is).

In respect of natural causes, the argument by climatologists is quite weak when analysed in some detail. The basic argument for natural causes is that it can be shown that the Earth has been in a

[127] Scientific proof (not logical deduction) needs to be established.

[128] A somewhat debatable point in itself.

[129] El Niño–Southern Oscillation (ENSO)

warm-age for hundreds of years, with temperatures still rising. Some, if not all. climatologists acknowledge this but now claim that the effect of greenhouse gases has overwhelmed natural causes starting with the industrial revolution and particularly in the past 40-50 years with the doubling of world population and fossil fuel use. That claim has been heavily criticised by some scientists.

From the discussion at Appendix E1, it is clear that both water vapour and CO2 are strong absorbents and radiators of IRR but that water vapour and clouds together have a far greater effect on surface temperature than does CO2, the latter contributing only around 25%. However, this conclusion does not necessarily in itself negate the primary claims of climatologists that greenhouse gases comprise the only 'thermostat' of the surface temperature. However, verification of that claim needs experimental proof, evidence of which in the research literature is yet to be located.

On balance, until proven otherwise conclusively by climatologists, a natural warm-age is believed to be the predominant 'thermostat' of the Earth, and not the non-condensable greenhouse gases.

The natural warm-age, water vapour and clouds are considered the major determinants of global warming, with non-condensable greenhouse gases as a far lesser cause.

Appendix: E1 - Earth's energy balance

Appendix: E2 - Cases for and against CO2 as the earth's thermostat

Australian Logistics Study Centre
Canberra, 24 July 2020

APPENDIX E1

EARTH'S ENERGY BALANCE

About this Appendix

The following discussion on the Earth's energy budget complements the theory behind climate global warming and change discussed in Annex B, *Genesis and theory*. Like the work in Annex B, this subject is part of the theoretical approach climatologists have taken to global warming, in contrast to the empirical approach by recording of the world surface temperature (Tw) and any increments thereto, namely the Temperature anomaly (Twi), by way of instrumented observations at the near surface and from satellites.

Two versions of the energy budget

Two leading authorities on the subject of the Earth's energy budget have been researched, in respect of how much short-wave solar radiation reaches the top of the atmosphere, how much long-wave infra-red radiation is emitted by the Earth and how these quantities are divided among contributing components. Figure E1-1 is a diagram produced by NASA [8], which is tabulated in Table E1-1. The second example at Figure E1-2 is taken from Figure 1.27 of the book by M.L. Salby [9] and is tabulated at Table E1-2. The two tables have been constructed to give a direct comparison between the two sources. While they differ for some of the individual components, the overall values for incoming and outgoing radiation are in close enough agreement.

Note: *Except for two, the values cited in these tables are not substantiated or sourced in other references. The first exception is that for Incident short-wave flux (incoming solar radiation), which is discussed later under 'Comments on these diagrams and derived tables'. The second exception is the value of 390-398 W/m^2 for 'emitted by surface', as derived from theory for emission from black bodies, assuming the Earth is a black body. While the origin is explained, the value is questioned by some critics.*

Correctly or not, the Salby reference is taken as the preferred basis of discussion here, as a known expert in atmospheric physics and having produced two extensive books on the subject and its updated version.

Notes about these diagrams and derived tables

These two diagrams purporting to describe the Earth's energy budget are fundamental in their own right, in coming from NASA and Professor Salby, but are still compendiums of research and writings by other scientists. Consequently, a few comments are necessary about them and the respective Tables E1-1 and E1-2 that this author has derived from them:

- The two diagrams are virtually the same in structure and values assigned to variables, although minor differences exist.
- Although not shown, there is general scientific agreement that the solar short-wave radiation (mostly visible light) reaching Earth averages about 1,360-1,370 W/m^2. But both diagrams start with a value of 340.4 and 343 W/m^2 at the Top of the atmosphere (TOA)[130]. Salby obtains his value of 343 by dividing 1,372 by 4, where '4' is the "ratio of the Earth's surface (4πD^2) to the area of a plane through the equator (πD^2)", where D is the diameter of an assumed spherical Earth. The mathematics are incorrect, as explained below by Ramanathan.
- All other values in both diagrams are given without explanation except that Salby does credit Ramanathan as a source, who worked for NASA at the time.
  - ➢ Ramanathan [10, p1341] gives the formula Fs = 1360.4/4*(1-α), where Fs is the net solar flux at the top of the atmosphere and α is the albedo effect, assumed to be 0.31.
    The factor '4' "*accounts for the fractional day of sunshine and the cosine of mean zenith*

[130] Top of atmosphere (TOA). Technically, there is no absolute dividing line between the Earth's atmosphere and space, but for scientists studying the balance of incoming and outgoing energy on the Earth, it is conceptually useful to think of the altitude at about 100 kilometres above the Earth as the "top of the atmosphere." The top of the atmosphere is the bottom line of Earth's energy budget, the Grand Central Station of radiation. It is the place where solar energy (mostly visible light) enters the Earth system and where both reflected light and invisible, thermal radiation from the Sun-warmed Earth exit. The balance between incoming and outgoing energy at the top of the atmosphere determines the Earth's average temperature. The ability of greenhouses gases to change the balance by reducing how much thermal energy exits is what global warming is all about. *https://earthobservatory.nasa.gov/*

angle [of the sun]". This would give a value of 340 W/m^2 with α=0 and 234.6 W/m^2 with α = 0.31. These values agree closely with those of NASA (340.4-99.9 = 240.5) and by Salby (343-106 = 237).

Note: *These values are averages over a year, given calculation by "the fractional day of sunshine and the cosine of mean zenith angle".*

- The other value of importance is that for emission of infra-red radiation emitted from the surface (398.2 W/m^2 by NASA and 390 W/m^2 by Salby). These values are determined by use of the Stephan-Bolzmann law which assumes that the Earth is a perfect 'black body', given by the formula W/m² = 5.670373 x 10-8 x K^4 (K = °Kelvin)[131]. An emittance of 390 W/m^2 results from an assumed temperature of the earth of 15°C (*all averages of course*).

- The notion that the Earth emits some 390 W/m^2 of infra-red radiation (that is like one 1,000 watt bar-radiator blasting away within every 3 m^2 of the Earth's surface during the day), and that 327 W/m^2 is reflected back to the surface by the atmosphere, is a bit hard to accept and implies contrivance on the parts of some scientists. The assumption that the Earth is a 'black body' and that the Stephan-Bolzmann law applies has been severely questioned by some critics, with good reason. First, the Earth is not a 'black body' but a 'grey body', meaning its emissivity is less than 1 (about 0.91). Second, these values assume that all thermal energy transferred from the Earth to the atmosphere is by radiation and very little by simple conduction of sensible heat.

  Note: *In engineering, heat transfer from one medium to another, e.g., from inside a room to the outside, is a function of the temperature difference (inside and outside) and the conductivity (emissivity) of the media in between. Blankets work this way with air as the main insulator.*

  Note: *Constants for the conductivity and its reciprocal emissivity, for most materials, have been determined empirically and make no distinction between thermal energy transfer by infra-red radiation or conduction by collision of molecules. Both occur, as proven by the design of vacuum flasks, where the vacuum between the two shells minimises conduction and the mirrored finishes on the insides of both shells minimise transfer of heat by radiation. The ratio between the two, although not necessarily of importance, would depend on the temperature and nature of the hot body and its source of thermal energy*[132].

  Note: *Have you ever wondered how gas molecules are able to scream about at great speed and in straight lines - all by themselves (as claimed by scientists) without any visible means of support - until colliding with the walls of the container, so causing pressure of the gas for a given absolute temperature?*

- 'Sensible' heat, that conducted from the Earth to the atmosphere, is said to be only 16 W/m^2 compared to the 390 W/m^2 radiated. Why only 16 W/m^2? It is not explained in the references. It implies that conduction accounts for only 3.2% (16/ (390+16+90)) of heat initially transferred from Earth to the atmosphere but 9.3% (16/169) (16/ (390-327+16+90)) of net transfer of heat. Note that 169 W/m^2 is also the value of the net solar radiation heating the earth. While most of the sensible heat would be from the oceans, part would be that exuded by the interior of the Earth itself. See also Annex L, *Energy*.

- Latent heat in the atmosphere (from condensation of water vapour) is said to be 90 W/m^2 by Salby (86.4 by NASA), but with no explanation of derivation. That is 53.2% (90/169). While this estimate is probably the result of atmospheric modelling, given that the latent heat of condensation of water vapour is known, the value has to be doubt, given the uncertainty (often admitted in the literature) in such modelling because of its sheer complexity and chaotic behaviour of the atmosphere and of the clouds therein.

- The remaining 63 W/m^2 (169-16-90) (37.3%) is the difference between radiation emitted and the back-radiation from the atmosphere (390-327).

[131] K = °Kelvin = K°C +273

[132] Technically, 'heat' is defined as the transfer of thermal energy from one medium to another, even though 'heat' is commonly used to mean thermal energy.

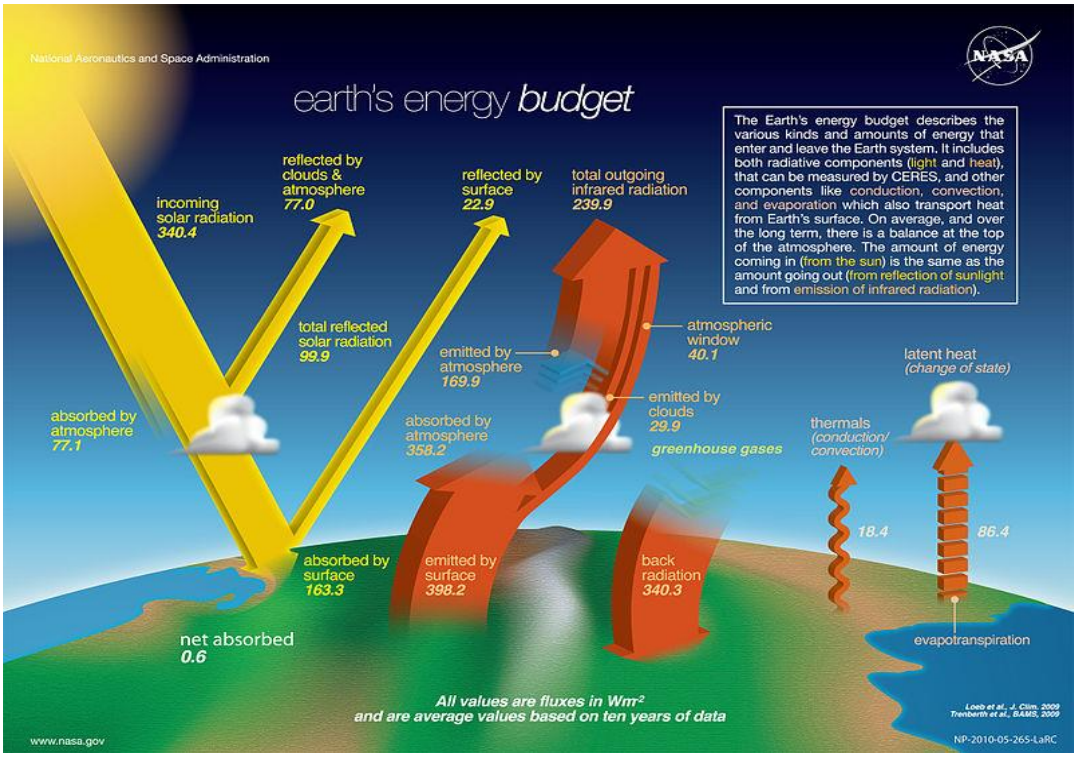


Figure E1-1 Earth's Energy budget (NASA) [no explanation given for values]
"The NASA Earth's Energy Budget Poster". *NASA. Archived from the original on 21 April 2014*.

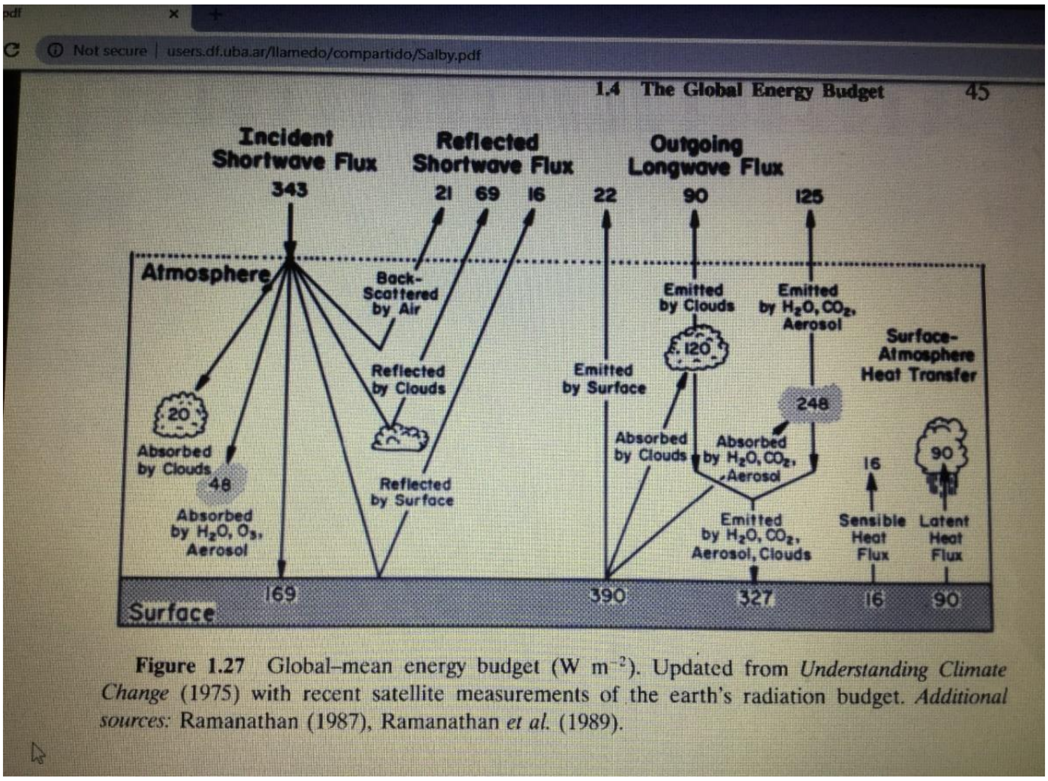


Figure E1-2 Salby reference, p45 [Some explanation given for values]

Table E1-1

Earth's Energy budget	NASA			
Radiance [0]	Nominal W/m^3	Calc W/m^2	%	Notes
Solar (Short-wave in)	**340.4**	**340.3**	**100%**	
Reflected		**99.9**	**29.4%**	[1]
Reflected - clouds		77.0		
Reflected - surface		22.9		
Reflected - air				
Absorbed - atmosphere		**77.1**	**22.7%**	[1]
Clouds				
Water vapour & Aerosols				
Absorbed - surface		**163.3**	**48.0%**	[1]
Infra-Red (long-wave out)	**239.9**	**239.9**	**70.5%**	[1]
Emitted by atmosphere		169.9		
Emitted by clouds		29.9		
Atmospheric Window		40.1		
Atmospheric Window		**40.0**	**11.8%**	[2]
Emitted by surface		398.2		[3]
Absorb by atmosphere		- 358.2		
At surface				
Absorbed by surface		**163.3**	**48.0%**	[1]
less Emitted by surface		- 398.2		
Plus Back radiation		340.3		
Net radiative forcing at surface		**105.40**	**31.0%**	[1]
Thermals & Latent heat		104.80	30.8%	
Thermals (sensible heat)		18.4		
Latent heat		86.4		
Net absorbed by Earth	**0.6**	**0.6**	**0.2%**	[4] [5] [6]
Notes:				
0. Except emission from Earth (Note 3), sources of figures cited are not given in references.				
1. General agreement between literature references				
2. Significant disparity between literature references				
3. 398.2 W/m^2 is Earth's gray body emission at about 15 °C				
4. NASA figure positive; Salby figure is zero.				
5. A forcing of 0.6 W/m^2 represents a Twi of 0.4 °C				
6. Actual Twi in 2020 is said to be 1 °C				

Table E1-2

Earth's Energy budget	M.L. Salby Fig 1.27		Bib 1	
Radiance [0]	Nominal W/m^3	Calc W/m^2	%	Notes
Solar (Short-wave in)	**243**	**343.0**	**101%**	
Reflected		**106.0**	**31.1%**	[1]
Reflected - clouds		69.0		
Reflected - surface		16.0		
Reflected - air		21.0		
Absorbed - atmosphere		**68.0**	**20.0%**	[1]
Clouds		20.0		
Water vapour & Aerosols		48.0		
Absorbed - surface		**169.0**	**49.7%**	[1]
Infra-Red (long-wave out)	**237.0**	**237.0**	**69.6%**	[1]
Emitted by atmosphere		125.0		
Emitted by clouds		90.0		
Atmospheric Window		22.0		
Atmospheric Window		**22.0**	**6.5%**	[2]
Emitted by surface		390.0		
Absorbed by clouds		- 120.0		
Absorbed by atmosphere		- 248.0		
At surface				
Absorbed by surface		**169.0**	**49.7%**	[1]
less Emitted by surface		- 390.0		
Plus Back radiation		327.0		
Net radiative forcing at surface		**106.00**	**31.1%**	[1]
Sensible heat (thermals)		**106.00**	31.1%	
Sensible heat (thermals)		16		
Latent heat		90		
Net absorbed by Earth	**0**	**-**	**0.0%**	[3] [4] [5]
Notes:				
0. Except emission from Earth (Note 3), sources of figures cited are not given in references.				
1. General agreement between literature references				
2. Significant disparity between literature references				
3. 390 W/m^2 is Earth's gray body emission at about 15 °C				
4. NASA figure positive; Salby figure is zero.				
4. Zero net forcing compared to 0.6 by NASA-				
5. Difference with NASA not explained.				

Tables E1-3 and E1-4

Table E1-3 tabulates the data from Table E1-2 (Salby) but in a different format to show how the various components contribute to what is emitted to space and back to Earth.

Table E1-3

IR Absorbed by surface	M.L. Salby Fig 1.27		[0]
Infra-red radiation	**CO2/H2O split #1**		
	W/m^2	**%**	**Notes**
Emitted to space	**237**	**100%**	
Direct (window)	22	9%	
H2O, CO2, Aerosols	125	53%	
Clouds	90	38%	
Emitted to surface	**327**	**100%**	[1]
H2O, CO2, Aerosols	89	27%	
Clouds	64	20%	
Sensible + Latent heat	106	32%	
Solar absorbed by atmosphere	68	21%	
Thermals & Latent heat	**106.00**	**100%**	[2]
Sensible heat (thermals)	16	15%	
Latent heat	90	85%	
Emitted to Surface by	**327**	**100%**	
CO2	78	24%	[3]
Water vapour, clouds & aerosols	249	76%	[4]
Notes:			
0. Derivation of figures cited not determined			
1. Figures from Salby, P46			
1. Figures from Salby, P45			
3. CO2 absorbs/emits 24% of IRR. From Table E1-3			
4. Water vapour, clouds & aerosols absorb/emit 76% of IRR			

Table E1-4 is <u>original work by the author</u> to derive from first principles, the relative power of CO_2 versus water vapour.

Relative absorption/emitting powers are derived by multiplying respective absorption coefficients and Optical density, both a function of respective concentrations. The values assume an average concentration value of 0.2% (2,000 ppm) for water vapour, rather than the oft-cited 0.4%.

Source references are given for how the absorption coefficients are derived. The optical densities have been derived from distributions of CO2 and water vapour with altitude, given that CO2 is present up to 40 km but water vapour limited to 17km maximum. Optical density can be thought of as like the different shades of sunglasses. For CO2, with an atmospheric concentration of 0.04%, but with density decreasing with altitude, the optical density of CO2 is that altitude to which CO2 would have a constant density. This value turns out to be 0.21 through 40 km. Because water vapour is restricted to much lower altitudes, its relative optical density is only 0.93. Multiplying the optical density by the absorption coefficient gives the relative absorption power of the two gases, with water vapour almost three times that of CO2.

The value of 24% for CO2 in Table E1-4 agrees closely with the 25% that has been cited by some researchers.

Zhong and Haigh [1, p102] say *"...despite having a concentration of less than 0.04%, CO2 is responsible for nearly a quarter of the total greenhouse trapping of radiation in the current atmosphere under clear-sky conditions."*

Water vapour, aerosols and clouds, together, radiate downwards a maximum of 62% of the total radiation and a minimum of 24%. Zhong and Haigh [1, p102] say *"...at the extremes of the wavelength range, indicating greenhouse trapping by H2O."* and *"...the impact of the individual gases [H2O and CO2] on downward radiation incident at the surface. This component is dominated by H2O due to the very strong emission of radiation by the near-surface atmosphere through the H2O continuum ...*".

Table E1-4

Absorption Power - CO2 vs Water vapour					
Element	[1] ppm %	[2] Asorb Coeffic	[3] Optical Density	[4] Relative Power N	%
				0.38	
CO2	0.04	0.44	0.21	0.09	24%
Water vapour	0.2	3.1	0.093	0.29	76%
Notes:					
1. Atmospheric concenrations of CO2 and Water vapour assumed					
2. IRR Absorbtivity at Earth's surface (m^-1)					
[https://en.wikipedia.org › wiki › Electromagnetic absorption by water]					
[https://en.wikipedia.org › wiki › Electromagnetic absorption by water]					
3. Optical density (relative atmospheric density)					
4. Relative IRR absorption power through atmosphere					

At the bottom layer of the atmosphere where clouds cover an average of 50% of the surface, with water vapour and clouds as high absorbents (and emitters) of infra-red radiation, and a CO2 concentration at only 0.04%, compared to the 0.2 to 0.4% for water vapour, it is reasonable to presume that water vapour and the clouds are responsible for much of the back radiation, as well as that for the latent heat of 90 W/m^2 (Salby value).

It is also clear from the foregoing that both water vapour and CO2 are strong absorbents and radiators of IRR, but that water vapour and clouds together have a far greater effect on surface temperature than does CO2, the latter contributing only around 25%.

However, this conclusion does not necessarily in itself negate the primary claims of climatologists that greenhouse gases comprise the only 'thermostat' of the surface temperature. For that, there needs to be experimental proof. Indeed, it has been shown by scientists as early as the mid-1800s (Tyndall - See Annex B, *Genesis and Theory*, *Box B2*), that CO2 and water vapour (as do other molecules of more than two atoms) indeed absorb radiation, especially IRR. Tyndall went so far as to claim that water vapour is by far the strongest of the greenhouse gases and he was right. Of course, while science has progressed a great deal since Tyndall's day, evidence of experimental proof that CO2 (and other non-condensable greenhouse gases) is the only real determinant (the thermostat) of Tw and Twi, has still not been proven.

Note: *After seven months of detailed research, this author has not been able to find any research paper that proves conclusively the claim that CO_2 is the only entity that controls world surface temperature. Many research papers discuss the relative properties and values attached of CO_2 versus water vapour but never address the claim of CO_2 being the 'thermostat'. Researchers simply take it as an article of faith. Further enquiries may be made by this author with Australian climatologists, to identify relevant research.*

Conclusions

It is clear from the foregoing that both water vapour and CO_2 are strong absorbents and radiators of IRR but that water vapour and clouds together have a far greater effect on surface temperature than does CO_2, the latter contributing only around 25%.

However, this conclusion does not necessarily in itself negate the primary claims of climatologists that greenhouse gases comprise the only 'thermostat' of the surface temperature. For that, there needs to be experimental proof; evidence in the research literature is yet to be located.

Australian Logistics Study Centre

Canberra, 26 March 2021

CASES FOR AND AGAINST CO2 AS THE EARTH'S THERMOSTAT

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6. Methane and Climate, W.A. van Wijngaarden and W. Happer, 2019.
7. Problems in climate science from the viewpoint of an historical geologist, Dr Howard Brady, ACDE Seminar, 6 October 2020.
8. Storms of my grandchildren, James Hansen, Bloomsbury, 2009.

About this appendix

This appendix comments on several of the references, in the context of the claim of climatologists that only CO2 (as well as other non-condensable greenhouse gases) acts as a 'thermostat' to determine the Earth's surface temperature (Tw) and increase thereof (Twi).

Claim by climatologists

From [1], there are two crucial issues that climatologists must prove for their thesis about climate global warming and change to be accepted as valid, namely:

- how the Average global surface temperature (Tw) and its increment, the Temperature anomaly (Twi) are actually changing and at what rate; and
- that the essential and only cause of temperature change is the change in concentration of non-condensable greenhouse gases in the atmosphere, particularly CO2.

In respect of the first point, although there is still some controversy, [1] concluded from the literature that there is general agreement that Twi was most probably, in 2020, at 1.06°C above pre-industrial times[133] and very gradually increasing under a business-as-usual scenario, ie consumption of fossil fuels around the world at current rates.

In respect of the second point, a primary conclusion of [1] was that climatologists have not yet proved their claim. An extract from [1] is given in Box E2-1.

> ***Box E2-1***
>
> *[from [1], Annex F, Demand for energy and emissions of the paper]*
>
> **The theory**
>
> Climatologists subscribe to the following theory:
>
> *Only CO2 (as well as other non-condensable greenhouse gases) acts as a 'thermostat' to determine the Earth's surface temperature (Tw) and increase thereof (Twi).*
>
> *Atmospheric water vapour increases with surface temperature, through increased evaporation of terrestrial waters.*
>
> *Water vapour and clouds do not determine the Earth's surface temperature but are functions of the surface temperature and 'feedback' phenomena controlled by the CO2 concentration.*
>
> *Water vapour absorbs a great deal of infra-red radiation, so heating and warming the atmosphere, but seen only as a positive feedback to global warming rather than a cause of surface temperature change.*

[133] Taken here as year 1750, but some references use the timeframe of 1720-1800.

Their arguments

Given their dismissal of natural causes for global warming, climatologists offer the following arguments as proof:

that only CO2 acts as the Earth's 'thermostat':

If burning fossil fuels stopped tomorrow and the atmospheric and ocean temperatures were to stabilise - as they were in pre-industrial times - evaporation from the oceans and subsequent cloud formation would stabilise also; ie not increase, and not be able to cause global warming.

Another argument used, prevalent in the literature, is that the life of water vapour molecules is only a matter of hours or days before it condenses into clouds and precipitates, implying that the greenhouse effect of water vapour is transient and of no consequence.

Despite the detailed research for [1], the author was not able to find any proof, by way of experimental research, that proved this second crucial claim by scientists to be correct (or incorrect). Rather, the claim is the result only of logical argument and deduction, and not backed-up by experimental evidence.

Notwithstanding this conclusion, [1] acknowledges that scientific proof of this claim may indeed exist somewhere in the literature. Note that [1] offers important information on this point that the climatologists have tended to ignore in their arguments.

Because this is a crucial issue to which their needs to be proof, readers who may be climatologists or even scientists in related disciplines[134] are invited to identify literature that would prove the second crucial claim by climatologists.

Note that there are literally thousands of technical papers purporting to validate the second claim, but virtually all are regurgitating the work of a few essential researchers and not adding to the body of knowledge, only to the fad that is climate change.

This appendix reviews the papers at References 2 through 7.

Evidence of the second claim

"Atmospheric CO2: the greenhouse thermostat", October 9, 2011[2] by Andrew Lacis,

This article [2] is a small paper but which succinctly puts the fundamental argument of climatologists that the atmospheric concentration of CO2, as the primary greenhouse gas, acts as the Earth's thermostat and that water vapour and clouds are but important feedback mechanisms to establish prevailing surface temperatures.

Dr Lacis from GISS NASA is a well-known climatologist and is often cited by authors of related papers. His case is presented in the Boxes E2-2 through E2-6.

He concludes that "*Humans are at a difficult crossroad. Carbon dioxide is the lifeblood of civilization as we know it. It is also the direct cause fuelling an impending climate disaster. There is no viable alternative to counteract global warming except through direct human effort to reduce the atmospheric CO2 level.*"

The case put by Dr Lacis is as good as it gets from climatologists. However, as his article says (BoxE2-3), his assessment comes about as the result of climate modelling experiments, as does all of the work upon which the Intergovernmental Panel on Climate Change (IPPC) has based its conclusions and input to international fora on global warming and climate change.

Thus, the validity of claims is still dependent on the validity of the computer simulation models used[135], which have been severely criticised by some other leading climatologists, the bases of criticism being the built-in weaknesses of all such models, ie validity of the myriad assumptions made, of the equations formulated by the scientists, and of data (initialising and otherwise) input to the model.

Unfortunately, as discussed, several times throughout [1], these assumptions, equations and data have been formulated by a very few scientists doing the fundamental modelling and are not likely to be made available to many others let alone made available for independent scrutiny and validation.

---

[134] Scientists in un-related disciplines need not comment as their opinion is no more valid that that of the man or woman in the street.

[135] The model used in the experiment is the GISS 2°×2.5° AR5 version of Model E with the climatological (Q-flux) ocean energy transport and the 250 m mixed layer depth. The model initial conditions are for a pre-industrial atmosphere. Surface temperature and TOA net flux utilize the left-hand scale.

Consequently, as concluded in [1], if simulation is the best that climatologists can do to substantiate their claims, their claim that CO2 as the primary thermostat of the Earth, is not yet proved and will remain so until the model/s used are independently validated or otherwise proved by experimental evidence.

Box E2-2

Atmospheric carbon dioxide performs a role similar to that of the house thermostat in setting the equilibrium temperature of the Earth. It differs from the house thermostat in that carbon dioxide itself is a potent greenhouse gas (GHG) warming the ground surface by means of the greenhouse effect. It is this sustained warming that enables water vapor and clouds to maintain their atmospheric distributions as the so-called feedback effects that amplify the initial warming provided by the non-condensing GHGs, and in the process, account for the bulk of the total terrestrial greenhouse effect. …. [2]

Box E2-3

This assessment comes about as the result of climate ***modelling*** experiments which show that it is the non-condensing greenhouse gases such as carbon dioxide, methane, ozone, nitrous oxide, and chlorofluorocarbons that provide the necessary atmospheric temperature structure that ultimately determines the sustainable range for atmospheric water vapor and cloud amounts, and thus controls their radiative contribution to the terrestrial greenhouse effect. From this it follows that these non-condensing greenhouse gases provide the temperature environment that is necessary for water vapor and cloud feedback effects to operate, without which the water vapor dominated greenhouse effect would inevitably collapse and plunge the global climate into an icebound Earth state. [2]

Box E2-4

From the foregoing, it is clear that CO2 is the key atmospheric gas that exerts principal control (80% of the non-condensing GHG forcing) over the strength of the terrestrial greenhouse effect. Water vapor and clouds are fast-acting feedback effects, and as such, they are controlled by the radiative forcing supplied by the non-condensing GHGs. [2]

Box E2-5

The bottom line is that atmospheric carbon dioxide acts as a thermostat in regulating the temperature of Earth. The rapid increase in atmospheric carbon dioxide due to human industrial activity is therefore setting the course for continued global warming. Because of the large heat capacity of the climate system, the global surface temperature does not respond instantaneously to the sharp upturn of the carbon dioxide thermostat, which at this moment stands at 386.80 ppm[136] compared to the normal interglacial maximum level of 280 ppm. Since humans are responsible for changing the level of atmospheric carbon dioxide, they then also have control over the global temperature of the Earth. Humans are at a difficult crossroad. Carbon dioxide is the lifeblood of civilization as we know it. It is also the direct cause fuelling ***an impending climate disaster***. There is no viable alternative to counteract global warming except through direct human effort to reduce the atmospheric CO2 level. [2]

Box E2-6

The basic physics for the present study is rooted in the high precision measurements documenting the rise of atmospheric carbon dioxide and other greenhouse gases as fully described in the Intergovernmental Panel on Climate Change (IPCC) AR4 report, and in the comprehensive HITRAN database (Rothman et al. 2009) of atmospheric absorption data. The radiative transfer calculations involve well-understood physics that is applied to the global energy balance of the Earth, which is maintained by radiative processes only, since the global net energy transports must equal zero. This demonstrates the nature of the terrestrial greenhouse effect as being sustained by the non-condensing GHGs, with magnification of the greenhouse effect by water vapor and cloud feedbacks, and leaves no doubt that increasing GHGs cause global warming. [2]

State of the climate 2020, CSIRO, Australia.

This recent CSIRO report [3] is interesting in that it relates global warming and climate change to the Australian scene, contrary to what virtually all available literature does, ie reporting about what

[136] ppm = parts per million of atmospheric particles

is said to be occurring in the Northern hemisphere and presuming that it applies equally to the Southern hemisphere.

Nevertheless, as good as the CSIRO report may be, it is still a compendium of work by other scientists, with limited input from sensors in and around Australia and, while giving a good account of likely changes in Australian surface temperatures, it cannot be taken as 'evidence' of climate change. There is a very large jump to make between some global warming (which is acknowledged) and non-reversible climate change for the worse.

Unfortunately, it has had the inevitable effect of setting the climate-change hares running in the media to feed further the frenzy of 'les moutons de Panurge' of climate change, as described in the letter to the editor by this writer at Box E2-7.

Box E2-7

The Editor, The Canberra Times

Climate changer hares

As could be expected, the CSIRO report 'State of Climate 2020' has set the climate changer hares running, to wit the article 'Leaders are lagging behind on climate' by Ms Ebony Bennett (Canberra Times, 14Nov20). This article, like so many others, is purely alarmist, gives one side of the story and contains several errors of fact.

First, the claims that 'Leaders are lagging ...' and that the government 'continues to be a laggard …' are false and unsupported assertions common to climate changers and those anti the Coalition government. A quick look at the Business Council's 'Scoping paper - energy and climate change', 2020, would show otherwise.

The Climate Institute's 'Climate of the nation report' is like most such reports, ie devoid of original research work and is but a regurgitation of others information supporting its biased climate agenda.

Contrary to the article's claim, the CSIRO report says that the frequency of tropical cyclones is not increasing.

Australia is in fact the largest exporter of coal but a poor fifth in total coal production, well after China. Australia is also the largest exporter of natural gas. These exports occur only because other nations need them. No foreign demand, no export. Natural trade preferences will end coal production in due course.

The ACT may be buying 100% renewable electricity but 63% of consumption is actually fossil fuelled from over the border. Political humbug? …

Using leftover Kyoto carbon credits is legitimate. To claim it is 'cheating' is pure sophistry.

To say that Australia, at 0.32% of the world's population, should be a "world leader in finding solutions to climate change" is pure fantasy and more sophistry.

Australia is not and cannot have any effect on climate change and thus investment on reducing its miniscule emissions is 100% waste. I challenge climate changers to prove otherwise.

What Australia must do is the heed the message of the 2020 CSIRO report and its predecessor 'Climate Change' issued in 2011. The principal message of these excellent reports is not to reduce emissions per se but to acknowledge that Australia is vulnerable to climate change caused by emissions by the rest of the world by population and that investment must concentrate on adaptation.

Alarmist busy-body climate changers are big on noise but are not addressing the real threat!

M. Flint

Erindale Centre

15Nov20]

Scientific papers against the notion of CO2 as the thermostat.

On the other hand, there are numerous and recent technical papers denying the CO2 claim of climatologists. Four of these are listed at [4]-[7], each of which will be discussed herein.

Re-evaluating the role of solar variability on Northern Hemisphere temperature trends since the 19th century. [4]

General comments

This paper of some 44 pages (excluding an extensive bibliography[137]) attempts to prove that global warming is a function only of the Total Solar Irradiance (TSI) and that the effect of CO2 concentrations on global warming is quite small if at all.

Indirectly, it claims to provide proof against the second claim of climatologists, namely that the essential and only cause of temperature change is the change in concentration of non-condensable greenhouse gases in the atmosphere, particularly CO2.

As expected, data presented and conclusions drawn in the paper are based on several assumptions, for which neither the validity nor sensitivity is tested. Thus, the assumptions are taken as fact by the authors.

A major part of the paper is concerned with establishing the cyclic frequency and values of TSI received from the sun and the net value at the top of the atmosphere after absorption and reflection by the atmosphere (including from clouds) and the albedo effect. The two values established agree with data sources used for [1].

Another major part establishes a new estimate of Northern Hemisphere surface air temperature trends since 1881, which are presented in the several figures as a Temperature anomaly (Twi used herein), relative to the average Temperature anomaly from 1961 to 1990, taken as 0 °C. [1] and data sources thereof define the Temperature anomaly as the change from the pre-industrial era. A base-line period of 1961-90 should be more accurate, except that trends in Twi should be the same in both cases, since 1961-90.

The paper clearly concerns only the 'Northern Hemisphere' surface air temperature and thus, draws no conclusions in respect of the Southern Hemisphere. [1] points out, with exceptions of course, that almost all of the published data on global warming and climate change concerns only the Northern Hemisphere and that conclusions made do not necessarily have much bearing on what happens in Australia.

Section 5. *Comparison between Northern Hemisphere temperature and solar activity trends*; and **Section 5.1**. *Fitting of Northern Hemisphere temperatures to changes in solar activity and atmospheric carbon dioxide (CO2)*, are the most relevant to these notes, for which there are detailed comments below.

As a general and important observation, while the paper appears to use Mauna Loa readings for global growth in CO2 concentrations, it does not mention the doubling of world population during 1980 to 2020 nor the corresponding doubling of total CO2 emissions (not retained ppm concentrations) in the same timeframe. Figures in the reference showing the relationship of CO2 concentrations with time, indeed show an upswing in the Temperature anomaly from 1980 through 2020, but attribute it to the TSI rather than CO2 levels.

As stated, (page 37), the paper concludes, essentially *"… suggests that Northern Hemisphere surface air temperature trends have been heavily influenced by changes in Total Solar Irradiance since at least 1881….*"

[137] Some 370 references cited.

Detailed comments

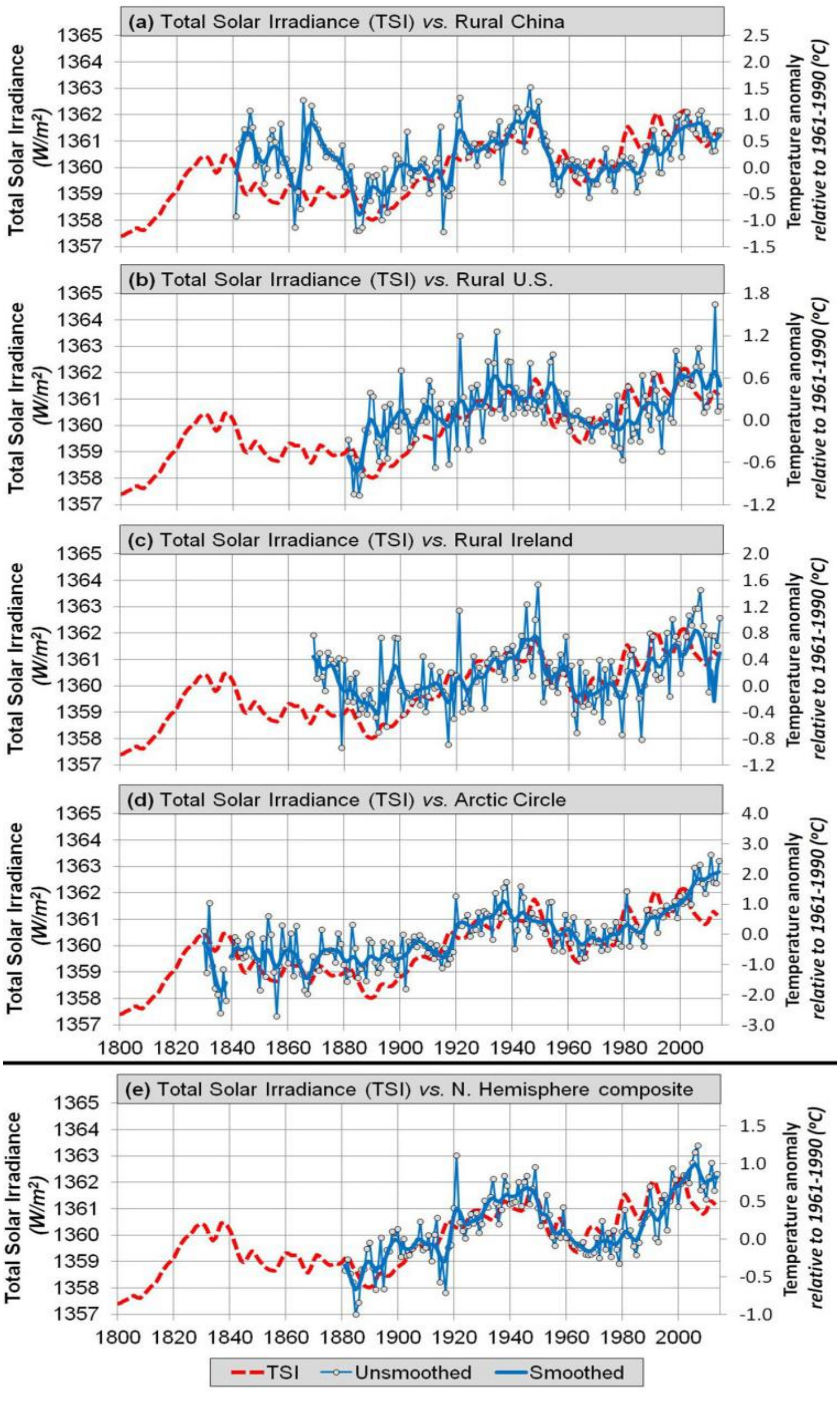

Figure 1 *Figure 27[4]***.** *Comparison between the updated Hoyt & Schatten Total Solar Irradiance trends (red dashed curve) and the various Northern Hemisphere regions/gradients discussed above.*

These graphs appear valid. Of note is that graphs for all regions and overall show the well-established fall in Twi for the period 1940-1970 and the strong increase since 1980, consistent with world population growth and total emissions.

Figure 27 (e). Given the 1961-90 baseline of 0°C, it would appear that Twi is about 0.75 in 2020, and some 1.25°C above the pre-industrial era. However, this result is overly influenced by what is happening in the Arctic. The Twi in China and the USA in 2020 appears to be about 1.05 or 1.06°C above that of 1880. [1] arrives at a value of 1.06 °C in 2020 from the pre-industrial era.

Section 5.1. *Fitting of Northern Hemisphere temperatures to changes in solar activity and atmospheric carbon dioxide (CO2)*

Para 1: "*If we assume a linear response between Total Solar Irradiance (TSI) and Northern Hemisphere surface air temperatures, …".* The validity of this assumption is questionable.

Para 3: "*… change in Total Solar Irradiance of 1 W/m2 should (on average) correspond to a change of ~0.211°C for Northern Hemisphere,".* This is a correlation only based on a questionable assumption,

Para 4: *"… If we approximate the average Northern Hemisphere surface air temperature as 288K and assume that it would be less than 4K in the absence of the Sun, then this implies Northern Hemisphere surface air temperatures are ~284K warmer than they would be in the absence of the Sun. Therefore, a 0.0735% change in the solar-induced Northern Hemisphere surface air temperature would be ~0.209K, i.e. 0.209°C. This is remarkably similar to the ~0.211°C response implied by our model. …".* This is an assumed relationship, the validity of which would probably not stand up to close scrutiny. It assumes a straight-line relationship for Twi as a function of only TSI, which could not be correct, given the myriad variables affecting the Earth's temperature and climate.

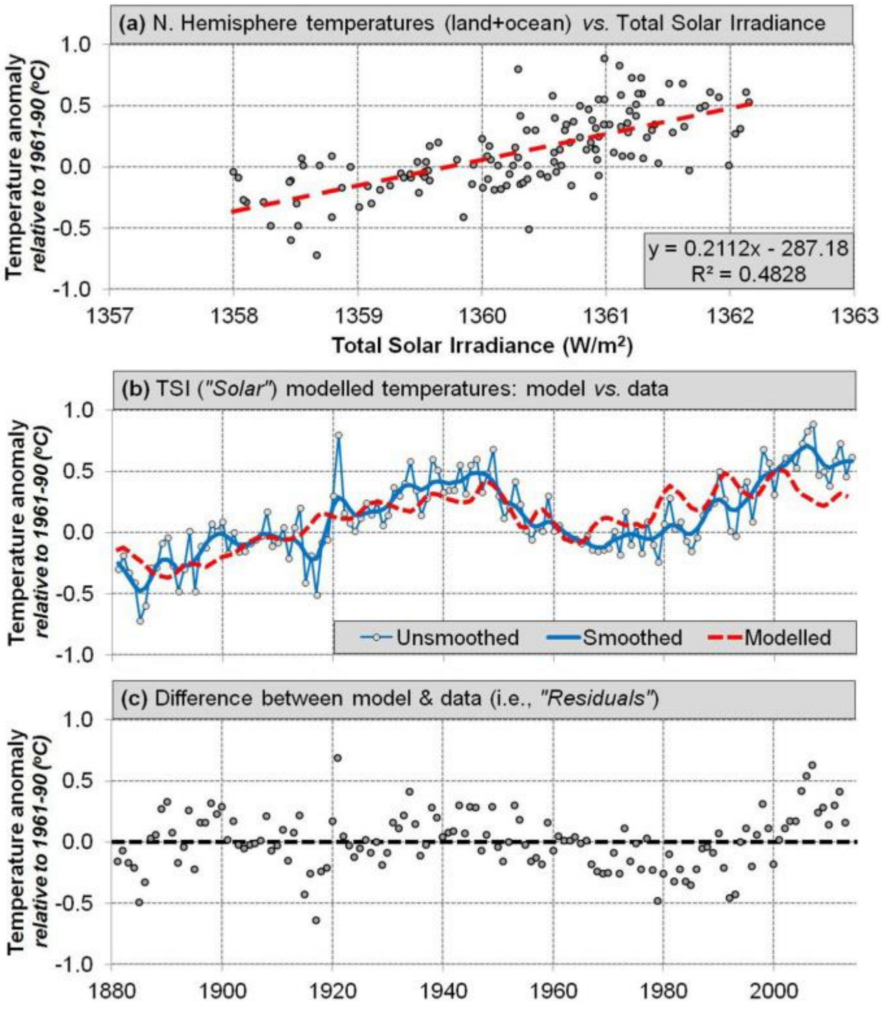

Figure 2. *Figure 28 [4]. Derivation of a model for our Northern Hemisphere composite (land & ocean version) based on Total Solar Irradiance trends.*

- *Figure 28 (a): N hemisphere temperatures (land+ocean) vs Total Solar Irradiance.*
  - This graph implies an ever-increasing linear relationship between TSI and Twi, yet TSI is a cyclic variable with well-established max/mins.
- *Figure 28 (b): TSI ("Solar) modelled temperatures: model vs data*
  - X-axis is assumed in Years as for 28(c)
  - If X-axis is Year, how was TSI observed before satellite data?

- *Figure 28 (c): Difference between model & data (i.e., "residuals")*
  - ➢ This figure defines 'residuals' as the '*difference between model and data*' (Twi against Year presumed). One can accept mapping of 'residuals' in Figure 28 (c) as validating the theoretical model, but that is all. Reading more into 'residuals', as later used in the paper, is considered a highly suspect practice.

Page 39: "*Hence, a Total Solar Irradiance Value of 1361 W/m2 would correspond to a Radiative Forcing of 340 W/m2*."

- ➢ These figures agree with sources used by [1].

Page 39: *…" we can neglect this seasonal variability and use the mean annual values at 1 Astronomical Unit."*

- ➢ 'Astronomical Unit' is accepted as the average distance of the Earth from the Sun. However, the cyclic nature of the TSI implies a frequency (about 11 years? from Figure 3) and a fairly constant maximum and minimum. Yet, the graphs in this paper, attempting to prove the singular cause and effect relationship between TSI and Twi, assume implicitly that TSI can continue to increase indefinitely, which it does not (at least not for millions of years yet).

Page 39. "*… if we assume that the planetary albedo remains relatively constant at 0.29, …*"

- ➢ Another untested assumption. Sensitivity analysis here might have been appropriate.

Page 39. *"… If the above model is accurate, then we can determine the maximum possible influence of Greenhouse Gases (GHG) on Northern Hemisphere by fitting the residuals to the changes since 1881 …".*

- ➢ Why use 'residuals' which are the errors between the model and observed data? Why not use the model or observed data as being close enough?

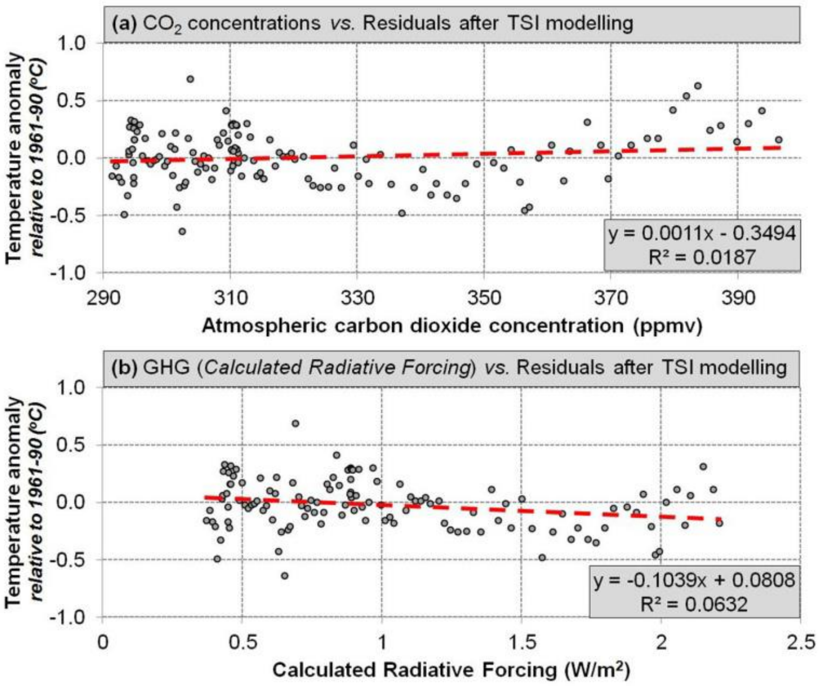

Figure 3. *Figure 29 4]. Attempts to fit the residuals from the solar model using changes in greenhouse gas concentrations.*

- *Figure 29 (a). CO2 concentrations vs 'residuals' after TSI modelling.*
  - ➢ If X-axis is CO2 ppm and Y-axis is Twi, where and how do 'residuals' come into it?
  - ➢ At a CO2 concentration of 413ppm (in 2020), according to this Figure 29(a), the TSI could be anywhere between 0.5 and 1.0. [1] has an increase in Twi of 0.62 °C from 1980 to 2020.
- *Figure 29(b). GHG Calculated Radiative Forcing vs Residuals after TSI modelling.*

- Neither the derivation or need for this graph is explained. The only comment in the paper is that "… *the fits are probably not significant*."

Page 39: "… *There does not appear to be much of a relationship between the residuals and either of the datasets, suggesting that greenhouse gases do not appear to have much influence on Northern Hemisphere surface air temperatures, after the above solar relationship has been accounted for. …".*

- This could be considered a leap of faith rather than a logical conclusion.

Page 40: *"Our model in Figure 30 also implies a larger temperature response to changes in atmospheric carbon dioxide than our model in Figure 28 & Figure 29: It implies that carbon dioxide (CO2) is responsible for a warming trend of 0.0063 × 110 = 0.69°C over the 1881-2014 period, where 0.0063 is the slope of the line in Figure 30(a). …".*

- Agrees with findings of [1]

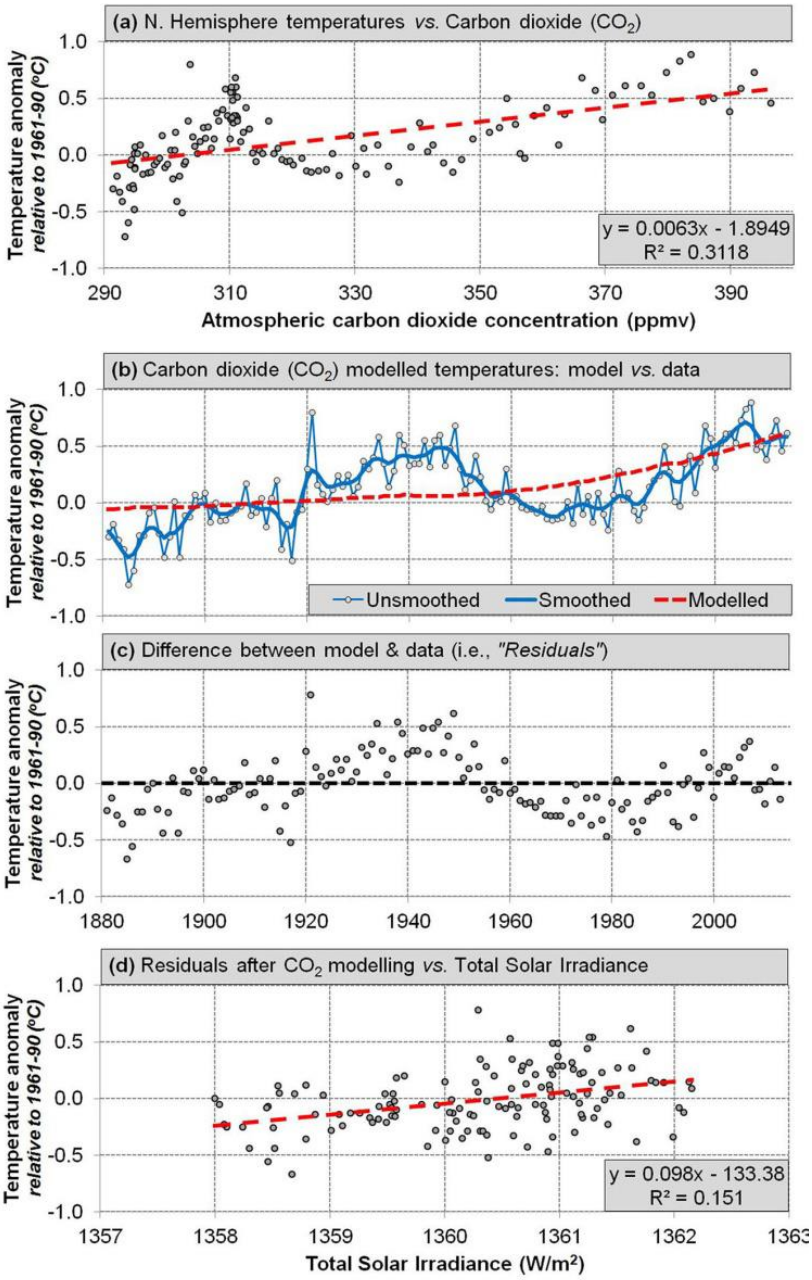

Figure 4. *Figure 30 [4]. As for Figure 28, but fitting using measured changes in atmospheric carbon dioxide (CO2).*

- *Figure 30(a). N hemisphere temperature vs CO2*
  - This graph of CO2 vs Twi is very similar to that derived in [1]. This graph comes up with a coefficient of 0.0063 °C/CO2ppm. [1] derived a value of 0.00816. This graph could be considered to show that Twi is a function of CO2 concentration?

- *Figure 30 (b) CO2 modelled temperature model vs data*
  - ➢ This graph does not make any sense without any explanation of derivation.
- *Figure 30(c) Difference between model and data (ie residuals)*
  - ➢ It is interesting (if probably not valid) in that it shows a distinct upswing in Twi from about 1980. One should note that world population and total greenhouse gas emissions (mostly CO2) both doubled between 1980 and 2020. CO2 ppm went up at a much lower rate at about 2ppm per annum [Table D1-2 of [1]].
  - ➢ This same upswing also shows up in most of the Figures (28(b), 29(a), 30(b), 30(c), and all four of Figure 31.

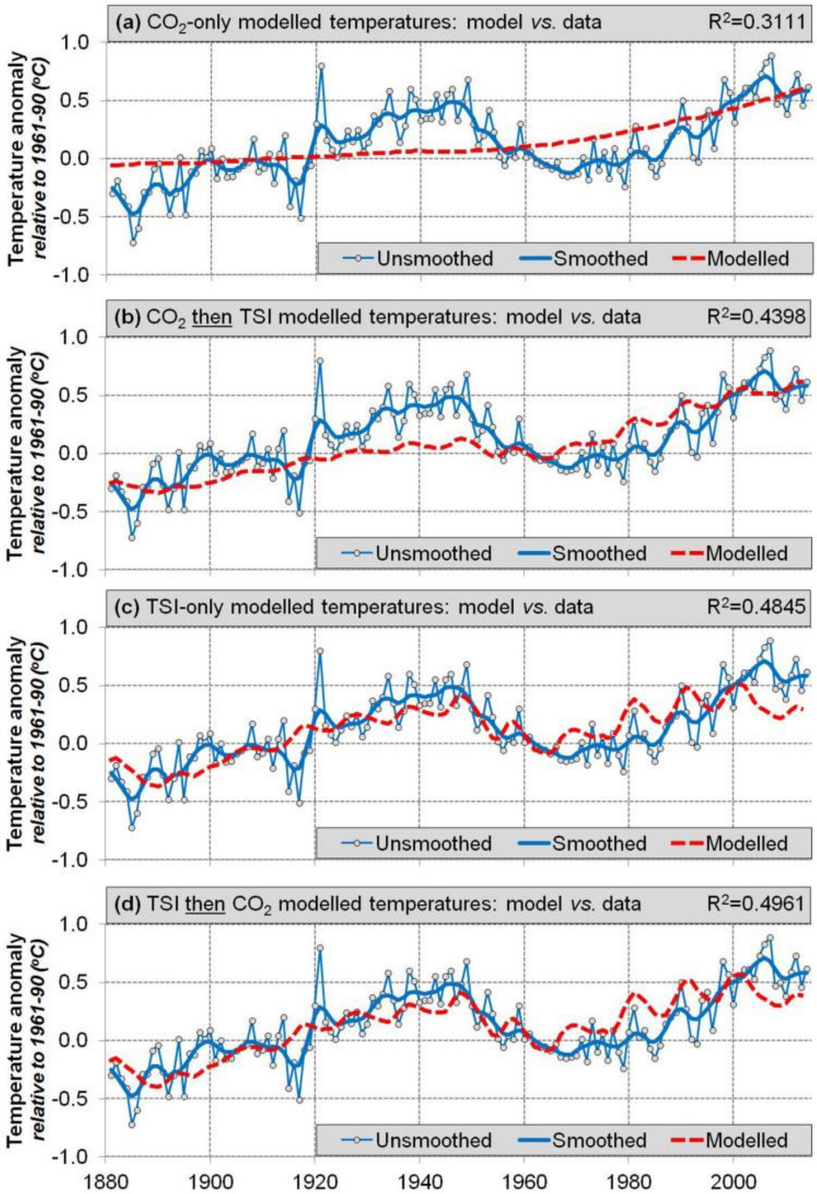

Figure 5. *Figure 31[4]. Comparison of the four different models to our Northern Hemisphere composite (land & ocean rescaled version).*

- *Figure 31(a) CO2 only modelled temperatures*
  - ➢ Data curve looks normal but modelled temperature is poor fit.
- *Figure 31(b) CO2 then TSI modelled temperatures model vs data*
  - ➢ Data curve looks normal; modelled temperature a better fit.
- *Figure 31(c) TSI-only modelled temperatures model vs data*

- TSI curve looks the same as the CO_2 curve in 31(a) implying that TSI vs Twi is the same as for CO_2 vs Twi. However, the thesis of this paper is that TSI controls Twi and that CO_2 effect is negligible. This graph says otherwise.

- *Figure 31(d) TSI then CO2 modelled temperatures model vs data*
  - Again, TSI vs Twi is the same as for CO_2 vs Twi.

Page 41:

- *"… The first two models, 31(a) and 31(b), describe our Northern Hemisphere composite rather poorly, while the latter two models describe the composite surprisingly well….".*
  - Just bad models?
- *"… This suggests that, since at least 1881, Northern Hemisphere temperature trends have been primarily influenced by changes in Total Solar Irradiance, as opposed to atmospheric carbon dioxide concentrations. …"*
  - This conclusion is not supported by the graphs in Figure 31, in fact, the opposite. Therefore, this conclusion should be seen as a great leap of faith rather than a valid deduction.
- *'… as we discussed in Section 1.1, correlation does not imply causation…"*
  - [1] makes the same point several times.
- *"Therefore, it is important to consider which of our four types of correlations apply.".*
  - It does not matter which form of correlation is most relevant – it is still correlation and not proved cause and effect.

Sections 5.2 *Soon's proposed mechanisms: Dynamical considerations* and **5.3**: *Connolly & Connolly's proposed mechanisms*

The relevance of these sections to the final conclusion needs explanation.

Section 6 – Conclusion

Page 41:

- *"… Similar to previous estimates, our composite implies warming trends during the periods 1880s-1940s and 1980s-2000s….".*
  - Agreed but the true cause is still debatable.
- *"… One reason why the hindcasts might have failed to accurately reproduce the temperature trends is that the solar forcings they used all implied relatively little solar variability.".*
  - True – but most climatologists dismiss TSI effect as negligible.
- *"… If the Hoyt & Schatten reconstruction and our new Northern Hemisphere temperature trend estimates are accurate, then it seems that most of the temperature trends since at least 1881 can be explained in terms of solar variability, with atmospheric greenhouse gas concentrations providing at most a minor contribution. …"*
  - This conclusion is considered to be not proved by this paper.

Conclusions of this review

As found in many technical papers, there can be leaps of faith and conclusions to support pre-conceived notions or policy positions. That may be the case here.

The graphs in Figures 27 [4] through 31[4] are not adequately explained, especially in respect of respective X-axes used (TSI, CO_2 concentrations and Year) and seem to be somewhat contradictory.

Given that TSI is cyclic in nature, there should be a corresponding cycle in Twi, as claimed. However, most of the graphs presented show a progressive increase in Twi with time, especially from about 1980, albeit with ups and downs.

TSI being cyclic with well-established max-mins, should not be able to continually increase the TI, as implied by this reference.

Much of the relevant literature says that the Earth has been in a warm-age for several hundred years, a notion that climatologists agree with, except that they claim the increase in temperature is due exclusively to the growth on greenhouse gases caused by human activity.

The so-called sceptics[138] say it is primarily due to natural causes, ie due to the cyclic relationship between the Earth, Sun and even the Moon, as well as the thermo-dynamic nature of the Earth itself.

This reference [4] is a highly researched paper[139] but, as presented, it is considered here not to prove the conclusion that "*the temperature trends since at least 1881 can be explained in terms of solar variability, with atmospheric greenhouse gas concentrations providing at most a minor contribution.*"

Dependence of Earth's Thermal Radiation on Five Most Abundant Greenhouse Gases, W.A. van Wijngaarden and W. Happer, 25 May 2020. [5]

This paper is some 38 pages, including some 47 references, by well-regarded scientists but who do not agree that increasing greenhouse gas concentrations (excluding water vapour) are the cause of global warming let alone climate change. As such, they are 'contrarians', if not 'heretics' according to the prevailing opinion on global warming. W. Happer is the founding member of the CO2 Coalition.

It is a highly scientific paper which, contrary to expectations, does not conclude that doubling CO2 concentrations does not affect the surface temperature Tw at all. In fact, the paper essentially confirms the earlier work of climatologists, including that by S. Manabe for the original Charney Report for the United Nations and published by the IPCC. Figures produced by Happer are similar but, as would be expected, more refined than those on Manabe, given the advances in scientific knowledge over the past 40 years.

The essential task for the Charney Report was to determine a value range for the Radiance forcing (ΔF) effect of doubling CO2 concentrations from pre-industrial times (1750-1800), ie from 286 to 560 ppm and the Climate Sensitivity, ie the change in average surface temperature (Tw) for a doubling of CO2 ppm (Tw/2xCO2).

Charney reported the following values:

- ΔF = 4 Watt/m^2, and for
- (Tw/2xCO2) = 1.5 °C_3°C_4.5°C.

The paper by Happer [5], with more refined techniques and data available, reported the following values:

- ΔF = 3 Watt/m^2, and for
- (Tw/2xCO2) = 2.2°C, well within the Charney range but lower than the Charney average of 3°C.

The work by Flint [1] determined a value for (Tw/2xCO2) of 2.6, but with far less sophisticated techniques than that used in [5].

[138] equally competent scientists as the few climatologists of note

[139] If one can believe that the authors have reviewed some 370 references cited.

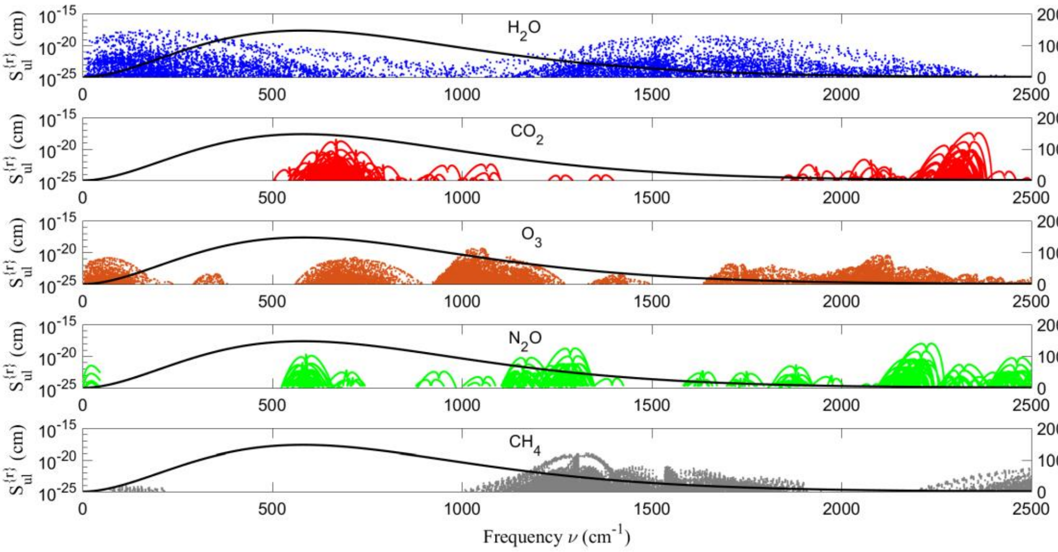

Figure 6: Reference line intensities for H2O, CO2, O3, N2O and CH4 from the HITRAN data base. The horizontal coordinate of each point represents the Bohr frequency of a transition. The vertical coordinate of the point is the line intensity.

Figure 6 (a copy of Figure 2 from [5]) Is an interesting graph in that it clearly shows the dominance of the blanket effect (blocking infra-red radiation) of water vapour (H2O) compared to that of CO2.

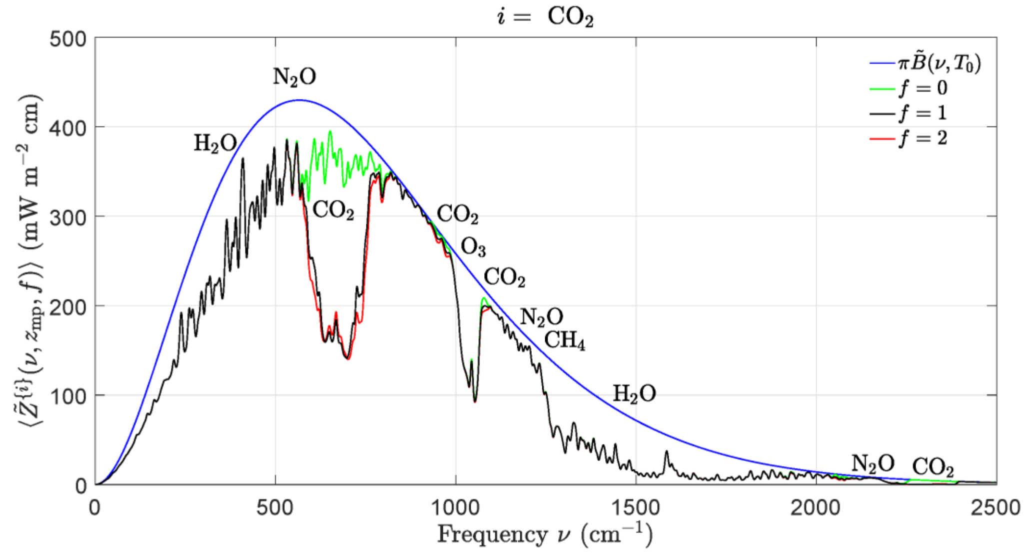

Figure 7: Effects of changing concentrations of carbon dioxide, CO2. The smooth blue line is for a transparent atmosphere with no greenhouse gases. The green line is with the CO2 removed but with all the other greenhouse gases at their standard concentrations. The black line is with all greenhouse gases at their standard concentrations. The red line is for twice the standard concentration of CO2 but with all the other greenhouse gases at their standard concentrations. Doubling the standard concentration of CO2 (from 400 to 800 ppm) would cause a forcing increase (the area between the black and red lines) of 3:0 watt/m^2.

Figure 7 (Figure 4 in [5]) is an interesting graph. Unfortunately, the minimal difference shown between the red and black lines implies that doubling CO2 has no effect on Forcing (F) and by further implication that doubling CO2 has no effect of surface temperature Tw.

The paper explains that the apparent small difference on the graph is in fact the difference in areas under the black and red curves, integrated over all frequencies. *"A doubling of CO2 concentration results in a 3 W/m2 decrease in the top of the atmosphere flux. This positive forcing changes the temperature profile as is discussed in Section 7." [p14 [5])*

"7 ***Temperature and Forcing****. The forcings due to instantaneous changes of greenhouse gas concentrations can be calculated quite accurately. Temperature changes induced by the forcings are less clearly defined because various feedbacks change the temperature profile of the atmosphere. After doubling CO2 concentrations, a new, steady state will eventually be established by these feedback processes." (p21 [5])*

*"**7.5 Climate Sensitivity.** A comparison of our result for the climate sensitivity defined as the surface warming due to doubling the CO2 concentration from 400 to 800 ppm, to other work is given in Table 5. These calculations considered the case of a clear sky one dimensional atmosphere in radiative-convective equilibrium. All groups get nearly the identical value for the case of fixed absolute humidity for a constant lapse rate of 6.5 K/km in the troposphere. Additional significant surface warming occurs for the case of fixed relative humidity. Our result of 2.2 K* [actually 2.3] *is substantially lower than the value obtained by the pioneering work of Manabe and Wetherald [35] who obviously did not have access to the current line by line information." (p31,[5])*

Thus, this paper determines a Climate Sensitivity of 2.3 °C/2xCO2, not ZERO. Analysis in [1] derived a figure of 2.6 K, albeit with much more rudimentary techniques.

Given also the forcing (F) of 3 watt/m^2 for 2xCO2, one arrives at a specific climate sensitivity of 2.3/3 = 0.77, which is very close to the figure of 0.75 of Manabe and Hansen [8].

*"**9. Conclusions.** ... The most striking fact about radiation transfer in Earth's atmosphere is summarized by Figs. 4* [Figure 2 herein] *and 5. Doubling the current concentrations of the greenhouse gases CO2, N2O and CH4 increases the forcings by a few percent for cloud-free parts of the atmosphere. Table 3 shows the forcings at both the top of the atmosphere and at the tropopause are comparable to those found by other groups." (p34 [5])*
....
"The surface warming increases significantly for the case of water feedback assuming fixed relative humidity. Our result of 2.3 K is within 0.1 K of values obtained by two other groups as well as a separate calculation where we used the Manabe water vapor profile given by (87). For the case of fixed relative humidity and a pseudo-adiabatic lapse rate in the troposphere, we obtain a climate sensitivity of 2.2 K." (p34[5])

Contrary to what some analysts may read into it, this paper simply refines the earlier estimates for forcing and climate sensitivity, for 2xCO2. It does not conclude that 2xCO2 has no effect on surface average temperatures.

Methane and Climate, W.A. van Wijngaarden and W. Happer, 2019 [6].

This paper is a follow-up to reference [5] but addresses more the probable effect of methane (CH2) on global warming.

Strangely, in apparent contradiction to [5], the introduction says, inter alia:

"The basic radiation-transfer physics outlined in this paper gives no support to the idea that greenhouse gases like methane (CH4), carbon dioxide (CO2) or nitrous oxide (N2O) are contributing to a climate crisis. ...." (p4[6])

The paper then goes on similarly and coming up with similar findings to those in [5], that show a positive effect of CO2 on Tw.

*"**6. Temperature changes caused by forcing changes.** Instantaneous forcing changes due to increments in the concentrations of greenhouse gases can be calculated accurately. The next step, using instantaneous forcing increments to calculate temperature changes, is fraught with difficulties and is a major reason that climate models predict much more warming than observed." (p12[6])*

Problems in climate science from the viewpoint of an historical geologist, Dr Howard Brady, 6 October 2020 [7]

*"**Abstract.** The climate system is vast with the interaction of forces we do not fully understand. Linking recent and future global warming to increasing carbon dioxide levels is problematic. Historical data exposes serious flaws in the IPCC reports with respect to, for example: the predictions of future sea levels; the relationship between carbon dioxide levels and temperature; the frequency and severity of storms. Applying the word 'unprecedented' to certain events shows an ignorance of the Earth's geological and environmental history. Climate change cannot be assumed to be geocentric without influence from cosmic and solar weather. Climate models are on steroids with respect to their estimate of what is called the Equilibrium Climate Sensitivity Index; that is, the estimate of future temperatures if carbon dioxide levels double. We cannot forget this statement: 'we are dealing with a coupled chaotic nonlinear system and therefore the prediction of future climate states is not possible..' IPCC Report 2001 (14.2.2.2)."*

Australia's Dr Brady is a member of the CO2 Coalition founded by Professor W. Happer and, as such, is a so-called 'contrarian' in respect of global warming and climate change.

The paper addresses many aspects of climate change such as claimed rising ocean levels and more prevalent and intense weather activity, but the following comments concern his treatment of *"The weak link between rising carbon emissions and the temperature of the Earth"(pp 7-11)*

It covers off early pioneering work on global warming but eventually gets to:

"An examination of the 20th century temperature profile as reported in the first IPCC reports further dispels a simple link between carbon dioxide levels and temperature.

The paper presents a graph (cannot be copied) similar to that at Figure 8, and describes it so:

"There were warming periods between 1910-1940 and 1970-2000 with nearly identical warming gradients; that is, a steady gradient around 0.16ºC/decade (cf. Figure 11). But in these two periods the decadal rises in carbon dioxide were vastly different; around 4-5 ppm/decade in the 1910-1940 period and around 15 ppm/decade in the 1970-2000 period. This suggested, at the very least, that other forces easily overrode any warming due to increasing carbon dioxide levels or that periodic warming trends were independent from changing carbon dioxide levels. To highlight this problem when carbon dioxide levels rose around 6ppm/decade between 1940-1970 world temperatures declined. Attempts to explain these discrepancies by varying pollution levels do not make sense. There was no great rise in coal production in struggling economies post WW11; economic recovery started to accelerate in the 1970s."

The values highlighted in red are approximate only. More accurate figures would be 3.8 ppm/decade and 14.3 ppm/decade, respectively. However, the point is well made: How can similar rates of increase in temperature Tw be the result of quite different rate of change in CO2 ppm?

Also, on this graph, the cooling period from 1940 to 1980 has not been convincingly explained by climatologists. It is a serious anomaly in the argument by climatologists that needs to be explained.

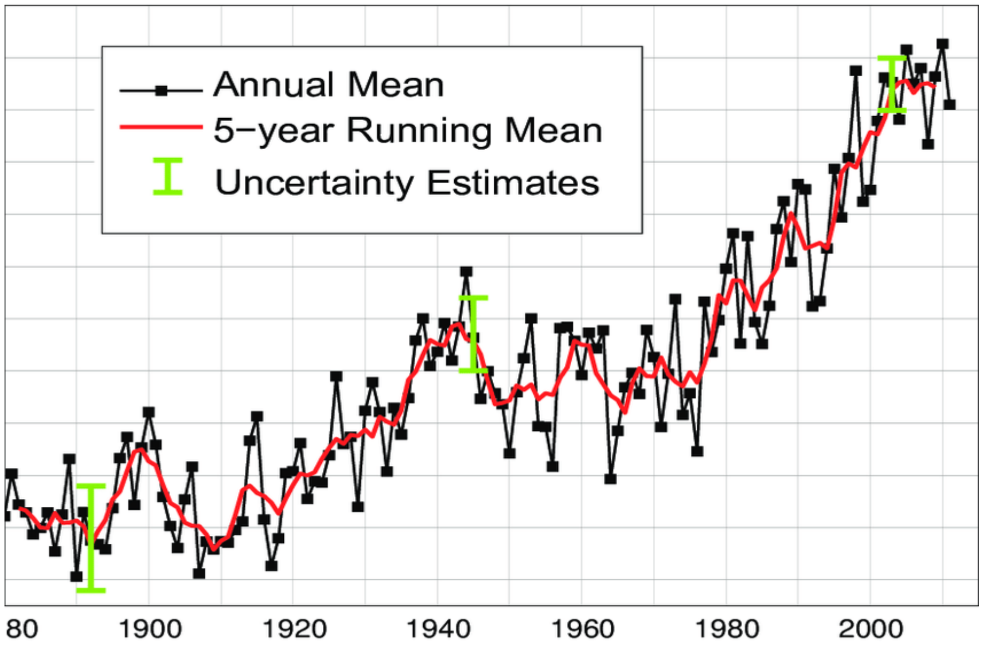

Figure 8. Global mean land-ocean temperature index, 1880 to present, with the base period 1951-1980. Source: GISS NASA (2012).

On page 11, the paper copies Figure 2 herein (taken from [5]) but interprets it differently to its authors, in that it presumes that the graph shows that 2xCO2 has no significant effect on forcing or by implication on temperature Tw.

The paper concludes:

"For these physicists [Happer and van Wijngaarten] *the "consensus" that carbon dioxide is the "control knob" of Earth's climate is not supported by their analysis. Their careful calculations imply that we have nothing to fear from rising carbon dioxide levels in the 21st century as the reasons for the recent global warming have to be found elsewhere; more probably in the Sun with its many different and very complicated interactions with the Earth." (p11 [7])*

Conclusions

The papers discussed in this appendix are probably as good as the published science gets.

There appears to be sound proof, at least theoretically, that 2xCO2 concentrations would produce a Radiation Forcing (F) of 3 W/m^2, a Climate sensitivity of 2.3°C and a Specific Climate Sensitivity of 0.77 °C/W/m^2.

However, a few serious anomalies remain. There are still valid questions to be answered in respect of the true relationship between CO2 ppm and temperature Tw, namely:

- How can similar rates of increase in temperature Tw be the result of quite different rates of change in CO2 ppm, for the periods 1910-1940 and 1970-2000?
- What is the scientific explanation for the distinct cooling period from 1940 to 1980 which has not been convincingly explained by climatologists? It is a serious anomaly in the argument by climatologists that needs to be explained.
- What is the true role of cosmic and solar weather on global warming, if any?
- What is the true role of water vapour and cloud behaviour around the planet? *"we are dealing with a coupled chaotic nonlinear system and therefore the prediction of future climate states is not possible.' IPCC Report 2001 (14.2.2.2).*

The second crucial claim that *"the essential and only cause of temperature change is the change in concentration of non-condensable greenhouse gases in the atmosphere, particularly CO2"* is still not proved.

This writer often asks himself, on one hand, whether the climatologists of repute and the so-called contrarians (of equal, relevant scientific knowledge) have ever sat down together to compare their respective methodologies, models, data sources to come to an agreed position, rather than writing papers of opposite positions, as if in a high school debate. On the other hand, one can understand why all those climatologists involved in 'research' and particularly those in preparation of the technical position commissioned by and espoused by the IPCC, are of one voice. Otherwise, they would be branded sceptics and contrarians and even lose their lucrative positions in their respective organisations for not toeing the 'party line'.

Australian Logistics Study Centre

26 March 2021

ANNEX F TO
A view on permanent climate change

DEMAND FOR ENERGY AND GREENHOUSE EMISSIONS

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About this Annex

This annex addresses the production and consumption of energy across the world in general and in Australia in particular; world and Australian coal production; renewable energy sources; and greenhouse gas emissions from these anthropological activities and puts into perspective Australia's almost negligible role in any global warming, let alone climate change.

Energy Sources

The primary sources of energy for use by humanity are as listed below, all of which, with the possible exception of nuclear, owe their existence to radiation from the sun, received over millions of years and every day:

- Fossil fuels comprising:
  - the various grades of petroleum, black coal, brown coal, peat and natural gas; and
  - old growth forests[140].
- Renewable energy: solar; wind; hydro; geo-thermal; bioenergy/biomass, marine (wave and tidal action); geothermal; and energy storage (batteries and pumped-hydro). This is the currently accepted scope of 'renewables' but see the following discussion.
- Nuclear [none in Australia].

World production and consumption of energy

This section is included because of the relationship between demand for energy and the emissions of greenhouse gases produced by that demand. In the past 40 years (1980-2020), both the world

[140] Old growth forests are not normally included as a fossil fuel but in fact they are just that. Trees 300 years old can hardly be considered as renewable sources.

demand for energy and greenhouse gas emissions have doubled, some 95% of which have been caused by burning fossil fuels.

Although not strictly true, for the purposes of this discussion, world production of energy equals world consumption plus that which may be stored one way or the other. Some countries produce a lot but use relatively little, while others produce little but consume a lot.

Caution: *In this discussion and in the tables shown, energy consumption may be given in various units of measurement.*

One record of world energy consumption is that at Table F1, from the Global Energy Statistical yearbook. [1] It also shows the world electricity consumption and its percentage of total energy, at about 15% in 2020.

Note in this table that the unit of consumption is in TeraWatts (TW), compared to the figures in Table F2 that are in TeraWatt Hours per annum (TWh pa). TW should be considered as the amount of power being consumed at a given time, e.g., at a set time on a given workday, whereas TWh pa is the consumption over a year.

Note also the quite large difference in the total consumption figures between Table F1 and Table F2 - 170,573 TW compared to 119,000 TWh. It is difficult to determine any valid relationship between these two measures without detailed analysis of data on hourly, daily, weekly and seasonal demand for power.

Table F1 [1]

World Energy Consumption

Year	Total Mtoe [1]	11.630 TW [2]	Elec TW	%	Notes
1980	6,800	79,084	8,000	10.1%	[3] [4]
1985	7,200	83,736	9,000	10.7%	
1990	8,000	93,040	10,000	10.7%	
1993	8,500	98,855	11,000	11.1%	
1995	8,800	102,344	12,000	11.7%	
2000	9,400	109,322	13,500	12.3%	
2005	10,900	126,767	15,500	12.2%	
2010	12,200	141,886	18,000	12.7%	
2015	13,000	151,190	21,000	13.9%	
2018	14,000	162,820	23,000	14.1%	
2020	14,667	170,573	26,000	15.2%	

Notes:
1 Mtoe = Millions Tonnes oli equivalent
2 TW = 11.63 Mtoe
3 Extrapolation index 2020/2018 = 1.05
4 Extrapolated figures in red
Glogal Energy Statistical year book
www.yearbook.enerdata.net/total-energy

World production and consumption of energy was relatively flat until about 1980. In the 40 years since it has doubled in direct proportion to the world population in the same period.

Most of the growth in global electricity consumption occurred in Asia (almost 80%, with China accounting for nearly 60%). Electricity demand in China accelerated against steady economic growth and industrial demand. Demand also increased in India, South Korea, Japan and Indonesia.

Table F2 shows the world consumption of energy but in TWh pa [2]. The figure of 22.7% for electricity consumption of the total is in contrast to Australia's percentage of electricity at 27%. This is most probably a consequence of Australia being a relatively high consumer of electricity as a developed nation compared to the majority of countries, many underdeveloped still.

Yet another reference [3] gives a world figure for consumption of fossil fuels at 147,000 TWh pa. Consequently, data can vary considerably by source.

From Table F13, world CO2 emissions in 2020 were determined to be 36,500 million tonnes. Given that there are 2.86 kg of CO2 produced for every tonne of coal burnt, these emissions represent the equivalent of 12,760 million tonnes of coal burnt. This is compared with the 10,236 million tonnes of oil equivalent (Mtoe).

According to another reference, Heat Values of Various Fuels [4], the crude oil/black coal heating ratio is 1.68 (42/25 MegaJoules/kg = 1.68), 10,236 million tonnes of oil equivalent would mean 17,190 tonnes of coal equivalent. This figure does not correlate well with 12,760, once again showing the discrepancy possible between data sources.

From another reference, Heat Values of Various Fuels [5], the crude oil/black coal heating ratio is 1.28 (161.3/205.7 Btu = 1.28). Thus, 10,236 million tonnes of oil equivalent (diesel & fuel oil) would mean 13,100 tonnes of bituminous coal equivalent. This figure is virtually the same as the 12,760 million tonnes of coal equivalent burnt.

One may conclude that the total world demand for energy in 2020 was in the order of 13,000 million of bituminous coal equivalent and 10,240 million tonnes of oil equivalent, producing about 36,500 million tonnes of CO_2 per annum, this latter figure corresponding to a concentration of CO_2 in the atmosphere of 413 ppm.[141]

Table F2 [2]

World Energy Consumption			TWh pa		
	11.630 [1]		1.018 [2]		
	Total		Electricity	[3]	
Year	Mtoe	TWh pa	TWh pa	%	Notes
1973	4.672	54,335	6,129	11.3%	
1980	-	60,000	*6,800*	11.3%	[4]
2010	8,677	100,914	21,431	21.2%	
2011	8,918	103,716	22,126	21.3%	
2012	8,979	104,426	22,668	21.7%	
2013	9,301	108,171	23,322	21.6%	
2014	9,425	109,613	23,816	21.7%	
2015	9,384	109,136	*24,233*	22.2%	[4]
2016	9,717	111,046	24,650	22.2%	[4]
2017	9,717	113,009	25,606	22.7%	
2018	9,887	114,987	*26,054*	22.7%	[4]
2019	10,060	116,999	*26,510*	22.7%	[4]
2020	10,236	119,046	*26,974*	22.7%	[4]

Notes:
1 Ratio: Millions Tonnes oil equivilalent to TeraWatt hours
1 1 Mtoe = 11.63 TW
2 Extrapolation index for figures in red.
3 % electricity of total
4 Extrapolated figures in red
en.wikipedia.org/wiki/World_energy_consumption

Note in this table that the unit of consumption is in TWh per annum, compared to the figures in Table F1 that are in TW.

TW should be considered as the amount of power being consumed at a given time, whereas TWh is the consumption over a year, normally.

TWh is the unit charged by electricity companies.

This table shows a much higher percentage of electricity to total demand, at 22.7% average for the world, compared to Australia's 27%.

The foregoing figures are tabulated in Table F3 for quick reference.

Table F3 [4] [5] [6]

World energy demand 2020				
Fuel Type	CO2 Pounds/ Btu*10^6 [1]	CO2 Ratio Oil/Coal	Heating Value MJ/kg [2]	Ratio MJ/kg
Coal	207.50	1.00	25.00	1.00
Fuel Oil	161.30	1.29	42.00	1.68
CO2 Emissions	2020 T*10^6			
Reported	36,500	[3]		
Fuel Oil Demand	[4] 2.86 T*10^6 [5] [6]	Coal Equivalent [7] [8]		Coal Equivalent [9]
Coal	12,762	**12,762**		12,762
Fuel Oil	10,236	**13,168**		17,196

Notes:
1. *www.eia.gov/tools/faqs/faq.php*
2. *www.world-nuclear.org/.../heat-values-of-various-fuels*
3. CO2 emissions 2020 - for 413ppm pa [Table F1-3]
4. Tco2/Tcoal = 2.86
5. Tcoal*10^6 = 36,500/2.86
6. *www. En.wikipedia.org/ .../world energy consumption*
7. World demand Coal equivalent [T*10^6]
8. Very high agreement indicating validity, based on CO2 emisions.
9. Poor correlation based on relative heating values

Australian Production and Consumption of energy

Table F4 is a general look at the Australian demand for energy, by sectors, extrapolated from 2016-17 to 2020. One may see that electricity and transport are the two main consumers, at 27% and 30% respectively.

141 Ppm = parts per million by volume.

Table F4 [7] Australian Energy Update, Aug18, Dept of the Environment and Energy

Australian Enegy Statistics [1]				
Consumption by Industry			**2.00**	[2]
	2016-17	**pa**	**1.03**	[3]
Sector	**%**	**%**	**2018-20**	**Notes**
Electricity	**27.5%**	**-2.0%**	**27%**	
Transport	27.5%	2.8%	30%	
Manufacturing	17.5%	-2.1%	17%	
Mining	10.9%	11.8%	14%	
Residential	7.5%	-50.0%	2%	
Commercial	5.6%	1.7%	6%	
Agriculture	1.9%	5.9%	2%	
Other	1.6%	1.0%	2%	
Total	**100.0%**		**100.0%**	
Notes:				
1. Australian Energy Update, Aug18, Dept of the Environment and Energy				
2. Two-year upgrade factor				
3. Two-year upgrade factor				

Table F5 shows the situation in Australia for CO2 emissions by sector. Again, as expected, electricity and transport, as users of fossil fuels, are the main players. While electricity generation may be causing 33.8% of emissions[142] at present, renewable energy sources that are increasing substantially every year will progressively bring this figure down, hopefully to sustainable levels. Refer to Appendix F1 for discussion on renewables.

Table F5 [8]

Share of Total emissions, by sector, Australia, June 2019		
Sector	**%**	**Notes**
Electricity	33.8	
Stationary energy (excl electricity)	18.9	[1]
Transport	18.9	
Fugitive emissions	10.6	[2]
Industrial proceses	6.5	
Agriculture	12.7	
Waste	2.2	
LULUCF	-3.4	[3]
Total	**100**	
Notes:		
1. Stationary energy excluding electricity includes emissions from direct combustion of fuels, ... manufacturing, mining, residential and commercial sectors.		
2. Fugitive emissions from the gas industry arise from leaks from equipment, venting or flaring of gas at every stage of the gas supply system.		
3. Fossil fuels, deforestation, land use and land-use changes		
Scoping Paper, 2019, Business Council Australia (BCA)		

Tables F6 and F7 give basic statistics for energy in general and for electricity in particular. In 2018-19, electricity was consuming 23.36% of total energy consumed and of that 21.16% was by renewables. At that rate, renewables accounted for 4.9% of total energy consumed.

The reference for Table F7 cites a figure of 27% of energy consumed for electricity and 23.17% of which is generated be renewables, giving a figure of 6.26% of energy provided by renewables.

Other sources claim the renewable figure in 2020 is as much as 24%. The actual figure is probably somewhere between 21% and 24%. For 2020, a figure of 24% is accepted in this paper for the contribution by renewables to the electricity sector consuming 27% of total energy demand, being only 6.5% contribution from renewable sources. Although a lot of claims are heard from the renewables industry about how renewables will power the Earth, 6.5% is a long way from replacing fossil fuels.

142 Electricity sector accounts for 33.8% emissions, from 28% of fossil fuels consumed in Australia.

Table F6 [9] [10]

Australian Enegy Statistics	[1]			
Consumption by Fuel	%	%	2.00	0.95
Sector	2016-17	pa	2018-19	
Fossil Fuels	**76.00%**	**12.10%**	**76.72%**	
Coal	2.90%	5.80%	3.09%	
Oil (refined products)	51.70%	2.40%	51.63%	
Gas	21.40%	3.90%	22.00%	
Electricity	**24.00%**	**5.20%**	**23.36%**	
Electricity (coal/gas fired)	19.30%	0.10%	18.42%	
Renewables	4.70%	5.10%	4.94%	**21.16%**
Total	**100.00%**		**100.09%**	**Actual=23%**
Notes:				
1. Department of the Environment and Energy			Update Aug18	

It is estimated that Australia produced 48,279 gigawatt-hours (GWh) of renewable electricity in 2018, which accounted for 21.3% of the total amount of electricity generated in Australia.
www.en.wikipedia.org/wiki/Renewable_energy_in_Australia

Table F7 [11]

Australian Electricity Generation	Dec-19
Sector	%
Fossil Fuels	**76.00%**
Gas	**4.50%**
Distillate	**0.70%**
Coal	**70.80%**
Black Coal	54.10%
Brown Coal	16.70%
Renewables	**23.17%**
Solar	**10.70%**
Roof	7.30%
Utility	3.40%
Wind	8.30%
Hydro	4.10%
Battery (discharge)	0.04%
Biomass	0.03%
Total	**99.17%**
Consumption by Industry	**100.00%**
Electricity	27.00%
Rest	73.00%
Renewables (% electricity use)	**6.26%**
www.RenewEconomy.com.au	

Table F8 gives an up to date (June 2020) snapshot of the generation of electricity in Australia. Note that these figures are for instantaneous production of electricity in MegaWatts (MW) at a specific time on 4 June 2020. Figures for annual consumption of electrical energy are measured in MegaWatt.Hours (MWh) and which is the basis of charging for consumption.

The instantaneous generation in Table F8 by renewables is 15.5% whereas, in terms of annual consumption by MWh is 23%. As mentioned earlier under 'World production and consumption of energy', it is difficult to determine any valid relationship between these two measures without detailed analysis of data on hourly, daily, weekly and seasonal demand for power.

Table F8 [12]

Electricity Generation - Australia 4 June 2020		[1]	MegaWatts (MW) generated [2]									
Region	Fossil Fuels					Renewables					Total	Total
	Coal		Gas	Fuel	Other	Hydro	Wind	Solar		Storage		
	Black	Brown		Liquid				Large	Small	Battery	MW	%
Western Australia	691	-	1,144	0	9	-	10	-	355	-	**2,210**	**7.5%**
Tasmania	-	-	0	-	0	1,643	112	-	0	-	**1,756**	**6.0%**
South Australia	-	-	1,214	0	0	-	61	23	113	19	**1,431**	**4.9%**
Victoria	-	4,738	466	-	0	1,544	0	8	36	11	**6,802**	**23.2%**
New South Wales	8,487	-	423	0	0	62	41	11	33	-	**9,058**	**30.9%**
Queensland	5,728	-	1,879	0	0	118	177	121	37	-	**8,061**	**27.5%**
Total	**14,907**	**4,738**	**5,126**	**0**	**9**	**3,367**	**402**	**163**	**574**	**30**	**29,316**	**100.0%**
%Source	**50.8%**	**16.2%**	**17.5%**	**0.0%**	**0.0%**	**11.5%**	**1.4%**	**0.6%**	**2.0%**	**0.1%**	**100%**	
%Coal : %Solar	**67.0%**							**2.5%**			**70%**	[3]
%Fossil : %Renewable	**84.5%**					**15.5%**					**100%**	[4]
Notes:												
1. www.reneweconomy.com.au/nem-watch/												
2. Megawatts generated on the day.		MegaWatt Hours (MWh) over a year can give differen statistics (see Note 4).										
3. Solar very small compared to coal												
4. Renewables only 15.5% instantaneous in MW compared to 23 % for annual consumption in MWh.												
https://reneweconomy.com.au/nem-watch/												

Table F9 shows Australia's per capita consumption of electricity compared to several other developed countries. Iceland's very high figure is explainable, given its cold climate but mainly because the cost of electricity there is very cheap in comparison.

Note: *All countries are different in climate and cost of energy, which should not be forgotten when making comparisons between countries.*

Table F9 [6]

Countries by electricity consumption		
Energy Consumption Source: mostly CIA	**KwH/p/Y Examples**	**Rank**
World	**2,674**	
Iceland	50,613	1
Liechtenstein	35,848	2
Norway	24,006	3
Kuwait	19,062	4
United Arab Emirates	16,195	5
Canada	14,930	6
Sweden	12,853	7
USA	12,071	8
Australia	**9,742**	**9**
Saudi Arabia	9658	10
China	**4,475**	11
India	1181	12
en.wikipedia.org/		

This table shows that, although Australia is a high consumer of electricity per capita at 9,742 KWh pa, it is still way down the list at 9th place, behind the USA and ahead of China. However, note China's relatively high consumption given its 1.4 billion population.

World coal production and reserves

A great deal of noise is made by environmentalists in Australia about its production of coal and thus its contribution to global greenhouse gas emissions. Yet, in reality, Australia is a relatively small producer of coal, although the largest exporter. In fact, Australia is down the list in 5th place, producing only 7% of the world's coal compared to China at 50%.

Note the figure of 20,165 million tonnes of CO2 produced by coal, being about 57% of the total world emissions of CO2 in 2020 of 35.6 million tonnes.

Table F10 [13]

Top World Coal Producers 2019			Tco2/Tcoal	2020/2018	
Country			2.86	0.99	[1] [2]
	2018 Tn*10^6	**2018 %**	**CO2 2018 Tn 10^6**	**CO2 2020 Tn 10^6**	**Notes**
PR China	3,550	50%	10,153	10,051	
India	771	11%	2,205	2,183	
USA	685	10%	1,959	1,940	
Indonesia	549	8%	1,570	1,554	
Australia	**483**	**7%**	**1,381**	**1,368**	**[3]**
Russia	420	6%	1,201	1,189	
Sth Africa	259	4%	741	733	
Germany	169	2%	483	479	
Poland	122	2%	349	345	
Kazakstan	114	2%	326	323	
Total [4]	**7,122**	**100%**	**20,369**	**20,165**	
Notes:					
1. 2.86 tonnes of CO2 per tonne of coal					
2. 2020/2018 ratio = 0.99					
3. Australia only 5th in world					
4. Totals only of those listed, not all in world.					
Source: IEA Coal Information 2021					

Table F11 shows the top three countries with highest quality coal reserves. Australia is third with 14% of world reserves, but is the biggest coal exporter.

"In 2016, Australia was the biggest net exporter of coal, with 32% of global exports (389 Mt out of 1,213 Mt total), and was the fourth-highest producer with 6.9% of global production (503 Mt out of 7,269 Mt total). 77% of production was exported (389 Mt out of 503 Mt total)." [14] www.en.wikipedia.org/wiki/Coal_in_Australia#:

"Export volumes are expected to grow from 874 million tonnes in 2019–20 to 898 million tonnes by 2020–21, and to 996 million tonnes by 2024–25." [15] www.publications.industry.gov.au/publications/resourcesandenergyquarterlymarch2020

Table F11 [16]

World coal reserves						
Countries by coal reserve						
Country	Anthracite & bituminous		Subbituminous & lignite		Total	
	Tons (mil)	%	Tons (mil)	%	Tons (mil)	%
United States	220,167	30%	30,052	9.40%	250,219	24%
Russia	69,634	9.50%	90,730	28.40%	160,364	15%
Australia	70,927	9.70%	76,508	23.90%	147,435	14%
https://en.wikipedia.org/wiki/List_of_countries_by_coal_reserves						

Extra row height required for both Russia and Australia entries to ideally separate the text from the flag image (as per USA above).

World Greenhouse gas emissions

Table F12 shows world CO2 emissions, as derived from emissions given in tonnes of carbon. Note that it is common for emissions to be stated by countries (under IPCC protocols) in tonnes of carbon, as derived by formula for the various sources of national production.

This source again gives world production of CO2 at about 36.5 million tonnes in 2020.

In terms of total emissions, Australia is ranked 16th in the world.

Table F12 [17]

Carbon and CO2 emissions - estimates 2020		[from 2014 data]			
[1]	1.069	3.67	[2]		
Country	Tcarbon	Tco2	%	Rank	Notes
World	9,319,790	36,522,519	100%		[3]
China	3,001,005	11,013,687	30.16%	1	[4]
USA	1,532,086	5,622,755	15.40%	2	
India	652,684	2,395,352	6.56%	3	
Russia	497,259	1,824,939	5.00%	4	
Japan	354,002	1,299,188	3.56%	5	
Germany	209,910	770,368	2.11%	6	
Iran	189,381	695,028	1.90%	7	
Saudi Arabia	175,258	643,198	1.76%	8	
Rep Korea	171,208	628,333	1.72%	9	
Canada	156,639	574,866	1.57%	10	
Brazil	154,486	566,963	1.55%	11	
South Africa	142,812	524,119	1.44%	12	
Mexico	140,041	513,951	1.41%	13	
Indonesia	135,348	496,728	1.36%	14	
UK	122,415	449,262	1.23%	15	
Australia	105,340	386,597	1.06%	16	[5]
Others	100,884	370,245	22.23%		
Notes:					
1. Data escalation rate = 1.069 (6 years @ 1.01122 pa)					
2. 3.67 Tco2 to Tcarbon					
3. 36,522,519 agrees with derivation from other data					
4. China producing 30.16 %					
5. Australia (Rank 16th) producing 1.06%					
Source: www.cdiac.ess-dive.lbl.gov/trends/emis/top2014.tot					

Table F13 give estimates from three different sources for CO2 generated in the world for 2020. All are in reasonable agreement but with 36.5 billion tonnes per annum being the most probable and all within an error band of +- 7%. The differences do illustrate, again, the variation in data for various sources.

Table F13 [18] [19]

World CO2 Emissions (2020)	
Tonnes CO2 10^9	Source
36.5	Actual total world CO2 emissions in 2020 [see emissions table Annex E]
40.00	*https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions*
41.57	*https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data*

As an example, Table F14 gives the growth in CO2 emissions from 1980 to 2020, according to the source listed. Note that the 2020 figure of 41.47 tonnes of CO2 exceeds the most probable value of 36.5 billion tonnes that has been derived from independent sources.

Table F14 [19]

World CO2 Emissions			
		3.67	[1]
Year	Tonnes Carbon 10^9 [2]	CO2 10^9	Notes
1980	5.30	19.45	
1985	5.40	19.82	[3]
1990	6.00	22.02	
1995	6.30	23.12	
2000	6.70	24.59	
2005	8.00	29.36	
2010	9.00	33.03	
2014	9.80	35.95	
2015	10.50	38.54	
2020	11.30	41.47	
Notes:			
1. 3.67 tonnes CO2 per tonne of carbon			
2. Emissions include cement manufacture			
3. Values in red, extrapolated from graph			
www.epa.gov/ghgemissions/			
global-greenhouse-gas-emissions-data			

Table F15 shows the estimated growth in CO2 emissions, given a population growth from 7.8 billion in 2020 to 10.9 billion in 2100.

Note that this source [20] gives a figure of 36.7 rather than 36.5 billion tonnes of CO2 pa, but well within a small error band.

In respect of Notes 4 and 5 in Table F15, refer to Annex G, W*orld population growth and consequences.*

Table F15 [20]

CO2 emissions - Growth			
Parameter	2020	2100	Notes
	Billions	Billions	
Population-world	7.795	10.875	[1]
CO2 Emissions World	Billions Tonnes pa		
At current rate by country	36.705	37.726	[2] [3]
At policy reduction rate		52.622	[4]
All achieving average emissions		56.169	[5]
Notes:			
1. Source: UN Probabilistic Population Projections - Aug19			
2. 2020 world CO2 emissions			
3. 2100 world CO2 emissions - at current emissions per capita.			
4. 2100 world CO2 emissions - at Policy reduction targets.			
0.041% growth pa - Not much but unsustainable			
5. 2100 world CO2 emissions - at average emissions per capita.			

Emissions per capita

Table F16 shows the CO2 emissions per capita for the higher emitting countries. Contrary to improper promotion by climatologists, Australia is only 14th in per capita production of emissions, even though Australia's per capita emissions are relatively high, especially in relation to Canada and the USA. However, one must note that every country's energy needs are different, as a function of many variables, particularly climate, population, population density, relative level of industrialisation and primary production and government policies.

In Australia's case, the emissions per capita are high because of our small population density in a large continent which exacerbates fossil fuel consumption, with a mild to hot climate (air-conditioning is cheaper than heating), a large primary production sector and a dependence on fossil fuel generation of electricity, given government policy not to have nuclear power plants.

Table F16 [21]

CO2 emissions per capita (Epc)			
Sample Countries	**EPc TCO2 pa**	**Rank**	**Notes**
Max	64.90		
Average	5.16	of 223	[1]
Median	2.60	countries	
Min	0.10	listed	
Australia	16.80	14	[2] [2A]
Canada	16.10	16	[2]
United States	16.10	17	[2]
Japan	9.40	32	[2]
Norway	9.40	33	[2]
Germany	9.10	36	[2]
China	8.00	44	[3]
New Zealand	7.70	50	[4]
United Kingdom	5.60	69	[5]
France	5.00	75	[6]
Sweden	4.50	84	[7]
Egypt	2.70	113	[8]
Brazil	2.40	116	[8]
Indonesia	2.10	120	[8]
India	1.90	136	[8]
Pakistan	1.00	156	[8]
Nigeria	0.60	172	[8]
Notes:			
1. Unlikely to be reached by all countries			
2. Needs to come down			
2A. Australia: only 1.17 % of world CO2 emissions			
3. Should not increase but will			
4. OK			
5. On average: 25% nuclear power			
6. On average: 70% nuclear power			
7. High % renewales and nuclear			
8. Sleepers - high population growth			
9. *en.wikipedia.org/... by countries CO2 emissions*			

Table F17 is a summary of Australia's position in respect of CO2 emissions. It shows that Australia is only 0.32% of the world's population and produces only 1.12% of world emissions in 2020. Note that elsewhere in the paper, the figure of 1.06% is used for Australia's contribution to world emissions and some literature may cite the figure of 1.03%. Whichever is actually correct, the figure is very small, to the point that whatever Australia does to lower emissions, will make virtually zero effect of global warming, let alone climate change.

Table F17 [21]

CO2 Emissions - World/Australia comparison					
	2020				
Parameter	World	Australia	%	Rank	Notes
Population [millions]	7,795	25.0	0.32%		[1]
CO2 Emissions [billions tonnes pa]	36.705	0.413	1.12%		[2]
CO2 Emissions per capita [tonnes pa]	5.43	16.50	304%	14th	[3] [4]
Notes:					
1. Australia's population could double by 2100					
2. Australia's emissions are negligible on a world scale.					
3. High but due mainly to Australia's relative transport costs.					
4. High per capita but still only 14 highest in world					
en.wikipedia.org/... by countries CO2 emissions					

Summary

The pertinent content of this annex is summarised in the Table F18.

It also poses several questions that Australian climatologists should be pressed to answer in a rational manner.

Table F18

Energy - Australia - 2020 Fact Sheet
Facts for 2020
Population
The world population is currently 7.8 billion, going to 10.9 billion by 2100.
The world population is currently growing at 36 million a year.
Australia has only 25 million, ie 0.32% of the world population (25M/7.B.)
Coal production
China is the world's biggest coal producer at 50% of total.
Australia is 5th and produces only 7% of world production.
Australia has third highest high-quality coal reserves at 14% of total.
Australia is the leading world exporter of coal.
Australia exports its high-quality coal only because other countries want to buy it.
Australia does not export GHG emissions.
Energy production
The world produces a total of at least 10.236 billion tonnes of oil equivalent per annum
The world produces a total of at least 12.762 billion tonnes of coal equivalent per annum
The world per capita consumption is 2,674 KWh pa.
Australia per capita consumption 9,742 KWh pa, but 9th in world.
CO2 Emissions
The world produced a total of 36.5 billion tonnes of CO2 per annum
World per capita production of CO2 was 5.16 tonnes.
Per capita consumption in one country was as high as 64.9 tonnes
Australia's per capita production of CO2 was 16.8 tonnes; ranked 14th in world.
But Australia produces only 1.06% of world emissions.
Renewable energy in Australia
Electricity accounts for 27% of energy consumed in Australia.
Renewables account for 24% of electricity generated in Australia
Therefore, renewables account for only 6.5% (0.27*0.24) of energy used in Australia.
Global warming and climate change
Australia is having virtually zero effect on global warming or climate change.
Australia is wasting resources investing billions in renewable energy.
Australia should invest to protect itself against detrimental climate change.
Questions Australian climatologists should answer
Why should Australia waste resources on renewable energy when we have zero effect on climate change?
Why damage ourselves economically by banning coal when other countries would buy dirtier coal?
Why deny developing countries the use of coal to better their lot?
Why should Australia do more to reduce GHG emissions than required to meet international obligations?
Why should Australia not be investing in climate-proofing itself rather than subsidising renewables?
Why should Australia continue to subsidise renewables at great cost with little result?

Conclusion

This annex has covered the subjects of world energy consumption, the sources of that energy (fossil fuels and renewables) and resulting greenhouse gas emissions[143] , as well as Australia's place in respect of each of these aspects.

Australian climatologists, like others around the world, aided and abetted by promoters and believers, especially in the Media, have been agitating loudly for the Federal Government to do more to prevent global warming and any consequent climate change. In particular they want to shut down the coal industry, the country's second biggest export earner, and **seek** more subsidies for renewable energy. Although well intentioned, in their eyes, Australia should do whatever it takes, at whatever cost to reduce greenhouse gas emissions.

Yet the reality is that whatever Australia does, it will have virtually zero effect on global warming and climate change. Our contributions to world emissions are miniscule now, so why waste billions of dollars more to have even less effect?

China is and will remain by far the world's biggest consumer of energy (and thus producer of emissions; 30%). It is by far the biggest coal producer in producing 50% of the world's coal, about seven times more than Australia in fifth place, and thus, the biggest emitter of greenhouse gases.

While Australia is indeed the world's leading exporter of highest-quality coal, it does not export greenhouse gas emissions; it exports coal and natural gas only because other countries want these products, without which they would use inferior coal and so produce greater levels of emissions. No buy - no export!

While coal is seen as the 'bad boy', world consumption of liquid petroleum products and natural gas are each larger or about the same as for coal. So, where are the complaints about petroleum and gas usage from the environmentalists still driving fossil-fuelled vehicles and happy to fly around the world? Is there not a bit of hypocrisy here?

India is currently a giant 'sleeper', which, with 1.4 billion people, can be expected to consume greater levels per capita of energy over the rest of the century, and with consequent greenhouse gas emissions. How can the industrialised nations morally deny developing nations the right to a better standard of living without the use of coal as the cheapest source of energy?[144]

Nevertheless, the climatologists, especially in Australia, are strangely quiet when it comes to China and India,

One often hears in the Media that Australia's per capita consumption of energy and emissions are relatively high. That is so but with good reason, given our geography and demographics. It is also modest compared to many other countries, Australia being 9th and 14th respectively on these measures.

China, the USA and Europe consume over 50% of the world's energy production, some 90% or more of which comes from fossil fuels. At about 1.06% of global emissions, Australia cannot in any way affect global warming let alone climate change. It has not and cannot. This does not mean that we do nothing, but we do need only to do our share as a responsible world citizen. We do not have to shoot ourselves in the foot trying to big-note ourselves to the other small emitting countries that tend to dominate votes in the United Nations. Australia could disappear off the map tomorrow and it would make no difference to global warming or climate change.

While pursuit of renewable energy sources is considered a good thing, there is a very, very long way to go. Australia may be the per-capita world leader in renewable energy, yet it accounts for only about 6.25% of the energy it consumes itself. The figure is much less for the world as a whole.

It is wrong for climatologists and the Media to imply that the Australian Coalition Government is not doing enough about climate change. It is doing as much as it needs to do to meet its international obligations. Why should it do more at considerable cost for no effect?

[143] CO2 is used as a proxy for all greenhouse gases.

[144] One should not be taken in by the claims that renewables are cheaper than coal/gas fired generators.

Our real challenge is to recognise the probable effects of climate change on Australia (not good), what, when and how they might occur and how we as a nation might best respond. Australia can move only to protect itself, climate-proof itself, as best it can against any changing climate such as extended droughts and bushfire disasters. That is where Australia's investment should go and not be wasted on chasing ineffectual reductions in greenhouse gas emissions.

Climate-proofing would include projects to capture the billions of tonnes of monsoonal rain running off into the sea each year; better arid-area farming and irrigation techniques; better education on water usage, to name a possible few.

And arguments one hears from proponents, that Australia should be out there leading an example to the world, although its contribution at 1.06% of emissions is miniscule, is specious, fatuous, grandiose and is sophistry if not hypocrisy as well. In his essay 'Of vainglory' in The Essays [22, p217] Sir Francis Bacon *writes "**A fly sat on the axle-tree of a chariot wheel and said, 'What a dust do I raise.**'"*[145]

Appendix F1, Renewable energy in Australia,

Australian Logistics Study Centre
Canberra, 24 July 2021 [amended 1Sep21]

[145] Incorrectly attributed to Aesop but was said by Lorenzo Bevilaqua [Note 1, The Essays, p217].

APPENDIX F1

RENEWABLE ENERGY IN AUSTRALIA

Introduction

All renewable energy produced in Australia is to meet the demand for electricity.

Its production is promoted continually and loudly by the political left, its fellow travellers, vested interests and self-proclaimed expert lobby groups, as the panacea to climate change.

The renewables industry in many countries is growing at a rapid rate, thanks largely to attractive and large subsidies from governments. In Australia, the industry attracts generous subsidies from all governments - Federal and State - warranted or not.

There is no real argument against the industry, given its main claim to fame of producing zero greenhouse gases when in operation. Of course, one never hears about the greenhouse gas 'footprint' of wind turbines, solar farms and the infrastructure to service them, ie getting and processing primary resources, manufacture, transport, installation, operation and maintenance and eventual disposal, noting that these installations have a limited life of some 20-25 years at best (some sources put the life of these sources as low as 15-25 years).

A major concern about the publicity of renewable energy is that, despite its impressive growth, it still produces only a fraction of electricity needs let alone of the total energy needs.

Australian energy lobby groups[146]

Climate Council

The Climate Council claims to be Australia's leading climate change communications organisation. The Council is headed up by Professor Tim Flannery and is made up of some of the country's leading climatologists, health, renewable energy and policy experts from various universities, including the Australian National University (ANU). See Box F1-1. It has an emailing list for subscribers.

Box F1-1 – Climate Council mission [23]

The Climate Council is Australia's leading climate change communications organisation. We provide authoritative, expert advice to the Australian public on climate change and solutions based on the most up-to-date science available.

We're made up of some of the country's leading climate scientists, health, renewable energy and policy experts, as well as a team of staff, and a huge community of volunteers and supporters who power our work. As an independent voice on climate change, we get climate stories into the media, produce hard-hitting reports, call out misinformation as we see it and promote climate solutions such as the transition to renewables.

The Climate Council was founded in 2013 by tens of thousands of Australians to create a new, an independent and 100% community-funded organisation in response to the abolition of the Australian Climate Commission.
www.climatecouncil.org.au

Clean Energy Council

The Clean Energy Council claims to be the peak body for the clean energy industry in Australia. See Box F1-2 for its mission statement. It has an emailing list for subscribers.

Box F1-2 – Clean Energy Council mission [24]

We are a not-for-profit, membership-based organisation. We represent and work with Australia's leading renewable energy and energy storage businesses, as well as rooftop solar installers, to further the development of clean energy in Australia. Our vision is for Australia to be powered by clean energy.

We are committed to accelerating the transformation of Australia's energy system to one that is smarter and cleaner. We do this through:

- Providing a strong voice for our members
- Standing up for the industry
- Developing and driving effective policy and advocacy
- Working with industry to continually improve standards and maintain integrity

146 All of these organisations have an emailing list for subscribers.

- Working closely with local, state and federal governments to increase demand for clean energy products
- Providing services and initiatives to members and the wider industry that help to grow the sector
- Promoting the clean energy industry.
  1. www.cleanenergycouncil.org.au

Renew Economy

Renew Economy is an Australian blog that reports daily and very 'energetically' on all facets of clean energy news and analysis, from around the world, but particularly for the Australian scene.

Although rather evangelic and somewhat biased, to say the least, the site appears to be a valuable resource which reports on just about anything **concerning** the renewable scene in Australia. [25] *www.reneweconomy.com.au/*

- Renewables: solar [rooftops; utility PV; solar-thermal]
- Storage: batteries; pumped-hydro
- EV: Hydrogen fuel cells

Australian Renewable Energy Agency (ARENA)

ARENA was established by the Australian Government on 1 July 2012. Its purpose is to improve the competitiveness of renewable energy technologies and increase the supply of renewable energy through innovation that benefits Australian consumers and businesses.

It has a very comprehensive website at *www.arena.gov.au/what-is-renewable-energy/* [26] which will tell a reader just about anything he or she would like to know about renewable energy - sources, batteries, electric vehicles, you name it.

Types of 'renewables'

Use of the term 'renewable' may be seen by some readers as incorrect from a semantic point of view, given that we do not actually create new energy, but rather simply convert it from one form to another.

So, at this point, there should be a distinction made between several types of renewables – neutral renewables, semi-neutral renewables, non-neutral renewables and nuclear renewables.

A neutral renewable source is one that is neutral in respect of the energy balance of the Earth System. Its essential features are that it does not add greenhouse gases or pollutants to the atmosphere (in operation)[147] or add new heat to the Earth System, the overall energy content of which remains unchanged. They extract energy from the Earth System, use it to do work and return it back to the System. Wind power, solar radiation and hydraulic power are the primary sources of neutral renewable electrical energy, with lesser quantities coming from the other sources.

A semi-neutral renewable source is the burning of bio-mass products which are produced from relatively quickly renewable vegetation (like sugar cane), and as such, can be thought of as energy neutral (longer term) in that the heat produced by burning is really only a short-term conversion from the energy form stored in the vegetation to another and, so, the earth's energy equation of the Earth System is not affected to any significant extent.

However, while burning bio-mass and bio-energy products such as ethanol (mixed with petrol), may be thought of as energy neutral, they cannot strictly be so considered because they do not necessarily burn cleanly and they put a greater percentage of greenhouse gases and pollutants into the atmosphere, per unit of energy produced.

A nuclear renewable source may not release greenhouse gases or pollutants into the atmosphere, but, different to a neutral renewable, all power generated by nuclear sources is ultimately released into the atmosphere and Earth System as new heat, like fossil and bio-mass fuels.

[147] However, all Neutral Renewable sources do have a 'dirty' through-life footprint from manufacture, transportation, installation, maintenance and support, through to disposal. These 'costs' are often neglected by proponents of 'renewables'.

All heat released initially into the atmosphere, from both non-renewables and nuclear renewables, has to be absorbed by the Earth System, whether by land and the oceans or remaining in the atmosphere, so contributing to global warming.

A non-renewable source is one that produces greenhouse gases and/or pollutants to the atmosphere (in operation)[148] and adds new heat to the Earth System, so changing the energy balance. The primary source of non-renewable energy is from burning fossil fuels (oil, coal and gas but also includes old growth forests)[149].

Australian production of renewables

See Tables F6 and F7 for production in percentage terms.

It is estimated that Australia produced 48,279 gigawatt-hours (GWh) of renewable electricity in 2018, which accounted for 21.3% of the total amount of electricity generated in Australia. [27]
www.en.wikipedia.org/wiki/Renewable_energy_in_Australia

However, the foregoing figures are considered outdated, updated references put the contribution of renewables to the energy sector at between 23% and 24% in 2020, with electricity accounting for 27% of Australia's total energy demand in 2020. Accepting the more generous figure of 24% gives a contribution of only 6.5% to the total energy demand.

Subsidies of renewables in Australia

Government (taxpayer) subsidies for renewable energy in Australia are quite large. They are continually encouraged by the 'green' proponents, but attract also a great deal of criticism from politicians and institutions alike.

The intention here is to give the scale of subsidies involved and not to offer a debate on value for money. It suffices to say that there is a great deal of investment and subsidy for zero effect on world greenhouse gas emission levels.

Box F1-1 [28]
Renewable energy subsidies to top $2.8b a year up to 2030, Financial Review, 13 March 2017.

Renewable energy sources such as wind and solar will receive subsidies of up to $2.8 billion a year up to 2030 to ensure Australia reaches its Renewable Energy Target, according to new research.

The research, commissioned by the Minerals Council of Australia, found solar photovoltaic technologies accounted for about half of the annual subsidies, or about $1.5 billion. Most of these came in the form of generous feed-in tariffs offered by state governments for households and businesses to install solar PV.

Subsidies paid to electricity generated by wind technologies amounted to about $902 million or 30 per cent of aggregate subsidies in 2015-16, according to the research by economic consultancy BAEeconomics.

On a per megawatt hour basis, solar received the largest subsidies with $214, followed by wind on $74, while other renewable sources received $33 per megawatt hour. The report found subsidies to coal generation amounted to about 40 cents per megawatt hour, while generation from non-renewable sources overall were 30 cents per megawatt hour.

As renewable energy increases its share of the national energy mix to the RET of 33,000 gigawatt hours by 2020, aggregate subsidies for renewable generation is expected to increase from $2.2 billion in 2017 to $2.8 billion a year from 2020 to 2030, the report found.

www.www.afr.com/politics/renewable-energy-subsidies-to-top-28b-a-year-up-to-2030-20170313-guwo3t

Energy from fuel cells

In his recent book "Superpower" [29], Professor Ross Garnaut makes a case for the future potential of Australia becoming a super power in renewable energy, not just for domestic and industrial use, but also for the production of hydrogen and then fuel cells.

[148] However, all Neutral Renewable sources do have a 'dirty' through-life footprint from manufacture, transportation, installation, maintenance and support, through to disposal. These 'costs' are often neglected by proponents of 'renewables'.

[149] Defined here as standing in 1980, before the world energy demand started to double by 2020.

Facilities for production of hydrogen by electrolysis, to be economically viable, would need to be co-located with complexes of huge renewable energy farms (solar and wind) and adequate, sustainable, fresh and pure water supplies. Whether hydrogen production is by electrolysis and/or other possible technologies, they would need the addition of ammonia production facilities (for the safe storage and transport of the hydrogen), and, preferably, a fuel cell production plant.

Although Professor Garnaut does not discuss in his book the economics of his ideas, he does conclude that the notion of exporting electricity to neighbouring countries (using high voltage direct current) would not be economically feasible. He says the better solution would be to use this renewable energy for processing our main mineral resources for iron and aluminium.

Such facilities are most likely to be a long way from and separate to the domestic/industrial grid. As such, any such project would need to be proven to be economic in its own right, ie without government subsidies. There is still a very long way to go on this proposition!

A Noddy's Guide to hydrogen

As for lithium batteries, there is also currently a lot of hyperbole about the future of hydrogen fuel cells as a better alternative for powering electric vehicles (EV).

The opportunity for hydrogen to compete favourably on a cost basis in local applications such as transport and remote area power systems is within reach based on potential cost reductions to 2025. Further, the development of a hydrogen export industry could represent a significant opportunity for Australia and a potential 'game changer' for the local industry and the broader energy sector due to associated increases in scale.

There is no shortage of information on the web about the future of hydrogen, even if a lot of it is promotional. Three good starters are:

- A quick coverage: [30] *www.thenewdaily.com.au/life/auto/2019/04/13/hydrogen-fuel-car-australia*
- In more detail: "Hydrogen for Australia's future", A briefing paper for the COAG Energy Council, Prepared by the Hydrogen Strategy Group, August 2018 {Dr Alan Finkel, Chairman]
- www.csiro.au/en/Do-business/Futures/Reports/Hydrogen-Roadmap .

So, what do we know about hydrogen?

- Hydrogen is a colourless, odourless, tasteless and non-toxic gas. It can be used like natural gas to heat homes and drive industrial processes. It can also be converted into electricity to power cars. It can produce little or zero emissions, making hydrogen very appealing to a world trying to reduce the greenhouse gas carbon-dioxide.
- In Australia, we have all the necessary resources to make hydrogen at scale: wind, sun, coal, methane, carbon sequestration sites and expertise.
- It is probably the most abundant element on the planet, comprising two atoms of the three making up every single molecule of water (H2O), but does not exist naturally as a gas for long, if at all.
- Hydrogen can be produced in an environmentally friendly manner. Even with coal as the main source of energy. Victoria is already producing hydrogen from brown coal, with exports of hydrogen in mind, albeit at a cost in greenhouse gas emissions.
- It is highly flammable and dangerous to use in its natural state. Special arrangements are required for its transport and storage. It is no longer used to float airships either, since the Hindenburg disaster of 6 May 1937.


]

- As an energy source for transport, it is not burnt as a fuel as such, but is used to generate electricity through hydrogen energised fuel cells.
- A fuel cell combines hydrogen and oxygen to produce electricity, heat, and water. Fuel cells are often compared to batteries in that both convert the energy produced by a chemical reaction into usable electric power.
- Direct emissions from a fuel cell vehicle are just water and a heat. This is a huge improvement over the internal combustion engine's litany of greenhouse gases.
- Fuel cells have no moving parts.
- In an automotive sense, the heavier the vehicle the more suitable it is for hydrogen because its carrying capacity isn't compromised by having to carry tonnes of batteries.
- Use of hydrogen fuel cells also permits faster refuelling of a vehicle than by electricity to charge batteries, taking about the same time as a load of petrol or diesel.
- A full six-kilogram tank of hydrogen shouldn't cost more than $85 (US$60) in today's money [if there was anywhere to actually refuel], for an estimated range of 650 km.
- However, it is far too early to tell how much hydrogen would cost at the "bowser". The 650 km Canberra-Sydney and back costs $80 at $1.50 /litre in a Subaru Outback.

However, there are serious downsides to overcome.

- The environmental cost of hydrogen production, distributing it and building a refuelling network to supply it are all major issues [and expensive].
- Hydrogen has to be produced via electricity and fresh/pure water, ie by electrolysis. It is an energy intensive process - both to produce pure water and for the electrolysis - and a 'dirty' one using traditional power sources.
- Wind and solar-generated electricity could negate the use of coal.
- But Australians are expecting a lot already from renewables which in 2020 still produce only 23% of our energy consumed, with wind and solar producing only 6% (the remaining 17% from hydro power).
- Hydrogen can also be extracted from fossil fuels such as methane or brown coal using carbon capture and storage – but, how efficiently and cleanly?
- To transport long distances, hydrogen may be stored in liquid ammonia or by liquefaction to minus 250 degrees to make it much more compact.
- Once transported in liquid ammonia it is then converted on-site back to hydrogen, (requiring more energy). The infrastructure already exists in Australia to transport ammonia.
- Liquefaction is a costly option requiring more energy consumption and possible emissions.
- Right now, the biggest factor to the success of hydrogen being widely available is a lack of infrastructure.

Despite the hyperbole, while the use of hydrogen has huge potential, there are very serious difficulties to overcome, probably the most difficult of which is producing it and getting it to consumers in an efficient manner, ie costing less than the economic value we receive and with minimal emissions. At present, in addition to the hefty cost of establishing and maintaining infrastructure, the production of electrolysis is only marginally efficient at best, ie consuming less energy to produce than we get to use somewhere.

There is a long way to go yet! Nevertheless, the giant petroleum and gas producers of the world are morphing into ‘energy’ companies, to embrace all forms of energy – not like what the US railroad companies did (to their regret), ie not to have recognised that they were in the ‘transport’ business not just rail.

ANNEX G TO
A view on permanent climate change

WORLD POPULATION GROWTH AND CONSEQUENCES

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5. www.bbc.com/news/world-47030233
6. www.iflscience.com/plants-and-animals/five-biggest-threats-human-existence/
7. IPCC Fourth Assessment Report, Working Group I (AR4, WG-I).

About this annex

This annex addresses the question of the world's population, how it has grown to date, more rapidly in more years, and to what level it may reach and level out, if at all. It then looks at the repercussions on humanity itself from in eating itself out of house and home. The real problem, in the minds of climatologists, is that population is creating greater demand for energy and, so, putting greater levels of greenhouse gas emissions into the atmosphere, so accelerating global warming and possible permanent climate change to the detriment of humanity.

The relationship between population growth and energy demand is not quite a simple matter of proportionality, as may be seen from discussion in Annex F, *Demand for energy and emissions*.

World Population

Population growth since early times, especially in the past 160 years, is well documented. Over the past 40 years since 1980. It has grown at an exponential rate, having doubled, to about 7.8 billion in 2020. [1]

As may be seen in Table G1, official projections expect world population to level out at about 9.8 billion, but with positive error bands, this could be out to perhaps 12.5 billion.

Table G2 shows the growth from 2020 to 2100 for the main geographical regions. The average rate expected is about 39 million a year. These numbers by region are very important because projections for energy consumption and consequent greenhouse gas production will not necessarily follow the overall population curve. Industrialised nations in the west have flattened out and even decreased their greenhouse gas emissions, whereas the developing nations, even China which is well advanced on others[150], have a long way to go to catch up with the western nations. The big sleeper is India, which will be the most populous nation by 2100, but currently with a very low energy consumption per capita.

These aspects are discussed in detail in Annex F, *Demand for energy and emissions*.

Box G1 [2]
Every two years, the United Nations makes projections for future population growth. Its latest median projection is a population of 9.7bn in 2050 and 10.9bn in 2100. Because many factors affect population growth, it makes a range of projections depending on different assumptions. Within its 95% certainty range, the difference in population in 2100 from the highest to lowest projection is almost 4bn people - more than half the population we have today.

The second graph above shows the UN's projected population if, on average, every other family had one fewer child or one more child than in the median projection ('minus half a child' or 'plus half a child' per family).

This shows the enormous difference in total numbers that arise from just very small variations in family size. If we can achieve that modest reduction in number of children born, we will have more than 3bn people fewer by 2100 - a lower population than we have today. [United Nations World Population Prospects 2019]

[150] There is considerable angst about China still sheltering as a 'developing' nation, when, in fact, it is very advanced technologically and economically.

Table G1-1 [1]

World population - Total 2020-2100			
Department of Economic and Social Affairs Bib. [1]			
www.population.un.org/wpp2019			
Year	**Millions**	*www.population.un.org/wpp2019/*	**Error Band**
2020	7,794,799		
2025	8,184,437		
2030	8,548,487		
2035	8,887,524		
2040	9,198,847		
2045	9,481,803		
2050	9,735,034		
2055	9,958,099		
2060	10,151,470		
2065	10,317,879		
2070	10,459,240		
2075	10,577,288		
2080	10,673,904		
2085	10,750,662		
2090	10,809,892		
2095	10,851,860		
2100	10,875,394	[1] [2]	0%
2100	11,419,163	[3]	5%
2100	11,962,933	[4]	10%
2100	12,506,703	[5]	15%
Notes:			
1. Levelling at about 10.9 billion			
2. Assumes zero probability of being less.			
3. very probable			
4. Probable			
5. A possibility			

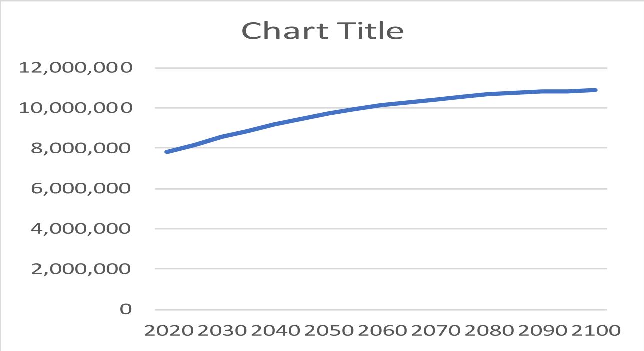


Table G1-2 [1]

World population - Regions 2020-2100			
Department of Economic and Social Affairs	Bib. [1]		
www.population.un.org/wpp2019			
Geographic regions	**Billions 2020**	**[1] [2] 2100**	**Growth %**
Africa	1.341	4.280	219%
Asia	4.641	4.720	2%
Europe	0.748	0.630	-16%
Latin America and the Caribbean	0.654	0.680	4%
Northern America	0.369	0.491	33%
Oceania	0.043	0.075	76%
Total	**7.795**	**10.875**	**40%**
Average Growth per annum		**0.0385**	**0.49%**
Notes:			
1. These numbers are important for energy consumption projections and greenhouse gas production.			
2. greenhouse gas production will not necessarily follow the population curve.			

The graphs in Figures G1-1A and G1-1B are produced by the United Nations (see Box G1). They elaborate more on the probable error bands on either side of the expected curve.

Figure G1-1A [3]

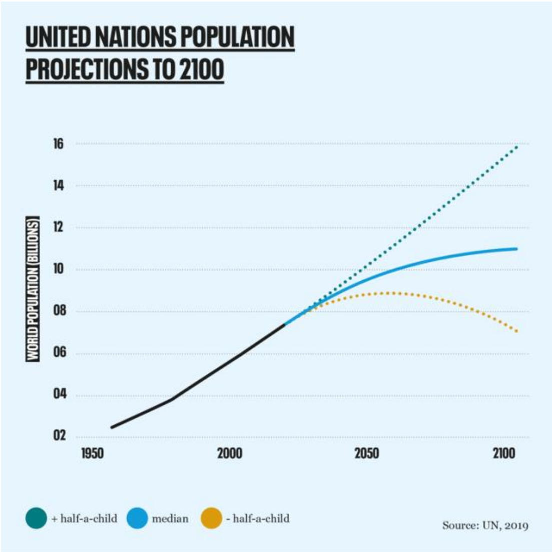
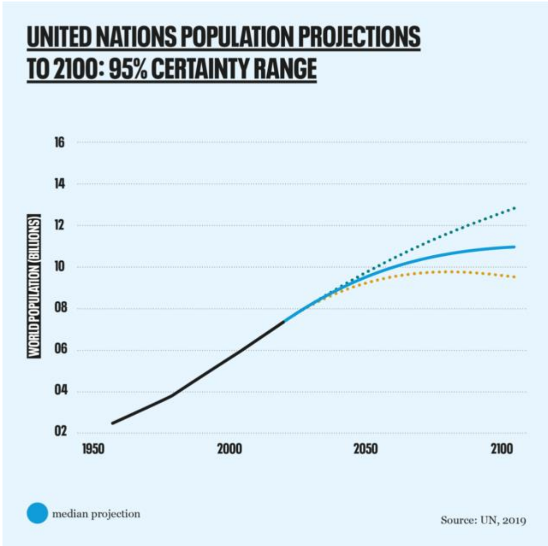
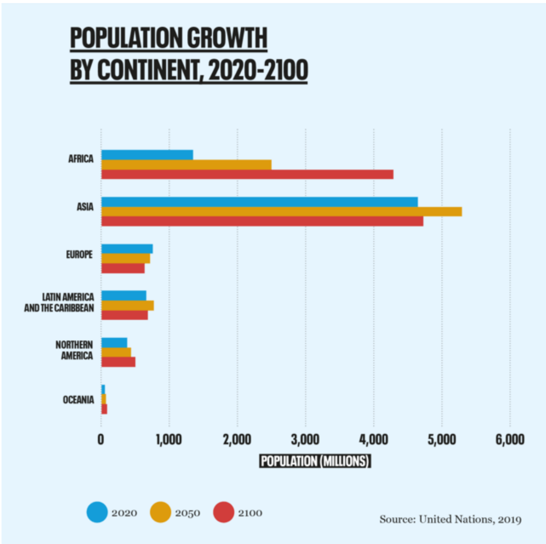


Figure G1-1B

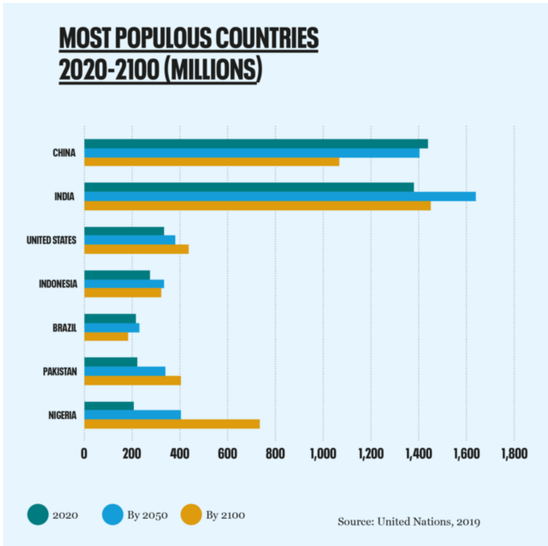


The charts in Figures G1-2A and G1-2B show in which regions the changes will most occur, notably Africa, India and China.

Box G1-2A



Box G1-2B



Consequences of overpopulation

Note that the discussion to follow deals only with the ill-effects of over-population in itself on the assumption (although invalid) that the levels of greenhouse gases in the atmosphere do not increase. Annex F, *Demand for energy and emissions* discusses how the increase in greenhouse gas emissions with population growth would aggravate the problems for humanity from global warming and consequent climate change.

There is no doubt about population growth causing ever-increasing consumption of the earth's resources and fouling the environment in the process, especially by:

- the demand for arable land, fresh water, minerals and vegetation;
- increasing production of food, consumer goods and infrastructure;
- increased production and consumption of energy in all its forms;
- destruction of greenery, especially the jungles of the Amazon, central Africa and Indonesia to create arable and grazing land;

- the increased use of synthesised fertilisers for enhanced food production and to compensate for exhausted arable land; and
- ever-increasing pollution of our water resources with enormous volumes of plastic waste – complete products like bottles and bags, as well as pulverised and degraded particles – killing ocean mammals and detectable in fish species and even in the deepest recesses of the oceans.

Population growth at its current exponential rate, if not checked, could lead to disaster for humanity, eating themselves out of house and home, no different to the lemmings, with or without any effect on global warming.

At the current rate, where population has doubled in the past 40 years, population could be 16 billion by 2060. However, as may be seen in Tables G1 and G2, population is expected to peak around 11 billion but, as may be seen in Figures at G1-1, 12.5 billion is also possible. Some scientists say that increasing standards of living for the poorer countries, especially in Africa and Asia, and birth-control education and economic increased wellbeing will progressively reduce the number of children per family to sustainable levels, ie birth rates equalling death rates. Maybe so, but that is still a 40-50% increase on now and a lot of mouths to feed.

Assuming, that reasonable/improved standards of living can in fact be achieved, despite a great deal of poverty and malnutrition already, it could take at least three, maybe five generations, ie 60 to 100 years.

The worst scenarios are when population becomes so large, with or without the effects of global warming, that there would be widespread famine and starvation causing mass migrations of races, especially across and out of the Eurasia, Africa and Central America, leading eventually to border enforcement skirmishes and war over scarce resources, particularly land with adequate fresh water resources and precipitation for survival. During this process, there is already serious loss of bio-diversity, especially of pollinating insects upon which the human race is indirectly but totally dependent for food such as cereals and fruit.

For at least 60 years already, those of Islamic faith have infiltrated most if not all western countries[151] and, in the past decade, there has been massive illegal immigration into the western nations, especially from the Middle East and Africa into Europe, the UK, the USA, Canada and Australia, and from Central America into the USA. There will eventually be serious bloodshed.

The increasing demands for food, particularly for meat (more and more being consumed by the 1.4 billion Chinese), is already causing large destruction of rainforests, in order to raise stock or crops like maize to feed that stock. In addition to grain to feed cattle, the oceans are being scoured of many species of fish, to turn into fish-meal for cattle and, in the process, are seriously affecting animals like penguins that depend on those fish species for survival.

The rainforests of the Amazon, Indonesia and central Africa are the ‘lungs’ of the earth, so their continued destruction is contributing directly to higher levels of CO2 in the atmosphere.[152] However, some sources say that vegetation growth is enhanced by higher levels of CO2 and has contributed significantly to the ability of humanity to feed itself. One should add that, although a few countries are making good headway on reforestation of their land, the global effect is not significant.

In particular, availability of fresh water resources could well prove to be a principal limiting factor on population growth, but with dire consequences. Yet, there are several ways that some (but only some) nations could supplement fresh water resources from use of sea water:

- Massive desalination plants already exist but are expensive to build and can consume masses of electricity, still largely dependent on generation from fossil fuels, which would simply add to global warming.
- These could be and are being powered from neutral-renewable energy sources (see definition at Annex L, *Energy*) but still require huge investment in both the plant and power and with substantial ongoing maintenance costs.

[151] None to far-eastern countries.

[152] One only needs to look at the great swathes of Brazil being turned into desert, admittedly for chasing gold rather than for arable land (on Google Earth®).

- Solar stills can also produce fresh water, given space and investment but are probably not economic on a large scale.
- Water is even being extracted from the air in some places, but almost certainly not an economic proposition on a large scale.

The billions of livestock, especially cattle, pigs and chickens, raised and slaughtered each year are causing significant methane emissions directly and from untreated excrement. For some time, research has been underway on diets for cattle to reduce methane emitted by belching, with promising results. Also, the recycling of excreted waste has already proven successful, with a closed, self-sustaining loop of stock breeding, capture and burning of methane for power - a win-win situation. Although methane is a powerful greenhouse gas and efforts to limit production by livestock are laudable, there are other potential sources of methane more significant. See Annex N, *Methane.*

The question has been raised many times by dieticians and others as to why some countries are dedicating huge areas of arable land to cropping just to feed cattle, an extremely inefficient (but obviously profitable) process, when crops from that land could and would be better used to feed people with grains and vegetables.

It will be seen in Annex F, *Demand for energy and emissions,* how world energy consumption and consequent CO2 emissions might track world population growth over the next 80 years. While both population and consumption of energy have doubled over the past 40 years from 1980 to 2020, mostly caused by China, that one-to-one correlation is not likely to hold over the rest of this century.

India and African nations currently consume far less energy per capita than the western nations and even China; they have a lot of catching-up to do, given that it is reasonable for them to aspire also to better standards of living like enjoyed in the West. Consequently, growth in world energy consumption can be expected to be at even greater rates than at present. See Annex F, *Demand for energy and emissions?*

Notwithstanding the strong but often irrational debate about anthropological (human-induced) climate change, it is extremely important to note that population growth would continue upwards until checked naturally, even if the global temperature were perfectly stable. Any human induced global warming would simply hasten the process. This means, as often spoken about by Dr Lomborg, (who does not deny that global warming is occurring) that the trillions of dollars being wasted in trying to combat climate change, with virtually zero effect, would be much better invested in saving humanity from itself. Some people think that the greatest existential threat to mankind is mankind itself - its need to breathe, eat, drink and powerful instincts to procreate

Although a check on population growth is obviously needed, based on past experience, it is unlikely that nations will undertake measures, other than more effective birth control perhaps, to control their populations. China has previously tried with a one-child policy and failed. Past societies (admittedly isolated) like Easter Island and some tribes in Central America and South American Andes, have literally eaten themselves out of house and home.

Nevertheless, one should not underestimate man’s most powerful primal instinct for survival at the expense of his fellow man - witness the hundreds of millions of poor souls murdered, sacrificed or simply allowed to starve by dictators and warmongers throughout history, particularly in the past century alone. Human beings are even capable of living and surviving in the most degrading conditions, no different to the other animals - the ‘law of the jungle’ prevailing.

Nor should one ignore attempts by powerful countries to dominate their regions or even the world to sew discord and misery throughout the world because of religion (witness the Middle-East), nor humanity’s bad habit of using technological advances for evil intent, ie adaptation for war. Will the future be any better? Thousands of years of history say no.

Box G2 - Charles Aznavour, 2011

J'ai connu *J'ai connu les chaînes* *J'ai connu les plaies* *J'ai connu la haine* *J'ai connu …* *Ce que l'homme fait à l'homme* *Au mépris de toutes lois* *Ce que l'homme fait à l'homme* *L'animal ne le fait pas* *Ce que l'homme fait à l'homme* *Prenant prétexte sa foi* *Ce que l'homme fait à l'homme* *Pourquoi le fait-il, pourquoi ?*	*I have known* *I have known chains* *I have known wounds* *I have known hate* *I have known …* *What man does to man* *With contempt for any law,* *What man does to man,* *Animals would not raise a paw.* *What man does to man,* *In the pretext of his faith,* *What man does to man,* *Why does he do that, saith?*

Existential threats

So far there have been identified two existential threats to humanity, within the next 60 to 100 years, namely the effects of permanent climate change and unchecked population growth. Are there others? As may be expected, opinions vary widely according to source, vested interest and politics.

Several world views

One source [4] identifies the following existential threats [level of risk is not implied]:

Box G3

Anthropogenic	**Non-anthropogenic**
Artificial Intelligence (AI)	Asteroid impact
Biotechnology	Cosmic threats
Cyberattack	Extra-terrestrial invasion
Environmental disaster	Global pandemic *[could be caused by humans by accident or deliberate biological warfare]*
Experimental technology accident	Natural climate change
Global warming	Volcanic activity
Mineral resource exhaustion	
Nanotechnology	
Warfare and mass destruction	
World population and agricultural crisis	*www.en.wikipedia.org/wiki/Global_catastrophic_risk#Potential_sources_of_risk*

The following lists of existential threats are what some sources say [*author's comments in […]*]:

Source 1 : [5] *www.bbc.com/news/world-47030233*

1. Climate change;
2. Artificial Intelligence (AI) *[Robots with human intelligence and attributes, independent of humans, within about 70 years];*
3. Nuclear war *[A growing risk every day];*
4. Solar storm *[very remote];*
5. Bioengineered pandemic [*In 2020, the world has experienced its worst pandemic for 100 years - as yet of unknown origin.*].

Source 2 : [6] www.iflscience.com/plants-and-animals/five-biggest-threats-human-existence/

1. Nuclear war;
2. Bio-engineered pandemic;

3. Super-intelligence (AI);
4. Nanotechnology[153]; [*health risks in the main*]
5. Unknown unknowns;
6. Conventional world-war arising from tensions between global powers, given continual technological advances; and
7. Unchecked world population growth.

Source 3: [7] If you have ever wondered what the United Nations world priorities are, given that the UN has sponsored the IPCC studies and global warming protocols, see the list below, taken from an IPCC report. Action on climate change is number 13.

Box G3 - United Nation priorities for humanity.

Source 4: Huffington Post, December 2009 [*admittedly things have changed somewhat since then*]:

1. Climate change;
2. End of Petroleum [*less a problem in 2020*];
3. Collapse of ocean fisheries;
4. Deforestation;
5. World food crisis;
6. World Overpopulation.

An Australian view

Notwithstanding that 'we are all in this together', it must be remembered that all countries are different. They have different problems, different social structures, different geography, different locations on the planet, different climates and different national interests to protect or project.

Consequently, existential threats to Australia must be seen and considered as quite different from every other nation. In the opinion of this author, they are, in order of risk[154], within this century:

1. Chinese expansionism, economic strangulation and Chinese diaspora flooding of this country with immigrants of doubtful allegiance *[well over 1 million already]*; [*high probability within 30 years + very high consequences]*
2. Competition for limited world resources, exacerbated by religious fanaticism, leading to mass, illegal migration and conflict (even nuclear war); [*high probability over next 50 years + very high consequences]*
3. For Australia, sustainable population growth, given its limited water resources and arable land; [*high probability over next 50 years + high consequences]*

[153] Nanotechnology is the generic name given to the production or use of very small, or 'nano' particles. These are particles that are less than one hundred nanometres or about one thousandth the width of a human hair. A nanometre is one billionth of a metre.

[154] Risk is defined here as the probability of the event times the detrimental severity of the event.

4. Artificial Intelligence (AI), eventually leading to loss of control by human intellect; *[Scary stuff and very few people know where it is heading.*] [*high probability within 30 years + high consequences]*
5. Nanotechnology; *[Scarier stuff, especially combined with future AI and very few people know of the problem, let alone appreciate the danger.]* [*high probability within 30 years + high consequences]*
6. Permanent climate change; [*high probability within 80 years + high consequences]*
7. Pandemics - from whatever source, even biological warfare; [*medium probability within 80 years + high consequences]*
8. Myriad other problems facing the world that would impact Australia's way of life and wellbeing. [of varying *probability within 80 years + variable consequences]*

Conclusions

Although the future never seems to turn out as expected, the world could well be heading for a 'perfect storm' in as little as 30 to 50 years, given its growing population, nationalistic threats, religious intolerance, advancing technology and general pollution of the atmosphere and waterways, let alone the strident claims of permanent climate change. Global warming and climate change could well turn out to be the least of the existential threats to the world and to Australia in particular.

World population doubled from 4 to 8 billion in the past 40 years with few signs yet of abatement. Growth could be to around 10 to 12 billion through the year 2100, unless checked by government controls, natural causes or serious conflict; one needs to recognise also that population-induced global warming and possible permanent climate change would exacerbate the other threats.

Nevertheless, while having captured the attention of governments and people around the world, global warming and permanent climate change, although possibly coming to pass within this century, should be kept well in perspective, compared to other existential threats within the same timeframe. The often-strident claims of Australian climatologists, rent-seekers and much of the Media are doing little to actually minimise global warming, but a lot to misinform and to panic unnecessarily the population.

Australian Logistics Study Centre
Canberra, 24 July 2020

PROMOTERS AND CRITICS

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About this Annex

This Annex identifies institutions and climatologists that profess to be principal supporters or critics of global warming and climate change, as well as some of the myriad websites and blogs pushing or pulling according to their vested interests, and presents credentials and essential arguments of those entities.

What is in dispute?

The fundamental variables of claimed global warming and consequential climate change are said by climatologists to be: world population growth as the driving factor, causing the concentration of greenhouse gases, especially carbon dioxide (CO2), in the atmosphere to increase, so causing the average world surface temperature to increase, with detrimental effects on mankind.

Fundamentals in dispute are:

- the claimed increase in the average world surface temperature, ie the Temperature anomaly (Twi);
- the claimed (or implied) cause and effect relation between atmospheric concentrations of non-condensable greenhouse gases[155], mainly CO2 and the Temperature anomaly (Twi);

  2. **Note:** *CO2 is used herein after as a proxy for all non-renewable greenhouse gases.*
- the claim that CO2 is the ‘thermostat’ of the Earth’s climate, ie that it is the concentration of CO2 and not water vapour that determines atmospheric temperatures around the globe;
- that apparent, more severe weather events are evidence of permanent climate change; and
- that the climate, however defined, could be changing permanently.

These aspects are defined more precisely and discussed in detail in Annex D, *Temperature change- fact or fiction?* and Annex E, *Temperature change - possible causes.*

[155] Excludes water vapour (H2O).

Authoritative research institutions and scientists

NASA

NASA is often cited as an important fundamental source of climate change research. Its website *www.climate.nasa.gov*, covers the subject in terms of evidence, causes, effects, scientific consensus, vital signs and frequently asked questions. As to NASA's direct role in climate change, see Box H1.

Box H1 [1].
Taking a Global Perspective on Earth's Climate NASA's role is to make observations of our Earth system that can be used by the public, policymakers and to support strategic decisions. Its job is to do rigorous science. However, the agency does not promote particular climate policies.
NASA conducts a program of breakthrough research on climate science, enhancing the ability of the international scientific community to advance global integrated Earth system science using space-based observations.
The agency's research encompasses solar activity, sea level rise, the temperature of the atmosphere and the oceans, the state of the ozone layer, air pollution, and changes in sea ice and land ice. NASA scientists regularly appear in the mainstream press as climate experts. So how did the space agency end up taking such a big role in climate science? ***https://climate.nasa.gov/evidence/***

NASA is heavily involved in direct research in specific areas, e.g., oceanography and the major effect that the oceans have on weather systems. See Box H2.

Box H2 [2]

Climate Variability
The ocean is a significant influence on Earth's weather and climate. The ocean covers 70% of the global surface. This great reservoir continuously exchanges heat, moisture, and carbon with the atmosphere, driving our weather patterns and influencing the slow, subtle changes in our climate. The oceans influence climate by absorbing solar radiation and releasing heat needed to drive the atmospheric circulation, by releasing aerosols that influence cloud cover, by emitting most of the water that falls on land as rain, by absorbing carbon dioxide from the atmosphere and storing it for years to millions of years. The oceans absorb much of the solar energy that reaches earth, and thanks to the high heat capacity of water, the oceans can slowly release heat over many months or years. The oceans store more heat in the uppermost 3 metres (10 feet) than the entire atmosphere, the key to understanding global climate change is inextricably linked to the ocean. Climate is influenced by storage of heat and carbon dioxide in the ocean, which depends on both physical and biological processes.
www.science.nasa.gov/earth-science/oceanography/ocean-earth-system/climate-variability

IPCC - The Intergovernmental Panel on Climate Change

The Intergovernmental Panel on Climate Change (IPCC) is the United Nations body for assessing the science related to climate change. The IPCC was created to provide policymakers with regular scientific assessments on climate change, its implications and potential future risks, as well as to put forward adaptation and mitigation options.

"The IPCC is an organisation of governments that are members of the United Nations or World Meteorological Organisation (WMO). The IPCC currently has 195 members. Thousands of people from all over the world contribute to the work of the IPCC." [3] *www.ipcc.ch*

IPCC reports are the fundamental references for international recognition and action (through the Kyoto protocol [4] and Paris Agreement [5]) of 1.5°C as the desirable limit and 2°C as a perilous level, in average global temperature rise (both from a specified baseline).

The IPCC does not perform its own climate change research, engaging climatologists for that.

CSIRO [6] www.csiro.au/

General

The Commonwealth Scientific and Industrial Research Organisation (CSIRO) is Australia's national science agency and claims to *"solve the greatest challenges through innovative science and technology"*.

As one might expect, CSIRO is probably the leading researcher in Australia and an advocate for the reality of climate change. Its published range of research is as follows:

- Providing the ocean and atmospheric science needed for a sustainable, healthy, and well-prepared Australia as part of a global effort focused on climate, energy and air quality interactions, and climate, carbon and water feedbacks.
- The CSIRO Climate Science Centre: Delivering the climate knowledge Australia needs to respond to a variable and changing climate.
- Atmospheric monitoring and modelling: Our scientists are working to understand how interactions between the land and the atmosphere affect the Earth system, and working with industry, regulators and the community in the search for solutions to our air pollution problems.
- Latest Cape Grim greenhouse gas data: The latest greenhouse gas data updated monthly from one of the cleanest air sources in the world.
- Australian Community Climate and Earth System Simulator (ACCESS): Scientists have built a weather and climate model for Australia using earth system modelling.
- Multiyear climate forecasts: Advancing climate forecasts by building a system to predict climate over the next one to ten years – providing important insights for industry and government.
- Earth Systems and Climate Change Hub (ESCC Hub): The ESCC Hub is providing world-class climate change science to Australia's decision-makers, bringing together climate, atmosphere and ocean researchers to address national climate challenges.
- National Computational Infrastructure (NCI): NCI is a national facility that provides world-class, high-end computing services to Australian researchers, including those working in the data-intensive areas of climate and Earth system science.
- Smoke forecasting for bushfires and prescribed burns: We have developed a smoke forecasting tool that is being used to help manage fine particle exposure from prescribed burns and bushfires in NSW and Victoria.
- State of the Climate 2018: State of the Climate 2018 is the fourth in a series of reports produced by CSIRO and the Australian Bureau of Meteorology. It provides a summary of observations of Australia's climate and analysis of the factors that influence it.
- Weather and environmental prediction: Through the Collaboration for Australian Weather and Climate Research (CAWCR), we're creating systems for predicting Australia's air quality, weather and climate.
- Climate Change: Science and Solutions for Australia.

Some scholarly articles by CSIRO climate research [7] are:

- The seasonal footprinting mechanism in the CSIRO general circulation models; DJ Vimont, DS Battisti, AC Hirst - Journal of climate, 2003.
- The Southern Ocean response to global warming in the CSIRO coupled ocean-atmosphere model, AC Hirst - Environmental modelling & software, 1999.
- Southern mid-to high-latitude variability, a zonal wavenumber-3 pattern, and the Antarctic Circumpolar Wave in the CSIRO coupled model.
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Publications

The following publication by CSIRO gives an excellent overview of the climate change argument, in the Australian context, albeit from a pro-climate change stance in 2011 [8]: "Climate Change", CSIRO, 2011:

- Chapter 1. Observations of global and Australian climate.
- Chapter 2. Climate and greenhouse gases.
- Chapter 3. Future Australian climate scenarios.

- Chapter 4. Climate change impacts.
- Chapter 5. Adaptation: reducing risk, gaining opportunity.
- Chapter 6. Adapting to heatwaves and coastal flooding.
- Chapter 7. Adapting agriculture to climate change.
- Chapter 8. Greenhouse gas mitigation: sources and sinks in agriculture and forestry.
- Chapter 9. Mitigation strategies for energy and transport.
- Chapter 10. Reducing energy demand: the imperative for behavioural change.
- Chapter 11. Responding to a changing climate.

Australian National University (ANU)

A component of the ANU is the Climate Change Institute (CCI) [9] (*climate.anu.edu.au)* employing some 300 researchers and staff[156], of which some 221 appear to be academics, but not necessarily climate experts in their own right. See Box H3.

Box H3 [10]
Professor Mark Howden, Director Climate Change Institute.
Professor Mark Howden … is also … a Vice Chair of the Intergovernmental Panel on Climate Change (IPCC) and a member of the Australian National Climate Science Advisory Committee. He was on the US Federal Advisory Committee for the 3rd National Climate Assessment and contributes to several major national and international science and policy advisory bodies.

Mark has worked on climate variability, climate change, innovation and adoption issues for over 30 years in partnership with many industry, community and policy groups via both research and science-policy roles. Issues he has addressed include agriculture and food security, the natural resource base, ecosystems and biodiversity, energy, water and urban systems. Mark has over 420 publications of different types. He helped develop both the national and international greenhouse gas inventories that are a fundamental part of the Paris Agreement and has assessed sustainable ways to reduce emissions. He has been a major contributor to the IPCC since 1991, with roles in the Second, Third, Fourth, Fifth and now Sixth Assessment Reports, sharing the 2007 Nobel Peace Prize with other IPCC participants and Al Gore.

The Institute claims to have done or is doing research on the following subjects:

- Built environment & climate change - Researchers are particularly focussed on the interrelationship between cities and climate change, notably the drivers and impacts of urbanisation, the interrelationship between urban structure, function and processes and urban carbon emission and extreme climate events.
- Business & climate change.
- Carbon dioxide removal - with recent research highlighting that average global temperatures may exceed the 1.5C target as quickly as 2026, it's becoming apparent that reducing our greenhouse gas emissions is unlikely to be enough to prevent dangerous climate change.
- Climate change & development in Asia & the Pacific - Many countries in the Asia and Pacific region are incredibly vulnerable to climate impacts, particularly our Pacific Islands neighbours and low-lying Asian nations such as Bangladesh.
- Climate change & the arts.
- Climate change psychology & communication.
- Climate extremes - As the world has warmed, due to anthropogenic greenhouse gas emissions, there has been a marked change in both the frequency and intensity of extreme weather events.
- Climate policy, economics, international negotiations & law.

[156] Canberra Weekly (p10), 13Feb20

- Climate, energy, water, food, forestry, biodiversity & land nexus - Food, energy, environment, biodiversity and water are critical systems to both people, ecosystems and landscapes.
- Culture, society, gender & climate change.
- Earth systems - Research on Earth systems considers processes of the atmosphere, ocean, cryosphere, biosphere and solid Earth, along with their interactions.
- Health & climate change - Addressing climate change will have numerous health benefits for our society. For example, reducing pollution caused by the burning of fossil fuels, reduces respiratory ailments and preventing our climate from warming further will help limit the impacts of heat stress.
- Security & climate change - Climate change will have major ramifications for international state and human security. It is already exacerbating tensions in areas of existing instability, increasing risks, changing the nature of conflict and acting as a threat multiplier.

Although the CCI is meant to be a research organisation, it appears to be like many organisations promoting the climate change agenda in that it primarily correlates the work of others, but supplementing here and there by some original research. One may get an appreciation of what the CCI has achieved – in its own words – from Box H4.

Box H4
Research stories 2019

- The impacts of a changing climate on public health
- How can we have better conversations about solving climate change?
- What's driving youth participation in the school climate strikes?
- Why we're in a water emergency and what we can do about it
- Exploring a “sacrifice-free” solution to climate change
- Telling the story of climate change: threat or emergency, and does it matter?
- Double counting of emissions cuts may undermine Paris climate deal
- Research stories 2018
- Designing a house that absorbs carbon dioxide
- Helping reduce hunger in rural Papua New Guinea
- How can we make our cities more climate friendly?
- Breeding climate resilient plants
- Who will take the lead on global climate action?
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- The Plutocene: Blueprints for a Post-Anthropocene Greenhouse Earth - Dr Andrew Glikson
- Integrated Groundwater Management - Concepts, Approaches & Challenges - Edited by Professor Tony Jakeman
- The oceans: a deep history by Professor Eelco Rohling
- The Call of the Reed Warbler - Charles Massy

Note: *By ‘original research’, this author means conduct by the scientific method, ie develop theories, hypothesise, gather data, perform experiments and modelling/simulating to prove/support hypotheses, documentation subject to peer review and publication in a reputable journal.*

There is no doubt that the ANU CCI is 100% behind the climate change movement, even to the extreme edge, with the Director and several researchers being directly involved with the preparation of IPCC documentation. Some publications border on evangelism of pending climate doom, in their views. For example, readers are referred to the August 2019 article by Joëlle Gergis. “*The terrible truth of climate change*”.[157]

[157] Joëlle Gergis is an award-winning climate scientist and writer based at the Australian National University. She is the author of *Sunburnt Country: The History and Future of Climate Change in Australia*.

Notwithstanding the foregoing, this author does not question the integrity with which the CCI has done its work, nor that it does not accurately report the work of basic researchers.

Given the reality that no matter what counter-climate change action Australia may take in respect of reducing CO2 emissions, it will have no effect on world or even local climate change, the CCI should, I dare say, be concentrating on how Australia could best deal with the climate change that it expects.

How the ANU's CCI may be influencing governments is difficult to determine, but one should presume that it has channels in to governments.

Australian Bureau of Meteorology (ABOM)

While the ABOM is the principal weather forecasting body for Australia, it also provides several services on climate in general, in respect of:

- Outlooks and influences (seven sub-categories, including El Nino and La Nina);
- Reports and summaries (five sub-categories, including drought);
- Climate data and various maps (four sub-categories, including long-term temperature data);
- Climate change (five sub-categories, including global trend maps); and
- About Australian climate (three sub-categories: Climate influences; Indian Ocean Dipole; and Southern Annular Mode).

Given that Australia should be planning how to cope with global warming and climate change (rather than wasting investment trying to influence it), the ABOM should be expected to play a principal role in how plans could best be achieved.

Principal Climate scientists

Dr James Hansen

Dr James Hansen [11] is one scientist who subscribes to all aspects of climate change and is well respected for his research, as he himself acknowledges[158], if disputed by noted critics. Hansen once worked for NASA but has claimed that NASA has tried at times to silence his views. Hansen is often cited in scientific papers related to climate change.

Professor L.M. Salby

Murry Lewis Salby is an American atmospheric scientist who focused on upper atmospheric wave propagation for most of his early career, and who more recently has argued against aspects of the scientific consensus that human activity contributes to climate change. He has written two textbooks, Fundamentals of Atmospheric Physics (1996) [12] and Physics of the Atmosphere and Climate (2011). The latter textbook, building on his first book, offers an overview of the processes controlling the atmosphere of Earth, weather, energetics, and climate physics. *[Wikipedia, 2020]*

He resigned at Colorado in 2008 and became professor of climate risk at Macquarie University in Macquarie Park, New South Wales. In 2013 the university dismissed him on grounds of refusal to teach and misuse of university resources.

Note: *However, to the knowledge of this author, there has been no critique of the validity of his research work or content of his books*.

Other promoters

The literature search done by this author reveals that the greater majority of the websites, blogs and even books rely on a relatively few sources of basic global warming data and information, to interpret in their own image for the most part. This includes scientists, who like many professionals, like to imply knowledge simply as a holder of an allied degree, instead of based on actual research done by them.

No doubt all of these sites would claim to provide a valid and valuable service. As examples, there are:

[158] The cover of J. Hansen's book claims that he is "the world's leading climate scientist".

- The Climate Council [13] "*... is Australia's leading climate change communications organisation. We provide authoritative, expert advice to the Australian public on climate change and solutions based on the most up-to-date science available. We're made up of some of the country's leading climate scientists, health, renewable energy and policy experts, …*" https://www.climatecouncil.org.au/resource/reports
- Renew Economy [14], a very active Australian website that reports daily on virtually all aspects of renewable energy, in Australia and abroad. Comment on the content of this website, is made in Annex F, *Demand for energy and emissions*. www.reneweconomy.com.au.
- Ceres [15], which tackles the world's biggest sustainability challenges, including climate change, water scarcity and pollution, and inequitable workplaces. Its stated mission: "*Ceres is transforming the economy to build a sustainable future for people and the planet*." www.Ceres.org
- Business Council of Australia. [16]
- The Energy and Climate Intelligence Unit (UK) is a non-profit organisation that supports informed debate on energy and climate change issues in the UK. [17]
- *www.climatechangeinaustralia.gov.au/en/climate-projections.* [18]
- *www.climatehealthconnect.org/wp-content/uploads/2016/09/Climate101.pdf* [19]
- *www.environment.gov.au › climate-science-data › climate-science › u...*
- *www.warmheartworldwide.org/*
- *www.vox.com › science-and-health › 9-questions-climate-change*
- Countless others.

Critics and what they say

Scientists, who speak up against the unethical promotion of global warming and climate change, say they are bona fide critics and resent being called 'sceptics' and 'contrarians'[159] by the promoters, vested interests and supporters of the climate change club. To cite professor Lindzen, "*A sceptic doubts and rejects the truth of what is being said by proponents, whereas a critic comments on the validity of what is being said*.", or words to that effect.

Unfortunately, and very unprofessionally, too many promoters, scientists as well as laypeople exhibit the tendency of evangelists and the politically correct brigade of today to brand as heretics all those who do not agree with their view of the world. Valid criticism to them is anathema.

Who are the critics?

Proponents of climate change claim that 97 per cent[160] of scientists agree that climate change is a reality. Within the remaining three percent, there are certainly eminent scientists who disagree.

"*Climate sceptics fall into three camps: those like Freeman Dyson, Bjorn Lomborg and Kiminori Itoh who acknowledge climate change, but think that carbon-based theory and current models are too simplistic to capture such a complex process; those like Ivar Giaever who think that the data is too thin to support such bold claims; and those like Will Happer who contend that the nice analogy of a greenhouse does not apply and that CO2 is too insignificant to be the culprit.*" [20] *Climate Change Primer. https://warmheartworldwide.org/climate-change.]*

Some leading critics, past and present, are:

- Professor Richard Lindzen (Box H5)[161]
- Dr Bjorn Lomborg (Box H6)
- Freeman Dyson (Box H7)

[159] 'Contrarian' is an epithet used by J. Hansen.

[160] Critics refute this claim, the sample of which has never been published.

[161] At least one ungracious scientist commentator, giving a lecture on the Internet, has accused DR Lindzen of making a career of being wrong on climate change.

- Kiminori Itoh (Box H8)
- Ivar Giaever (Box H9)
- Will Happer (Box H10)
- Michael Shellenberger (Box H11)

Box H5
Bio: Professor Richard Siegmund Lindzen is an American atmospheric physicist known for his work in the dynamics of the middle atmosphere, atmospheric tides, and ozone photochemistry. He has published more than 200 scientific papers and books.
Born: 8 February 1940 (age 80 years), Webster, Massachusetts, United States
Education: Harvard University (1961)
Thesis: Radiative and photochemical processes in strato- and mesospheric dynamics (1965)
Field: Atmospheric Physics.
Books: Dynamics in Atmospheric Physics (1990); Dynamics in Atmosphere.

Box H6
Bio: Bjørn Lomborg is a Danish author and President of his think tank, Copenhagen Consensus Center.
Born: 6 January 1965 (age 55 years), Frederiksberg, Denmark
Education: Aarhus University, School of Business and Social Sciences,
Quotes:
Even if I was a bad right-wing guy, to the extent of whether my arguments are right or wrong, they're right or wrong independently if I'm right or left.

I really try to say things as they basically are and it so happens that it is a good message that things are getting better, but there are still problems.

Just because there is a problem doesn't mean that we have to solve it, if the cure is going to be more expensive than the original ailment.

Books: The Skeptical Environmentalist (1998); Cool It: The Skeptical Environmentalist's Guide to Global Warming (2007); Global Crises, Global Solutions (2004); Haiti Prioritizes: Costs and Benefits for Development Solutions (2018); The Real State of the World (2004).

Box H7
Bio: Freeman John Dyson FRS is an American theoretical physicist and mathematician, of British origin, known for his work in quantum electrodynamics, solid-state physics, astronomy and nuclear engineering.
Born: 15 December 1923 (age 96 years), Crowthorne, United Kingdom.
Awards: Templeton Prize, Wolf Prize in Physics.
Quotes:
It is characteristic of all deep human problems that they are not to be approached without some humour and some bewilderment.
Technology is a gift of God. After the gift of life, it is perhaps the greatest of God's gifts. It is the mother of civilizations, of arts and of sciences.
You ask: What is the meaning or purpose of life? I can only answer with another question: Do you think we are wise enough to read God's mind?

Books: Disturbing the universe (1979): The Scientist as Rebel (2006); Infinite in All Directions (1988); Maker of Patterns: An Autobiography Through Letters (2018); Dreams of Earth and Sky (2015).

Box H8
Bio: Kiminori Itoh is on the faculty of Yokohama National University. His research focuses on environmental meteorology.
Dr. Kiminori Itoh earned his Ph.D. in Industrial Chemistry at the University of Tokyo in 1978. He is the author of the Japanese-language book 'Lies and Traps in the Global Warming Affair'. Dr. Itoh's biggest academic contribution is the development of optical waveguide spectroscopy for solid surfaces, for which he received awards from relevant academic societies.
From 1989 to present, Dr. Itoh has been working at Yokohama National University, mostly in the field of environmental meteorology including optical biochemical sensing and theoretical as well as experimental biodiversity measurements. For instance, he recently developed extremely highly sensitive gas sensing systems and two-dimensional DNA electrophoresis methods.

His interest in the global warming issue started around 1995 when he was asked to deliver a lecture on environmental meteorology. He wondered why the effect of solar changes had been largely neglected by most climatologists, and felt it was dangerous that Japan was considering increased use of nuclear power plants to decrease carbon dioxide emissions.
Dr. Itoh has written (or participated in) four books on this issue. He also has a patent on sunspot number anticipation and contributed to the IPCC AR4 as an expert reviewer.
https://www.heartland.org/about-us/who-we-are/kiminori-itoh

Box H9
Bio: Ivar Giaever
Born: April 5, 1929, Bergen, Norway
Alma mater: Norwegian University of Science and Technology; Rensselaer Polytechnic Institute.
Known for Solid-state physics;
Awards: Oliver E. Buckley Condensed Matter Prize (1965); Nobel Prize in Physics (1973).

Box H10
Bio: William Happer, American physicist
William Happer has specialised in the study of atomic physics, optics and spectroscopy. He is the Cyrus Fogg Brackett Professor of Physics, Emeritus, at Princeton University, and a long-term member of the JASON advisory group, where he pioneered the development of adaptive optics. Wikipedia.
Born: 27 July 1939
Books: Optically Pumped Atoms, Optical Pumping: Principles and Applications.
Education: Princeton University (1964), University of North Carolina at Chapel Hill (1960).
Awards: Sloan Research Fellowship, Davisson–Germer Prize in Atomic or Surface Physics.

Box H11
Bio: Michael Shellenberger is President of Environmental Progress, an independent research and policy organisation.

Some highlights of his book ‘Apocalypse never’ [presented without comment – not necessarily accepted]:

- Factories and modern farming are the keys to human liberation and environmental progress,
- The most important thing for saving the environment is producing more food, particularly meat, on less land,
- The most important thing for reducing pollution and emissions is moving from wood to coal to petrol to natural gas to uranium,
- 100 per cent renewables would require increasing the land used for energy from today’s 0.5 per cent to 50 per cent,
- We should want cities, farms, and power plants to have higher, not lower, power densities,
- Vegetarianism reduces one’s emissions by less than 4 per cent,
- Greenpeace didn’t save the whales — switching from whale oil to petroleum and palm oil did,
- “Free-range” beef would require 20 times more land and produce 300 per cent more emissions,
- Greenpeace dogmatism worsened forest fragmentation of the Amazon, and
- The colonialist approach to gorilla conservation in the Congo produced a backlash that may have resulted in the killing of 250 elephants.

Books: Apocalypse never, Harper Collins, June 2020. [not available in Australia until October 2020] [21]
Why Environmental Alarmism Hurts Us All, Harper Collins.
Article: “Sorry, but I cried wolf on climate change”, The Australian 1Jul20. [22]

Prof Richard Lindzen

In his book [11], Hansen often cites Richard Lindzen as his primary critic and opponent. Table H1, copied from Hansen’s book, gives the primary differences between the two men on this subject.

One could summarise Lindzen’s arguments here, but readers are encouraged to search for Lindzen on the Internet and listen to a few of his most recent presentations on YouTube®.

Table H1

Climate Sensitivity			
Hansen vs Lindzen [Hansen, p279]			
Item	**Contention**		**Notes**
1	**Observed global warming**		
	Hansen	0.5 - 0.76 °C in past century; 0.03 °C in past 25 years.	
	Lindzen	since 1850, more likely 0.1 - 0.3 °C	[1]
2	**Climate sensitivity (equilibrium response to 2 x CO2**		
	Hansen	3 +- 1 °C	[2]
	Lindzen	<1 °C	[1]
3	**Water vapour feedback**		
	Hansen	Positive upper and lower troposphere water vapour Decreases with global warming	[3]
	Lindzen	Negative upper and lower troposphere water vapour Decreases with global warming	[3]
Notes:			
1	Not upheld by literature		
2	Generally collaborated bu closer to 2 °C		
3	Not considered proved - by literature search and research.		

Dr Bjorn Lomborg

When one reads the frequent Media articles by Dr Bjorn Lomborg and listens to his presentations on the Internet, he gives the impression that he is not so much against the notion of global warming and the claimed causes, as he is to the way nations are prepared to waste trillions of dollars in attempting to combat it. He says that, by all means pursue (rationally) ways to reduce CO_2 emissions, e.g., by 'renewable' energies, but that humanity has other existential threats to worry about and for which the trillions being wasted on trying to combat climate change would be much more effectively spent by improving the lot of humanity.

Freeman John Dyson

Although a noted critic, Freeman Dyson admits that he is not really an expert or up to date anymore on climate change. His main thesis has been that proper land management and use of vegetation could well be the answer to controlling levels of CO_2.

Kiminori Itoh

See Box H12 here and Box H8 (above) for biography.

Box H12 [23]

Dr. Kiminori Itoh writes of "inaccurate temperature measurements," including chapters that call man-made global warming fears "the worst scientific scandal in the history."

"I also cited the opinions of Dr. Akasofu (Professor Emeritus, University of Alaska) in the last part of the book. He sincerely advises us, 'When people come to know what the truth is, they will feel deceived by science and scientists.' I sincerely think he is correct," Itoh wrote.

Itoh concludes his book with six points:

1. The global temperature will not increase rapidly if at all. There is sufficient time to think about future energy and social systems.
2. The climate system is more robust than conventionally claimed. For instance, the Gulf Stream will not stop due to fresh water inflow.
3. There are many factors that cause the climate changes, particularly in regional and local scales. Considering only greenhouse gases is nonsense and harmful.
4. A comprehensive climate convention is necessary. The framework-protocol formulism is too old to apply to modern international issues.
5. Reconsider countermeasures for the climate changes. For instance, to reduce Asian Brown Cloud through financial and technical aid of developed countries is beneficial from many aspects, and can become a Win-Win policy.
6. The policy makers should be 'Four-ball jugglers.' Multiple viewpoints are inevitable to realize sustainable societies."

https://www.ocregister.com/2008/06/18/japanese-ipcc-scientists-says-global-warming-worst-scientific-scandal/; 2008

Ivar Giaever

See Box H13

Box H13
Global warming
Giaever has repeatedly professed scepticism of global warming, calling it a "new religion."

In a featured story in Norway's largest newspaper, Aftenposten, 26 June 2011, Giaever stated, "It is amazing how stable temperature has been over the last 150 years." [13]

On 13 September 2011, Giaever resigned from the American Physical Society over its official position. The APS Fellow noted: "In the APS it is OK to discuss whether the mass of the proton changes over time and how a multi-universe behaves, but the evidence of global warming is incontrovertible?"

As part of the 62nd Lindau Nobel Laureate Meeting, Giaever commented on the significance of the apparent rise in temperature when he stated, "What does it mean that the temperature has gone up 0.8 degrees Kelvin: probably nothing."

Giaever repeated his claims in a speech in 2015: "The American Physical Society, of which I was a member, say that 'the evidence is incontrovertible', that global warming exists. Now think about that. This is a physical society, and they say 'you cannot discuss global warming, because we believe it's happening.' It's like the Catholic Church. There are lots of incontrovertible truth[s] in the Catholic Church, I'm sure. And here there's a[n] incontrovertible truth in a physical society."
A main point of Giaever's speech was discussing reliability of the statistical calculation of this temperature with respect to the spatial distribution of measurement locations over the globe, especially what he viewed as poor coverage in the southern hemisphere and Arctic.

L. Rowand Archer

Archer has produced a recent book titled *"Climate Change Baffles Brains: Climate Charlatans Commit Intellectual Fraud"* [24], in which he debunks comprehensibly of what he sees as the many claims 'proving' global warming and climate change. An abstract is given in Box H14.

Box H14
Abstract of Archer reference [24]
A review of the research literature concerning the environmental consequences of increased levels of atmospheric carbon dioxide leads to the conclusion that increases during the 20th and early 21st centuries have produced no deleterious effects upon Earth's weather and climate. Increased carbon dioxide has, however, markedly increased plant growth. Predictions of harmful climatic effects due to future increases in hydrocarbon use and minor greenhouse gases like CO2 do not conform to current experimental knowledge. The environmental effects of rapid expansion of the nuclear and hydrocarbon energy industries are discussed.

Critical websites and blogs

The sample of websites and blogs listed in Box H15, may give readers an idea of the proliferation of information that illustrates scepticism today, if not bona fide criticism, about global warming and climate change.

Box H15 - Links for Climate Scepticism

Climategate [10 articles]

Second Climategate - temperature measurements were faked [5 articles]

Daily Climate News [6 articles]

Science Oriented Skeptic Web Sites [6 articles]

Additional Blogs [7 articles]

Skeptical Columnists [6 articles]

News Articles (More Recent News Here) [20 articles]

IPCC and Climate change Scandals [2 articles]

- *Guide to Recent Scandals - Orange County Register, 2-15-10.*
- *Hurricane Fraud at IPCC - by Chris Landsea, head of hurricane center.*

Exposing the Climate Change Hoax [11 articles]

- science structural corruption - Richard Lindzen
- An Expensive Urban Legend - Roy Spencer

- None Dare Call It Fraud - Paul Driessen
- Obama Climate Report—Scare Tactic - David Deming
- History of the IPCC
- A Call for Abolishing the IPCC - Vincent Gray
- Why the IPCC Should be Disbanded - Science and Public Policy Org
- IPCC Loss of Credibility - Michael Fox
- Hockey Stick Graph—Statistical Fraud
- Hockey Stick Graph—Data Corruption
- Thirty-one thousand scientists signed a petition saying humans are not the cause of global warming.
- Renewable or Green Technology [4 articles]
- The German Experience with Solar and Wind Energy
- The Negatives of Wind Power - Jon Boone
- Windmills on Mountains in Maine
- Master Resource - Energy Technology

Oceans [6 articles]

- Why Oceans Are Not Rising (and links)
- Satellite Measurements on Sea Level
- ARGO Measurements Low - Roy Spencer
- Ocean Heat, Not Atmosphere, Melts Polar Ice - Guardian, September 23, 2009
- Oceans Heating from Below - Vincent Gray
- Ocean Acidification - J Floor Anthony

Temperature and Weather Patterns [14 articles]

Water Vapor and Precipitation [2 articles]

Radiation [2 articles]

Science Explantations [3 articles]

Organizations [3 articles]

Books [9 articles]

- Convenient Myths - by Klaus Kaiser
- The Deniers - by Lawrence Solomon
- Climategate—The Crutape Letters - by Mosher and Fuller
- Red Hot Lies - by Christopher Horrner
- Climatism - by Steve Goreham
- The Hockey Stick Illusion - by Andrew Montford
- Interview of Montford
- Heaven and Earth: Global Warming, the Missing Science - by Ian Plimer
- Slaying the Sky Dragon - by Hans Schreuder and John O'Sullivan

Videos [2 articles]

Documents [5 articles]

- Little Ice Age Recovery Data - by Syun-Ichi Akasofu
- Surface Temperature Records: Policy Driven Deception? - by Joseph D'Aleo and Anthony Watts
- List of 450 Science Papers Denying AGW - there is "peer reviewed" opposition, Monckton—Dlugolecki Debate - pdf, 3.7 Mb
- The Skeptics Handbook - Joanne Nova
- Europe's Disastrous Climate Policy - a study by British Taxpayers Alliance

What do the critics say?

Global warming is said by many authorities, promoters and supporters to cause climate change to such an extent as to cause catastrophic weather events and disruption, failure of the world eco-systems and, presumably, lead eventually to extinction of the human race[162]. There certainly have been such major events in recent times: a perceived increase in hurricane/cyclone and tornado activity (not proven), huge floods (record flooding of Jakarta 1-3 January 2020), severe droughts

[162] Irrespective of what happens to the earth's climate, the human race is unlikely to become extinct. Homo sapiens have proven to be great survivors through extreme climate changes, e.g., ice ages. However, the quality of life could well deteriorate significantly.

like now in Australia, and most widespread bushfires, particularly in North America and Australia in 2019-20.

It would appear that the majority of world scientists (whether involved in climate science or not[163]) subscribe to the cause/effect chain. NASA says that 97% of scientists agree that climate change is happening. However, certain well-known scientists are critics about the accuracy of world temperature increases:

- Observed global warming since 1850 is more likely to be 0.1+-0.3°C. [Lindzen] [rather than the claimed 1.05°C].
- Climate sensitivity (equilibrium response to 2 X CO2) is < 1°C. [Lindzen] [rather than 3=-1.5°C].
- Water vapour feedback is negative. Upper troposphere decreases with global warming. [Lindzen]
- Humanity has greater existential threats to worry about and for which the trillions being wasted on trying to combat climate change would be much more effectively spent by improving the lot of humanity [attributed to Lomborg]. See also Annex G, *World population growth and consequences*, for the world and Australia in particular.
- The global temperature will not increase rapidly if at all. There is sufficient time to think about future energy and social systems. [Kiminori]
- The climate system is more robust than conventionally claimed. For instance, the Gulf Stream will not stop due to fresh water inflow. [Kiminori]
- There are many factors that cause the climate changes, particularly in regional and local scales. Considering only greenhouse gases is nonsense and harmful. [Kiminori]
- *"What does it mean that the temperature has gone up 0.8 degrees Kelvin: probably nothing*." [Giaever]
- The average temperature of the Earth has varied within a range of about 3°C during the past 3,000 years. It is currently increasing as the Earth recovers from a period that is known as the Little Ice Age.
- Glaciers have been shortening (retreating) since the 1820's, so are not due to increase of CO2 ppm. Glaciers regularly lengthen and shorten in delayed correlation with cooling and warming trends.
- Atmospheric temperature is regulated by the sun, which fluctuates in activity; by the greenhouse effect, largely caused by atmospheric water vapour (H2O); and by other phenomena that are more poorly understood.
- Annual number of strong-to-violent category F3 to F5 tornados in the U.S. since 1950 and 2006 has decreased by 43%.
- Climate change is not making natural disasters worse. [Shellenberger]
- There has been no increase in the annual number of Atlantic hurricanes that made land fall between1900 and 2006. [Shellenberger]
- Habitat loss and the direct killing of wild animals are bigger threats to species than climate change. [Shellenberger]
- Wood fuel is far worse for people and wildlife than fossil fuels. [Shellenberger]
- 100 per cent renewables would require increasing the land used for energy from today's 0.5 per cent to 50 per cent. [Shellenberger]

[163] Unless scientists are directly involved in climate research, their opinion carries no more weight than the man and woman in the street. This comment goes also for unqualified TV presenters and other celebrities who use their celebrity to promote the interests of climate change.

- Global sea levels measured by surface gauges have been rising since between 1850, so predates the increase in hydrocarbon use, even the very large increase in hydrocarbon use [doubling since 1980].
- And from other literature; See Annex D, *Temperature change - fact or fiction?*
  - Sensors around the world are heavily concentrated in developed countries of the northern hemisphere and sparse in most of the remaining world, especially in Africa, most of Asia and South America. Temperature predictions are probably only relevant to the northern hemisphere.
  - Sensors are often poorly located, giving higher readings than actual.
  - Temperature averaging is subject to inadequacy of modelling[164,] even on the most powerful computers, to report let alone predict future temperature changes.
  - Algorithms used by computers are suspect and need verification.
  - Reported temperature data are being subject to biased manipulation to show an increase.
  - The use of one average figure for the planet does not and cannot reflect accurately the obvious differences from one regional, prevailing climate to another.

Conclusions

Essentially, the critics do not accept that the average global temperature[165] is increasing, let alone being the result of the increase of atmospheric CO2 and, thus, not contributing to climate change. They claim that vested interests have been manipulating temperature data and performing invalid modelling to show increases.

The planet has been in another warm cycle for hundreds, maybe thousands of years.

Glaciers have been retreating and sea levels have been on the rise since the early 1800s, before the industrial age and massive increase in world population.

Contrary to common belief, storm events may have increased in intensity, but not in frequency.

Increased levels of CO2 have increased the Earth's vegetation and ability to feed itself.

There is no evident proof of a cause-and-effect relationship between CO2 concentration and global warming or climate change.

Australian Logistics Study Centre
Canberra, 24 July 2020

[164] Computer simulation and modelling is completely dependent on the validity of assumptions made.

[165] A flat global average does not preclude increases at different latitudes or climatic regions.

PERMANENT CLIMATE CHANGE

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About this Annex

This annex looks at what constitutes a climate, how that may change permanently and the consequences of permanent change.

Climate

The so-called 'climate change' is manifested by the weather events around the globe, in frequency and intensity (violence and destructive power), supposedly caused by how the various types of climate could be changing.

However, while the weather in a given region is undoubtedly a direct function of the climate of that region, they are not the same thing. The weather is the short-term behaviour of the atmosphere whereas the climate is the long-term nature of a region, often described in terms of long-term weather patterns.

The climate of any particular region is influenced by a host of interacting factors. These include latitude (how far from the equator); topography (flat, mountainous etc); elevation (over land or sea); prevalence to water (within and surrounding); ocean temperatures and currents (particularly the effect of El Nino, La Nina and the Indian Ocean Dipole (IOD)), vegetation, and prevailing winds and the seasons. The global climate system and any changes that occur within it also influence local climate.

There are many ways that different types of climate are defined but, generally, there are five broad types: tropical, dry, mild, cold, and polar. There are also important subcategories including rain forest, desert, tundra, savanna, and steppe.

Depending on the season of the year, these factors will cause variations to temperature (land, air oceans), humidity and atmospheric pressure, which in turn cause weather events, manifested mainly by the combination of temperatures, winds and precipitation (rain, snow, ice).

Permanent climate change occurs when changes in Earth's climate system result in new weather patterns that remain in place for an extended period of time, maybe forever.

So, what might be causing a permanent change in climate, or for the long term? The big question!

The exponentially-increasing human population is said by many to be the primary cause of global warming and consequent climate change, by burning fossil fuels, cutting down rainforests for more arable land and farming livestock. This adds enormous amounts of greenhouse gases and particulate matter to those naturally occurring in the atmosphere, enhancing the greenhouse effect and global warming.

Greenhouse gases

A greenhouse gas (sometimes abbreviated GHG) is a gas that absorbs and emits radiant energy within the thermal infrared range, so causing what is erroneously referred to as the 'greenhouse effect'. Primary greenhouse gases in earth's atmosphere are water vapour, carbon dioxide, methane, nitrous oxide and ozone, water vapour being recognised as the most powerful absorber of infra-red radiation (IRR). The other greenhouse gases are often referred to as non-condensable, to distinguish them from water vapour.

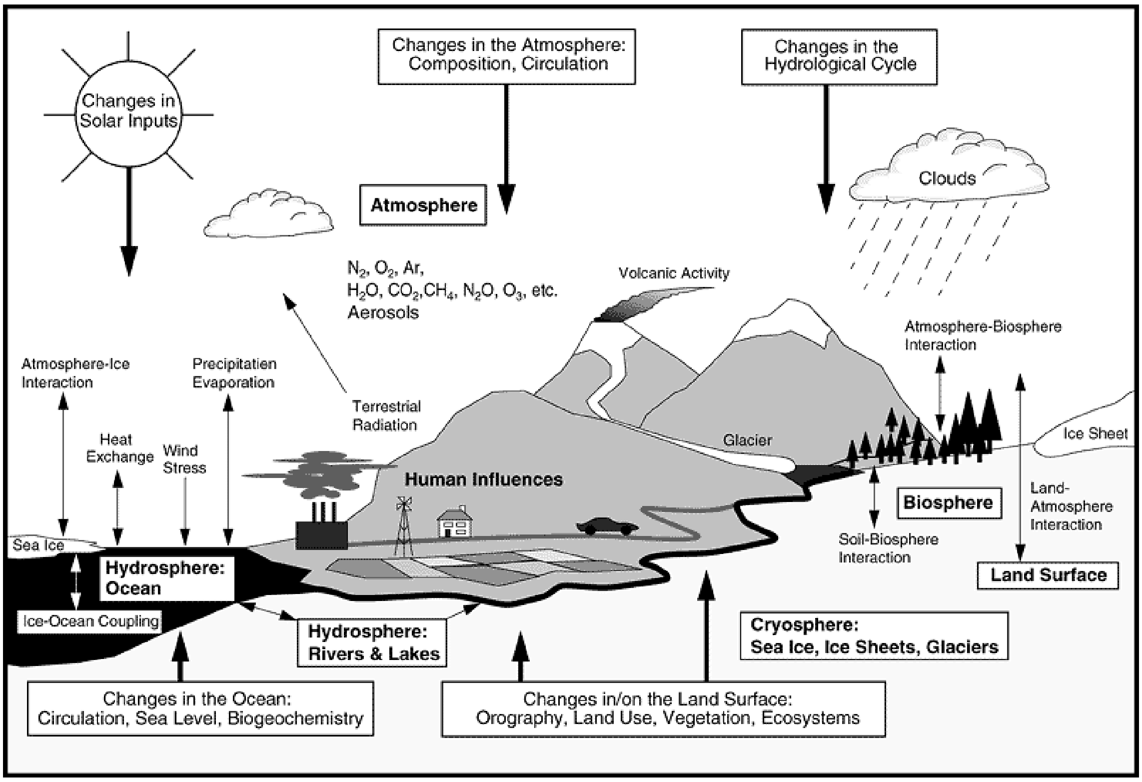
The effect of combustion-produced carbon dioxide on the global climate, a special case of the greenhouse effect first described in 1896 by Svante Arrhenius, has also been called the Calendar effect.

Global warming is projected to have a number of effects on the oceans. Ongoing effects include rising sea levels due to thermal expansion and melting of glaciers and ice caps[166], and warming of the ocean surface, leading to increased temperature stratification.

The claimed effects of global warming include far-reaching and long-lasting changes to the natural environment, to ecosystems and human societies caused directly or indirectly by human emissions of greenhouse gases. It also includes the economic and social changes which stem from living in a warmer world and the responses to those changes. The net effect of these changes is seen by some commentators as an existential threat to civilisation. However, there are scientists who believe that a warmer planet, through more CO2 in the atmosphere would have several advantages like better vegetation growth and fewer deaths caused by cold weather.

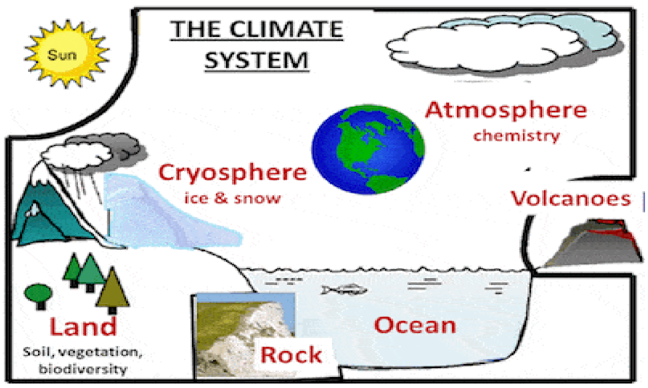
A detailed model of the Earth's climate system is shown in Figure I1, with a simplified model shown at Figure I2.

Figure I1 [1] **– Earth's Climate System**



[166] Note that floating ice sheets do not cause any sea rise when melted, because the volume of water contained is the same as when melted. This can be easily demonstrated by dropping ice cubes into a measuring jug of water.

Figure I2 [2]



https://warmheartworldwide.org/climate-change/?

What is weather

Weather is the day-to-day state of the atmosphere, and its short-term variation in minutes to weeks. People generally think of weather as the combination of temperature, humidity (sweatiness), precipitation, cloudiness, visibility, and wind.

While the weather obeys all of the known laws of physics, its behaviour is often described as the most important case of chaos theory. As such, it is notoriously difficult to model, let alone predict, what it will do with any accuracy. Super computers are needed to model it but are not good enough yet, in the opinion of some scientists, to predict with valid accuracy.

Note: *This should be thought of more as a limitation of the scientists' ability to exploit the power of modern computers, rather than a limitation of the computers themselves.*

So, where do the weather forecasts come from? Meteorology depends on known, general weather patterns for continents and their regions, for the time of the year, as well as a collection of atmospheric data around the globe. Modelling, depending on sophistication, provides a forecast, normally in terms of temperature, air pressures, wind and precipitation forecasts, with variable degrees of accuracy and reliability. But have some sympathy for our meteorologists because they are up against one of the most intractable problems the earth faces. The weather (local, national and international) gets a mention every evening on television. Anyone may form an opinion of how accurate forecasts are, given the weather that actually arrives.

Clouds and climate change

Cloud cover of the Earth is said to average about 50% of the time and varies greatly by region, season and latitude.

There are generally three main types of clouds: high-level clouds (5-13 km): cirrocumulus, cirrus, and cirrostratus; mid-level clouds (2-7 km): altocumulus, altostratus, and nimbostratus; and low-level clouds (0-2 km): stratus, cumulus, cumulonimbus, and stratocumulus.

Even after many years of intense scientific research without clear scientific agreement, the jury is still out on the relative influence of clouds on global warming. Aerosols - carbon black (soot), other particulate matter and fluorocarbons - are very prevalent in the atmosphere and contribute also to the said greenhouse effect, some negatively.

Clouds themselves, depending on type and time of day may cause positive or negative feedback; the science on their net effect is still unclear but is generally accepted as 'positive feedback'.

These issues are treated further in Annex E, *Temperature change – possible causes*, and Annex O, *Aerosols and other pollutants*.

What is permanent climate change

Climate change occurs when changes in Earth's climate system result in new weather patterns that may remain in place for extended periods of time, beyond the cyclic variations in the weather [3].

However, what is most important is to determine if there is a 'permanent' climate change afoot. While there is no end of conjecture and even panic incited by vested interest, there is as yet no proof of permanent change, despite some apparently unusual weather events over the past decade or so. Largely ending in 2019/20, Australia has experienced an extended drought of some seven years in places, but the flooding rains have come back (February 2020) more drenching than ever along the eastern coast. Australia has also experienced a devastating bush fire season in 2019-20, the worst for many years, but by no means unprecedented.

Permanent climate change, let alone due to CO2 emissions, is a long way from being proven.

Consequences

To listen to the doomsayers, the Earth is "*going downhill like a snowball headed for hell*"[167]. What these people are saying in reality, is that 'humanity' may be on its way to hell. The Earth will be here for billions of years after the human race has managed to extinguish itself.

Luckily though, the human race, with all of its faults, has intelligence, resourcefulness and an extremely strong survival instinct. In millennia past, scientific ignorance and superstition ruled the conduct of most societies, but that is no longer the case. The human race has the intellect, if not the will yet, to properly define a proven problem and to apply technology and international cooperation to minimise the risks. Nevertheless, there will always be countries willing to unduly influence (bully) lesser nations instead of cooperating with them.

More severe weather events and damage?

Again, literature is awash with books and media articles about the ill-effects of a permanent climate change induced by an increasing world population. In particular, we are bombarded daily with claims of more severe weather events and consequential damage, hurricanes/typhoons and cyclones, droughts, melting ice and sea-level rise, thawing tundra, water and food shortages, mass migration and competition between races and nations for dwindling resources, even to the point of warfare.

Climatologists are saying that, because of climate change, the regions towards the poles are becoming warmer and that the latitudes +- 40 degrees about the equator are becoming drier. As a result, certain regions will receive greater precipitation, with more violent storms and more severe droughts in areas like Australia that have been drought prone for millennia.

Precipitation

Certainly, if the oceans are warming, there will be greater evaporation from the oceans which must eventually precipitate somewhere. However, the argument is that the greater precipitation will occur over less widespread regions, especially away from the normally wetter tropical regions.

Hurricanes etc

A common claim in climate change literature is that hurricanes[168], typhoons[169], cyclones[170] and tornadoes[171] are becoming more frequent and more violent. Please note that hurricanes normally generate only in the Gulf of Mexico region and ravish the Caribbean, Central America and the southern and eastern coasts of the USA. Tornadoes are mainly a phenomenon of the north American continent. Typhoons are the same as hurricanes but occurring in eastern Asia.

[167] Merle Haggard, country musician and songwriter.

[168] Hurricanes are huge circular windstorms, turning anti-clockwise, occurring in the Northern Hemisphere, and originating over oceans, mostly in the North Atlantic.

[169] Typhoons are like hurricanes but occurring in Asia and India.

[170] Cyclones are also like hurricanes but turning clockwise in the Southern Hemisphere, around northern and north-eastern Australia, as well as the south Pacific Ocean regions.

[171] Tornadoes are violent, tight turning wind storms, originating on land, and mostly occurring in the mid-west of the United States of America. Although very rare of any significant intensity in Australia, they have occurred and done considerable damage – one instance being the extensive destruction of the town Killarney (hometown of this author) on the Darling Downs, Queensland in 1968, with the death of a young girl.

Cyclones are also a type of hurricane, but occurring in the southern hemisphere and are the principal violent weather threat to northern Australia.

While there is some evidence of hurricanes/typhoons and tornadoes becoming more violent, contrary to some expert reports, the frequencies of these are not increasing. See Box I1.

Box I1 [4] [5]
Globally, about 70 to 110 tropical storms form each year, with about 40 to 60 reaching hurricane strength. But records show large year-to-year changes in the number and intensity of these storms. More recently (2000-2013), the average is about 16 tropical storms per year, including about eight hurricanes.
www.c2es.org › content › hurricanes-and-climate-change

For the 21st century, some models project no change or a small reduction in the frequency of hurricanes, while others show an increase in frequency. More recent work shows a trade-off between intensity and frequency – that as warmer oceans bolster hurricane intensity, fewer storms actually form. For the continental United States in the *Atlantic Basin, models project a 45-87 percent increase in the frequency of Category 4 and 5 hurricanes despite a possible decrease in the total frequency of all storms.
www.c2es.org › content › hurricanes-and-climate-change

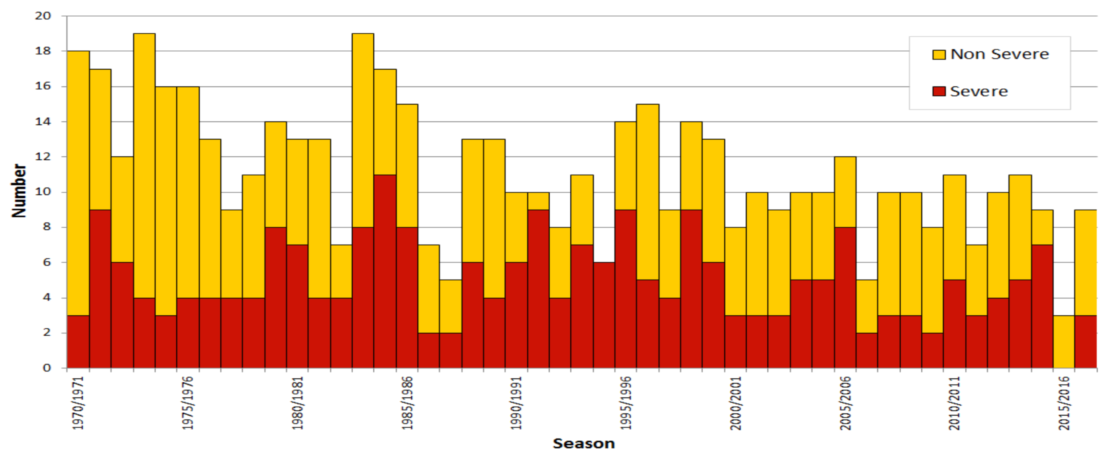
Visually there does not appear to be any significant trend in the total number of hurricanes on the number of Category 3 or higher. The visual impression is confirmed for a compilation of the averages by decades, as shown below. *http://www.sjsu.edu/faculty/watkins/GWcyclones.htm*

Tropical Cyclone Trends

Neither are cyclones around Australia increasing in frequency or intensity. See Box I2 and Figure I2.

Box I2 [6] [7] [8]
Tropical cyclones are like giant engines that use warm, moist air as fuel. That is why they form only over warm ocean waters near the equator. The warm, moist air over the ocean rises upward from near the surface. Air from surrounding areas with higher air pressure pushes in to the low pressure-area.
www.spaceplace.nasa.gov › hurricanes
Tropical cyclones in the Australian region are influenced by a number of factors, and in particular variations in the El Niño – Southern Oscillation. In general, more tropical cyclones cross the coast during La Niña years, and fewer during El Niño years.
The number of severe tropical cyclones (minimum central pressure less than 970 hPa) is dominated by variability with periods of lower and higher frequencies of occurrence. There is less confidence in the earlier intensity data with continuous satellite coverage commencing in 1979.
www.bom.gov.au/cyclone/climatology/trends.shtml
How often do tropical cyclones occur? There is a cyclone season in the south-west pacific that occurs between the months of December and April. On average there are about 11 tropical cyclones that take place each season.
www.juliacoffey.tripod.com

Figure I2 [9]



http://www.bom.gov.au/cyclone/climatology/trends.shtml

Droughts

Certainly, Australia has just endured a very long drought, seven years in some areas. While the drought is persisting in some places, most areas, especially along the east coast, have received very heavy rain during February 2020, some at record levels. However, Australia has always suffered cycles of devastating droughts and 'flooding rains', not just since European settlement in 1788, but for millennia before that.

Where is the evidence that droughts are becoming more frequent and/or more intense in Australia?

Precipitation over Australia and the lack thereof causing droughts are heavily influenced by the behaviour of the Pacific and Indian Oceans, namely by El Niño and La Nina in the Pacific and the Indian Ocean Dipole (IOD).

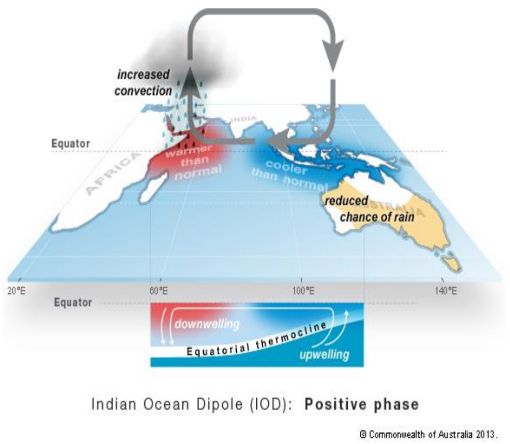
Cooler ocean temperatures leading to less precipitation across the country occur with a positive IOD in the north-west and an El Nino event in the north-east of the country, these combining to lessen precipitation and thus causing drier seasons if not droughts. A negative IOD, manifested by warmer ocean water temperatures on the north-west coast and a La Nina event causing warm water along the north-east coast combine to increase precipitation across the country.

The combined effect of the IOD, El Nino and La Nina, is the predominant determinant of precipitation across Australia. However, these ocean events are, in turn, heavily influenced by the prevailing conditions in each of the oceans, namely the trade winds, water temperature, currents, salinity and sea-levels.

IOD

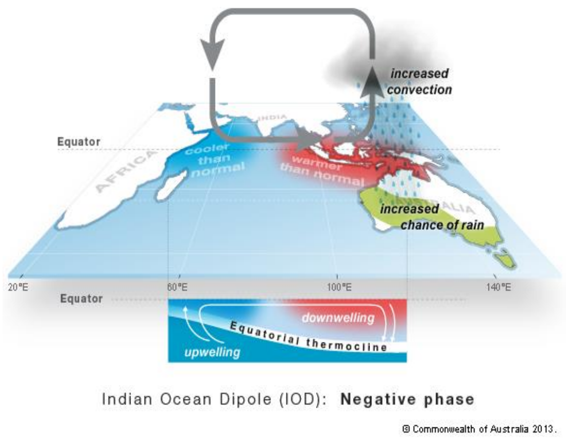
Since 1960, when reliable records of the IOD began, to 2016 there have been 11 negative IOD and 10 positive IOD events. Each has averaged about five years apart but have varied widely between 1 and 12 years apart. Thus, prediction can be difficult - see diagram below. 'Red' is the negative (warm) phase and 'blue' the positive (cool) phase.

Figure I3A [10]



http://www.bom.gov.au/climate/iod/

Figure I3B



El Niño and La Nina

El Niño and La Nina events are actually the two halves - the warm and wet, and cool and dry - of a naturally occurring weather cycle called the "El Niño-Southern Oscillation," or ENSO. See Box I4.

Box I4 [11]

Some climate models predict that the ENSO cycle will intensify as the planet gets hotter, leading to even warmer, wetter El Niños and drier La Niñas—and more devastating impacts on communities around the world. Others show less intensification, or none at all. Scientists are racing to understand the phenomenon better.

El Niños and La Niñas generally occur about every two to seven years. In between, ocean temperatures and rainfall patterns become more average. The patterns aren't perfectly clear, though—a strong El Niño doesn't necessarily mean the following La Niña will be particularly intense, and vice versa.

La Niña events tend to settle in for longer than El Niños, persisting for somewhere between nine months to two

years.
https://www.nationalgeographic.com/environment/weather/reference/el-nino-la-nina/

While El Niños and La Niñas generally occur about every two to seven years, it is how they coincide and even overlap in time with the IOD that determines the general precipitation levels across Australia that will vary markedly from east to west. All four cycles average roughly every five years but vary widely. Given the variability of all strong variables involves predictions of overlaps and, thus, precipitation and droughts across Australia could be difficult. Monsoons in the north are caused by other weather phenomena peculiar to the tropics. Not to be ignored, the Southern Ocean will also be of influence on cold air masses from Antarctica, which affects weather patterns across southern Australia, from the south-western part of Western Australia, across to and through Victoria and Tasmania.

How these events might be changing with global warming will largely determine precipitation and droughts across Australia in future decades. However, as yet, the jury is still out on this question.

In his book [12, p47], Hansen dismisses the effects of El Nino, La Nina and the IOD as 'sloshing' and of no impact on permanent climate change. Nevertheless, the author of this document would argue that whatever happens in Australia's climate will be very much and predominantly influenced by Indian Ocean and Pacific Ocean behaviour as well as by cold air masses from Antarctica.

Bushfires

There is little doubt that 2019-20 has been a relatively hot summer and, combined with an extended drought, built-up fuel loads and intrusion of development into these vulnerable zones, has led to devastating and wide-spread bushfires over these months. This of course led to wildly irrational claims by vested interests and the gullible that it was all due to climate change. Whether the summer of 2019-20 was an exceptionally bad year for bushfires, let alone due to climate change, has been disputed by more rational sections of the Australian community. A Royal Commission was established to determine the extent, causes and consequences of the fires. Hopefully, the Commission may make some judgement as to whether global warming was indeed the real cause or whether the fires were part of natural cycles, e.g., a one-in a hundred-year occurrence.

The Reef

"*Even with the 1°C of warming we've already experienced, 50 per cent of the Great Barrier Reef is dead. We are witnessing catastrophic ecosystem collapse of the largest living organism on the planet. As I share this horrifying information with audiences around the country, I often pause to allow people to try and really take that information in.*" [13] *https://climate.anu.edu.au/. "The terrible truth of climate change", Joëlle Gergis, August 2019.]*

This is an example of the work being done by one of some 300 staff of ANU's Climate Change Institute (CCI).

Readers should note that, while the above statement may be true, the reef will not die out. Given rising ocean temperatures, permanent or of significant duration, the reef can be expected to migrate progressively south and will be here a long time after humanity has disappeared from the planet.

In the meantime, however, there could be serious economic damage due to loss of tourist dollars if the reef is severely impacted and even serious loss of hatcheries for commercial fish stocks[172].

Melting glaciers, icecaps and se-level rise

A common and popular ploy of climatologists and fellow travellers is to point out retreating glaciers, melting icecaps and sheet ice as evidence of global warming and sea-level rises. Critics point out that such effects on ice have been going on for hundreds if not thousands of years, given that the Earth is in a natural warming cycle. This is not in fact disputed by climatologists but who say that anthropologically induced global warming is accelerating the melting.

[172] These aspects have not been researched by this author.

Thawing tundra

A possibly nasty scenario, with arctic latitudes supposedly getting warmer, as climatologists are predicting, would be the progressive thawing of the tundra in northern Europe, Russia, Canada and Alaska.

Scientists report that there are very significant levels of CO2, methane and mercury currently trapped in the permafrost that would escape into the atmosphere, so exacerbating the global greenhouse effect as well as the very poisonous mercury vapour posing a health threat.

The travel TV program "*Russia With Simon Reeve* (BBC2, 2017" was reviewed by the Guardian (UK) [14]. A few extracts from the report:

"Reindeer herding is getting (even) harder because of climate change. Sometimes it now rains instead of snows, even in winter. The rain then freezes, the reindeer can't get at their lichen, and they die. … Simon is taking a keen interest in environmental matters – the plight of the Siberian tiger, mass deforestation, huge craters that appear and fart out methane when the permafrost melts …"

This author watched the program. The 'huge crater' appeared to be a 'sink hole' but was said to be a direct result of the permafrost thawing. Why just this one hole – should there not also be others?

A late report on the situation in the Russian Arctic is given in Box I5. Thawing permafrost would appear to pose a significant threat with undesirable greenhouse gas emissions and there also seems to be little chance of stopping it. However, while climatologists are quick to blame anthropological global warming, one must not forget that the Arctic is exposed to massive levels of solar radiation during its short summer, and that the current warm phase that the Earth has been subject to for some hundreds of years, cannot be discounted as the cause.

But, where are corresponding reports of thawing in Canada and Alaska, or is it only in Russia?

Box I5 [15]
A Disastrous Summer in the Arctic 27Jun20
Record heat is hastening the dissolution of Siberian permafrost, perennially frozen ground that, when thawed, unleashes greenhouse gases and dramatically destabilizes the land.

The remote Siberian town of Verkhoyansk, three thousand miles east of Moscow and six miles north of the Arctic Circle, has long held the record, with another Siberian town, for the coldest inhabited place in the world.

Anthropogenic climate change is causing the Arctic to heat up twice as fast as the rest of the planet. Climate models had predicted this phenomenon, known as Arctic amplification, but they did not predict how fast the warming would occur.

On May 29th, outside Norilsk, the northernmost city in the world, the thawing ground buckled, causing an oil-storage tank to collapse and spew more than a hundred and fifty thousand barrels, or twenty-one thousand tons, of diesel fuel into the Ambarnaya River. The spill was the largest to ever occur in the Russian Arctic.

With its abundant plant life, the Arctic, for tens of thousands of years, was a carbon sink for the rest of the planet. Permafrost across the Arctic and boreal regions contains between 1.46 trillion and 1.6 trillion tons of organic carbon, which is almost twice the amount present in the atmosphere today. This carbon includes hidden pouches of ancient methane, plus long-frozen organic matter (akin to a frozen compost pile) that can release carbon and methane once microbial life awakens in the warming ground.

The result is thermokarst, the strange and sometimes shocking topography that forms as the land slides, sags, and sinks. Mysterious sinkholes suddenly appear, drunken forests fall, and hillocks destroy farmland. One of Russia's most extreme examples of thermokarst, known as the Batagay megaslump, is a two-hundred-and-eighty-foot-deep, half-mile-wide depression, situated just outside Verkhoyansk. It first began forming as a small gully in the nineteen-sixties, because of deforestation, but has grown significantly in recent years.
https://www.newyorker.com/news/annals-of-a-warming-planet/a-disastrous-summer-in-the-arctic

Mercury

Vast amounts of toxic mercury have accumulated in the arctic tundra, potentially threatening the health and well-being of people, wildlife and waterways, according to a University of Massachusetts Lowell (UMass) investigating the source of the pollution. [16]

A research team led by Prof. Daniel Obrist, chairman of UMass Lowell's Department of Environmental, Earth and Atmospheric Sciences, found that airborne mercury is gathering in the arctic tundra, where it gets deposited in the soil and ultimately runs off into waters. Scientists have long reported high levels of mercury pollution in the Arctic. The new research identifies gaseous mercury as its major source and sheds light on how the element gets there.

"*Now we understand how such a remote site is so exposed to mercury,*" Obrist said. Although the study did not examine the potential impact of global warming, "*if climate change continues unchecked, it could destabilize these mercury deposits in tundra soils and allow large amounts of the element to find its way into arctic waters*", he added. *[www.sciencedaily.com]*

Disease

In addition, the masses of additional stagnant water from melting ice and thawing tundra would cause massive increase in insect populations, especially vectors of disease like mosquitos. However, note that these latitudes have always suffered from plagues of mosquitos and gnats in the summer.

Water, food shortages and mass migration

Given population induced global warming, droughts and more concentrated regions of precipitation, one may see how fresh water and arable land for food production could become in short supply. Under that scenario, there could be devastating consequences of famine, mass migration of races, if not whole nations, which would inevitably lead to violence and war over resources needed for survival.

"*What are the causes of mass migration? Today people are moving more than ever before. The reasons for migrating are complex but people usually flee from their home due to war, persecution, global warming, the climate crisis, water degradation, land rush and food poverty*." [17] *[https://www.google.com/search]*

One should note that there have been mass migrations of races before in history, induced by climate change, e.g., the migration of Nordic races down into Eastern Europe around 200BC. See Box I6.

While induced by other reasons, the natives of North America did not appreciate the Great Atlantic Migration of the 19th century, nor did the natives in Australia, New Zealand, Africa and South America appreciate the forced colonisation by Europeans.

Box I6 [18]
During the Iron Age various Germanic tribes migrated from Scandinavia to East-Central Europe. This included the Rugii, Goths, Gepids, Vandals, Burgundians and others [42] [47] [48]. The Rugii might have originated in Western Norway (Rogaland) [49]. The migrations of most of these tribes is thought to have occurred around 200 BC, though the Vandals might have migrated earlier [48] according to the historian.
https://en.wikipedia.org/wiki/North_Germanic_peoples#Prehistory

Conclusions

While there is some evidence of hurricanes/typhoons and tornadoes becoming more intense, contrary to some expert reports, the frequencies of these are not increasing.

The combined effect of the Indian Ocean Dipole (IOD), El Nino and La Nina, is considered by this author to be the predominant determinant of precipitation across Australia. These ocean events are, in turn, heavily influenced by the prevailing conditions in each of the oceans, namely the trade winds, water temperature, currents, salinity and seal-levels. How these phenomena may be influenced in the long-term by increasing surface temperature is somewhat difficult to say, they being up to a thousand years away, given the varying inertia of the ocean currents at all depths.

While there have been many reports of the Great Barrier Reef dying off, permanently or for significant durations, given rising ocean temperatures, the reef can be expected to migrate progressively south and will be here a long time after humanity has disappeared from the planet. In the meantime, however, there could be serious economic damage due to loss of tourist dollars and possible damage to commercial fish stocks, if the reef is severely impacted by global warming.

In respect of retreating glaciers, melting icecaps and sheet ice as evidence of global warming and sea-level rises, critics point out that such effects on ice have been going on for hundreds of years, given that the Earth is in a natural warming cycle. This is not in fact disputed by climatologists but who say that anthropologically-induced global warming is accelerating the melting.

Scientists report that there are very significant levels of CO2, methane and mercury currently trapped in the arctic permafrost that with warming could escape into the atmosphere, so exacerbating the global greenhouse effect as well as the very poisonous mercury vapour posing a health threat.

In addition, the masses of additional stagnant water from melting ice and thawing tundra would cause massive increase in insect populations, especially vectors of disease like mosquitos.

Given population induced global warming, droughts and more concentrated regions of precipitation, one may see how fresh water and arable land for food production could become in short supply, especially in Australia. Under that scenario, there could be devastating consequences of famine, mass migration of races, if not whole nations, which would inevitably lead to violence and even war over resources needed for survival.

Australian Logistics Study Centre
Canberra, 24 July 2020

ANNEX J TO
A view on permanent climate change

WHAT CAN AND IS BEING DONE

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About this annex

This annex addresses the important matter of what can be done and what is being done, in response to the challenge of possible permanent climate change, but in an economically responsible way and recognising that, while 'we are all in this together', on planet Earth, what the world institutions like the United Nations (UN) might expect to occur as a whole, is not necessarily in the best interests of any given nation, especially one like Australia.

Introduction

Climate change due to rising levels of non-condensable greenhouse gases like carbon dioxide (CO2) in the atmosphere is either real, as promoters claim; not happening, as critics claim; or somewhere in between and controllable with reasonable investment.

Given an objective statement "*To reduce national greenhouse emissions and pollution, subject to reasonable cost*", and Australia's international obligations under the Kyoto protocol of 2005 (see Definitions) and the Paris Agreement of 2015, there are many things that Australia can do. *Running around like 'Chicken Littles" or acting like the "Extinction Rebellion" protesters are not two of them!*

What can be done

Policies and initiatives have been under way for many years already by Australian governments and industry, to reduce greenhouse gases retained in the atmosphere, in tacit if not explicit recognition that these are the primary causes of global warming and any consequent permanent climate change.

There are many and varied ways that greenhouse gas levels in the atmosphere, especially of CO2, can be decreased. All have a place to contribute but, hopefully, each in an economically responsible way (for each country) according to each's ability to decrease emissions.

A non-exclusive range of means of greenhouse gas reduction appears to be as follows (not in any specific order):

- High Efficiency Low Emission (HELE) coal-fired power generation **[*limited if any*]**;
- reduced use of coal-fired electricity generators in favour of other fossil fuels such as natural gas and oil which produce significantly less greenhouse gases;
- nuclear power generation ***[not in Australia]***;
- use of renewable energy sources;
- energy storage – batteries; dams (several options available for pumped hydro);
- promotion and provision of infrastructure for electric vehicles (EV);
- electrification of public transport;

- CO_2 capture and sequestration, e.g., into basalt, like in Iceland[173];
- recycling of waste;
- exploitation of current and new technologies;
- development of hydrogen and fuel cell production **[*limited if any*]**;
- land fill methane capture and production of electricity;
- livestock methane capture and recycling of waste in closed-loop, self-sustaining entities;
- land use, land use change and forestry management (LULUCF), including reforestation;
- government subsidies or public investment for the foregoing means;
- carbon trading schemes; and
- taxes on carbon.

Unless otherwise flagged, the foregoing means are being exploited already to some extent, by many countries, including Australia.

Criteria for policy development

There is so much hyperbole and misinformation being generated about climate change by vested interests, rent-seekers, carpet-baggers and believers that governments are being unreasonably pressured by popularism to adopt inappropriate solutions **for** the reduction of greenhouse gas production.

Clearly governments need to establish firm criteria for the development of policies to meet international obligations for reduction of greenhouse gases. One set of criteria could be as follows:

- consistency with their national interests;
- economically responsible;
- consistency with their national resource capability;
- market led initiatives with minimal subsidies;
- based on science and technology;
- morally responsible; pulling one's weight; and
- keeping all issues in perspective.

There is no real place for emotional popularism; the matter is too important to be corrupted by politics or by entities who or which would insinuate themselves as the interpreters to the ignorant masses of what is meant by 'climate science'.

International protocols and obligations

Paris Agreement [1]

The essential articles of the 2015 Paris Agreement are Articles 2.1, 9.5 and 13.7, as shown in Box J1.

The Agreement requires 'best efforts' only of signatory countries, except for some reporting requirements.

The Agreement talks of 'developed' and 'developing' countries and, as may be expected of a United Nations document, the Agreement is big on the 'developed' countries helping the under-developed countries to cope with climate change.

On this point, a major bone of contention is that China is still classed as a 'developing' nation, so enjoying special economic dispensations, at the expense of the Western industrialised nations, when clearly it is economically and technologically on a par with them. In the past 40 years, China's economy has grown at some 7-8% per annum and increased its energy consumption (and greenhouse gas production) from less than 2 to over 8 million tonnes per capita.

[173] Scientists in Iceland are turning carbon dioxide into rock [https://www.weforum.org/agenda/2019].

Box J1
Paris Agreement - Article 2

1. This Agreement, in enhancing the implementation of the Convention, including its objective, aims to strengthen the global response to the threat of climate change, in the context of sustainable development and efforts to eradicate poverty, including by:

(a) Holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels, recognising that this would significantly reduce the risks and impacts of climate change;
(b) Increasing the ability to adapt to the adverse impacts of climate change and foster climate resilience and low greenhouse gas emissions development, in a manner that does not threaten food production; and
(c) Making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development.

2. This Agreement will be implemented to reflect equity and the principle of common but differentiated responsibilities and respective capabilities, in the light of different national circumstances.

Article 9

5. Developed country Parties shall biennially communicate indicative quantitative and qualitative information related to paragraphs 1 and 3 of this Article, as applicable, including, as available, projected levels of public financial resources to be provided to developing country Parties.

Article 13

7. Each Party shall regularly provide the following information:

(a) A national inventory report of anthropogenic emissions by sources and removals by sinks of greenhouse gases, prepared using good practice methodologies accepted by the Intergovernmental Panel on Climate Change and agreed upon by the Conference of the Parties serving as the meeting of the Parties to this Agreement; and

(b) Information necessary to track progress made in implementing and achieving its nationally determined contribution under Article 4.

Australian Government position

Australian's emissions target

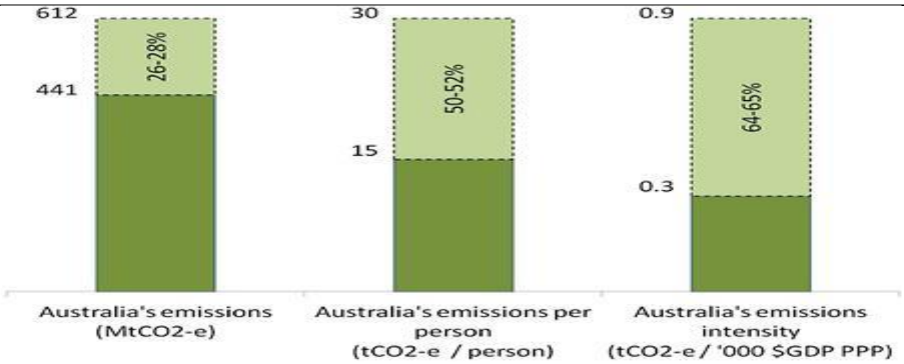
Under the Kyoto Protocol and the Paris Agreement, in 2016, Australia joined more than 170 countries in signing-up to a global deal that seeks to combat climate change by reducing greenhouse gas emissions.

Australia is committed to reduce emissions to 26-28 per cent on 2005 levels by 2030 [See Box J2]. This target would represent a 50-52 per cent reduction in emissions per capita and a 64-65 per cent reduction in the emissions intensity of the economy between 2005 and 2030. [2]

Note: *There is some confusion as to whether Australia is committed to reduce emissions* ***to*** *26-28 per cent on 2005 levels by 2030, or* ***by*** *26-28 per cent from 2005 levels. This statement seems to be in error. The graphs in Box J2 and J3 clearly show a reduction* ***by*** *26-28%. A reduction by 26-28% has been used throughout this paper.*

The Federal Government's current position is summarised in Boxes J2 and J3.

Box J2
Australia's target
Australia will reduce emissions to 26-28 per cent on 2005 levels by 2030. This target represents a 50-52 per cent reduction in emissions per capita and a 64-65 per cent reduction in the emissions intensity of the economy between 2005 and 2030.
Our targets build on our success to date.
Australia outperformed its first target under the Kyoto Protocol. Our Direct Action Plan on climate change has us on track to meet our commitment to reduce emissions by five per cent below 2000 levels by 2020, which is equivalent to 13 per cent below 2005 levels.



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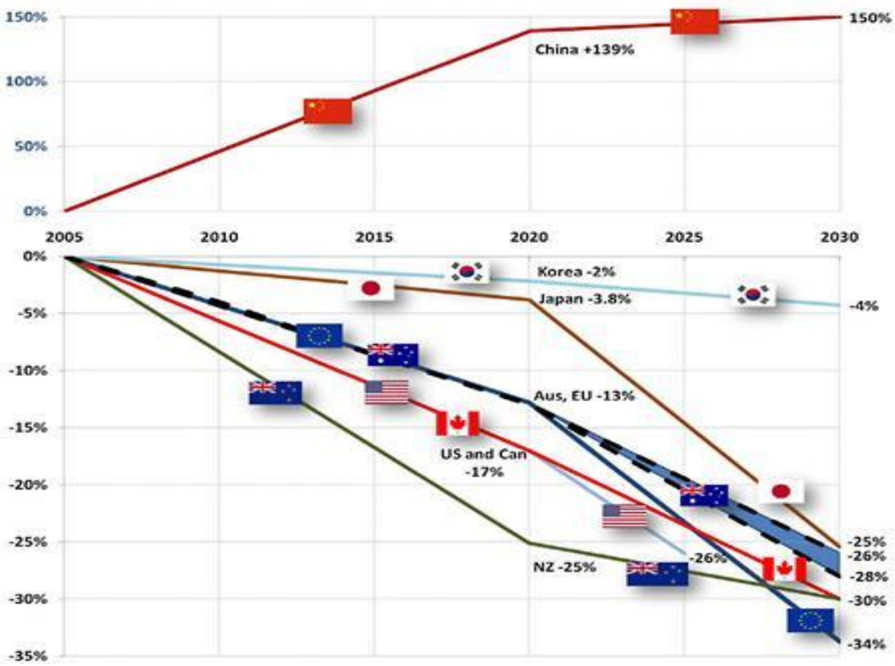
https://www.environment.gov.au/climate-change/publications/factsheet-australias-2030-climate-change-target

Box J3 [2]
Australia's efforts to reduce emissions are in line with other countries

Other countries are acting on climate change and taking strong commitments to Paris. It is important that all countries, and especially major emitters, work together to reduce emissions. Australia is responsible for around 1.3 per cent of global emissions.
Our target is a fair contribution for Australia. When expressed against a common base year of 2005, Australia's target is similar to those announced by the United States, the European Union, Canada, New Zealand and Japan.

Figure J1.



When expressed against a common base year, Australia's target is comparable to other countries' targets. 2 ?
Source: Department of the Environment analysis
https://www.environment.gov.au/climate-change/publications/factsheet-australias-2030-climate-change-target

What the critics of the Government are saying

Essentially, in spite of its genuine efforts, the critics are giving the Federal Government a hard time about its emissions reduction programs and, unfortunately undermining the Government's efforts and generating mistrust. Political motives cannot be discounted. Climate change is very much a political football in Australia, if not the world.

Before becoming too critical of the Government, these critics could do well to read the Scoping Study by the Business Council of Australia (BCA) [3], the aims for which are shown in Box J4.

The BCA paper goes on to give an excellent outline of all the Federal Government programs put in place since 2012 to reduce CO2 emissions, particularly the $billions invested in 'renewable' sources. Nevertheless, it too is not without its critics. The journalist, Terry McCrann has been particularly scathing in a critique of the BCA's policy position. [4] "*Emissions debate goes from inane to ridiculous*", The Weekend Australian, 23-24 May 2020.

Mr McCrann has another vicious swipe at the misinformation by climatologists and camp followers in his article "twittering twerps' hot air over coal demise" [5] The Weekend Australian, 20-21 June 2020.

Box J4
BCA Scoping Paper - energy and climate change policy, 10-Feb-20

For over a decade we have supported strong action on climate change:

We support the science of climate change.

We support the Paris Agreement and transitioning to net-zero emissions by 2050.

If we can meet our emissions reduction targets without carryover credits then we should.

We support the need for a market-based carbon price to drive the transition and incentivise investment in low and no-emissions technology.

Technology needs to drive the transition which will not only get us to a net-zero emissions future but will also create new jobs, opportunities and industries and maintain Australia's competitiveness.

We supported the Rudd government's Carbon Pollution Reduction Scheme (CPRS), called for an Emissions Intensity Scheme, supported a Clean Energy Target (CET) and most recently worked hard to bring industry and the community together to support the National Energy Guarantee (NEG). Further information on our record is available here.

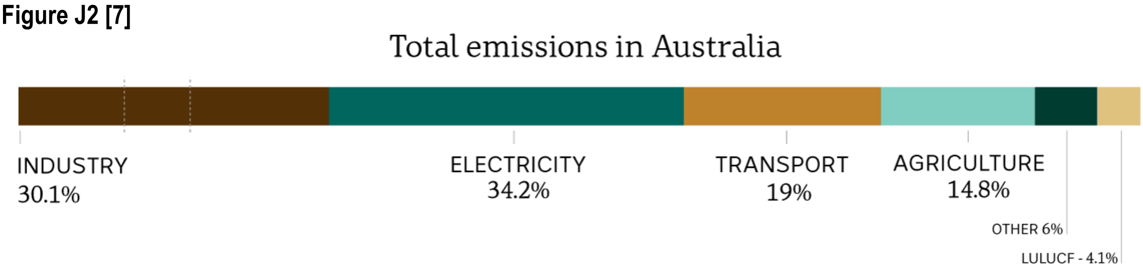
The ABC

In 2019 (and often since in programs like 'The Drum'), the ABC asked *"Will we make it? Are Australia's efforts to curb global warming enough to meet our Paris target?"*, as presented by Stephanie March, on Four Corners, April 2019. Readers who may have missed the transmission, can see it on *YouTube: Four Corners: Climate of Change.* [6]

The program gives a good overview of the climate change situation in Australia, covering the four main culprits of CO2 emissions, with interviews with respected climate analysts and consultants.

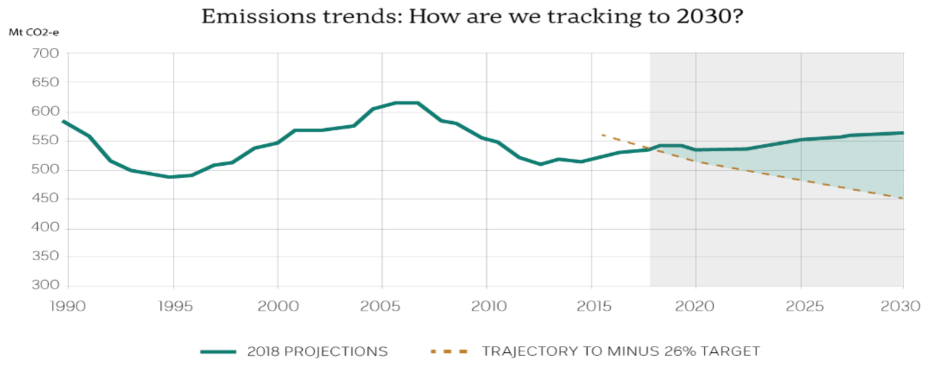
The diagrams of Figure J2 are taken from the ABC article.[174]

Figure J2 [7]



The Government's own projections show Australia is not on track to meet its current Paris target.

[174] Note in Figure J2 that the electricity sector may account for 34.2% of emissions but only 27% of total energy consumed in Australia.



https://www.abc.net.au/news/2019-04-01/is-australia-on-track-to-meet-its-paris-emissions-targets/10920500

In particular, the ABC, as one would expect, is a major and unrelenting critic of the current federal government. If one watches the ABC programs - the 7:00 News, the 7:30 Report, The Drum and The Insiders and Q&A - these do not miss any opportunity to criticise the Government on its climate change policies and action.

Others

One particular, erroneous criticism that the Media and even some climate change analysts maintain is that the Government is acting unethically in counting carbon credits earned from past years. They have even gone so far as to claim that Australia is a 'laughing stock' after its presentations at the Madrid conference on climate change in June 2020. [8]

"*Emissions projections released as Taylor left Australia suggested the Morrison government was on track to meet its 2030 target (at least a 26% emissions cut below 2005 levels), but only if it used carryover credits. Without them it expected emissions to achieve just a 16% cut*."
[https://www.theguardian.com/environment/2019]

Use of credits may be unethical in the eyes of biased critics but, until banned under the Paris Agreement, use of credits is legitimate practice whether climate changers like it or not. See Box J5. Disallowing them would be like educational institutions refusing to honour credits for subjects done in the past (even though some institutions put a time limit on credits).

Box J5
About 100 countries at UN climate talks challenge Australia's use of carryover credits (late 2019].

Australia's plan to use an accounting loophole to meet its international emissions targets has been formally challenged at UN climate talks, with about 100 countries wanting the practice banned under the Paris agreement.

Delegates from developing countries led by Belize and Costa Rica have introduced a ban on using carryover credits from the Kyoto protocol into the text of the rulebook for the Paris climate agreement, which is being debated at a meeting in Madrid.

It is a crucial debate for the Morrison government as it relies on using the accounting measure to meet its commitment under the Paris deal. The emissions reduction Minister, Angus Taylor, arrived in Madrid on Sunday ?? to make Australia's case at the second week of the talks. *www.theguardian.com/environment/2019*

When the ABC, The Guardian and other critics of what Australia is doing about climate change start to address what the really big polluters like China are doing, they may achieve some credibility in the eyes of rational Australians, but until then they are simply on an ego-centric, political joyride, at taxpayer expense.

What Australia is doing to reduce emissions

Despite the often-harsh criticism by vested interests, Governments are not resting on their arms reversed or on their laurels, whether state, territory or Federal. A great deal is being done.

We must never lose sight of the fact that Australia is responsible for only around 1.06% of global emissions in 2020. Australia could disappear off the planet tomorrow and it would not make any difference to climate change. Climate changers cannot argue with the truth of this statement but attempt, with sophistry and narcissism, that Australia with its 25 million citizens (0.03% of world) should be showing 'leadership' to the world of 8 billion. Where is the leadership by the major emitters? Even Australia's Chief Scientist was asked in 2017, "*what difference it would make to the climate if we reduced global emissions by the equivalent of Australia's total emissions (1.3%), he had to reply, 'virtually nothing'*" [9]

Readers here and Australians need to note that there is no one silver bullet to reducing emissions and that it will take decades to make even modest inroads against excessive emissions. Whether it can be done without wrecking the Australian economy in the process is another but very legitimate question. There are too many climate changers ignorant of the economic damage that their agendas would do. *"Softly, softly, catchee monkey"*, should be a guide.

Policies and initiatives have been under way already for many years by both governments and industry, by way of the following non-exclusive list:

Federal Government initiatives:

- Emission Reduction Fund (see definition, Annex T, *glossary*);
- Industry Safeguard Mechanism (see definition, Annex T, *glossary*);
- Land use, land use change and forestry (LULUCF);
- High Efficiency Low Emission (HELE) coal-fired power generation;
- Government subsidies for renewable energy production;
- Direct action for CO2 sequestration;
- energy storage - Snowy-2 pumped hydro initiative;
- support for new technologies [part of energy policy];
- renewable energy targets - set and acted upon by state and territory governments; and
- reduced use of coal-fired electricity generators in favour of other fossil fuels such as natural gas and oil which produce significantly less greenhouse gases [part of energy policy].

Policies under consideration (non-exclusive):

- a carbon trading scheme [as recommended by Professor Garnaut [10]];
- a carbon tax [was introduced under the Gillard government with claimed success while in force, but abolished by the succeeding Abbott government);
- CO2 capture and sequestration (trials but no full-scale activity due to costs of current technologies); and
- development of hydrogen and fuel cell production in Australia [being recommended by Professor Garnaut [11].

Other policies for consideration:

- nuclear power generation [not being acted upon despite potential]; and
- livestock methane capture and recycling of waste in closed-loop, self-sustaining entities [little if any in Australia to date].

In respect of renewable energy, while Australia has made impressive inroads to renewable energy production (at considerable subsidised expense), one must keep things well in perspective. To date, Australia has managed to generate some 21.3 to 24%[175] [12] of its electricity consumption from renewables. However, given that the electricity sector consumes 27% of all energy consumed in Australia, renewables account for only about 6.5% of the country's total energy consumption. Unless hydrogen comes to the rescue (a long way away yet if ever), renewables will never be able to produce all or anywhere near Australia's total needs. However, they may be able to do enough to reduce Australia's greenhouse gas emissions by at least 1% per annum.

State Government initiatives (in the main but possibly with Federal financial assistance):

- electrification of public transport;
- recycling of waste;
- land fill methane capture and production of electricity (being done by all or most governments);

[175] Depending on data source.

- energy storage - batteries; dams and pumped hydro);
- hydrogen production; "*In April 2018, the federal and Victorian governments announced a brown coal-to-hydrogen project that would operate out of AGL Energy's Loy Yang A power station. Construction is expected to begin in 2019, and hydrogen production by 2020 or 2021* [13]; and
- promotion of electric vehicles (EV) (see annex Q, Electric vehicles).

Activities by other Australian entities

Several significant companies - industrial and service - are progressively changing internal operational policies to reflect changing attitudes to climate change. Such action has not been without controversy, often being seen as 'virtue signalling' by Board members and CEOs and neglect of their primary duty to shareholders. A particular case is financial institutions refusing to finance investment in coal-fired power generation. On the other hand, the Construction, Forestry, Maritime, Mining and Energy Union (CMMEFU) has recently endorsed the development of HELE coal power generation.

Progress

The following are extracts from an Australian Department of Energy Emissions Report, as reported in The Australian, 29 May 2020. [14]:

- Greenhouse gas emissions fell 0.9 per cent last year to 532.5 million tonnes.
- Expressed as an emissions budget, the latest government estimates are for Australia to beat its 2030 target by 16 million tonnes.
- China has turned to coal to drive its pandemic recovery, approving five new coal-fired power plants totalling 7960 megawatts in March, more than during the whole of last year.
- Energy Minister Angus Taylor has confirmed Australia will join Japan and New Zealand in resisting calls to lift its Paris agreement targets to stick with already announced emissions reduction targets for 2030. Mr Taylor told parliament this week that he would write to the UN to say Australia would not update its target for 2035 or 2040 until 2025.
- Electricity demand was down 2.8 per cent in April, year-on-year, but petrol sales were down 43 per cent, diesel down 10 per cent and aviation fuel down by 79 per cent.
- The December-quarter figures show that emissions from electricity production for the 2019 calendar year were down 2.9 per cent, or 5.3 million tonnes.
- Most of the increase was due to strong growth in LNG exports which were up 11 per cent, making Australia the world's largest LNG exporter last year.
- Emissions per capita and the emissions intensity[176] of the economy fell to their lowest levels in three decades. "*The emissions intensity of the economy was 63.4 per cent lower than in 1990".*
- "*Emissions per capita were lower than 1990 by 41.2 per cent while the emissions intensity of the economy was 63.4 per cent lower than in 1990*", the Energy Department report said.
- Mr Taylor said only four countries had formally committed to net zero emissions by 2050[177] to the UN. He said the government's long-term strategy would "*set out how Australia can contribute to meeting the goals of the Paris agreement, including to achieve net zero emissions globally in the second half of the century*".

What the world is doing

This subject would be far too much to cover here, but a few comments are considered appropriate.

[176] An emission intensity (also carbon intensity, C.I.) is the emission rate of a given pollutant relative to the intensity of a specific activity, or an industrial production process; for example, grams of carbon dioxide released per megajoule of energy produced, or the ratio of greenhouse gas emissions produced to gross domestic product (GDP). Emission intensities are used to derive estimates of air pollutant or greenhouse gas emissions based on the amount of fuel combusted, the number of animals in animal husbandry, on industrial production levels, distances travelled or similar activity data.

[177] What does 'net zero emissions by 2050' really mean – all fossil fuel emissions (unrealistic) or just for electricity production (feasible)?

The really big emitters are China, USA, India and Europe, between them accounting for some 60-70% of all annual CO2 emissions and related pollutants.

Other countries are in the process of building many new coal- or gas-fired powerhouses. Australia exports coal and only because others want to buy it for its high (less polluting) quality. A legitimate argument is often made by the Federal Government that, if Australia stopped exporting coal, world emissions would increase. Such would be the case given that Australia accounts for only 7% of world coal production[178].

Europe has been doing a lot in respect of renewables and promotion of EVs but often neglect, in lauding their progress in phasing out fossil fuels, that several have significant levels of nuclear power, e.g., England at 21% and France at 70%, whereas Australia has no nuclear power. In spite of progress, there are now reports that Europe is tiring of the massive subsidies that they have poured into renewables and other initiatives for little evident decrease in global warming.

China is by far the biggest emitter, at about 30% of total, with its 1.4 billion people, already well up the scale as energy consumers per capita (8 million tonnes per annum), but most likely to be due to their massive industry exporting to the whole world. There are reports of China making some inroads against emissions, but is continuing to build many fossil-fuelled powerhouses.

India also has 1.4 billion people and are building many fossil-fuelled powerhouses. However, the problem that India poses for the world, is that it is coming off a very low base as to per-capital consumption of energy (2.9 million tonnes per annum) and, so, has a great deal of catching up to do in respect of standards of living – that will take a great deal of energy, far beyond the capabilities of renewables. For detailed discussion on these matters, see Annex F, *Demand for energy and emissions*, and Annex G, *World population growth and consequences.*

The USA is reported to have made massive investment in renewable energy, especially in some states like California. The USA is also investing heavily in manufacture of EVs. It remains a power house in technology development and should be capable of developing affordable means to control emissions. However, the USA will remain heavily dependent on fossil fuels for transport and industry, agriculture and transport for many decades yet.

When one reads the frequent articles by Dr Bjorn Lomborg [15] and listens to his presentations on the Internet, he gives the impression that he is not so much against the notion of climate change and the claimed causes, as he is to the way nations are prepared to waste trillions of dollars in attempting to combat it. He says that, by all means pursue (rationally) ways to reduce CO2 emissions, e.g., by 'renewable' energies, but that humanity has other major existential threats to worry about and for which the trillions being wasted on trying to combat climate change would be much more effectively spent by improving the lot of humanity.

Net zero emissions by 2050

The IPCC Glossary [16] defines Net zero emissions as *"Conditions in which any remaining anthropogenic carbon dioxide (CO2) emissions are balanced globally by anthropogenic CO2 removals. Net-zero CO2 emissions are also referred to as carbon neutrality."*

Several countries (and some Australian states have signed-up and made a commitment under the United Nations' Kyoto Protocol and Paris Agreement to achieving Net zero emissions by 2050 (only 30 years away). But is such a target really feasible or just an objective? How do these countries – rich or poor - plan to get there and pay for it without severely damaging their economies and aspirations for a better standard of living? Some countries, e.g., the United Kingdom (UK), have even legislated its commitment, but is as yet under-achieving on targets.

UK Legislation

In 2008, the UK enacted a law for climate change, the Climate Change Act 2008. [17]

It sets out the following target for 2050:

> *(1) It is the duty of the Secretary of State to ensure that the net UK carbon account for the year 2050 is at least [F1100%] lower than the 1990 baseline.*
>
> *(2) "The 1990 baseline" means the aggregate amount of—*

[178] For instance, China is the world's largest producer of coal per annum. Australia is 5th on the list of producers.

(a) net UK emissions of carbon dioxide for that year, and

(b) net UK emissions of each of the other targeted greenhouse gases for the year that is the base year for that gas.

In Britain, the Institute for Government is the leading think tank working to make government more effective. It provides rigorous research and analysis, topical commentary and public events to explore the key challenges facing government. In Box J6, it comments on the UK government legislation. [18]

Box J6 – Comment on UK legislation

Net zero refers to achieving a balance between the amount of greenhouse gas emissions produced and the amount removed from the atmosphere. There are two different routes to achieving net zero, which work in tandem: reducing existing emissions and actively removing greenhouse gases.

A gross-zero target would mean reducing all emissions to zero. This is not realistic, so instead the net-zero target recognises that there will be some emissions but that these need to be fully offset, predominantly through natural carbon sinks such as oceans and forests. (In the future, it may be possible to use artificial carbon sinks to increase carbon removal, research into these technologies is ongoing.)

When the amount of carbon emissions produced are cancelled out by the amount removed, the UK will be a net-zero emitter. The lower the emissions, the easier this becomes.

The Climate Change Act 2008 named six major greenhouse gases: carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride. Carbon dioxide makes up the bulk of these. This is principally produced by burning fossil fuels in, for example, coal power stations; the main sources for the other greenhouse gases include industrial processes and waste management, such as agriculture and landfill sites. Combined, these accounted for around 19% of all UK emissions in 2018.

The UK's emissions of all greenhouse gases have been falling steadily over the past 30 years, though levels have risen globally. In 2018, UK emissions stood at 57% of their 1990 levels.

Is the 2050 net-zero target feasible?

The UK is currently [2019] not on track to meet its previous, less ambitious, target of 80% emissions reductions by 2050. The CCC has said that getting to net zero (i.e., meeting the 100% target) is "technically feasible but highly challenging".[8] Doing so will require sustained policy interventions across several sectors – many of which will be complex, costly and time-consuming.

And the initial signs are not positive: in its July 2019 progress report, the CCC said the UK government's policy actions "[fell] well short of those required for the net-zero target". The UK is also not on track to meet some of its pre-existing future carbon budgets, set before the net-zero target was adopted (more on carbon budgets is found below).

The government has announced some policy changes in response, such as bringing forward the ban on the sale of new petrol and diesel cars from 2040, but more is needed.

Six nations have passed laws formally establishing net zero targets: Sweden and Scotland by 2045, and the UK (as a whole), France, Denmark and New Zealand by 2050. Similar legislation has been proposed in the EU, Spain, Chile and Fiji. The UK was the first G7 nation to legislate for this.*https://www.instituteforgovernment.org.uk/explainers/net-zero-target*

What else Australia could do

Environmentalists in Australia - individuals, institutions, think-tanks and supportive media - are vocal even strident in their demands and criticism of the government.

Australia (let alone the PM) has not caused global warming, even if its per-capita emissions are high (but overall, miniscule in world emissions) and it can do nothing to stop global warming. Australia could disappear off the planet tomorrow and it would not make a scrap of difference to global warming.

All Australia has to do is to do its fair share, as it is with renewable energy, but not try to lead the world. Shutting down our coal exports is the craziest of ideas. We export coal only because other countries want it as the best available. If we refused to export coal (a shot in our left foot), these countries would buy more polluting coal from others (shot in right foot). It should be noted also that China is by far the world's biggest coal producer, about seven times more than Australia in fifth place. Even Indonesia produces more coal than Australia. Nevertheless, Australia is a leading coal-exporter but exports coal only because other countries want to buy it for its high quality. No buy - no export!

And where are the arguments by the environmentalists (so busy criticising Australia) about the Middle East exporting oil and burning unimaginable quantities themselves to air-condition their cities and homes?

Only action by the big polluters, especially China, India and the USA stand any chance of stemming global warming (if indeed human induced warming is a fact, as it probably is). World minions like Australia can be big on virtue-signalling, but rather small on rational thinking.

Our real challenge is to recognise the probable effects of climate change on Australia (not good), what, when and how they might occur and how we as a nation might best respond. Australia can move only to protect itself as best it can, to climate-proof itself. It has been suggested by some that a royal commission to sort out fact from fiction on global warming and its effects would go a long way to getting some rationality into the argument.

While very noisy and essentially pushing a populist and emotive agenda, environmentalists in Australia and their supporters need to answer the following questions, if they ever expect to achieve credibility in the eyes of more rational Australians and the Federal government, who ultimately bears responsibility for the economic wellbeing of the nation:

- How can Australia, with its miniscule 1.06% contribution to world emissions ever hope to change the climate in Australia?
- Why should Australia do more than meet its international commitments to show that it is a responsible world citizen, if that means stress on the economy?
- How would denying Australia's high-quality coal to the developing world decrease emissions while those countries continue to build coal-burning power plants that would otherwise use inferior coal and so exacerbate world greenhouse gas emissions?
- Exactly what actions do they see Australia taking to get to net zero emissions by 2050 and the effects – direct and economic costs - of doing that? Where is their rational plan to meet their claims?
- How do they see renewable energy being the panacea for getting to net zero emissions by 2050 (if ever), given that in 30 years to date Australia's renewable energy has managed only 24% maximum of the electricity market and a pathetic 6.5% of its total energy consumption?

The COVID-19 virus, as nasty as it is (2020), could be a long-term blessing. For 30 years or more, the western world of commerce has given its technology to, sold it to or had its intellectual property stolen by China. The virus, having clearly emanated from China, has the potential to severely damage world trade to the point of a several years of economic depression. However, it does give countries, now heavily dependent on China, like Australia, an opportunity to restart their own manufacturing, even if at a premium.

While equitable world trade is the source of national wealth, the economic dictum of "*trade where you have an economic advantage*" has its limits. Australia is a good case of having reduced itself to a quarry at the expense of its manufacturing sector. Australia can and should start manufacturing again. Given a continuing boom in renewable energy farms, all of which would have to be replaced within 25-30 years, manufacture of our own demand for solar panels would be a good start. A hydrogen future, as promoted by Garnaut, could also be a winner but its viability is yet to be demonstrated.

See Annex R, *Letters to editors* for further comment.

Conclusions

The world is working on the problem and investing trillions of dollars in trying to reduce greenhouse gas emissions in an attempt to limit global warming to the targets of 1.5°C and maximum of 2°C, recommended by the IPCC and enshrined in the Kyoto Protocol and the Paris Agreement.

Despite the often-harsh criticism by vested interests, Australian Governments - Federal, state and, territory state - are not resting on their arms reversed or on their laurels. A great deal of positive work is being done, despite the sometimes-vicious criticism. Australia will meet its obligation to reduce its greenhouse gas emissions by 26-28 per cent on 2005 levels by 2030.

Use by the Australian Government of carbon credits, obtained in past years, may be unethical in the eyes of her critics but, until banned under the Paris Agreement, use of credits is legitimate practice.

When the ABC, The Guardian and other critics of what Australia is doing about climate change start to address what the really big polluters are doing, they may achieve some credibility in the eyes of rational Australians but, until then they are simply on narcissistic joyrides, mostly at taxpayer expense.

Several significant Australian companies are progressively changing internal operational policies to reflect changing, personal attitudes to climate change. Such action has not been without controversy, often being seen as ‘virtue signalling’ by Board members and CEOs and neglect of their primary duty to shareholders.

The really big emitters are China, USA, India and Europe, which between them account for some 60-70% of all annual CO2 emissions and related pollutants.

We must never lose sight of the fact that Australia accounted for only about 1.06% of global emissions in 2020. Whatever Australia does, its effect on global emissions, let alone climate change and global warming, would be negligible. Climate changers cannot argue with the truth of this statement but attempt, with arguments of sheer sophistry, that Australia with its 25 million citizens (0.3% only) should be showing ‘leadership’ to the world of 8 billion.

Australia only needs to demonstrate to the world that it is meeting its international obligations and doing it best to reduce its emissions. It does not have to do more, let alone trying to big-note itself as a world paragon to lead the world to lower emissions.

Australian Logistics Study Centre
Canberra, 24 July 2020

THE EARTH SYSTEM

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About this Annex

This Annex is an introduction to what constitutes that referred to in the literature as the Earth System. It is descriptive only and meant only to give the setting for global warming and to complement the information in other annexes.

While it deals generally with the atmosphere and oceans of the planet, readers will find specific data on these may be found in others Annexes.

Introduction

The concept of 'the Earth System' is fundamental to the subject of global warming and climate change. For the purposes of this document, it is defined here as: *"The physical combination of all land, all water (in oceans and fresh on land) and the atmosphere, as well as the dynamic activity on and within these components."*

The Earth System obeys all of the known laws of physics; its behaviour is described as the most important case of chaos theory, the state of which, at any time in the future, is virtually impossible to predict, notwithstanding recognisable general trends. Super computers are needed to model it but, in the opinion of some scientists, computer modelling still cannot yet predict with valid accuracy.

It should be noted that, no matter how powerful a computer, modelling the dynamic nature of the Earth System rests upon the simplifying assumptions made, the mathematical equations developed from theory and the accuracy of data fed in for each variable by the modellers about how they believe the system works. Assumptions are necessary to make the combinatorial problem of the myriad variables manageable and to disregard variables of minor effect. However, under chaos theory, even the effect of minor variables is said to magnify to importance (think of the butterfly effect).

Note: *No scientific report that has used computer modelling should ever neglect to identify all assumptions underlying the models, in respect of variables and data used, or conduct sensitivity testing. Unless this occurs, the scientific paper should be considered with caution. An industry adage about computer modelling is that, once the modeller has obtained enough data about a system to develop formulae and to cull lesser variables yet maintain adequate predictive accuracy, he/she could probably forecast the future result as well as the computer simulation using that data*[179].

The Earth

Our earth is the third planet 150 million kilometres (kms) from the sun. It is obloid in shape (but near spherical) of 12,756 kms in diameter and 40,054 kms in circumference at the equator. From the centre to the surface (6,378 kms), it is comprised of several layers - the inner core, outer core, mantle and crust. The inner core is solid iron at a temperature of 4,000°C, surrounded by liquid iron, which generated the Earth's magnetic field. Above the core, the mantle of rock is about 2895 kms in depth and ranges in temperature from 1,100°C to 3,600°C. The upper mantle is about 760 kms thick and contains pockets of molten material, which may find their way to the surface through fractures, causing volcanic activity. Above that, the crust is comprised of land and terrestrial water bodies of which the oceans take up 70% of the Earth's surface area. The crust, the atmosphere above and all living things on land, in the waters and the air comprise the biosphere. By comparison, the crust is quite thin from 5 kms under the oceans to 40 kms under land. [1, p 20]

As one may imagine, the Earth contains an unimaginable amount of thermal energy which, through conduction and radiation, continuously warms the surface. However, as discussed further

[179] A thesis by this author was based on a computer simulation of a complex system. Professionals doing computer modelling/simulations for a living may not agree with this observation.

in Annex L, *Energy*, the emission per square metre (m^2) is relatively small compared to other components of the Earth's energy budget.

The Earth's axis is tilted normally between 22.1 and 24.5 degrees, averaging 23.5 degrees, from the plane of its orbit around the sun. This tilt gives rise to the opposite seasons in the two hemispheres and essentially a single season year-round about the equator. It also affects the level of radiation reaching the earth, but climatologists believe that this effect is relatively small in respect of increased global warming. [1, pp 6-9]

The earth has ice-caps at the North and South poles, both of which, in conjunction with the hot band either side of the equator, have a fundamental effect on the earth's climates and weather systems, through prevailing flows of air masses (Hadley cells) and ocean currents. Water contained by the ice-caps (all fresh), principally of Greenland and Antarctica, comprises about 2% of the total water resources on Earth.

Land

The land masses are made up of rock (mostly basalt), soils, vegetation and fresh water. The earth's fresh water is all on land, both on the surface as lakes, rivers, ice or snow, but also in vast subterranean aquifers, but comprises only 2% of all water resources to meet the needs of 8 billion people and growing to 10 or even 12 billion by 2100. The land itself is a major determinant to the climate of a continent or region through its location on the planet in respect to the equator and polar regions as well as its topography, particularly the prevalence, location and height of mountain ranges.

The ice–albedo (sunlight reflective) effect is thought to have a significant effect on the temperature of the earth, at least regionally, due mainly to glaciers, polar icecaps and sheet ice.

Note that there is considerable controversy about the progressive disappearance of glaciers and ice-caps. Critics of global warming agree with climatologists that glaciers and icecaps are retreating, except that it has been happening for a very long time, due to a natural long-term warm cycle the Earth is now experiencing, rather than to global warming. Climatologists also agree that they have been melting for a long time, but say that they are now melting at an accelerated rate because of global warming.

Box K1
Ice–albedo feedback is a positive feedback climate process where a change in the area of ice caps, glaciers, and sea ice alters the albedo and surface temperature of a planet. Ice is very reflective, therefore some of the solar energy is reflected back to space. [Wikipedia]

Oceans

The oceans cover 71 percent of the earth's surface and contain about 98 percent of the earth's water (all salty but of varying salinity). All fresh water comes from the ocean by way of evaporation and precipitation from clouds onto land, eventually returning to the ocean, in a never-ending cycle.

The oceans vary in depth from the relatively shallow continental shelves to the deepest location of 11,034 metres of the Mariana Trench [1]. The ocean floors are said to comprised totally of basalt[180], mostly covered by particulate matter and detritus of once-living things precipitating to the floor.

The physics of the oceans is absolutely fundamental to continental and regional climates and weather systems that prevail around the world, on a daily and seasonal basis. The oceans comprise a gigantic heat sink and reservoir of absorbed minerals and gases, especially carbon dioxide (CO2). There are huge, powerful currents - warm and cold - moving within, shifting heat around the globe in never-ending cycles which, depending on depth and location, can take from months near the surface, but possibly 1,000 years for the deepest currents. It is the delayed effect of the deeper currents that climatologists refer to as thermal 'inertia'. [2, pp 72, 73, 251]

[180] Basalt is a mafic extrusive igneous rock formed from the rapid cooling of magnesium-rich and iron-rich lava exposed at or very near the surface of a terrestrial planet or a moon. More than 90% of all volcanic rock on Earth is basalt.

However, while the cycles themselves are generally known, the day-to-day status of water temperature by region cannot be predicted with accuracy, but probably close enough.

In particular El Nino and La Nina activity in the Pacific Ocean and the Indian Ocean Dipole (IOD) are primary determinants of climate (droughts and precipitation) on Australia and some other countries.

Box K2
El Niño–Southern Oscillation (ENSO) is an irregularly periodic variation in winds and sea surface temperatures over the tropical eastern Pacific Ocean, affecting the climate of much of the tropics and subtropics. The warming phase of the sea temperature is known as El Niño and the cooling phase as La Niña. [Wikipedia]

The Indian Ocean Dipole (IOD), also known as the Indian Niño, is an irregular oscillation of sea surface temperatures in which the western Indian Ocean becomes alternately warmer (positive phase) and then colder (negative phase) than the eastern part of the ocean. *[Wikipedia]*

Although much is made by climatologists of the increase in CO2 (and other non-condensing greenhouse gases) in the atmosphere caused by burning fossil fuels, it is very important to realise that the CO2 level in the atmosphere is varied also and continuously as a function of the temperature of the ocean surface (caused primarily by water vapour and clouds) and atmospheric pressure thereon, ie the ocean is continuously absorbing CO2 and emitting CO2. Absorption makes the oceans more acidic which, in excess, can be detrimental to life in sea.

Atmosphere

The atmosphere comprises the layers of gases surrounding a planet and is held in place by gravity.

The most common gases in earth's atmosphere are nitrogen, oxygen and argon. Lesser trace gases, including carbon dioxide, nitrous oxide, methane, and ozone account for about 0.1 per cent of the atmosphere. See Boxes B3 and B4.

Box K3 [3]
Atmosphere
The gaseous envelope surrounding the earth, divided into five layers – the troposphere which contains half of the Earth's atmosphere, the stratosphere, the mesosphere, the thermosphere, and the exosphere, which is the outer limit of the atmosphere. The dry atmosphere consists almost entirely of nitrogen (78.1% volume mixing ratio) and oxygen (20.9% volume mixing ratio), together with a number of trace gases, such as argon (0.93 % volume mixing ratio), helium and radiatively active greenhouse gases (GHGs) such as carbon dioxide (CO2) (0.04% volume mixing ratio) and ozone (O3). In addition, the atmosphere contains the GHG water vapour (H2O), whose amounts are highly variable, but typically around 1% volume mixing ratio. The atmosphere also contains clouds and aerosols. See also Troposphere, Stratosphere, Greenhouse gas (GHG) and Hydrological cycle. *[IPCC Glossary]*

Box K4
Air composition, temperature, and atmospheric pressure vary with altitude, and air suitable for use in photosynthesis by terrestrial plants and breathing of terrestrial animals is found only in earth's troposphere and in artificial atmospheres.
The atmosphere helps to protect living organisms from genetic damage by solar ultraviolet radiation, solar wind and cosmic rays. The current composition of the Earth's atmosphere is the product of billions of years of biochemical modification of the paleo-atmosphere by living organisms. *[Wikipedia]*

The water content of the atmosphere may be in a pure gaseous form as water vapour (the strongest of the greenhouse gases) or in a saturated form as visible clouds. However, there is also a great deal of particulate matter such as black carbon (soot), ash, dust and man-made aerosols in the atmosphere that also contributes significantly to an enhanced greenhouse effect.

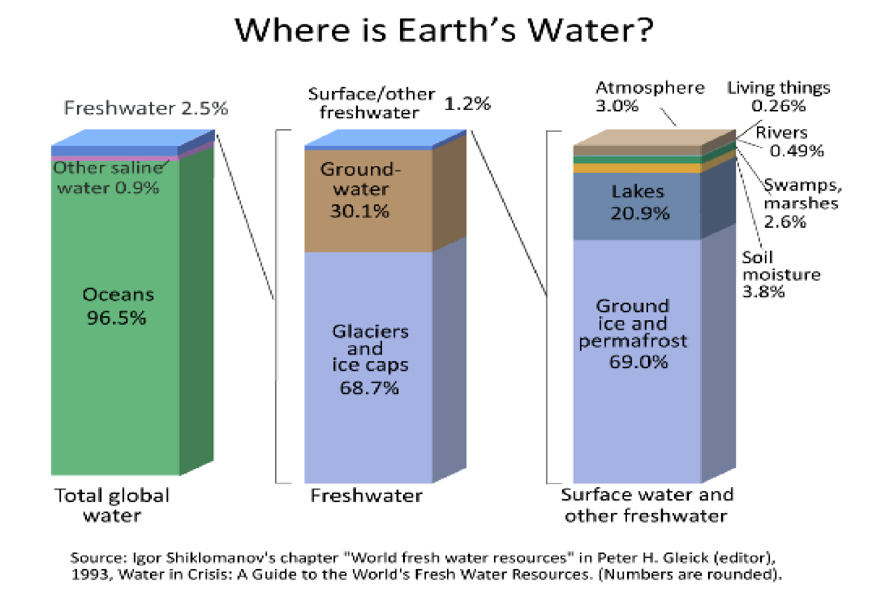
A more detailed description and importance of the atmosphere is given at Annex E, *Temperature change - possible causes* and in Annex O, *Aerosols and other pollutants*.

Earth's Water

In respect of the essential need for fresh water to all life on land and in the air, it becomes a more precious commodity every day with the relentless and exponential growth in world population and other detrimental factors at work such as droughts, release of molten ice water into the oceans and pollution in general. Availability of fresh water is seen by some scientists as a probable limiting factor on the ever-increasing population of the planet, to the point of competition (even war) over this scarce resource.

The diagram in Box K5 shows the known distribution of water on our planet.

Box K5



Australian Logistics Study Centre
Canberra, 24 July 2010

ANNEX L TO
A view on permanent climate change

ENERGY

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About this Annex

This annex discusses the nature of the various forms of energy and their relevance to the debate on global warming and climate change. It is meant to be descriptive only and in no way quantitative in how it affects global warming or climates. Other annexes between them cover specific information on this subject.

Nature of Energy

The whole universe is made up of matter and energy, these being interchangeable (albeit with some effort), according to the famous Einstein equation, E=M*c^2, where M is mass and ‘c’ is the speed of light (299,792,458 metres per second). Matter is made up of atoms and molecules (groupings of atoms) which are always in motion - moving, bumping into each other or vibrating one way or another - and so possessing kinetic energy. Matter can also absorb and emit radiation according to their elemental properties. All matter above the absolute zero temperature of minus 273 °C possesses some level of energy, both kinetic and radiative.

Note: *The variable ‘c’, in Einstein’s formula, is also the speed of all frequencies of electro-magnetic radiation (EMR), in free space. EMR is able to travel through most media, including outer space but, luckily for security of communications, it can be blocked by suitable metal screening, e.g., by iron and aluminium.*

The source of all energy within the Earth System is the sun, received in the form of high-frequency electro-magnetic radiation (EMR), mostly visible and ultra-violet light (UVR), at present and ever since creation of the solar system. See Annex C - *Radiation and concept of forcing* for detail.

The First Law of Thermodynamics states that *“Energy cannot be created or destroyed; the total quantity of energy in the universe stays the same”.* It could have added that all energy consumption, in whatever form, ends up a heat to be absorbed by components of the Earth System or radiated out into space.

One may also presume that the energy balance (equation) for the Earth System (defined here as the combination of the land, oceans and atmosphere) is constant, ie incoming solar radiation energy equals infra-red radiation (IRR) radiation back out to space, plus the sum of the various forms of energy contained and stored within the Earth System. See also Annex E, *Temperature change - possible causes.*

One way or another, radiation energy from the sun has been and is being constantly transformed into different forms of energy within the Earth System. While all are important, only those relevant to possible global warming and the climate are discussed here.

Forms of Energy

Energy exists in many different forms, the most important being: electro-magnetic; kinetic; thermal; potential; gravitational; electrical; mechanical; chemical; nuclear (atomic); tidal; earthquakes and sound. Each form can generally be converted into one or more of other forms, but not necessarily in the reverse order.

Electro-magnetic energy

Electro-magnetic energy, in the form of electro-magnetic radiation (EMR) is the primary form of energy for the planet in that it is the form of the Sun’s radiation that powers all things on Earth and is the source of all other types of energy on Earth, with the possible exception of gravitational, nuclear, tidal and sound energy. Radiation is in the form of a 'transverse wave'[181].

EMR exists everywhere at all times and has many applications according to frequency.

- Radiation from the Sun is used by growing vegetation through photosynthesis, or converted to heat or as kinetic and potential energy. As heat (thermal energy) always flows from hot to cold, a certain percentage will be lost to space, particularly of an evening, by way infra-red radiation. [See main discussion under 'Radiation, Annex C, *Radiation and concept of forcing.*].
- EMR is the essential entity that permits radio communications in all its forms, including mobile telephones.
- EMR is also essential to many aspects of our lives, including radar for vehicle navigation, X-rays for health diagnoses and micro-waves for cooking.

However, like many phenomena and discoveries/inventions, EMR is a two-edged sword, in being both very useful to humanity but also very dangerous. Ultra-violet (UV) radiation causes sunburn and skin cancers. Frequencies used in microwave ovens would also damage human flesh. Radar frequencies, because of high power, are particularly dangerous. There has been concern for quite some time about the possible harmful effects of mobile telephone frequencies, especially of late with the frequencies to be used for fifth generation (5G) communications, but these operate off very low power levels, which is why they are considered safe by most knowledgeable people.

Kinetic energy

Kinetic energy is that stored in moving objects or fluid masses, including the molecular matter comprising these. In the context of global warming, it is the kinetic energy of the atmosphere and oceans that is of most interest. In the atmosphere, huge amounts of kinetic energy are possessed in the winds (air masses in motion), generated in response to the perennial inter-action between the Earth and the Sun. Likewise, under the same influences, the great ocean currents contain and distribute around the planet masses of kinetic energy.

Thermal energy

See later in this annex under 'Thermal energy (heat)'.

Potential energy

Potential energy is any form of energy that has stored potential to do work. The presence of potential energy is not always obvious but a prime example, in the context of energy production are dams to store water and to use gravitational forces to generate electricity. In the context of global warming, the atmosphere itself is an important source of potential energy, e.g., stored in clouds, explained well in the book by Salby [1].

Potential energy (mechanical) is that stored in static masses which, if allowed to, would collapse under the force of gravity, through conversion to other forms of energy[182]. Dams comprise an important example. Earthquakes are another example.

Gravitational Energy

Gravitational 'energy' is said in some references [2] to be the potential energy a physical object with mass has in relation to another massive object due to gravity. Strictly speaking, gravitation is one of the four fundamental forces of nature and not a form of energy per se. But it is said to produce '*gravitational potential energy*'.

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[181] There are two types of mechanical waves:
Longitudinal waves - In this type of wave, the movement of the particles is parallel to the motion of the energy ie the displacement of the medium is in the same direction to which the wave is moving. Example – Sound Waves, Pressure Waves.
Transverse waves - When the movement of the particles (including photons) is at right angles or perpendicular to the motion of the energy, then this type of wave is known as Transverse wave. Light is an example of a transverse wave. Some of the other examples are – 'Polarized' waves & Electromagnetic waves.

[182] A natural process known as entropy, ie all things will eventually collapse or degrade to its component parts if not kept in place by internal forces and external maintenance by man.

Electrical Energy

Electrical energy is the energy carried by moving electrons or ions in a conducting medium. It is one of the most common and useful forms of energy and most other forms can be converted to electrical energy. Of most interest here is electricity produced from conversion of chemical energy stored in fossil fuels like coal, from the kinetic energy absorbed by wind turbines and from solar radiation energy.

Note: *"Lightning, as a massive arc, is a special form of electricity, being the conduction of electrons and ions within and between clouds, and between clouds and the earth, so relieving the electric potential built up by friction between two entities. Other arcs, like used in arc-welding and cinema projectors, may be struck by creating and maintaining a high enough electrical potential between two objects (anode and cathode)."*

Mechanical Energy

Mechanical energy of machines and systems is a combination of other forms of energy, primarily thermal, electrical, kinetic and potential. A classic store of mechanical energy is in flywheels, like those in car engines.

Chemical energy

Chemical energy is a very important form of and is stored in the bonds of chemical compounds (atoms and molecules). It is that energy released in a chemical reaction, often in the form of heat. For example, we use the chemical energy in fossil fuels like coal and wood by burning them, ie by increasing their internal energy with high temperatures to a point of chemical reaction and transformation.

Nuclear energy

Nuclear energy is that possessed within every single atom of matter. Such energy is expressed by Einstein's famous equation E=Mc^2. It can be produced either by a fusion process (combining atoms) or fission process (splitting of atoms). The fission process is the only method used to date, as described in Box L1. On the other hand, although a practical fusion process is a holy grail of science - because of its promise of infinite, cheap energy - it has so far eluded scientists, except in a few experimental cases.

Uranium is the principal raw material. It is mined in several countries, including Australia which is the largest exporter, albeit a non-user itself except for experimental and medical purposes. Other fissile material includes plutonium and thorium.

Box L1 [3]

"Nuclear reactors are the heart of a nuclear power plant. They contain and control nuclear chain reactions that produce heat through a physical process called fission. That heat is used to make steam that spins a turbine to create electricity. With more than 450 commercial reactors worldwide, including 95 in the United States, nuclear power continues to be one of the largest sources of reliable carbon-free electricity available.

The main job of a reactor is to house and control nuclear fission - a process where atoms split and release energy.

Reactors use uranium for nuclear fuel. The uranium is processed into small ceramic pellets and stacked together into sealed metal tubes called fuel rods. Typically, more than 200 of these rods are bundled together to form a fuel assembly. A reactor core is typically made up of a couple hundred assemblies, depending on power level.

Inside the reactor vessel, the fuel rods are immersed in water which acts as both a coolant and moderator. The moderator helps slow down the neutrons produced by fission to sustain the chain reaction.

Control rods can then be inserted into the reactor core to reduce the reaction rate or withdrawn to increase it.

The heat created by fission turns the water into steam, which spins a turbine to produce carbon-free electricity.
www.energy.gov/ne/articles/nuclear-101-how-does-nuclear-reactor-work

Tidal and water wave energy

Tidal energy, essentially the potential energy of the rising mass of water twice daily (creating temporary dams), due to the gravitational force of the moon on the Earth, can be harnessed to generate electricity. Although the idea has been around for many decades, production plants are yet very few due to economics.

Water waves are caused by the wind and is, in effect, the transfer of kinetic energy from the wind into potential and kinetic energy of moving waves, according to their speed and height. While waves can be used to generate electricity, again, production plants are few.

An interesting use of water waves, on a very small scale, is to operate pumps to evacuate bilge water from boats, when moored.

Water waves are in the form of a 'transverse wave' (see Footnote 181). Note that 'longitudinal sound waves also travel through water, whatever the dynamic state of the water mass.

Earthquakes

Earthquakes are not a form of energy as such but are the result of potential energy being released through the movement of masses of the Earth's structure, which is dissipated eventually by shockwaves through the Earth, often causing terrible damage to property and life. Earthquakes at sea are responsible for tidal waves (tsunamis).

Although mentioned here, earthquakes are not relevant, in the context of global warming.

Shockwaves produced by earthquakes are a combination of both types - 'transverse' and 'longitudinal' (see Footnote181).

Sound wave energy

Sound energy is produced when material, solid or fluid, is made to vibrate. It travels out from a source (like an explosion) as waves in all directions through all media, except a vacuum.

Although mentioned here, sound energy is not relevant, in the context of global warming,

Sound waves are classed as a 'longitudinal wave' (see Footnote 2). [4]

Thermal Energy (heat)

In popular language, thermal energy is almost always referred to as 'heat' but, technically, heat is defined as the <u>transfer of thermal energy</u>. Thus, heat is not energy in itself.

A few definitions

"… experimental evidence shows that the particles of a body are very rapid motion and that the kinetic energy of this motion is really the heat [thermal energy] content of the body." [5, p317]

"*Thermal energy refers to several distinct physical concepts, such as the internal energy of a system; heat or sensible heat, which are defined as types of energy transfer (as in work); or for the characteristic energy of a degree of freedom in a thermal system kT, where T is absolute temperature and k is the Boltzmann constant."* [6] *https://en.wikipedia.org/wiki/Thermal_energy*

Nature of thermal energy

Understanding thermal energy is fundamental to the whole question of global warming and climate change. Along with the kinetic energy of the winds and ocean currents, it is a primary component of the Earth's energy system, all powered by the Sun, that determines the regional climates, weather systems and local weather at all times, and according to the perennial Earth/Sun physical inter-relationship.

Thermal energy, as an example of kinetic energy, results in an object or a system having a temperature that can be measured in one of several scales - degrees Centigrade[183] (°C) [freezing point 0 °C]; absolute temperature in degrees Kelvin (°K) [absolute zero is -273 °C]; degrees Fahrenheit (°F) [freezing point 32 °F] ; and absolute temperature in degrees Rankine (°R) [absolute zero is -459 °F] - according to the standards system being applied.

Thermal energy of a given mass is proportional to the temperature above absolute zero of -273 °C (or -459 °R).

Thermal capacity is a physical property of matter, defined as the amount of thermal energy that has to be supplied to a given mass of a material to produce a unit change in its temperature.

[183] Also referred to as 'Celsius'.

The international system (SI) unit for thermal energy is the Joule and that for thermal capacity is Joule per degree Kelvin (J/°K).[184]

Propagation of thermal energy

The first law of thermodynamics says that *"energy cannot be created or destroyed, merely transformed from one kind to another*." It could have added that all energy consumption, in whatever form, ends up as thermal energy (heat). For example, all of the chemical energy in fossil fuels, when burnt, creates thermal energy which, after being used to produce useful work, must be absorbed within the atmosphere, by the land and oceans or emitted into space.

Thermal energy is transferred as heat from one location within a body or to other bodies, contiguous or distant by convection, conduction or by infra-red radiation. Transfer is always one-way only, from a 'hotter' body to a 'cooler' body, depending on the medium. Mediums comprise solids, fluids (air, water and molten material) and vacuums or near vacuums like outer-space.

Convection transfers thermal energy by physical movement of 'heated' molecules in a fluid, e.g., when water is heated and boils; in the atmosphere and ocean currents. Transfer of energy by convection is a primary feature of the atmosphere and of weather systems.

Conduction is the transfer of energy from one particle to another (molecules or atoms) within and between solids and fluids by transfer of kinetic energy when particles collide. Note that lightning - within and between clouds and between clouds and the earth - is a special form of conduction by electrical discharge, ie the transfer of massive amounts of electrons from one body to another.

Radiation is the transfer of energy in electro-magnetic form from hotter to cooler bodies, at any distance but with radiative power reducing with the square of the distance from the source. Radiation, in the context of heat, means the infra-red range of the electro-magnetic spectrum (bands leading into the red of the visible spectrum). Infra-red radiation can occur in any of the four media and particularly in a vacuum (like space) in which neither convection nor conduction can occur.

Solids and fluids may acquire thermal energy (be heated) from several sources. Solids may be heated by hotter fluids in contact; by the electrical resistance of the solid itself, e.g., in hotplates and radiators; by inductance, e.g., some hotplates; by micro-wave electro-magnetic radiation, e.g., in micro-wave ovens; and by infra-red radiation from sources like radiators.

In the case of combustion, e.g., burning coal, its stored chemical energy is released (at an elevated temperature) directly into the surrounding gases (normally air) as increased kinetic energy of the gas molecules which, in turn, impart that energy to another body, e.g., a steam boiler, which then imparts it to the contents of the vessel, and so on.

However, how does the energy get from the hot gas to the metal vessel when it is presumed that the electrons of the gases, let alone whole molecules, are presumed to remain within and not physically move into the metal? Either the energised (vibrating) molecules of the gases are imparting kinetic energy by colliding with the molecules of the metal pot, ie by conduction, or by radiation or both. How much each may be is another question. In some cases, there must be a certain amount of transfer by electro-magnetic radiation, given that heated material, at elevated temperatures, e.g., burning coal, will emit electro-magnetic radiation at different frequencies, all the way from infra-red radiation, dull glow to the bright white light produced by super-heated wire of an incandescent lamp.

What is the mechanism of heat transfer from a solid, e.g., a hot iron bar, to the surrounding air or vice versa? Do the iron molecules collide with the air molecules, thus imparting kinetic energy or is it by radiation? Probably a combination of both. From a solid to a fluid, transfer is mainly by conduction to the closest layer of fluid in contact with the solid, after which that energy is further transferred throughout the fluid by convection. In the reverse order, convection brings thermal energy into contact with the cooler solid and transfers energy by conduction (the principle behind heat exchangers).

Radiation is theorised to be the release of electro-magnetic energy (as waves or photons) when electrons of atoms move from a higher energy orbit to a lower energy orbit, e.g., as the theory

[184] Other measures may also apply, according to the units of mass and temperature scale used.

behind light produced in fluorescent tubes. Energy is first provided to cause electrons to move from lower to higher-energy orbits, e.g., by electric fields, radiation or direct conduction.

New Heat into atmosphere from fossil fuels

All of the chemical energy in fossil fuels, when burnt, ends up as new thermal energy, initially into water coolers or directly into the atmosphere, but eventually absorbed by the atmosphere, the land and oceans, or emitted into space as infra-red radiation.

Burning fossil fuels is said to be the planet's biggest source of human-induced greenhouse gases. In particular, each tonne of a fossil fuel burnt produces almost three tonnes of CO2 (2.86 for some coals)[185], as well as releasing the large quantities of thermal energy into the atmosphere.

Whereas CO2 is readily blamed as the main culprit of global warming, the climate change literature rarely mentions the effect that vast amounts of new heat being pumped into the atmosphere by burning fossil fuels, energy that has been stored for millions of years. Except for that part radiated into space, all energy consumed, irrespective of form, ends up as additional, new heat content of the Earth System, ie contained in the land, water and atmosphere. This new heat is generated continuously by fossil fuels and at an increasing rate, consistent with the demand for energy.

Assuming that in pre-global warming the 'natural' greenhouse effect of the atmosphere radiated back into space X per cent of the radiated energy coming from the sun, one could presume that at least X per cent of new energy from burning fossil fuels would be radiated to space, leaving 100-X percent of that new heat to be absorbed by, and thus to increase the temperature of, the earth's system.

In contrast to new heat, renewable energy sources may add heat to the atmosphere temporarily, but do not add to the overall energy content of the Earth System. They extract energy from the system depending on type - wind, solar or other - convert it into electricity which does work in various ways and then release it back into the System as thermal or radiation energy.

Contrary to initial perceptions, it can be shown that despite the massive amounts of thermal energy released into the atmosphere by burning fossil fuels, the overall effect on the average world temperature (Temperature anomaly (Twi)) is very small, compared to that caused by the Sun's continuous radiation upon Earth.

At least one scientific study[186] corroborates the finding that the effect of this new heat, as massive as it may be, is trivial compared to the long-term effects of the CO2 released by burning that fuel [7].

See further discussion in Annex E, *Temperature change - possible causes and* Annex F, *Demand for energy and emissions*.

Earth's Thermal Energy

In respect of heat coming from the internal molten content of the Earth, by both conduction and IRR, often referred to as comprising the 'sensible' heat going into the atmosphere, its power can be shown to be in the order of only 0.03% of Earth's total energy budget at the surface [8], given the surface area of the Earth, and can be ignored as far as global warming is concerned.

Conclusion

This annex is meant to be descriptive only and in no way quantitative in how it affects global warming or climates. Other annexes between them cover that aspect.

Australian Logistics Study Centre
Canberra, 24 July 2020

[185] Varies significantly with type of fuel – coal, oil, gas.

[186] The study referred to is very technical in detail, requiring extensive knowledge of physics and mathematics to comprehend.

THE NATURE OF CARBON DIOXIDE (CO2)

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About this Annex

This Annex describes the properties and nature of carbon dioxide (CO2)[187], identified by climatologists as the primary antagonist in the global warming and climate change debate, so that a better understanding may be obtained by readers as to its real place in the scheme of things.

However, reference should be made also to detail in Annex E, *Temperature change - possible causes,* Annex F, *Demand for energy and emissions* and Annex G, *World population growth and consequences* for detailed discussion.

Introduction

The threat of <u>permanent</u> climate change because of global warming is the primary issue under discussion in the world today, and climatologists[188] have fingered an increasing concentration of non-condensable[189] greenhouse gases (GHG) in the Earth's atmosphere, as the primary cause.

Excluding water vapour (H2O), CO2 is undoubtedly the principal of the several non-condensable greenhouse gases, including methane and nitrous oxide, which scientists say are causing global warming through the greenhouse effect. However, one needs rather to talk of an 'enhanced' greenhouse effect given that this phenomenon has been around forever and is essential to all life on this planet. But what is being claimed now is that the greenhouse effect is warming the planet to an unsustainable and dangerous level.

It is further stated by climatologists that the increase in greenhouse gas concentrations, particularly CO2, is due to the increase in world population (anthropological causes) and consequent demand for energy, the greater majority of which is generated by burning fossil fuels. This position has been determined by the Intergovernmental Panel on Climate Change (IPCC) of the United Nations, which promotes it through its international forums. [1]

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[187] Only CO2 is discussed as the principal greenhouse gas and representative of the others except water vapour.

[188] Climatologists comprise those scientists concerned primarily with research and analysis of data ascribed to global warming, climate change and consequences.

[189] Although water vapour is also classed as a greenhouse gas, it is 'condensable' and dismissed by climatologists as the primary cause of global warming.

Although most literature on the subject also includes water vapour as a greenhouse gas, climatologists largely dismiss it as the primary cause of global warming, although much more prevalent in the atmosphere and with greater radiation absorption properties than CO2.

Note: *As discussed in* Annex E, *Temperature change - possible causes*, an important distinction is made between the primary and secondary causes of global warming.

Basic information and data about the nature, prevalence and attributed effects of CO2 are presented and discussed at **Appendix 1** to this Annex.

The literature often cites greenhouse gas emissions in terms of CO2 equivalents (CO2e), which is seen as a more valid measure of greenhouse gas concentrations. In this document, concentrations of CO2 only have been used as a proxy for all non-condensable greenhouse gases. See Box M1.

Box M1
Carbon dioxide equivalent (CDE)
Carbon dioxide equivalency is a quantity that describes, for a given mixture and amount of greenhouse gas, the amount of CO2 that would have the same global warming potential (GWP), when measured over a specified timescale (typically 100 years).
Equivalent CO2 (CO2e) is the concentration of CO2 that would cause the same level of radiative forcing as a given type and concentration of greenhouse gas. Examples of such greenhouse gases are methane, perfluorocarbons, and nitrous oxide. CO2e is expressed as parts per million by volume (ppmv).
www.en.wikipedia.org/wiki/Carbon_dioxide_equivalent

Sources of CO2e emissions

Greenhouse gases (excluding water vapour) are generated mainly by human activity (Boxes M2, M3) but significant amounts of CO2 and methane, in particular, may also occur naturally.

Box M2 – Sources of CO2 [2]

CO2 enters the atmosphere through burning fossil fuels (coal, natural gas, and oil), solid waste, trees and other biological materials, and also as a result of certain chemical reactions (e.g., manufacture of cement). It is removed from the atmosphere (or "sequestered") when it is absorbed by plants as part of the biological carbon cycle.
Carbon dioxide is constantly being exchanged among the atmosphere, ocean, and land surface as it is both produced and absorbed by many microorganisms, plants, and animals. However, emissions and removal of CO2 by these natural processes tend to balance absent anthropogenic impacts. *www.epa.gov/ghgemissions/overview-greenhouse-gases*

Box M3 – Sources of CO2 [3]

Direct and indirect emissions

Direct emissions are produced from sources within the boundary of an organisation and as a result of that organisation's activities. These emissions mainly arise from the following activities:

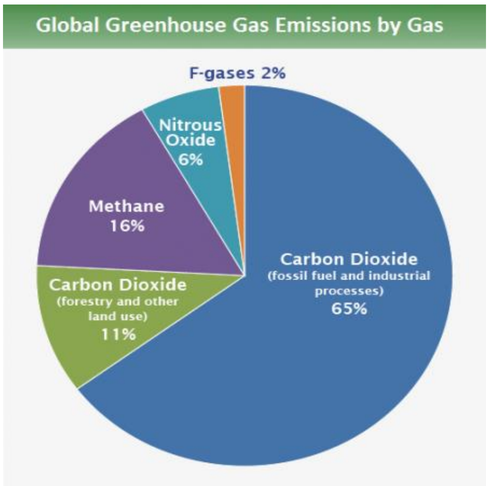
- generation of energy, heat, steam and electricity, including carbon dioxide and products of incomplete combustion (methane and nitrous oxide);
- manufacturing processes which produce emissions (for example, cement, aluminium and ammonia production);
- transportation of materials, products, waste and people; for example, use of vehicles owned and operated by the reporting organisation;
- fugitive emissions: intentional or unintentional GHG releases (such as methane emissions from coal mines, natural gas leaks from joints and seals); and
- on-site waste management, such as emissions from landfill sites.

Indirect emissions are those generated in the wider economy as a consequence of an organisation's activities (particularly from its demand for goods and services), but which are physically produced by the activities of another organisation. The most important category of indirect emissions is from the consumption of electricity. Other examples of indirect emissions from an organisation's activities include upstream emissions generated in the extraction and production of fossil fuels, downstream emissions from transport of an organisation's product to customers, and emissions from contracted/outsourced activities. The appropriate emission factor for these activities depends on the parts of upstream production and downstream use considered in calculating emissions associated with the activity. [*National Greenhouse Accounts Factors, Australian National Greenhouse Accounts, Australian Government, July 2017]*

It may be seen from Box M4 that, while CO2 is the predominant non-condensable greenhouse gas, at about 76%, methane and nitrous oxide (NO2) are quite significant. These latter gases are very strong absorbers of infra-red radiation (IRR), but are in very small concentrations within the atmosphere and of relatively small half-lives, compared to CO2.

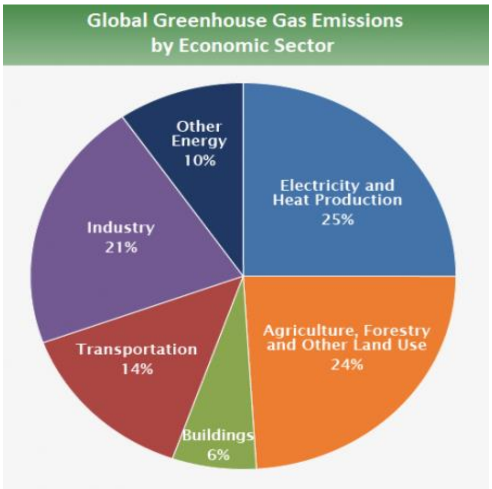
Box M5 shows the proportions by sectors of energy consumption in the USA. Respective figures for Australia are similar but different.

Box M4



www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data [4]

Box M5



www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data [4]

Contentious issues

Climatologists claim and that they can prove the following phenomena concerning global warming, that:

- although only 0.0413% of the atmosphere[190] in 2020, CO2 is the principal greenhouse gas and the ‘thermostat’ of the planet;
- because of its ‘longevity’ in the atmosphere, CO2 is the principal cause of global warming;
- since the start of the industrial revolution, concentration of CO2 in the atmosphere has risen by some 47% to the 2020 level of 413 parts per million (ppm)[191];
- the increase in CO2 has been caused mainly by the increased burning of fossil fuels; which has been caused by a continuing increase in world population;
- global warming is manifested by the Average world surface temperature (Tw) and its increment, referred to as the Temperature anomaly (Twi) which has risen by about 1.05°C above the pre-industrial levels and continues to rise gradually;
- CO2 is the primary driver of Twi, ie that Twi is a function of ppm (Twi = f(ppm);
- water vapour is not the primary driver of global warming, even though the latter is recognised also as a powerful greenhouse gas;
- cloud behaviour is not a primary cause of global warming;
- global warming is causing ‘permanent’ climate change;

[190] Assumes equal distribution throughout the atmosphere, although it is obvious that local levels will be higher or lower. CO2 levels in building often measure between 1000 and 2000 ppm.

[191] ppm means parts per million moles of air particles. A ‘mole’ is scientifically defined in terms of molecules.

- Desirable limits Twi above 1.5°C and 2°C have been set by the IPCC [1]. The upper limit of 2°C should be considered as the maximum value permissible before unacceptable and irreversible changes to and consequences of climate change occur.

Significant debate still exists within the scientific community as to the validity of the foregoing claims. So, where does the truth lie?

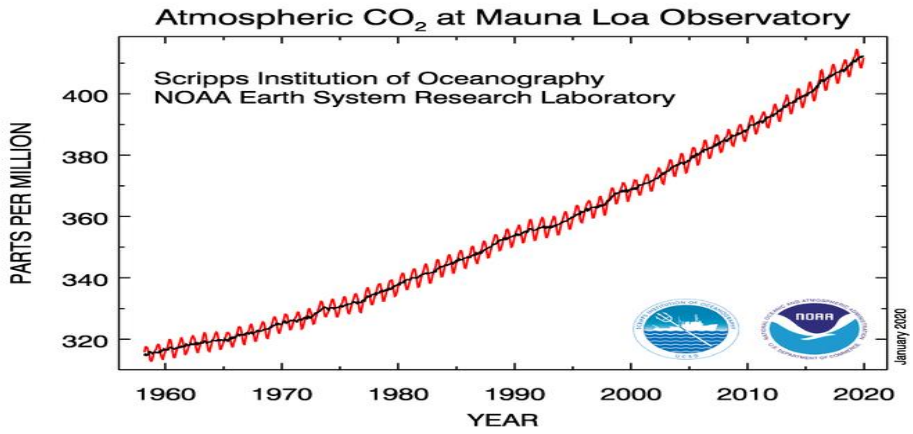
All of these questions are addressed in detail in Annex E, *Temperature change-possible causes,* Annex D, *Temperature change - fact or fiction?* Annex F, *Demand for energy and emissions* and Annex G, *World population growth and consequences.*

CO2 concentrations

The average concentration of CO2 in the atmosphere has indeed been increasing gradually since the start of the industrial revolution. The record is well established and not in dispute. The Mauna Loa record [5] (Figure M1) is considered the best, but one must remember that it is one point only on the planet at 3,400 metres altitude and assumes that CO2 is well mixed at all altitudes, albeit concentration decreasing with altitude, and all around the globe. In fact, actual world emissions in 2020 give a concentration of 413ppm in 2020.

Over the past 40 years (1980-2020), growth of CO2 concentration in the atmosphere has been 22.2% generated mainly by the burning fossil fuels that release some 3.67 kg[192] of CO2 per tonne of carbon and 2.86 kg of CO2 per kg for power generating coal consumed.[193] So, why has the change been only 22.2%? While the tonnage of CO2 released into the atmosphere has doubled in the past 40 years, implying that the CO2 concentration should have doubled. The answer lies in the fact that this tonnage is relatively small compared to the total weight of CO2 in the atmosphere. According to the Mauna Loa record, that concentration (ppm) is currently growing at about 0.505% per annum, ie about 2.08ppm per annum.

Figure M1 [5]



www.acs.org/content/acs/en/climatescience/energybalance/earthtemperature.html

It is very important to this discussion to realise that the CO2ppm in the atmosphere is varied continuously as a function of the temperature of the ocean and atmospheric pressure thereon, ie the ocean is continuously absorbing and re-emitting CO2 to the atmosphere. The oceans comprise a gigantic heat sink and reservoir of absorbed minerals and gases, especially CO2, mainly in the form of calcium carbonate (limestone, coral, shells etc). See also Box M1-1.

Virtually all CO2 exists in the troposphere and, to a much lesser extent, in the stratosphere of the atmosphere [see Box M6]. Note that, depending on latitude, tropospheric temperatures decrease

[192] Available references often state carbon emissions in tonnes of carbon released rather than in tonnes of CO2, thus a need to take care in correct calculation of CO2 tonnage.

[193] Burning of coal generates about 2.86 kg of CO2 per Kg of coal. Other fossil fuels like oil and gas generate less CO2 but within about 20%. But note that statistics are often given in terms of tonnes of carbon.

from an average of 15°C at sea level to about -30°C by what is referred to as mid-troposphere[194]. Temperature at the top of the troposphere is about -55°C

Given that all bodies give up or absorb thermal energy to achieve equilibrium with their respective environment, all components of the atmosphere, including CO2, give up acquired energy, the higher the altitude and, ultimately to space as infra-red radiation (IRR).

> **Box M6** [6]
> **Troposphere**
> The troposphere is the lowest layer of Earth's atmosphere, and is also where nearly all-weather conditions take place. It contains 75% of the atmosphere's mass and 99% of the total mass of water vapour and aerosols. The average height of the troposphere is 18 km (11 mi; 59,000 ft) in the tropics, 17 km (11 mi; 56,000 ft) in the middle latitudes, and 6 km (3.7 mi; 20,000 ft) in the polar regions in winter. The total average height of the troposphere is 13 km.
> By volume, dry air contains 78.08% nitrogen, 20.95% oxygen, 0.93% argon, 0.04% carbon dioxide, and small amounts of other gases. Air also contains a variable amount of water vapour. Except for the water vapour content, the composition of the troposphere is essentially uniform. The source of water vapour is at the Earth's surface through the process of evaporation. The temperature of the troposphere decreases with altitude. And, saturation vapour pressure decreases strongly as temperature drops. Hence, the amount of water vapour that can exist in the atmosphere decreases strongly with altitude and the proportion of water vapour is normally greatest near the surface of the Earth.
>
> The troposphere is heated from below by latent heat, longwave radiation, and sensible heat. Surplus heating and vertical expansion of the troposphere occurs in the tropics. At middle latitudes, tropospheric temperatures decrease from an average of 15°C (59-degree Fahrenheit) at sea level to about −55°C (-67-degree Fahrenheit) at the tropopause. At the poles, tropospheric temperature only decreases from an average of 0°C (32-degree Fahrenheit) at sea level to about −45°C (-49-degree Fahrenheit) at the tropopause. At the equator, tropospheric temperatures decrease from an average of 20°C (68-degree Fahrenheit) at sea level to about −70 to −75°C (-94 to -103-degree Fahrenheit) at the tropopause. The troposphere is thinner at the poles and thicker at the equator. The average thickness of the tropical troposphere is roughly 7 kilometres greater than the average tropospheric thickness at the poles.
> *[https://en.wikipedia.org/wiki/Troposphere]*

CO2 from burning fossil fuels

Over the past 40 years, both world population and demand for energy have increased exponentially by 100%, 95% of the energy being generated by burning fossil fuels. Correlation between the two variables is almost 100%. In the same period, there has been an almost linear growth of CO2 concentration in the atmosphere of 22.2%[195], but is currently curving upwards slightly at 0.505% per annum (Mauna Loa data).

As well as the billions of tonnes of CO2, burning fossil fuels[196] also release into the atmosphere several noxious gases, e.g., methane, as well as aerosols like carbon black and particulate matter. In addition, huge amounts of new heat[197] are released which the atmosphere, land and oceans are expected to absorb or radiate into space. Discussed in detail in Annex F, *Demand for energy and emissions* and Annex L, *Energy*.

World population

Over the past 40 years, world population has increased by 100%, from 4 billion to 7.8 billion (April 2020). There is almost 100% correlation between the increase in population and the demand for energy. The United Nations [7] and some scientists [8] say that population will peak

---

194 The term 'mid-troposphere', set at 7-8km, is an important concept in respect to theoretical approach to climate sensitivity. See Annexes C, D and E.

195 The difference (22% vs 100%) is explained by the fact that only 46% of CO2 released into atmosphere is absorbed and that that is only a fraction of the total content of CO2 in the atmosphere.

196 All of the energy in fossil fuels, when burnt, ends up as heat into the atmosphere, which must be either absorbed in the atmosphere, the land and oceans or emitted into space. The first law of thermodynamics says that "energy cannot be created or destroyed, merely transformed from one kind to another." It could have added that all energy consumption, in whatever form, ends up as heat.

197 Fossil fuels comprise millions of years of the sun's radiation on earth, sequestered underground for millions of years. Burning it means that the heat generated is 'new' to the Earth's energy balance.

at about 11 or 12 billion but that remains to be seen. United Nations World Population Prospects 2019 (*www.population.un.org/wpp2019)* [9] puts the population in 2100 at 10.9 billion.

In the meantime, the possibility of an additional 4 billion people could be catastrophic for humanity in itself, even without the complication of climate change. That would be a 50% increase on planetary resources already under strain with the current population.

Readers may have wondered how the billions of humans, who exhale CO2 with every breath, may affect concentrations and thus contribute to global warming. The answer is not much at all. See Box M7 for a brief explanation.

See also detailed discussion at Annex G, *World population growth and consequences.*

Box M7 [10]
Exhaling CO2
Human beings do exhale almost 3 billion tons of carbon dioxide annually, but the carbon we exhale is the same carbon that was "inhaled" from the atmosphere by the plants we consume. (When we eat meat, we're still eating the same carbon, except that it passes through livestock on its way into our mouths and out into the atmosphere.) The only way to add to the carbon in the atmosphere is to take it from a sequestered source like fossil fuels—where it has been safe from the atmosphere for millions of years—and combust it. So, breathe easy.
The average human exhales about 2.3 pounds of carbon dioxide on an average day. (The exact quantity depends on your activity level—a person engaged in vigorous exercise produces up to eight times as much CO2 as his sedentary brethren.) *www.slate.com/news-and-politics/2009/08/are-you-heating-the-planet-when-you-breathe.html*

Is CO2 the principal cause of global warming?

See detailed discussion at Annex E, *Temperature change-possible causes*.

Thermal properties of CO2 compared to other gases

The quantity of heat absorbed and retained by CO2 in the atmosphere compared to other greenhouse gases, is the primary issue under discussion as to the predominant cause of any global warming and consequent climate change. But, is that true?

Table M1 shows the absolute and relative values for Specific Heat of relevant atmospheric gases. It shows that it takes less energy per unit to heat CO2 than air[198] and over twice as much to heat the same weight of water. Specific heat is the amount of heat per unit mass required to raise the temperature by one degree Celsius.

Table M2 shows the absolute and relative values of Internal Energy (thermal) for the same gases. It shows that CO2 can absorb some 44% more energy per unit than air (N2 and O2) and some 16% more than water vapour, but note that the concentration of CO2 (0.04%) is relatively small compared to the air as a whole and its water vapour content (0.4%).

Table M3 shows the absolute and relative values of the conductivity of the same and other gases. It may be seen from Table M3 that CO2 is a better insulator than dry air, having a thermal resistivity of 135% compared to air (thermal conductivity 76% compared to air) and that the conductivity (and thermal resistivity) of water vapour is about the same as for air. But again, the concentration of CO2 is small.

Note: *Thermal resistance is the ability of a material to resist flow of heat (insulation) and that thermal resistivity is the reciprocal of thermal conductivity.*

[198] Dry air is almost totally comprised of nitrogen (N2) and oxygen (O2).

Table M1

Specific Heat (SH) [1]			
Element	SH (J/(kg K))	Relative to Air	Notes
Dry Air	**992**	**100%**	
CO2	**834**	**84%**	[2]
N2	1,040	**105%**	[3]
O2	913	**92%**	[3]
Water vapour (WV)	**2,020**	**204%**	[4]
Notes:			
1. www.schoolphysics.co.uk/age16-19/			
2. SH of CO2 84% of dry air			
3. Weighted average same as air, as expected.			
4. SH of water twice that of CO2			

Table M2

Internal Thermal Energy (Enthalpy) [1]			
Element	Energy [2] BTU/lb*Mol	80 °F/ 26.7 °C Relative to Air	Notes
Dry Air	**395**	**100%**	
CO2	**570**	**144%**	[3]
N2	395	**100%**	[4]
O2	402	**102%**	[5]
Water vapour (WV)	**490**	**124%**	[5] [6]
Notes:			
1. Standard Handbook for Mech Eng, McGraw-Hill, 1978, p6-62			
2. pound-mole (noted lb-mol or lbmol)			
entities in 12 lb of 12C. One lb-mol is equal to 453.59237 mol.			
3. CO2 holds 44% more heat than air			
4. As expected, N2 ans O2 abour the same as air			
5. Water vapour holds 44% more heat than air			
6. Water vapour holds 86% that of CO2			

Table M3

Thermal conductivity [1]					
Element	Temperature °F	°C	Conductivity BTU/h/ft*°F	Relative to Air	Notes
Dry Air	**32**	**0**	**0.0140**	**100%**	
CO2	32	0	0.0084	60%	
CO2	**80**	**26.7**	**0.0106**	**75.7%**	[2]
CO2	212	100	0.0128	91%	[3]
Methane	**32**	**0**	**0.0170**	121%	[4]
N2	32	0	0.0140	100%	[5]
O2	32	0	0.0142	101%	[6]
NO2	32	0	0.0090	64%	[7]
Water vapour (WV)	**212**	**100**	**0.0142**	**101%**	[8] [9]
Notes:					
1. Standard Handbook for Mech Engineers, McGraw-Hill, 1978, p6-62					
2. At working temperature, CO2 is 76% as effective as air					
3. At 212 °F , CO2 is 91% as effective as air as a conductor					
4. Methane is 21% more effective than air					
5. N2, same as air as expected.					
6. O2, almost same as air as expected.					
7. NO2 only 64 % effective as air and less than CO2					
8. Water vapour almost same as air at 212 °F					
9. Water vapour at 212 °F assumed to hold for presence in air					

So, what is the import of these relative thermal characteristics of CO2 versus air in general and water vapour?

Certain literature uses the analogy that the greenhouse gases act like a 'blanket' to keep the Earth warm; the greater the concentrations, the greater the warming.

In the same way, blankets keep a human body warm as does insulation in a home to prevent too much heat from being transmitted to the colder air outside.

Technically, heat is defined as the flow of thermal energy from one body at a given temperature to another at a lower temperature. The heat flow, or loss of thermal energy from the inside is a function of the temperature difference between inside and outside and the insulation property (thermal resistivity) of the surrounds (walls, etc.) of the internal body.

A blanket insulates because of the combined thermal resistivity of the fabric/material used and particularly of the air trapped freely or deliberately within the fabric.

The atmosphere does act like a 'blanket' to the Earth, but the 'blanket' is comprised of the atmosphere as a whole, not just the greenhouse gases therein.

Given that CO2 comprises only 0.0413% of the atmosphere (in 2020), its total thermal resistance is totally swamped by that air and water vapour. Thus, one may conclude that it is air and water vapour that provides the insulating blanket for Earth and not the so-called greenhouse gases (excluding water vapour). See detailed discussion at Annex E, *Temperature change - possible causes.*

Readers might also consider how two principal features of the Earth, namely the land masses and oceans might affect global temperature, which vary quite significantly around the globe according to hemisphere, regions, seasons and weather conditions. In particular, consider what happens over the vast deserts of this planet, comprising some 10% of the Earth's surface (33% of the land mass, occupying 29% of the Earth's surface). Deserts certainly heat up during the day but lose virtually all of that heat back to space of an evening. CO2 most probably does not trap much of that heat.

Some 90% of all heat radiated back into space (both that absorbed from the Sun's short-wave radiation and from the new heat absorbed from the burning of fossil fuels, is from the vast heat sinks that are the oceans.

Longevity of CO2 in the atmosphere

Although CO2 comprises only 0.0413% of the atmosphere, its claimed predominant effect is said by climatologists to be due to its 'longevity' in the atmosphere, in excess of 1,000 years, before some 80% dissipation (absorption by land, vegetation and the oceans). Its half-life is about 30 years. See Box M8.

Box M8 [1] [11]

About 50% of a CO2 increase will be removed from the atmosphere within 30 years, and a further 30% will be removed within a few centuries. The remaining 20% may stay in the atmosphere for many thousands of years.
[IPCC Fourth Assessment Report, Working Group I (AR4, WG-I) Executive Summary of Chapter 7]

Atmospheric lifetime: 50-200 years. No single lifetime can be defined for CO2 because of the different rates of uptake by different removal processes.
[U.S Greenhouse Gas Inventory Reports]

While there is no doubt that CO2 absorbs heat radiated from the earth and that generated by burning fossil and biomass fuels, at several frequencies within the IRR spectrum, so do other important media, especially water vapour. CO2's claim to infamy lies also in its claimed longevity, continuously absorbing and re-emitting heat whereas water molecules and methane are relatively short-lived, ie the heat content is relatively quickly dissipated to CO2 in the atmosphere or reabsorbed by the land, vegetation and oceans. With CO2 lasting for so long, the effect of radiation absorbed is said to be cumulative as more and more CO2 is generated from burning fossil fuels; a bit like adding a thicker blanket.

It is not as though each molecule of the CO2 gets a birthdate and soaks up a chunk of energy when it enters the atmosphere and keeps it for its life. CO2 is like any other type of matter (solid, liquid or gas) in that it displays the same properties in respect of heat. It gets hot if heated (think flue gases from burning coal), but soon cools by transfer of its thermal energy to the temperature of its environment, according to its emissive properties and any cooling mechanism applied.

It can be shown that CO2 and other greenhouse gases take in energy at specific IRR frequencies but emit just as much. Yet that is no different to iron atoms getting hot when heated. The process is the same in all cases, ie whatever the frequency of IRR, the atoms become more 'excited' as they take in energy. Once the heat source stops, all atoms and molecules radiate their heat to their environment to reach a stable temperature, that of the environment.

While it takes considerable time to dissipate, all new CO2 generated, the volume is thus largely but not 100% cumulative. Currently (2020) the CO2 concentration is 413ppm and is increasing at a rate of 0.0505%, ie about 2.08 ppm per annum. This rate is additive to the concentration but of which 50% will be lost within 30 years (1.00505 x 2.08 per annum), a negligible amount. So, for all intents and purposes, under 'business as usual', CO2 concentration is increasing at 0.505% per annum. It is still a very small part of the atmosphere.

Note: *The Mauna Loa CO2 record indicates an annual increase in 2010 of 0.0505% per annum.*

Note: *This Annex is meant to describe only the nature of CO2. How it may affect global warming is discussed in detail in Annex B, Genesis and theory, Annex C, Radiation and concept of forcing, and Annex E, Temperature change - possible causes.*

As a conclusion, essentially from discussion in the aforementioned Annexes, CO2 (as well as other non-condensable greenhouse gases) does play an important role in insulating the earth, but the effect of water vapour and clouds is much more important. Nevertheless, that does not mean that increasing CO2 is not a problem, given its contribution to global warming and its effect on ocean acidity levels. In the ocean, carbon dioxide reacts with seawater to form carbonic acid, which causes the acidity of seawater to increase, which puts marine habitats in danger.

Note: *This conclusion may be seen to fly in the face of the conventional wisdom of climatologists and the United Nations (IPCC) which has endorsed their findings.*

Is global warming (Twi) a function of CO2 ppm?

See Annex D, *Temperature change-fact or fiction?* Annex E, *Temperature change – possible causes* and what the critics say at Annex H, *Promoters and critics,* for detailed discussion on this issue.

Is CO2 the primary driver of global warming?

Climatologists say that CO2 is the primary driver of global warming and not water vapour, even though the latter is acknowledged as the most powerful greenhouse gas.

For detailed discussion, see Annex E, *Temperature change-possible causes.*

Conclusions

Both world population and the consequent demand for energy have doubled in the past 40 years (1980-2020) with an almost 100% correlation. About 95% of energy has been obtained from burning fossil fuels, which has pumped huge amounts of greenhouse gases, especially CO2, into the atmosphere. In 2020, some 36.5 billion tonnes of CO2 were released into the atmosphere. This may sound a lot, but the 46% retained in the atmosphere is very small compared to the total weight of the atmosphere. There are some 2.86 kg of CO2 produced for every tonne of coal burnt, but up to 20% less for less polluting fossil fuels, especially oil and natural gas.

CO2 concentration in the atmosphere has increased by 22% in the past 40 years and is currently (2020), increasing at 0.505% or 2.08ppm per annum. The record is well documented and not really in dispute.

The fundamental claim by climatologists that the increasing CO2 concentration (ppm), as the claimed ‘thermostat’ of the planet, is the sole driver of global warming and consequent climate change may be correct, but is not yet proven. See annex E. *Temperature change– possible causes.*

Notwithstanding the more important effect of water vapour on global warming, CO2 production from burning fossil fuels is still a major problem as far as the consequences of warming and acidification of the oceans are concerned, so needs to be minimised.

Appendix 1 to Annex M - Nature of CO2

Australian Logistics Study Centre
Canberra 24 July 2020

APPENDIX 1 TO ANNEX M

PHYSICAL NATURE OF CO2

Introduction

CO2 is a colourless, normally odourless gas that occurs naturally in earth's atmosphere, with a concentration in 2020 of 0.0413 per cent by volume (413ppm[199]). It is essential to all life on the planet - animals breath it out as a waste product and vegetation takes it in as essential for photosynthesis and growth. It is not noxious in itself, but can kill a person or animal by asphyxiation if concentrations in the air breathed is too high, e.g., in low lying areas or caves where there can be high concentrations because it is heavier than air.

While climatologists are saying that average atmospheric concentrations above about 600 ppm would cause serious environmental and degradation of life as we now know it, people living and working in buildings sustain levels of CO2 from 1,000-2,000 ppm every day without harm.

See Box M1-1 for natural sources of CO2.

Box M1-1 [12]
Natural sources of CO2
Natural sources include volcanoes, hot springs and geysers, and it is freed from carbonate rocks by dissolution in water and acids. Because carbon dioxide is soluble in water, it occurs naturally in groundwater, rivers and lakes, ice caps, glaciers and seawater. It is present in deposits of petroleum and natural gas.

As the source of available carbon in the carbon cycle, atmospheric carbon dioxide is the primary carbon source for life on earth and its concentration in Earth's pre-industrial atmosphere since late in the Precambrian period has been regulated by photosynthetic organisms and geological phenomena. Plants, algae and cyanobacteria use light energy to photosynthesise carbohydrate from carbon dioxide and water, with oxygen produced as a waste product.

In one day, the average person breathes out around 500 litres of the greenhouse gas CO2 – which amounts to around 1kg in mass. This doesn't sound much until you take into account the fact that the world's population is around 8 billion, collectively breathing out around about 3,500 million tonnes of the stuff each year – which is around 7 per cent of the annual CO2 tonnage churned out by the burning of fossil fuel around the world. So, on the face of it, we humans are a significant contributor to global warming. But, in reality, the CO2 we're breathing out is part of a natural cycle, by which our bodies convert carbohydrates from CO2-absorbing plants into energy, plus water and CO2. As such, we're not adding any extra CO2. In contrast, burning fossil fuels like coal releases CO2 which has been locked up for millions of years, producing a net contribution to global warming.
www.en.wikipedia.org/wiki/Carbon_dioxide

Concentration of CO2 in the atmosphere

Concentrations of CO2, recorded from 1975 to 2020, are shown in Table M1-1 and Box M1-2.

Table M1-1

Growth-CO2ppm

Year	CO2 ppm
1975	330
1980	337
1985	343
1990	353
1995	360
2000	369
2005	377
2010	390
2015	400
2020	413

www.esrl.noaa.gov

Box M1-2 [13]

Recorded levels of CO2, from 1975 to 2020, as measured by the Mauna Loa observatory.
https://www.esrl.noaa.gov/gmd/ccgg/trends/

There is general acceptance by all scientists of these figures. However, in themselves, they do not necessarily imply that CO2 is the main contributor to any global warming or climate change, as is often said to be the case.

Some critics disagree that CO2 is the principal cause of global warming, given other major factors at play like water vapour, carbon black, particulate matter pollutants and heat being pumped into the atmosphere.

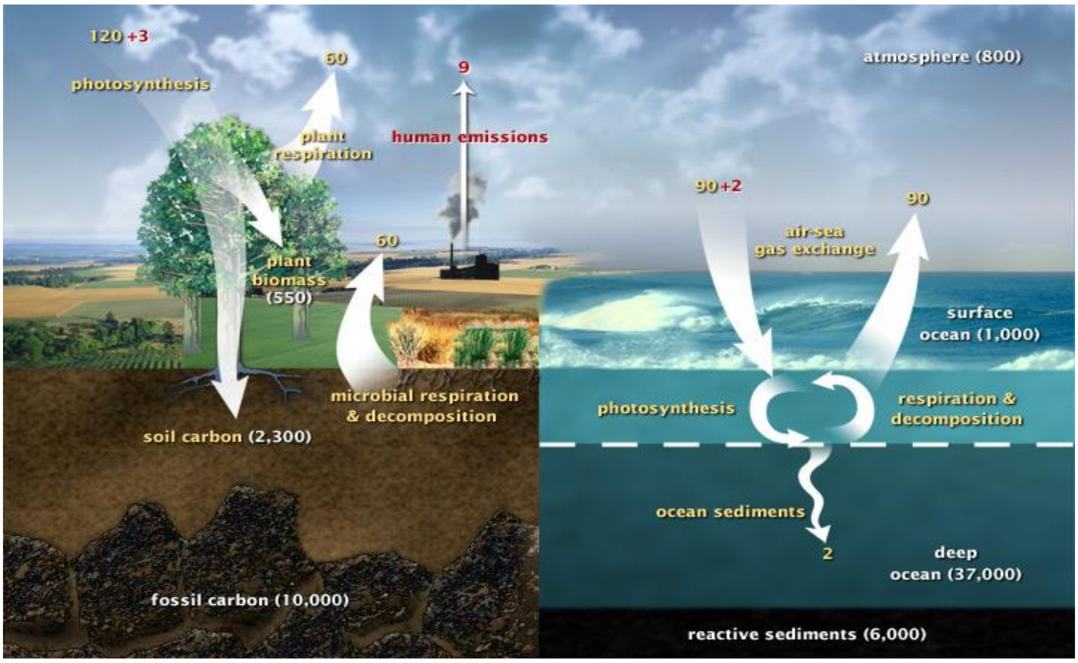
Note: *CO2 emission rate in 2020 is 413ppm according to world emissions data.*

[199] ppm means parts per million moles of air particles. A 'mole' is scientifically defined in terms of molecules.

Natural cycle of CO2

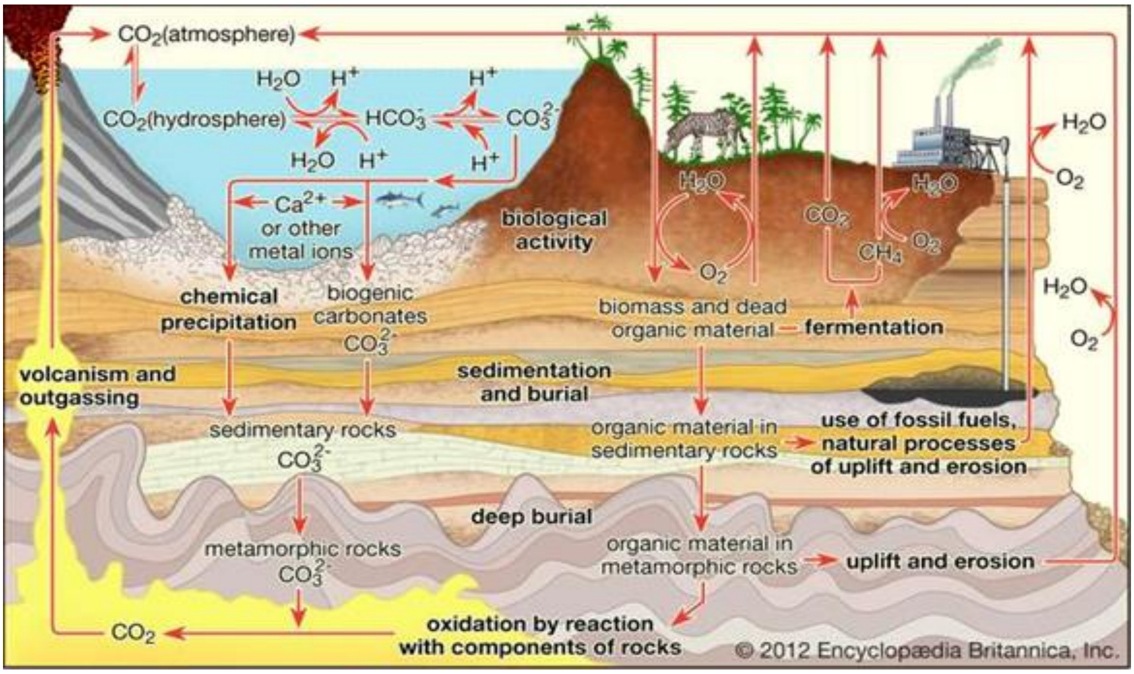
See Figures M1-1 and M1-2 for two diagrams of natural CO2 cycles.

Figure M1-1 [14]



This diagram of the fast carbon cycle shows the movement of carbon between land, atmosphere, and oceans. Yellow numbers are natural fluxes, and red are human contributions in gigatons of carbon per year. White numbers indicate stored carbon. [*Diagram adapted from U.S. DOE, Biological and Environmental Research Information System]*

Figure M1-2 CO2 Cycle



CO2 in the oceans

Of all carbon released initially into the atmosphere from all sources, mainly from burning fossil fuels, some 26% has been absorbed by the oceans, about 28% used by vegetation, with 46% remaining in the atmosphere.

It is very important, in this discussion, to realise that the CO2 level in the atmosphere is varied continuously as a function of the temperature of the ocean and atmospheric pressure thereon, ie the ocean is continuously absorbing CO2 from and releasing it into the atmosphere. It is not all due to burning fossil fuels.

Box M1-3 [15]
Ocean storage of carbon dioxide (CO2) is a method of carbon sequestration. The concept of storing carbon dioxide in the ocean was first proposed by Italian physicist Cesare Marchetti in his 1976 paper "On Geoengineering and the carbon dioxide problem" [1]. Since then, the concept of sequestering atmospheric carbon dioxide in the world's oceans has been investigated by scientists, engineers, and environmental activists. 39,000 GtC (gigatonnes of carbon) currently reside in the oceans, while only 750 GtC are in the atmosphere.
Of the 1300 Gt carbon dioxide from anthropogenic emissions over the last 200 years, about 38% of that has already gone into the oceans [2]. Carbon dioxide is currently emitted at 10 GtC per year and the oceans currently absorb 2.4 Gt carbon dioxide per year. The ocean is an enormous carbon sink with the capacity to hold thousands more gigatons of carbon dioxide. Ocean sequestration has the potential to decrease atmospheric carbon dioxide concentrations according to some scientists. www.en.wikipedia.org/wiki/Ocean_storage_of_carbon_dioxide

Basic CO2 facts

Some basic facts about CO2 (for 2020) are given in Table M1-2.

In order to determine the annual changes to CO2 concentration, it is necessary to know the weight of CO2 in the atmosphere at a given time, weight of CO2 generated by burning fossil fuels (and biomass) and the weight of air in the atmosphere.

The weight of atmospheric CO2 is determined from the weight of the atmosphere and the CO2ppm count.

The weight of the atmosphere turns out to be 5.148*10^15 tonnes and of CO2 in 2020 at 3.289*10^12 tonnes, ie a ratio of 0.000639 or 0.0639%.

The average weight of CO2 produced by fossil fuels in 2020 is calculated at 36.7 billion tonnes of which 46% is absorbed into the atmosphere, ie 16.8 billion tonnes, ie an annual increase of 0.51%.

Note: *This independent calculation of 36.7 billion tonnes of CO2 released into the atmosphere in 2020 corroborates other derivations of 36.5 billion tonnes.* See Annex F, *Demand for energy and emissions*.

CO2 Increase in the atmosphere (2020)

Table M1-3 gives further information on the derivation of the weight of CO2 in the atmosphere and the contribution of CO2 from burning fossil fuels in 2020.

- Estimates, based on the information in Table M1-4, are:
  - Actual CO2 emissions 2020 Tonne/y: 36.70
  - Projection 1 - 2100 Tonne/y: 37.70 Assumes current emission rates by country
  - Projection 2 - 2100 Tonne/y: 52.60 Assumes policy set emission rates by country.

This independently derived estimate 0.51% for annual growth in CO2ppm is marginally higher than the rate of 0.505% per annum, determined from the Mauna Loa CO2ppm record (less than a 2% error). Also, CO2 emissions in 2020 is taken elsewhere in this paper as 36.5 billion tonnes per annum rather than the slightly higher value of 36.7 (see Note 10 of Table M1-3 and at Table M1-4).

Table M1-2

Carbon dioxide (CO2) - some basic facts

	Nature					
	Essential to all life on Earth, including vegetation.					
	Animals breath out CO2					
	Vegetation takes it in and captures the carbon content.					
	Colourless, odourless					
	Is dangerous to people and animals, if in excesive concentrations.					
	A major product of burning fossil fuels					
	Variable	**Qualifier**	**Unit**	**Value**	**Mult**	**Notes**
	Concentration	**In atmosphere**	ppm			[1]
	1920	actual		303		
	2020	actual		413		
	2020	from Fossil fuels		417.7		
	2025	Table D1-2		428.4		[2]
	2030			439.5		
	2035			450.8		
	2040			462.4		
	2045			474.3		
	2050			486.5		
	2055			499.0		
	2060			511.8		
	2065			525.0		
	2070			538.5		
	Density of CO2 & Air					
	At 100% CO2		Kg/m3	1.84		[3]
	In the atmosphere		Kg/m3	73.44	10^(-5)	
	Weight of air		Kg/m3	1.23		[4]
	Ratio weights CO2/Air			1.50		
	Weight of Air	In atmosphere	Tonnes	5.148	10^15	[5]
	Weight of CO2	In atmosphere				
	2020		Tonnes	3.289	10^12	[6]
	Production of CO2 pa	**from Fossil fuels**				
	Actual CO2 emissions 2020		Tonne/y	*36.70*	1E+09	[7]
	Projection 1 - 2100		Tonne/y	37.70	1E+09	[8]
	Projection 2 - 2100		Tonne/y	52.60	1E+09	[9]
	Absorption of CO2					
	by atmosphere		%	46		[10]
	by oceans		%	26		[10]
	by vegetation		%	28		[10]
	Absorption of Heat by CO2					
	Absorbs Infra-red radiation	(heat)	µm	15.00		[11]
		at known frequencies	µm	4.30		
		IRR	µm	2.70		
			µm	2.00		

Notes:

1	parts per millions of moles of air
2	Probable ppm growth of CO2 in atmosphere, from 2020- based on actual CO2 emissions data.
3	At 25°C at standard atmos pressure.
4	At 15°C at standard atmospressure.
5	https://micpohling.wordpress.com/
6	Considered accurate for 2020
7	Actual CO2 emissions 2020
8	Projection 1 - 2100; assumes current emission rates by country
9	Projection 2 - 2100 - assumes policy set emission rates by country
10	scripps.ucsd.edu › programs › keelingcurve › 2013/07/03 › how-much-...
11	**Note**: The 46% figure may be less in 2020
12	micro-meters

Table M1-3

CO2 into atmosphere from Fossil fuels - in 2020				
Item	**Unit**	**Value**	**Mult**	**Notes**
CO2 Basic Facts				
Concentration in 2020	ppm	413.00		[1]
Tonnes produced per tonne coal	Tco2/Tcoal	2.86		
Molecular weight	g/Mol	44.10		
Weight - 0 Km Alt	Kg/m3	1.836		[2]
Earth Dimensions				
Pi π		3.1415		
Diameter D	Km	12,756		
Circumference π*D	Km	40,073		
Surface Area π*D^2	Km^2	511,170,856		
Factor	m^2/Km^2	1,000,000		
Surface Area π*D^2	m^2	511,170,856,344,000		[3]
Surface Area π*D^2	m^2	5.11	1E+14	[3]
Atmosphere-Air				
Air Pressure	kPa	101.30		[4]
Gravity	m/s^2	9.80		[4]
Weight Air/m^2	Tonne/m^2	10.34		
Weight Air	Tonne	52.82	1E+14	
Weight Air (estimated)	**Tonne**	**5.282**	**1E+15**	[5]
Weight Air (actual)	**Tonne**	**5.148**	**1E+15**	[6]
Atmosphere-CO2 (2020)	ppm	**413.00**	**1E-06**	[7]
Molecular weight	g/Mol	44.0095		
Factor		28.7700		[8]
Factor		0.000632		[8]
Factor		6.32	1E-04	[8]
Weight Air - Atmosphere	Tonne	5.148	1E+15	
Weight CO2 - atmosphere (2020)	**Tonne**	**3.25233**	**1E+12**	[9]
CO2 to atmos pa (2020)				
Actual CO2 emissions 2020	Tonne/y	*36.50*	1E+09	[10]
2020 emissions data	Tonne/y	36.70	1E+09	[11]
Projection -2100 Policy set limits	Tonne/y	52.60	1E+09	[12]
% CO2 absorbed by Atmosphere	%	46%		[13]
CO2 retained by atmos pa (2020)	Tonne/y			
Actual 2020	Tonne/y	16.79	1E+09	[14]
2020 emissions data	Tonne/y	16.88	1E+09	[14]
Projection -2100 Policy set limits	Tonne/y	24.20	1E+09	[14]
Actual CO2 emissions 2020	%/y	0.5162%		[15]
2020 emissions data	%/y	0.5191%		
Projection -2100 Policy set limits	%/y	0.7440%		

Notes:

1. per million moles of all moles in atmosphere
2. At 25°C (77°F or 298.15K) at standard atmospheric pressure.
3. scripps.ucsd.edu › programs › keelingcurve › 2013/07/03 › how-much-...
4. math.stackexchange.com › questions › calculate-the-mass-of-the-earths-...
5. Agrees very closely with literature (5.148*10^15)
6. https://micpohling.wordpress.com/
7. **Note:** 2020 rate from emissions data; but 413ppm, according to observed CO2 records.
8. https://micpohling.wordpress.com/
9. Considered accurate for 2020 - from emissions tables.
10. CO2 emissions 2020 - for 413ppm pa
11. Projection 1 - 2100; assumes current emission rates by country
12. Projection 2 - 2100 - assumes policy set emission rates by country
13. scripps.ucsd.edu › programs › keelingcurve › 2013/07/03 › how-much-...
14. Calculated rate for 2020
15. **Note:** 2020 rate from emissions data; but 0.505%, according to observed Twi records.

Table M1-4 gives estimates from three different sources for tonnes of CO2 generated in the world for 2020. All are in reasonable agreement, but with 36.5 billion tonnes per annum being the most probable and all within an error band of +- 7%. The differences do illustrate, again, the variation in data for various sources.

Table M1-4

World CO2 Emissions (2020)	
Tonnes CO2 10^9	Source
36.5	Actual total world CO2 emissions in 2020 [see emissions table Annex E]
40.00	*https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions*
41.57	*https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data*

METHANE

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7. www.esrl.noaa.gov/gmd/education/info_activities/pdfs/CTA_the_methane_cycle.pdf

About this Annex

This Annex is but a brief introduction to the subject of methane, a powerful non-condensable greenhouse gas in its own right, but of very small concentration in the atmosphere compared to carbon dioxide (CO2). Although not a significant threat yet, it could become so due to potential thawing of northern hemisphere tundra.

Nature

Methane is a colourless odourless gas that occurs abundantly in nature and as a product of certain human activities. It is a molecule of carbon and hydrogen atoms with the chemical formula CH4 and is among the most potent of the greenhouse gases.

The main sources of atmospheric methane are: emissions from anaerobic decomposition in natural wetlands and paddy rice fields; emission from livestock production systems (including intrinsic fermentation and animal waste); and biomass burning (including forest fires, charcoal combustion, and firewood) and, potentially from thawing of the northern hemisphere tundra and arctic permafrost. [1]

While an estimated 1.3 to 1.5 billion cows on the planet are significant offenders, they aren't the main cause of our planet's methane problem. Most methane emissions come, directly or indirectly, from humans. [2]

The billions of cattle, pigs and chickens raised and slaughtered each year are causing significant methane emissions and pollution from untreated excrement. However, research is underway on diets for cattle to reduce methane emitted by belching, with promising results. Also, the recycling of excreted waste has already proven successful, to the extent that captured methane is enough or more to power the stock-raising enterprise. A win-win!

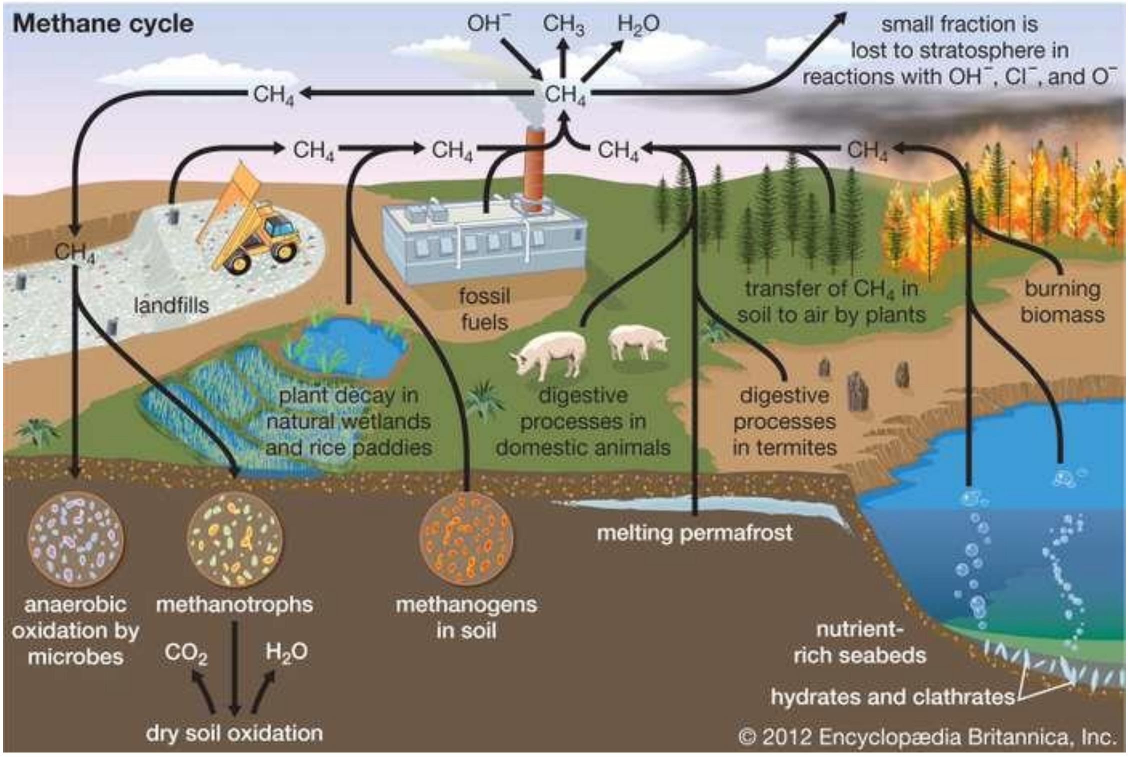
While CO2 is typically painted as the bad boy of greenhouse gases, methane is roughly 30 times more potent as a heat-trapping gas, [3] but its concentration in the atmosphere in 2020 is only about 2 ppm compared to 413 for CO2. It has an atmospheric lifetime (before total dissipation) of about 10 years compared to 50-1,000 years for CO2. [4]
Further, calculations suggest that the contribution by CH4 relative to that of CO2 will decrease substantially, from 35% in 1992 to 15% in 2050 [5]. However, this reference would be assuming no further increase in the Temperature anomaly (Twi).

By extrapolation, in 2020, CH4 has about 25% the greenhouse gas effect of that for CO2. This is quite a significant figure and should be worthy of national efforts to reduce methane emissions. However, promoters of climate change exaggerate the effect of methane as if it were just as harmful as CO2 is believed to be. See Box N1 and the diagram below in Figure N1 showing the CH2 cycle, for more information.

It is thought that thawing of the arctic permafrost could exacerbate global warming by releasing methane and other hydrocarbons now trapped therein, which would contribute further to global warming. See Annex I, *Permanent climate change* for more detail on the threat of thawing of the tundra and Arctic permafrost.

Box N1 [6]
Methane is lighter than air, having a specific gravity of 0.554. It is only slightly soluble in water. It burns readily in air, forming carbon dioxide and water vapour; the flame is pale, slightly luminous, and very hot. Methane in general is very stable, but mixtures of methane and air, with the methane content between 5 and 14 percent by volume, are explosive. Explosions of such mixtures have been frequent in coal mines and collieries and have been the cause of many mine disasters.
Methane concentrations have also varied over a smaller range (between roughly 350 and 800 ppb) in association with the Pleistocene ice age cycles (see Natural influences on climate). Preindustrial levels of CH4 in the atmosphere were approximately 700 ppb, whereas levels exceeded 1,867 ppb in late 2018. (These concentrations are well above the natural levels observed for at least the past 650,000 years.) The net radiative forcing by anthropogenic CH4 emissions is approximately 0.5 watt per square metre—or roughly one-third the radiative forcing of CO2.
Encyclopaedia Britannica, 2020.

Figure N1 [7]



https://www.esrl.noaa.gov/gmd/education/info_activities/pdfs/CTA_the_methane_cycle.pdf

ANNEX O TO
A view on permanent climate change

AEROSOLS AND OTHER POLLUTANTS

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About this Annex

This Annex addresses harmful matter in the atmosphere, other than non-condensable greenhouse gases, that have some influence on global warming, namely aerosols. It also makes reference to non-atmospheric pollutants plaguing the planet because of human activity. It is intended only as a primer, given that the subject matter is vast and the object of a great deal of research and government attention.

General

Industrialisation and rapid growth in world population over the past 170 years or so has been progressively polluting the atmosphere with additional greenhouse gases and aerosols, which threaten the natural behaviour of the atmosphere and are potentially detrimental to life, mostly caused by the burning of fossil fuels to meet a soaring demand for energy. See Annex G, *World population growth and consequences*, Annex F, *Demand for energy and emissions*, and Annex L, *Energy*.

While aerosols can be strong absorbents of infra-red radiation, the effects are short-lived, a matter of days to weeks only. However, some references cite carbon black as the second most important cause of greenhouse effect after CO2, but others rank the culprits as water vapour first, followed by CO2 then by black carbon.

Aerosols

Aerosols are "*particles of matter, solid or liquid, larger than a molecule, but small enough to remain suspended in the atmosphere. Natural sources include salt particles from sea spray and clay particles as a result of weathering of rocks, both of which are carried upward by the wind. Aerosols can also originate as a result of human activities, e.g. the burning of fossil fuels and in this case are often considered pollutants. The most important contribution is SO2. Aerosols have a significant cooling effect with strong regional variation that is not fully understood.*" [1]

'Aerosol' may be seen as a general term embracing both particulate matter and numerous chemical particles, including ions of various elements.

It is important to note that aerosols and particulate matter are important if not essential to cloud formation as nuclei for condensation of water vapour in to water droplets.

Carbon black (or black carbon)

"*Black carbon is a distinct type of carbonaceous material that is formed primarily in flames, is directly emitted to the atmosphere, and has a unique combination of physical properties. It strongly absorbs visible light, is refractory with a vaporization temperature near 4000K, exists as an aggregate of small spheres, and is insoluble in water and common organic solvents. In measurement and modelling studies, the use of the term "black carbon" frequently has not been limited to material with these properties, causing a lack of comparability among results.*" [2]

Known too as black carbon (BC), it is also defined as "*Operationally defined aerosol species based on measurement of light absorption and chemical reactivity and/or thermal stability. It is sometimes referred to as soot. BC is mostly formed by the incomplete combustion of fossil fuels, biofuels, and biomass but it also occurs naturally. It stays in the atmosphere only for days or weeks. It is the most strongly light-absorbing component of particulate matter (PM) and has a warming effect by absorbing heat into the atmosphere and reducing the albedo when deposited on snow or ice."* [1]

Carbon black consists of tiny particles of pure carbon released as a result of the incomplete combustion of fossil fuels, biofuels and biomass. These particles are extremely small, ranging from 10 µm (micrometres), the size of a single bacterium to less than 2.5 µm, one thirtieth the width of a human hair and small enough to pass through the walls of the human lung and into the bloodstream.

Carbon black has a density of 1.8 to 2.1 g/cm3 [1.8 to 2.1 Kg/m3 (at 20°C)] and is practically insoluble in water.

Although carbon black may fall out of the lower atmosphere in days, while it is suspended in the air, it absorbs the sun's heat millions of times more effectively than CO2. "*Thus, there is a very high probability that black carbon emissions, independent of co-emitted species, have a positive forcing and warm the climate. We estimate that black carbon, with a total climate forcing of +1.1 W/m2, is the second most important human emission in terms of its climate forcing in the present-day atmosphere; only carbon dioxide is estimated to have a greater forcing*.' [2] See Annex C, *Radiation and concept of forcing*.

When wind carries carbon black over snow, glaciers or ice caps where it falls out onto the white, normally reflective surface, it is particularly damaging because it contributes directly to melting.

The subject and effect of carbon black is quite extensive and, while important to the subject of global warming, it suffices here to mention its basic role in global warming. To know more on this subject, readers should access the book "*Bounding the role of black carbon in the climate system: A scientific assessment"* [2]. It is a very comprehensive reference and contains just about anything and everything one would want to know about carbon black.
www.agupubs.onlinelibrary.wiley.com/

The 'brown cloud'

Black carbon is a major contributor to the 'brown' cloud referred to by Ramanathan in a 2006 article "Global warming" [3], in which he talks about the 'brown haze' that occurs every year over the North Indian Ocean between November and May.

The article identifies several components of the 'haze', namely: black carbon, dust, organics (not defined), ammonia ions, sulphate ions (largest component), potassium ions, sea salt, nitrate ions and miscellaneous other ions. Black carbon is identified as probably the most insidious component of the haze as far as health is concerned.

The article goes on to say that the cooling effect of the haze, especially over the tropics, can cause less evaporation from the oceans, decreases the size of rain droplets and suppress precipitation to a point of decreasing monsoonal rains.

Other pollutants

Other pollutants such as smoke from various sources (home fires, bushfires, volcanoes), ash and dust are normally short-term irritants, but exceptional events have occurred.

While rare, huge volcanic eruptions can cause significant disruption, at least locally, the ill effects of which could last for months if not years, their overall effect on long-term global warming is considered very small. Nevertheless, it may be noted, without further comment, that volcanic ash has in the past caused extended ill-effects on climate in some regions (droughts)[200] and can exist for many years in the atmosphere, even to the highest levels of the stratosphere where it has some effect on solar radiation reaching the Earth.

Smog [smoke + fog]

Many large cities around the world have suffered or are suffering from what is generally referred to as smog, being the 'brown' clouds referred to by Ramanathan [3]. They are generally associated with an inversion of atmospheric pressure and with or without the complication of fog actually being present.

London was once famous for its 'pea-soup' fogs laced so heavily with sulphur dioxide (rotten egg gas) to make one's eyes water and prevent activity outdoors.[201] Los Angeles was famous too for

[200] For example, the devastation caused by the explosion of Santorini about 1600 BC, the 'dark ages', after about 600 AD (which some pundits have blamed on volcanic activity) and the drought in Egypt in 44-41 BC.

[201] This author experienced one of the very worst of London smog in December 1962, which lasted for over a week, during which no one could venture outside.

its automobile-induced, brown smog over the city. In the 1970s, it was not unusual to see a dirty brown haze over even moderately large cities in the USA.[202]

Today, it is cities like Delhi, Beijing and others in China (15 million people not uncommon) that regularly get 'smogged-in', due primarily to pollution generated by inadequately controlled industrial activity and inversions in weather systems.

Non-atmospheric pollutants

Since the start of the industrial revolution, there have been many types of pollutants ejected into and detrimentally affecting the environment. In particular, one could include sewerage dumped into waterways and oceans, dumping chemical waste into waterways and simply over the land, mountains of excreted waste from intensive animal farming and domestic waste, especially plastic products.

Except in underdeveloped countries, sewerage is generally under control. After much publicity, scandal, court cases and legislation, chemical pollution is largely but not totally under control. Excreted waste from animal farming does not have to be wasted or allowed to pollute, being profitably recyclable into fertilisers and used to generate methane for power.

However, plastic pollution is a growing and deeply concerning problem. See Box O1 for some history.

Box O1 [4]

The first synthetic polymer was invented in 1869.
World War II necessitated a great expansion of the plastics industry in the United States, as the need to preserve scarce natural resources made the production of synthetic alternatives a priority. Plastics provided those substitutes. Nylon, invented by Wallace Carothers in 1935 as a synthetic silk, was used during the war for parachutes, ropes, body armour, helmet liners, and more. Plexiglas provided an alternative to glass for aircraft windows. A Time magazine article noted that because of the war, 'plastics have been turned to new uses and the adaptability of plastics demonstrated all over again'.
The unblemished optimism about plastics didn't last. In the post-war years there was a shift in perceptions as plastics were no longer seen as unambiguously positive. Plastic debris in the oceans was first observed in the 1960s, a decade in which people became increasingly aware of environmental problems.
Plastic's reputation fell further in the 1970s and 1980s as anxiety about waste increased. Plastic became a special target because, while so many plastic products are disposable, plastic lasts forever in the environment. It was the plastics industry that offered recycling as a solution.
Despite growing mistrust, plastics are critical to modern life. Plastics made possible the development of computers, cell phones, and most of the lifesaving advances of modern medicine. Lightweight and good for insulation, plastics help save fossil fuels used in heating and in transportation. Perhaps most importantly, inexpensive plastics raised the standard of living and made material abundance more readily available.
Since it's clear that plastics have a valuable place in our lives, some scientists are attempting to make plastics safer and more sustainable. www.sciencehistory.org/the-history-and-future-of-plastics

Plastics have always used petroleum as source material, and have proliferated in kind and volume ever since. In the main, plastics replaced glass, paper, metals and even wood in the production and packaging of other products. The big plastic polluters are those to package food and drink for markets and plastic bags to cart them away. Unfortunately, the main problem is that plastics are non-biodegradable and can exist intact in oceans and landfills for hundreds of years. Not all plastics are recyclable.

Plastic waste is seriously polluting waterways, especially in Asia, and are causing serious issues for marine animals. There are huge floating masses of plastic rubbish in various parts of the world's oceans, carried and brought together by the prevailing currents. Marine birds are dying from being trapped by, or by consuming plastics. Fish caught for human consumption are found to have plastics in stomach contents and even nano-particles in the flesh. Plastic items and trash have been found on the ocean floors even at great depths.

[202] In 1976, this author was studying in Dayton, Ohio. One evening he and his son attended a first-grade baseball match in Cincinnati (the Cincinnati Reds were the world champions at the time). The air pollution, caused by an inversion, was so bad that one could barely see people on the other side of the stadium. Upon returning to Canberra in an August, the pristine air of Canberra was astonishing and so welcome.

Anti-pollution measures have shown to require strong legislation for adequate control. Some Governments have banned the use of plastic bags. Many governments have enforced the recycling of plastic waste. Without going into detail, literature shows that there are several formal classifications of plastics, essentially according to criteria as to recyclability.

Waste management is big business for those in that business, but at considerable expense to taxpayers. Not all waste processed can be used. For example, there are mountains of crushed glass that could be reused but economically difficult compared to the use of abundant raw materials.

Conclusion

Pollution, whether atmospheric, on land or in our waterways and oceans, is man-made; solutions too have to be man-made. That requires strong legislation and a balancing act between utility and cost, in all its forms (economic, social and environmental - often referred to as the 'triple-bottom line' so dear to the hearts of environmentalists).

Australian Logistics Study Centre
Canberra, 24 July 2020

INDUSTRIAL REVOLUTION

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About this Annex

This Annex is a brief introduction to the industrial revolution, as the presumed start and cause of the threat today of global warming and possible permanent climate change.

History

"The Industrial Revolution, … was the transition to new manufacturing processes in Europe and the United States, in the period from about 1760 to sometime between 1820 and 1840. This transition included going from hand production methods to machines, new chemical manufacturing and iron production processes, the increasing use of steam power and water power, the development of machine tools and the rise of the mechanized factory system." [1]

The presumed problem of global warming is believed to have started with the industrial revolution, starting about 1760 but not gathering speed until the early 1800's, powered by recently developed steam engines. Steam powered production and mass transportation were the driving forces but needed masses of coal. Despite its current label by environmentalist as a pariah, the world could not have been where it is today without coal. With its many grades of quality, it has been essential also to other major activities, notably steel-making, chemical derivatives and heating of commercial, industrial and domestic premises.[203] Except for electricity generation and steel manufacture, coal has long since relinquished its crown to petroleum and gas products, also fossil fuels.

The industrial revolution then engendered progressive scientific research, invention and continual, remarkable technological progress, mainly in the United Kingdom and Western Europe, but later to be eclipsed by development in North America. In particular, medical and agricultural science has led to an exponential increase in world population to today's figure of some eight (8) billion souls. Statistics of population growth are accepted by most parties as accurate. See also under Annex G, *World population growth and consequences*.

Today sees a vitriolic and largely irrational debate about climate change, particularly the non-sensical push by some to stop coal production in Australia to lessen world CO_2 emissions. Others see the power of human intelligence to mitigate any problem through technology. This aspect is pursued in Annex J, *What can and is being done*.

The peoples of the world are consuming ever-increasing amounts of the earth's resources to feed and house themselves and to be mobile, which requires vast amounts of energy, at a proportionate rate in the main[204], some 90 per cent of which is coming from fossil fuels - coal, oil and gas.

An 'enhanced greenhouse effect' is said to have been created by burning fossil fuels, which is pumping billions of tonnes of CO_2, several noxious gases, carbon black and other particulate matter into the atmosphere every year, as well as huge amounts of heat that the atmosphere is expected to absorb or radiate into space[205]. See also Annex L, *Energy*.

The concentration of CO_2 in the atmosphere is believed to have increased from about 280 ppm[206] in 1760 to the recorded 413 ppm in 2020. [2]

Statistics on atmospheric CO_2 levels are generally accepted by all parties as being accurate.

[203] Note that coal has for many years been able to be synthesised into gas and petrol, even though the latter has not been necessary while adequate supplies of petroleum are available.

[204] Energy consumption in developed countries is relatively stable compared to the big two of China and India and the other developing countries.

[205] Fossil fuels comprise millions of years of the sun's radiation on earth, sequestered underground for millions of years.

[206] ppm = parts per million of Moles in the atmosphere.

ANNEX Q TO
A view on permanent climate change

ELECTRIC VEHICLES (EV)

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10. Hydrogen for Australia's future, COAG Energy Council, Prepared by the Hydrogen Strategy Group, August 2018 [Dr Alan Finkel, Chairman]
11. www.csiro.au/en/Do-business/Futures/Reports/Hydrogen-Roadmap.

About this Annex

This annex looks at the situation in Australia in respect of the adoption of electric vehicles (EV) and how this sits with the probable availability of renewable energy, throughout the country.

Introduction

There has been a great deal of chat at present (2019-20) about EVs, with pundits, electioneering politicians and climate watchers waxing lyrically about their future, and with virtually all major car manufacturers in a race for potential market share. Although these cars are still relatively expensive, early adopters of EVs will undoubtedly have a good run for a few years with running costs, until the market takes off and electricity distribution and consumption costs and inevitable government charges start to bite.

What is the realistic future for electric vehicles in Australia? Indeed, what is feasible here, given our well-known constraints of low population, vast distances, reliance on vehicles, abundant energy resources but reliant on imported liquid fuels? A few facts will help to clarify things for readers currently bamboozled by climate hype and, election promises and, dare I say it, deliberate misinformation from the more idealistic members of our society.

Nevertheless, EVs are a reality and numbers will inevitably grow as infrastructure permits.

Renewable energy for EVs

A big unknown at present is whether electricity from renewables will ever be able to keep up with traditional demands for power (domestic and industry) as well as replacing the consumption of petrol and diesel by ICVs[207]. The full potential of EVs will not be realised unless they are powered by renewable energy, and we are a long way off that position, given that renewables in 2020 account for only 6.5% of Australia's annual energy demand, the greater majority still being provided by fossil fuels. However, even if powered off a fossil-fuelled grid, EVs can result in significantly lower greenhouse gas and aerosol production than ICVs, because of relative efficiencies.

In 2018, there were some 19 million registered vehicles in Australia, of which some 14.26 million were passenger vehicles. Commercial vehicles used in cities could readily be EVs, but long-haul transport as EVs is unlikely, unless a clear economic case can be made for conversion, ie unless there are significant time and cost savings to operators – 'time is money'. Buses are currently a major target as EVs, with good reason.

Most of the 15 million cars are in our cities, many primarily for commuting, but also essential for family use. EVs lend themselves particularly well to city users, especially for commuting and as run-arounds and for reduction of pollution.

It can be shown that by 2050 there could be about 22.5 million EVs (passenger cars), assuming a generous 75% of cars being EVs by then. There are huge savings on offer, but at a cost.

[207] An article in The Australian (5Apr19) discusses whether the EV roll-out is a 'threat to the power grid'.

There will be large savings in fossil liquid fuels currently used in cars, about 70% (maybe 80%)[208] of which is converted into heat and wasted. All that fuel not burnt means less greenhouse gas and aerosol pollution (particularly CO2). On the other side though: there will need to be a large investment in generation of renewable electricity and recharging networks; there will not necessarily be fewer vehicles on the road and traffic congestion (and travel time lost) will not be less (as some pundits may think). Less pollution will be good for commuter health, albeit in Australia, it has negligible impact on world climate change.

According to the Australian Bureau of Statistics [1], at end-June 2018, there were 14,258,620 passenger cars in Australia, running a total of 179,761 million kms per annum. Let's assume 15,000,000 at end-June 2019, running 180,000 million kms per annum.

Currently available EV cars consume from 16 to 20 KwH[209] per 100km. It can be shown that a good average, given a current average city speed of 45 kmph, is just on 18 KwH per 100 km. With an EV efficiency[210] of 70%, a fleet of 15 million passenger EVs would consume about 46,250 GwH[211] of electricity per annum. Each EV would consume an average of 3.1 MwH per annum. In 2050, there could be 22.6 million EV passenger cars consuming 69,703 GwH per annum.

Would renewable energy generation into the national grid be able to cope? How feasible is all this for renewables and EV adoption, given the political mess on energy and EVs at present?

To put things in perspective, in 2020 Australia produced 55.093 GwH of renewable energy, being 24% of the electricity sector at 27% of total demand, being only 6.5% of the total energy consumed. [2] *www.assets.cleanenergycouncil.org.au/documents/resources/reports/clean-energy-australia/clean-energy-australia-report-2020.pdf*.

By 2050, one could expect annual production to at least double, and for massive EV adoption to be accommodated. However, no matter what Australia does with EVs, it will have negligible effect on the world climate. By all means have EVs, but let them evolve as economic sense dictates. Government subsidies would be largely wasted (even if attractive politically).

"*Eventually electric cars can be great, but not yet. Too expensive, range anxiety and our subsidies buy a few tons of CO2 at exorbitant prices. The CO2 emission produced in manufacturing are such that it would take 60,000 km of travel for CO2 emissions to be recovered.*" [4]

A recent article by the CSIRO is summarised in Box Q1.

Box Q1 [3] **CSIRO says Australia's car fleet could be fully electric by 2050,** 18Jun 2020

Australia's main scientific research body, the CSIRO, says Australia's entire car fleet could be fully electric by 2050, with the share of EVs in new car sales reaching more than 70 per cent as early as 2030 and 100 per cent of new car sales by 2040.
Naturally, it assumes a zero emissions target by 2050, and the "step change" scenario points to a share of renewables of more than 90 per cent within two decades.
The forecast is one of five scenarios canvassed by the CSIRO for electric vehicles, rooftop solar and battery storage to help inform the 20-year blueprint – known as the Integrated System Plan – being put together by the Australian Energy Market Operator.
The CSIRO study does not lay out a prescriptive policy path to reach the "step change" scenario and a totally electric fleet, but it does assume that "price parity" between electric and petrol cars is reached by 2025 (as opposed to 2035 under the slow change scenario), and that other limitations, such as infrastructure (charging stations) are not a restraint.

[208] Only 20-30% of energy consumed by ICVs is converted to 'wheels on road" power, the rest is wasted as heat into the atmosphere and later absorbed into the land and oceans, with the rest (not enough because of CO2 production) radiated out into space.

[209] KwH = Kilowatt.Hours, ie thousands of watts power generated/consumed for H hours.

[210] Percentage of power consumed by EVs converted to work done (at wheels on road), which is much higher than for ICVs.

[211] GwH = Giga watt.Hours, millions of watts power generated/consumed for H hours.

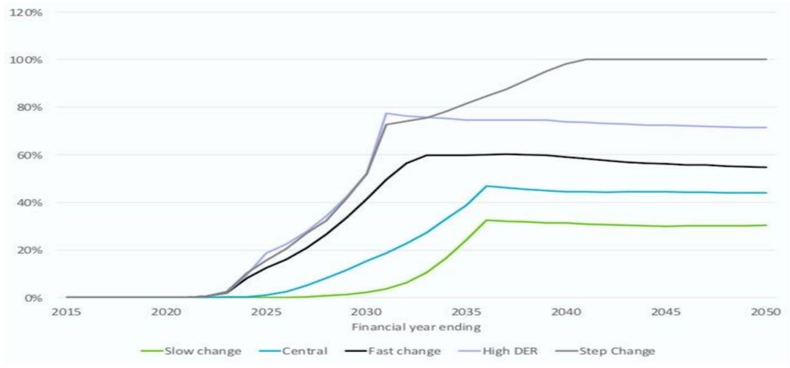

Figure 5-14 Projected sales share of electric vehicles by scenario

https://thedriven.io/2020/06/18/csiro-says-australias-car-fleet-could-be-fully-electric-by-2050/

Carbon footprint

Carbon footprint is normally defined as the total greenhouse gas emissions caused by an individual, event, organisation, or product, expressed as carbon dioxide equivalent. It should have said also, over the 'life-cycle' of the product.

The life-cycle of a product or system comprised of products is from its inception, through its useful life to its disposal. The main phases are production and processing of raw material input, design, facilities, manufacture, distribution, operations and maintenance (O&M) and eventual, environmentally safe disposal, all of which have economic and environmental costs. The latter are represented by pollution in all its forms, especially the greenhouses gases and aerosols (mainly carbon black), but also the heat injected into the atmosphere.

All products and projects have 'carbon footprints', some of which are 'hefty', for example, a city's water supply, by the time dams and reticulation are built and maintained, and the water continuously purified. Of course, industry is recognised as a major source of known or potential pollution, which must be controlled by vigilant governments.

So, what might be the true 'carbon footprint' of EVs? Proponents never actually say.

Batteries or fuel cells?

The two viable energy sources for EVs are batteries, charged from home or grid resources, and hydrogen fuel cells, fuelled by pure hydrogen from a yet-to-exist distribution infrastructure.

While battery driven EVs have certain advantages, their future is limited unless recharged by renewable energy.

Battery powered EVs will predominate in the city, but elsewhere, limitations on range and availability of charging facilities could well limit their usefulness.

While some manufacturers like Tesla are developing battery powered pick-up trucks (utilities in Australia) and even 40-tonne semi-trailers, it is very unlikely that batteries will ever power heavy road vehicles, but could well be powered by hydrogen fuel cells. Nevertheless, this notion is challenged in some quarters, e.g., by "*Dutch electric vehicle expert Auke Hoekstra has taken to Twitter to explain why he believes electric trucks such as the Tesla Semi, rather than hydrogen-powered trucks, will corner the majority of the 40-tonne semi-trailer and trucking market and replace diesel*." [5]

Hydrogen

As for lithium batteries, there is also currently a lot of hyperbole about the future of hydrogen fuel cells as a better alternative to power electric vehicles (EV).

The opportunity for hydrogen to compete favourably on a cost basis in local applications, such as transport and remote area power system, is within reach based on potential cost reductions in coming years. In the eyes of some pundits, the development of a hydrogen export industry represents a significant opportunity for Australia and a potential 'game changer' for the local industry and the broader energy sector, due to associated increases in scale. However, while a proponent of hydrogen production, Professor Garnaut, in his latest book [6], does not believe that Australia could export hydrogen economically.

There is no shortage of information in the literature or on the web about the future of hydrogen, even if a lot of it is promotional. Four good starters are:

- Super-Power, Australia's low-carbon opportunity, Ross Garnaut, La Trobe, 2019. [6]
- A quick coverage, see *www.thenewdaily.com.au/life/auto/2019/04/13/hydrogen-fuel-car-australia* [7]
- In more detail: "Hydrogen for Australia's future", A briefing paper for the COAG Energy Council, prepared by the Hydrogen Strategy Group, August 2018 [Dr Alan Finkel, Chairman] [8]
- *www.csiro.au/en/Do-business/Futures/Reports/Hydrogen-Roadmap*. [9]

Despite the hyperbole and while the use of hydrogen has huge potential, there are very serious challenges to overcome, probably the most difficult of which is producing it and getting it to consumers in an efficient manner, ie costing less than the economic value it offers. At present, in addition to the hefty cost of establishing and maintaining infrastructure, the production of electrolysis is only marginally efficient at best, ie consuming less energy to produce than we get to use somewhere. It could really only be viable if powered by renewable energy.

There is a long way to go yet! Nevertheless, the giant petroleum and gas producers of the world are morphing into 'energy' companies, to embrace all forms of energy - the opposite to what the US railroad companies did (to their regret), ie to have recognised too late that they were in the 'transport' business not just railways.

See also 'A Noddy's Guide to Hydrogen' in Annex F, *Demand for energy and emissions*.

Conclusions

So, what does all this mean for the future of EVs in Australia?

EVs are a reality and adoption will increase at an increasing pace, as economics, subsidies and government policy permit.

The brightest future for EVs is obviously in cities where short, daily running is predominant, recharging networks relatively cheaper to install and where roof-top solar is prevalent for overnight charging of vehicles.

However, adoption of EVs in Australia can never be hoped to match what is occurring in densely populated countries, or those with cheap renewable power like Norway. ICVs will always be a necessity in Australia.

The CSIRO predicts that Australia's entire car fleet could be fully electric by 2050, but assuming achievement of a zero-emissions baseline by 2050 (a big ask for Australia).

Growth in renewable electricity generation will not only have to cope with adoption of EVs, but also will have to cope with the increase in domestic, commercial and industrial demand. Nevertheless, EV demand will be accommodated, if at a cost, and buyers should not expect the annual cost of owning an EV to be any less than for your current ICV. Governments will want their share to recover lost excise on fuel and to maintain infrastructure.

A most important conclusion though, is that the adoption of EVs in Australia should be as economic development and productivity gains permit. Contrary to what is being said politically, there is no imperative to push adoption of EVs through subsidies or law. After all, the reality is that whatever Australia does with EVs, it will have negligible effect on world climate change - very much greater influences than Australia's puny effort are at work.

Australian Logistics Study Centre
Canberra, 24 July 2020 [amended 1Sep20]

ANNEX R TO
A view on permanent climate change

LETTERS TO EDITORS

About this annex

This annex contains letters written by this author to editors of the Canberra Times, to the Australian and to certain journalists, on the subjects of global warming and climate change. If not so stated, a listed letter was not published. That was the prerogative of the editor.

1	**Chicken Littles of climate change,** 16Oct19 [As submitted to Canberra Times and The Australian] This is an open letter to all the Chicken Littles of climate change. Notwithstanding that climate change for the worse may indeed be underway, you should have a hard think about some facts: While it might make you feel good and virtuous, no matter what you do in Australia will have any effect whatsoever on climate change, given its miniscule contribution to global emissions. We could destroy our economy and return to horse & buggy days with zero effect on the global climate. You are not about 'saving the planet', you are about saving yourselves. The planet, including the reef, will be here for millions, if not billions of years after the human race has extinguished itself. And, if you think you are setting a good example to, or even leading the world, think again. If you have ever lived overseas, you would know that most people there have probably never heard of Australia, let alone what Australia may do and even less about what you may think. Any climate change will be long term. In the meantime, there are much greater existential threats for you and your offspring to think, worry about and protest against, given the political mess the world has been in for over 20 years now, with illegal immigration, the forces of Islam tearing the world apart and a nuclear China arming itself to the teeth. Ask yourself why China would be doing that if not to subjugate all it can in the future, including Australia as an early casualty. China could cripple us economically at any time, if it wished to, but will probably choose instead to simply flood us with immigrants, of allegiance only to the motherland.
2	**Chicken Littles of Climate** 16Oct19 [As **published** Canberra Times 18/10/19] This is an open letter to all the Chicken Littles of climate change. Notwithstanding that climate change for the worse may indeed be underway, you should have a hard think about some facts. While it might make you feel good and virtuous, no matter what you do in Australia will have any effect whatsoever on climate change, given its miniscule contribution to global emissions. We could destroy our economy and return to horse and buggy days with zero effect on the global climate. You are not about "saving the planet", you are about saving yourselves. The planet, including the reef, will be here for millions, if not billions of years after the human race has extinguished itself. While it might make you feel good and virtuous, no matter what you do in Australia will have any effect whatsoever on climate change, given its miniscule contribution to global emissions. We could destroy our economy and return to horse and buggy days with zero effect on the global climate.
3	**Chicken Littles of climate change – Part 2** 18Oct19 I thank the Canberra Times for publishing in part my letter (18Oct19) about Chicken Littles of climate change, but the main message of the letter had been edited out. That is, any climate change will be long term. In the meantime, there are much greater existential threats for you and your offspring to think, worry about and protest against, given the political mess the world has been in for over 20 years now, with illegal immigration, the forces of Islam tearing the world apart and a nuclear China arming itself to the teeth. Ask yourself why China would be doing that if not to subjugate all it can in the future, including Australia as an early casualty. China could cripple us economically at any time, if it wished to, but will probably choose instead to simply flood us with immigrants, of allegiance only to the motherland.
4	**Chicken Littles of climate change – Part 3** 26Oct19 It is sad to see the reaction by Paul Pentony (26Oct19) to my letter of 18Oct about climate change. There was never any insult intended to those suffering from bad weather conditions that many believe to be the result of a climate change for the worse. Unfortunately, the main message of the original letter had been edited out, ie that any climate change will be long term and that, in the meantime, there are much greater existential threats to human kind and Australia in particular to be more concerned about. In respect of whether we should be 'leaners' or 'lifters', obviously 'lifters' but not waste our time, effort and billions trying to lead the world. We need only to keep up with what the big polluters of China and the USA may be doing to limit global warming.

5	**China's interference?** 25Nov19 [To Canberra Times and The Australian] [**published** Canberra Times 27Nov19] There has been a great deal of attention given to China in the media lately, with very good reason. We Australians need to know that there are much, greater and pressing existential threats to us and our offspring to think about, worry about and protest against than long-term global warming, given the political mess the world has been in for over 20 years now, with a pandemic of illegal immigration and the forces of Islam tearing itself and the world apart. Whatever you may be thinking about China, ask yourself the following question: why is a nuclear China arming itself to the teeth and 'colonising' the Pacific, if not to corrupt and subjugate all others, economically or otherwise as necessary, including Australia as a probable early casualty. China could cripple us economically at any time, if it wished to, but will probably choose instead to simply compromise our information systems, infiltrate our institutions and flood us with immigrants of allegiance only to the motherland. How can any individual or country ever believe anything the Chinese Government may say? Given the mess in Hong Kong and that Chinese intentions have been comprehensively exposed, the world is at a very dangerous flashpoint. We have been warned!
6	**Big immigration** 27Nov19 [To Canberra Times and The Australian] [**published** The Australian 30Nov19] So, our erstwhile, Mandarin-speaking Prime Minister says (Canberra Times, 27Nov19) that we need a population of 50 million people to have any chance of countering China's 1.45 billion (and counting). But I did not see or hear where Mr Rudd saw these 25 million immigrants coming from. Of course, China would be very willing and able to provide those numbers with 'selected' immigrants and the Islamic world would too. These sources would be totally unacceptable. So, where could we get this huge Number? We could get some from the Island nations, the Philippines and other Christian countries, but nowhere enough. The only major source that could possibly be acceptable would be India. Would an Australia dominated by Indians be OK? Even if Australia could manage to house, feed, and provide enough water for a population 50 million (doubtful in itself), what chance would we have against a belligerent China anyway (unless we go nuclear)?
7	**Van Onselen is wrong** 21Dec19 [to The Australian] Peter Van Onselen is wrong (The Australian,21Dec19) in decrying the argument by many that no matter what Australia does (including disappearing completely off the map), it would not have made the slightest difference to global warming and its ensuing effects. His arguments about 'sedentary couch potatoes', 'donating', 'voting', 'recycling', and even his citing the collective world reaction to 'chlorofluorocarbons' are simply not relevant to the global warming argument. Australia (let alone the PM) has not caused global warming, even if its per-capital emissions are high (but overall, miniscule) and it can do nothing to stop it. All Australia has to do is to do its bit, as it is with renewable energy, but not try to lead the world. Shutting down our coal exports is the craziest of ideas. We export coal only because other countries want it as the best available. If we refused to export coal (a shot in our left foot), these countries would buy more polluting coal from others (shot in right foot). And where are the arguments from these pundits and the Twittersphere about the Middle East exporting oil and burning unimaginable quantities themselves to air-condition their cities and homes? Only action by the big polluters, especially China, India and the USA stand any chance of stemming global warming (if indeed human induced warming is a fact, as it probably is). World minions like we may be big on virtue-signalling but rather small on rational thinking. The reality is that no matter what we do, it won't make a scrap of difference to any global warming. What we can do though is to start now on how to protect ourselves against what appears to be the inevitable – and that is the real challenge we Australians face. It has been suggested by some that a royal commission to sort out fact from fiction on global warming and its effects would go a long way to getting some rationality into the argument.

8	**Climate change believers need to face unpleasant facts too**. 10Jan20 [To Canberra Times] Keith Hill (Letters 10Jan20) claims that “facts don't matter to deniers”. But, let me tell the complaining ‘believers’ a few facts they may not want to hear. The PM has not caused the bushfires, the drought, climate change or global warming. Nor has Australia caused the drought, climate change or global warming. However, Australia collectively, citizens as well as past and present administrations, at all levels of government, must bear some responsibility for the devastating bushfires we are currently experiencing. China consumes about 30% and the USA 19% of the world’s energy production, some 90 % or more of which comes from fossil fuels. Australia consumes 1.04%. Compared to the world average, Australia’s per capita consumption of energy is relatively high (about 10,000 KwH/year) with good reason, given our geography and demographics, but is modest compared to that by many other countries, especially in the Middle-East and northern Europe (Finland at over 50,000). China is by far the world's biggest coal producer, about five times more than Australia in fifth place. Indonesia produces more coal than Australia. Please recognise that Australia exports coal only because other countries want to buy it for its high quality. No buy - no export! While coal is seen as the ‘bad boy’, the use of petroleum products far exceeds that of coal in Australia and the world. So where are the complaints about petroleum usage from virtually all of us still driving fossil fuelled vehicles? While pursuit of renewable energy sources is a good thing, there is a very long way to go. Australia may be the per-capita world leader in renewable energy yet it accounts for only about 6.25% of the energy it consumes. The figure is much less for the world as a whole. Australia is kidding itself if it thinks it can affect global warming or climate change. It has not and cannot. Its affect is and will remain far too small to make any difference. Our real challenge is to recognise the probable effects of climate change on Australia (not good), what, when and how they might occur and how we might best respond. Australia can move only to protect itself as best as possible. So, all you complaining letter writers, use what intellect you may have to work on how you and your country might best cope with change, instead of complaining and self-flagellating about the climate mess you believe the world to be in.
9	**Climate change emotion** 2Feb20 [to Canberra Times] Letter writers like Sue Wareham and Rod Holesgrove (Letters, 2Feb20) need to get a rational and non-political grip on themselves in respect of global warming. A few facts may help. Australia could disappear off the planet tomorrow and it would not make a scrap of difference to global warming. Our emissions are miniscule and any contribution we might make to reducing them might be good for the ego but would not do much for the planet. China is by far the world's biggest coal producer, about five times more than Australia in fifth place. Indonesia produces more coal than Australia. Please recognise that Australia exports coal only because other countries want to buy it for its high quality. No buy - no export! Our real challenge is to recognise the probable effects of climate change on Australia (not good), what, when and how they might occur and how we as a nation might best respond. Australia can move only to protect itself as best it can. So, all you complaining letter writers, use what intellect you may have to work on how you and your country might best cope with change, instead of complaining, blaming others and self-flagellating about the climate mess you believe the world to be in.

10	**Australia is doing enough!** 17Jan20 [to The Australian] The article "Who's not doing enough on climate change", 17Jan20, is very misleading. The author may be a trained journalist but that has not stopped him from misrepresenting the truth. Australia does not export fossil fuel emissions; we export coal and gas only because other countries want these products. No buy – no export! Those countries cause the emissions from what we export – we do not. China is by far the world's biggest consumer of energy (and thus producer of emissions) and the biggest coal producer, about seven times more than Australia in fifth place. Indonesia produces almost as much as Australia. The statement our per capita emissions "… are highest among developed rich countries" is simply wrong. Australia's per capita consumption of energy is relatively high (about 10,000 KwH/year) with good reason, given our geography and demographics, but is modest. We are way down the list when compared to many other developed countries in North America, the Middle-East and northern Europe (e.g., Finland at over 50,000). It is wrong to imply that the Coalition government is not doing anything about climate change. It is doing as much as it needs to do to meet its international obligations. China, the USA and Europe consume over 50 % of the world's energy production, some 90 % or more of which comes from fossil fuels. At about 1.03% of global emissions, Australia is kidding itself if it thinks it can affect global warming or climate change. It has not and cannot. This does not mean that we do nothing, but we do need only to do our bit. We do not have to shoot ourselves in the foot trying to big-note ourselves to the other small emitting countries. Australia could disappear off the map tomorrow and it would make no difference to global warming or climate change. While coal is seen as the 'bad boy', world consumption of liquid petroleum products is greater than coal and gas is almost the same. So where are the complaints about petroleum and gas usage from virtually all of us still driving fossil fuelled vehicles? Is there not a bit of hypocrisy here? While pursuit of renewable energy sources is considered a good thing, there is a very, very long way to go. Australia may be the per-capita world leader in renewable energy, yet it accounts for only about 6.25% of the energy it consumes itself. The figure is much less for the world as a whole. Our real challenge is to recognise the probable effects of climate change on Australia (not good), what, when and how they might occur and how we as a nation might best respond. Australia can move only to protect itself as best it can.
11	**Australia's carbon emissions** 27Feb20 [To Canberra Times] The Canberra Times (27Feb20) article "Australia's carbon emissions: simple maths, hard calls" is largely correct in its observations but is in error factually and by omission. In the first instance, Australia is not the second biggest emitter per capita. According to figures from Emissions Database for Global Atmospheric Research (EDGAR), in 2018, Australia emitted 16.8 metric tons per capita (fossil fuels and cement manufacture) which placed it in 12th place of over 200 countries (and other entities) registered. In terms of energy consumption (2016), for which the world average was 2,674 KwH/person/year, Australia's consumption was considerably higher at 9,742 KwH/p/y, but was only ninth in the world. By comparison, the leader was Iceland at 50,613 KwH/p/y. In respect of 'simple maths', 361,262 kilo-tonnes divided by 23.5 million people is 15.4 tonnes per person, not 15.4 kilo-tonnes. Given probable different data sources, 15.4 and 16.8 are roughly the same. In respect of a net zero-emissions (all sectors) target by 2050, It is improper to imply that Australia should be emulating the UK PM who recently declared such a target. Among other factors, the UK obtains about 20% of its electricity from nuclear power, Australia has no nuclear power generation. The UK is the size of Victoria; per capita, its transport sector lends itself to emissions savings compared to Australia. However, almost 50% of electricity in the UK is still generated by fossil fuels. Mr Johnson will have a hard time getting to net zero emissions just for electricity, let alone doing away with all fossil fuel emissions (less CO_2 extraction) in 30 years. The Media continues to report that there is a perception around the world that Australia is an energy guzzler and big CO_2 emitter. Given that that is not true, and that our annual emissions are miniscule at 1.04%, it is up to the Governments and the Media to contradict those false perceptions with facts, not to fan the flames. In respect to 'pulling its weight', that is all Australia has to do, and we are at least doing that. Australia does not have to big-note itself by trying to lead the world.

12	**Let's restart our manufacturing sector** 18Mar20 [To The Australian] The COVID-19 virus, as nasty as it is at present, could be a long-term blessing. For 30 years or more, the western world of commerce has given its technology to and sold its sole to China. The virus has the potential to severely damage world trade to the point of a lasting depression. However, it does give countries, now dependent on China, like Australia, an opportunity to restart their own manufacturing, even if at a premium. While equitable world trade is the source of national wealth, the economic principal of trade where you have an economic advantage has limits. Australia is a good case of having reduced itself to a quarry at the expense of its manufacturing sector. Australia can and should start manufacturing again. Given a continuing boom in renewable energy farms, all of which would have to be replaced within 25-30 years, manufacture of our own demand for solar panels would be a good start.

ANNEX S TO
A view on permanent climate change

GLOSSARY

Definitions [Main reference: sr15_glossary.pdf [IPCC]]

Term	Definition
Absorption of Radiation	The uptake of radiation by a solid body, liquid or gas. The absorbed energy may be transferred or re-emitted. [IPCC]
Aerosols	Particles of matter, solid or liquid, larger than a molecule but small enough to remain suspended in the atmosphere. Natural sources include salt particles from sea spray and clay particles as a result of weathering of rocks, both of which are carried upward by the wind. Aerosols can also originate as a result of human activities, e.g. the burning of fossil fuels and in this case are often considered pollutants. The most important contribution is SO2. Aerosols have a significant cooling effect with strong regional variation which is not fully understood. *[IPCC Glossary]*
Albedo	The ratio of reflected to incident light; albedo can be expressed as either a percentage or a fraction of 1. Snow covered areas have a high albedo (up to about 0.9 or 90%) due to their white colour, while vegetation has a low albedo (generally about 0.1 or 10%) due to the dark colour and light absorbed for photosynthesis. Clouds have an intermediate albedo and are the most important contributor to the Earth's albedo. The Earth's aggregate albedo is approximately 0.3. *[IPCC Glossary]*
An extreme weather event	An extreme weather event is an event that is rare at a particular place and time of year. [IPCC]
Anthropocene	Era of man. The 'Anthropocene' is a proposed new geological epoch resulting from significant human-driven changes to the structure and functioning of the Earth System, including the climate system. *[IPCC Glossary]*
Anthropogenic climate change	Climate change caused by increase in the atmospheric concentration of greenhouse gases which inhibits the transmission of some of the sun’s energy from the earth’s surface to outer space. These gases include carbon dioxide, water vapor, methane, chlorofluorocarbons (CFCs), and other chemicals. The increased concentrations of greenhouse gases result in part from human activity -- deforestation; the burning of fossil fuels such as gasoline, oil, coal and natural gas; and the release of CFCs from refrigerators, air conditioners, etc. *[IPCC Glossary]*
Artificial Intelligence	Computer systems able to perform tasks normally requiring human intelligence, such as visual perception and speech recognition. *[IPCC Glossary]*
Atmosphere	The mixture of gases surrounding the Earth. The Earth's atmosphere consists of about 79.1% nitrogen (by volume), 20.9% oxygen, .036% carbon dioxide and trace amounts of other gases. The atmosphere can be divided into a number of layers according to its mixing or chemical characteristics, generally determined by its thermal properties (temperature). The layer nearest the Earth is the troposphere, which reaches up to an altitude of about 8 km (about 5 miles) in the polar regions and up to 17 km (nearly 11 miles) above the equator. The stratosphere, which reaches to an altitude of about 50 km (31 miles) lies atop the troposphere. The mesosphere which extends up to 80-90 km is atop the stratosphere, and finally, the thermosphere, or ionosphere, gradually diminishes and forms a fuzzy border with outer space. There is relatively little mixing of gases between layers. [IPCC Glossary]
Biochar	Stable, carbon-rich material produced by heating biomass in an oxygen-limited environment. Biochar may be added to soils to improve soil functions and to reduce greenhouse gas emissions from biomass and soils, and for carbon sequestration. [Footnote: This definition builds from IBI (2018)]. [IPCC]

Biomass	Organic non-fossil material of biological origin. For example, trees and plants are biomass. [IPCC Glossary] [except old-growth forests]
Biomass energy	Energy produced by combusting biomass materials such as wood. The CO2 emitted from burning biomass will not increase total atmospheric CO2 if this consumption is done on a sustainable basis (i.e., if in a given period of time, regrowth of biomass takes up as much carbon dioxide as is released from biomass combustion). Biomass energy is often suggested as a replacement for fossil fuel combustion which has large greenhouse gas emissions. [IPCC Glossary]
Biosphere	The region on land, in the oceans, and in the ➔atmosphere inhabited by living organisms. [IPCC Glossary]
Black carbon (BC)	Operationally defined aerosol species based on measurement of light absorption and chemical reactivity and/or thermal stability. It is sometimes referred to as soot. BC is mostly formed by the incomplete combustion of fossil fuels, biofuels, and biomass but it also occurs naturally. It stays in the atmosphere only for days or weeks. It is the most strongly light-absorbing component of particulate matter (PM) and has a warming effect by absorbing heat into the atmosphere and reducing the albedo when deposited on snow or ice. [IPCC]
Blue carbon	Blue carbon is the carbon captured by living organisms in coastal (e.g., mangroves, salt marshes, seagrasses) and marine ecosystems, and stored in biomass and sediments. [IPCC]
Carbon budget	This term refers to three concepts in the literature: (1) an assessment of carbon cycle sources and sinks on a global level, through the synthesis of evidence for fossil-fuel and cement emissions, land-use change emissions, ocean and land CO2 sinks, and the resulting atmospheric CO2 growth rate. This is referred to as the global carbon budget; (2) the estimated cumulative amount of global carbon dioxide emissions that is estimated to limit global surface temperature to a given level above a reference period, taking into account global surface temperature contributions of other GHGs and climate forcers; (3) the distribution of the carbon budget defined under (2) to the regional, national, or sub-national level based on considerations of equity, costs or efficiency. [IPCC]
Carbon cycle	The complex series of reactions by which carbon passes through the Earth's atmosphere, biosphere, hydrosphere, and lithosphere. For example, plants remove carbon in the form of CO2 from the atmosphere and use it to produce carbohydrates in living organisms (photosynthesis). When those organisms die, the carbon is returned to the Earth as carbon dioxide, as ➔fossil fuels (during decay), or as inorganic compounds such as calcium carbonate (limestone). *[IPCC Glossary]*
Carbon dioxide (CO2)	The main greenhouse gas affected directly by human activities. CO2 also serves as the reference to compare all other greenhouse gases (carbon dioxide equivalents). The major source of CO2 emissions is fossil fuel combustion. CO2 emissions are also a product of forest clearing, biomass burning, and non-energy production processes such as cement production. Atmospheric concentrations of CO2 have been increasing at a rate of about 0.5% per year and are now about 30% above preindustrial levels. *[IPCC Glossary]*
Carbon dioxide capture and storage (CCS)	A process in which a relatively pure stream of carbon dioxide (CO2) from industrial and energy-related sources is separated (captured), conditioned, compressed and transported to a storage location for long-term isolation from the atmosphere. Sometimes referred to as Carbon Capture and Storage.
Carbon dioxide equivalent	A metric measure used to compare the emissions from various greenhouse gases based upon their global warming potential. The carbon dioxide equivalent for a gas is derived by multiplying the tons of the gas by the

	associated global warming potential. Carbon may also be used as the reference and other greenhouse gases may be converted to carbon equivalents. *[IPCC Glossary]*
Carbon Dioxide Equivalent (CO2-e)	The universal unit of measurement used to compare the emissions from each of the greenhouse gases, based upon their Global Warming Potentials (GWP). It is derived by multiplying the tonnes of greenhouse gas by the associated GWP. [Garnaut Climate Change Review, 2008]
Carbon footprint	Carbon footprint is historically defined as the total greenhouse gas emissions caused by an individual, event, organization, or product, expressed as carbon dioxide equivalent. It should have said also, over the 'life-cycle' of the product.
Carbon sequestration	The process of storing carbon in a carbon pool. [IPCC]
Carbon sequestration	The uptake and storage of carbon. Trees and plants, for example, absorb carbon dioxide, release the oxygen and store the carbon. *[IPCC Glossary]*
Carbon sink	Any reservoir that takes up carbon released from some other part of the carbon cycle. For example, the atmosphere, oceans and forests are major carbon sinks because much of the CO2 produced elsewhere on the Earth ends up in these bodies. *[IPCC Glossary]*
Carbon tax	Tax proportional to CO2 emissions, e.g. by placing a surcharge on the carbon content of oil, coal, and gas. Carbon taxes exist in several Scandinavian countries. *[IPCC Glossary]*
Carbon tax	Tax proportional to CO2 emissions, e.g. by placing a surcharge on the carbon content of oil, coal, and gas. Carbon taxes exist in several Scandinavian countries. *[IPCC Glossary]*
Carbon trading scheme	Carbon trading, sometimes called emissions trading, is a market-based tool to limit GHG. The carbon market trades emissions under cap-and-trade schemes or with credits that pay for or offset GHG reductions. Cap-and-trade schemes are the most popular way to regulate carbon dioxide (CO2) and other emissions.
Carryover credits	Certified Emission Reductions (CERs) CERs are verified and authenticated units of greenhouse gas reductions from abatement or sequestration projects which are certified under the clean development mechanism. *[IPCC Glossary]*
Climate	Climate in a narrow sense is usually defined as the average weather, or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. The classical period for averaging these variables is 30 years, as defined by the World Meteorological Organization. The relevant quantities are most often surface variables such as temperature, precipitation and wind. Climate in a wider sense is the state, including a statistical description, of the climate system.
Climate change	Climate change refers to a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings such as modulations of the solar cycles, volcanic eruptions and persistent anthropogenic changes in the composition of the atmosphere or in land use. Note that the Framework Convention on Climate Change (UNFCCC), in its Article 1, defines climate change as: 'a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods'. The UNFCCC thus makes a distinction between climate change attributable to human activities altering the atmospheric composition and climate variability attributable to natural causes Change in climatic variables (temperature, precipitation). There is natural and anthropogenic climate change. [IPCC Glossary]

Climate change commitment	Climate change commitment is defined as the unavoidable future climate change resulting from inertia in the geophysical and socio-economic systems. Different types of climate change commitment are discussed in the literature (see sub-terms). Climate change commitment is usually quantified in terms of the further change in temperature, but it includes other future changes, for example in the hydrological cycle, in extreme weather events, in extreme climate events, and in sea level.
Climate extreme (extreme weather or climate event)	The occurrence of a value of a weather or climate variable above (or below) a threshold value near the upper (or lower) ends of the range of observed values of the variable. For simplicity, both extreme weather events and extreme climate events are referred to collectively as 'climate extremes.' [IPCC]
Climate feedback	An atmospheric, oceanic, terrestrial, or other process that is activated by the direct climate change induced by changes in radiative forcing. Climate feedbacks may increase (positive feedback) or diminish (negative feedback) the magnitude of the direct climate change. [IPCC Glossary]
Climate feedback	An interaction in which a perturbation in one climate quantity causes a change in a second and the change in the second quantity ultimately leads to an additional change in the first. A negative feedback is one in which the initial perturbation is weakened by the changes it causes; a positive feedback is one in which the initial perturbation is enhanced. The initial perturbation can either be externally forced or arise as part of internal variability. [IPCC]
Climate forcing	In accordance with the basic laws of thermodynamics, as Earth absorbs energy from the sun, it must eventually emit an equal amount of energy to space. The difference between incoming and outgoing radiation is known as a planet's radiative forcing (RF). [www.climate.gov]
Climate model	A numerical representation of the climate system based on the physical, chemical and biological properties of its components, their interactions and feedback processes and accounting for some of its known properties. [IPCC]
Climate projection	A climate projection is the simulated response of the climate system to a scenario of future emission or concentration of greenhouse gases (GHGs) and aerosols, generally derived using climate models. [IPCC]
Climate sceptics	Scientists and lobby groups that deny that anthropogenic change is occurring or say it is beneficial. [IPCC Glossary]
Climate sensitivity	Climate sensitivity refers to the change in the annual global mean surface temperature in response to a change in the atmospheric CO2 concentration or other radiative forcing. [IPCC] Climate sensitivity is the globally averaged temperature change in response to changes in radiative forcing, which can occur, for instance, due to increased levels of carbon dioxide (CO2).
Climate Solutions Fund	On 25 February 2019 the Australian Government established a Climate Solutions Fund to provide an additional $2 billion to continue purchasing low-cost abatement, build on the success of the Emissions Reduction Fund and continue the momentum to reach Australia's 2030 emissions reduction target. The additional funding ensures Australian farmers, businesses and Indigenous communities continue to have opportunities to undertake emissions reduction projects that provide local benefits. *https//www.environment.gov.au/climate-change*
CO2 capture and sequestration	Carbon capture and storage (CCS) captures CO2 at a power station or industrial facility such as a steel, LNG or cement plant. The captured CO2 is then stored safely and permanently in deep underground geological structures, or by other physical, chemical or biological means. [www.coal
CO2 concentration	Average parts per million (ppm) of CO2 in the atmosphere.
CO2 equivalent (CO2-eq) emission	The amount of carbon dioxide (CO2) emission that would cause the same integrated radiative forcing or temperature change, over a given time horizon, as an emitted amount of a greenhouse gas (GHG) or a mixture of GHGs.

	There are a number of ways to compute such equivalent emissions and choose appropriate time horizons. Most typically, the CO2-equivalent emission is obtained by multiplying the emission of a GHG by its Global Warming Potential (GWP) for a 100-year time horizon. For a mix of GHGs it is obtained by summing the CO2-equivalent emissions of each gas. CO2-equivalent emission is a common scale for comparing emissions of different GHGs but does not imply equivalence of the corresponding climate change responses. There is generally no connection between CO2-equivalent emissions and resulting CO2-equivalent concentrations. [IPCC}
Credit	Originally defined as a "quantifiable and verifiable recognition of the reduction, avoidance or sequestration of carbon dioxide or other greenhouse gases as a result of a carbon offset project", the word "credit" was discontinued in the official language of the climate negotiations after COP 3 in favour of Emissions Reduction Units (ERUs), and Certified Emission Reductions (CERs). "Credit" was a difficult term because it held a number of different technical meanings and connotations in different languages – making negotiations on issues involving GHG "credits" confusing. However, "credit" is still used as colloquial expression for emission permits accruing from projects. In the domestic context (credit trading) it is still a valid term to define project-based reductions from a baseline. Credit trading Domestic emissions credit trading differs from allowance trading inasmuch there is no absolute emissions target. The credit is created as a reduction from a baseline. [IPCC Glossary]
Credit trading	Domestic emissions credit trading differs from allowance trading inasmuch there is no absolute emissions target. The credit is created as a reduction from a baseline. [IPCC Glossary]
Decarbonisation	The process by which countries, individuals or other entities aim to achieve zero fossil carbon existence. Typically refers to a reduction of the carbon emissions associated with electricity, industry and transport. [IPCC Glossary]
Decoupling	Decoupling (in relation to climate change) is where economic growth is no longer strongly associated with consumption of fossil fuels. Relative decoupling is where both grow but at different rates. Absolute decoupling is where economic growth happens but fossil fuels decline. [IPCC Glossary]
Desertification	Progressive destruction or degradation of existing vegetative cover to form desert. This can occur due to overgrazing, deforestation, drought, and the burning of extensive areas. Once formed, deserts can only support a sparse range of vegetation. Climatic effects associated with this phenomenon include increased albedo, reduced atmospheric humidity, and greater atmospheric dust (aerosol) loading. [IPCC Glossary]
Double CO2 ppm	A doubling of the CO2 concentration in the atmosphere, used as a scientific measure of average world temperature change, from a baseline.
Drought	A period of abnormally dry weather long enough to cause a serious hydrological imbalance. Drought is a relative term (see Box 3-3), therefore any discussion in terms of precipitation deficit must refer to the particular precipitation-related activity that is under discussion. For example, shortage of precipitation during the growing season impinges on crop production or ecosystem function in general (due to soil moisture drought, also termed agricultural drought), and during the runoff and percolation season primarily affects water supplies (hydrological drought). Storage changes in soil moisture and groundwater are also affected by increases in actual evapotranspiration in addition to reductions in precipitation. A period with an abnormal precipitation deficit is defined as a meteorological drought. [IPCC}
Earth Energy Balance	Energy contained within the atmosphere, oceans, waterways and vegetation of the Earth (but excluding the internal energy content of the Earth itself), at a given point in time, noting that the system is always dynamic.
Earth System	The physical combination of all land, all water (in oceans and fresh on land) and the atmosphere, and the dynamic activity on and within these components.

Earth system model (ESM)	A coupled atmosphere–ocean general circulation model in which a representation of the carbon cycle is included, allowing for interactive calculation of atmospheric CO2 or compatible emissions. Additional components (e.g., atmospheric chemistry, ice sheets, dynamic vegetation, nitrogen cycle, but also urban or crop models) may be included. [IPCC]
Ecosystem	The complex of plant, animal, fungal, and microorganism communities and their associated non-living environment interacting as an ecological unit. Ecosystems have no fixed boundaries; instead, their parameters are set according to the scientific, management, or policy question being examined. Depending upon the purpose of analysis, a single lake, a watershed, or an entire region could be considered an ecosystem. Ecosystems are endangered by climate change. [IPCC Glossary]
El Nino	A climatic phenomenon occurring irregularly, but generally every 3 to 5 years. El Ninos often first become evident during the Christmas season (El Nino means Christ child) in the surface oceans of the eastern tropical Pacific Ocean. The phenomenon involves seasonal changes in the direction of the tropical winds over the Pacific and abnormally warm surface ocean temperatures. The changes in the tropics are most intense in the Pacific region, these changes can disrupt weather patterns throughout the tropics and can extend to higher latitudes, especially in Central and North America. The relationship between these events and global weather patterns are currently the subject of much research in order to enhance prediction of seasonal to interannual fluctuations in the climate. [IPCC Glossary]
El Niño-southern oscillation (ENSO)	The term El Niño was initially used to describe a warm-water current that periodically flows along the coast of Ecuador and Peru, disrupting the local fishery. It has since become identified with warming of the tropical Pacific Ocean east of the dateline. This oceanic event is associated with a fluctuation of a global-scale tropical and subtropical surface pressure pattern called the Southern Oscillation. This coupled atmosphere–ocean phenomenon, with preferred time scales of two to about seven years, is known as the El Niño-Southern Oscillation (ENSO). It is often measured by the surface pressure anomaly difference between Tahiti and Darwin and/or the sea surface temperatures in the central and eastern equatorial Pacific. During an ENSO event, the prevailing trade winds weaken, reducing upwelling and altering ocean currents such that the sea surface temperatures warm, further weakening the trade winds. This phenomenon has a great impact on the wind, sea surface temperature and precipitation patterns in the tropical Pacific. It has climatic effects throughout the Pacific region and in many other parts of the world, through global teleconnections. The cold phase of ENSO is called La Niña.
Emissions	Pollutants released into the air or waterways by human activities. Air emissions pertain to atmospheric air pollution; water emissions refer to pollutants released into waterways. [IPCC Glossary]
Emissions limit	The limit on the number of tonnes of greenhouse gas that can be emitted by covered sectors. [Garnaut Climate Change Review, 2008]
Emissions Trading	An administrative approach used to reduce the cost of emissions control by providing a market-based and tradeable instrument for achieving reductions in emissions. [Garnaut Climate Change Review, 2008]
Energy	Energy, in physics, the capacity for doing work. It may exist in potential, kinetic, thermal, electrical, chemical, nuclear, or other various forms. There are, moreover, heat and work—i.e., energy in the process of transfer from one body to another. *www.google.com*
Energy balance (equation)	Energy balance (equation) for the Earth System (defined here as the combination of the land, oceans and atmosphere) is constant, ie radiation from the sun in equals radiation back out to space, plus the sum of the various forms of energy contained and stored within the Earth System.
Enhanced Greenhouse Effect	The natural greenhouse effect has been enhanced by anthropogenic emissions of greenhouse gases. Increased concentrations of carbon dioxide,

	methane, and nitrous oxide, CFCs, HFCs, PFCs, SF6, NF3, and other 32 photochemically important gases caused by human activities such as fossil fuel consumption and adding waste to landfills, trap more infra-red radiation, thereby exerting a warming influence on the climate. climate change, global warming. [IPCC Glossary]
Feedback Mechanisms	A mechanism that connects one aspect of a system to another. The connection can be either amplifying (positive feedback) or moderating (negative feedback). Climate Feedback. [IPCC Glossary]
Forcing mechanism	A process that alters the energy balance of the climate system, i.e. changes the relative balance between incoming solar radiation and outgoing infrared radiation from Earth. Such mechanisms include changes in solar irradiance, volcanic 35 eruptions, and enhancement of the natural greenhouse effect by emission of carbon dioxide. radiative forcing. [IPCC Glossary]
Fossil fuel	Fuels derived from organic compounds containing carbon and hydrogen that were laid down in the Earth's crust during past geological periods by formerly living plants and animals. These include coal, petroleum and natural gas. Coal has the largest ratio of carbon to hydrogen, followed by oil and natural gas. When carbon is burned, it unites with oxygen to form CO2, and hydrogen unites with oxygen to form H2O (water vapor), both of which contribute to the greenhouse effect. Coal combustion produces more CO2 per unit of energy than oil or natural gas. [IPCC Glossary]
Fourier's law	Fourier's law of thermal conduction states that the time rate of heat transfer through a material is proportional to the negative gradient in the temperature and to the area. .4 June 2019
Fuel cell	A fuel cell is a device that generates electricity by a chemical reaction. Every fuel cell has two electrodes, the anode (which is positively charged) and the cathode (which is negatively charged). The reactions that produce electricity take place at the two electrodes. Every fuel cell also has an electrolyte, which carries electrically charged particles from one electrode to the other, and a catalyst, which speeds the reactions at the electrodes. Multiple fuel cells are usually assembled into a stack and generate direct current (DC). Hydrogen is the basic fuel for fuel cells, but fuel cells also require oxygen. */www.studentenergy.org/topics/fuel-cell*
Fugitive emissions	Fugitive emissions are intentional or unintentional releases of gases from anthropogenic activities such as the processing, transmission or transportation of gas or petroleum. In particular, they may arise from the production, processing, transmission, storage and use of fuels, and include emissions from 36 combustion only where it does not support a productive activity (e.g., flaring of natural gas at oil and gas production facilities). [IPCC Glossary]
geothermal heat flux.	the amount of heat moving steadily outward from the interior of the earth through a unit area in unit time. [nsidc.org]
Glacier	A perennial mass of ice, originating on the land surface by the recrystallisation of snow and showing evidence of past or present flow. A glacier typically gains mass by accumulation of snow, and loses mass by melting and ice discharge into the sea or a lake if the glacier terminates in a body of water. Land ice masses of continental size (>50 000 km2) are referred to as ice sheets. [IPCC]
Global land-Ocean Temperature Index	An index of the average surface temperature of the world's oceans.
Global mean surface temperature (GMST)	Area-weighted global average of land surface air temperature over land and sea surface temperatures, unless otherwise specified, normally expressed relative to a specified reference period. [IPCC]
Global warming	An increase in the near surface temperature of the Earth. Global warming has occurred in the distant past as the result of natural influences, but the term is most often used to refer to the warming predicted to occur as a result of increased emissions of greenhouse gases. Scientists generally agree that the Earth's surface has warmed by about 0,7 degree Celsius in the past century.

	The IPCC concluded that increased concentrations of greenhouse gases are causing an increase in the Earth's surface temperature and that increased concentrations of sulphate aerosols have led to relative cooling in some regions, generally over and downwind of heavily industrialised areas. Climate Change, Enhanced Greenhouse Effect. [IPCC Glossary]
Global warming potential (GWP)	The index used to translate the level of emissions of various gases into a common measure in order to compare the relative radiative forcing of different gases without directly calculating the changes in atmospheric concentrations. GWPs are calculated as the ration of the radiative forcing that would result from the emission of one kilogram of a greenhouse gas to that from the emissions of one kilogram of carbon dioxide over a period of time (usually 100 years). [Garnaut Climate Change Review, 2008]
Global Warming Potential (GWP)	The index used to translate the level of emissions of various gases into a common measure in order to compare the relative radiative forcing of different gases without directly calculating the changes in atmospheric concentrations. GWPs are calculated as the ratio of the radiative forcing that would result from the emissions of one kilogram of a greenhouse gas to that from emission of one kilogram of CO2 over a period of time (usually 100 years). [IPCC Glossary]
Greenhouse effect	A term used to describe the effect on the Earth's temperature that results from the capture of heat by molecules of carbon dioxide, water vapor, methane, nitrous oxide, CFCs, ozone and other trace gases in the Earth's atmosphere. Shortwave solar radiation can pass through the clear atmosphere relatively unimpeded, but longwave infrared radiation emitted by the warm surface of the Earth is partially absorbed and then re-emitted by these greenhouse gases in the cooler atmosphere above. The atmosphere's major constituents, nitrogen and oxygen, are transparent to both incoming solar radiation and outgoing infrared radiation. Without the greenhouse effect, the Earth's surface temperature would much less than it actually is and not sustain life. [IPCC Glossary]
Greenhouse gas	Greenhouse gases (also known as CO2-e or carbon dioxide equivalents) are actually a number of gases that trap heat in the atmosphere – including carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O). *www.cncf.com.au/*
Hadley cell	The Hadley cell, named after George Hadley, is a global scale tropical atmospheric circulation that features air rising near the Equator, flowing poleward at a height of 10 to 15 kilometres above the earth's surface, descending in the subtropics, and then returning equatorward near the surface. [wikipedia.org]
Holocene	The Holocene is the current interglacial geological epoch, the second of two epochs within the Quaternary period, the preceding being the Pleistocene. The International Commission on Stratigraphy defines the start of the Holocene at 11,650 years before 1950. [IPCC]
Hydrological cycle	The cycle in which water evaporates from the oceans and the land surface, is carried over the Earth in atmospheric circulation as water vapour, condenses to form clouds, precipitates as rain or snow, which on land can be intercepted by trees and vegetation, potentially accumulates as snow or ice, provides runoff on the land surface, infiltrates into soils, recharges groundwater, discharges into streams, flows out into the oceans, and ultimately evaporates again from the ocean or land surface. [IPCC]
Ice sheet	A mass of land ice of continental size that is sufficiently thick to cover most of the underlying bed, so that its shape is mainly determined by its dynamics (the flow of the ice as it deforms internally and/or slides at its base). [IPCC]
Indian Ocean Dipole (IOD)	The Indian Ocean Dipole (IOD), also known as the Indian Niño, is an irregular oscillation of sea surface temperatures in which the western Indian Ocean becomes alternately warmer (positive phase) and then colder (negative phase) than the eastern part of the ocean. *https://en.wikipedia.org/*

Industrial revolution	A period of rapid industrial growth with far-reaching social and economic consequences, beginning in Britain during the second half of the 18th century and spreading to Europe and later to other countries including the United States. The invention of the steam engine was an important trigger of this development. The industrial revolution marks the beginning of a strong increase in the use of fossil fuels, initially coal, and hence emission of carbon dioxide (CO_2). [IPCC]
Industry Safeguard Mechanism	The Emissions Reduction Fund is central to the Government's Direct Action Plan to cut emissions to five per cent below 2000 levels by 2020 and to 26 to 28 per cent below 2005 levels by 2030. It comprises an element to credit emissions reductions, a fund to purchase emissions reductions, and a safeguard mechanism. The crediting and purchasing elements will lower national emissions, while funding businesses to undertake projects that will improve their productivity, for example through more efficient industrial processes, improved household and commercial energy efficiency and improved soil productivity. The safeguard mechanism will protect taxpayers' funds by ensuring that emissions reductions paid for through the crediting and purchasing elements of the Emissions Reduction Fund are not displaced by significant increases in emissions above business-as-usual levels elsewhere in the economy. https//www.environment.gov.au/climate-change
Irradiance	The solar irradiance is the output of light energy from the entire disk of the Sun, measured at the Earth. It is looking at the Sun as we would a star rather than as an image. The solar spectral irradiance is a measure of the brightness of the entire Sun at a wavelength of light. *www.nasa.gov › mission_pages › sdo › science › Solar Irradiance*
Irreversibility	A perturbed state of a dynamical system is defined as irreversible on a given timescale, if the recovery timescale from this state due to natural processes is substantially longer than the time it takes for the system to reach this perturbed state. [IPCC]
Kyoto Protocol	The Kyoto Protocol is an international treaty which extends the 1992 United Nations Framework Convention on Climate Change (UNFCCC) that commits state parties to reduce greenhouse gas emissions, based on the scientific consensus that (part one) global warming is occurring and (part two) it is extremely likely that human-made CO_2 emissions have predominantly caused it. The Kyoto Protocol was adopted in Kyoto, Japan, on 11 December 1997 and entered into force on 16 February 2005. There are currently 192 parties (Canada withdrew from the protocol, effective December 2012) to the Protocol. [Wikipedia]
La Nina	La Nina is a climate pattern that describes the cooling of surface ocean water along the tropical west coast of South America. *www.nationalgeographic.org/*
Life cycle assessment	Compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product or service throughout its life cycle. This definition builds from ISO (2018).
Life cycle cost	The through-life cost, either direct or direct and imputed terms, of development, production, operation, maintenance, logistical support and disposal of a system or product; wind generators and solar farms, both of limited life.
Long-lived climate forcers (LLCF)	Long-lived climate forcers refer to a set of well-mixed greenhouse gases with long atmospheric lifetimes. This set of compounds includes carbon dioxide and nitrous oxide, together with some fluorinated gases. They have a warming effect on climate. These compounds accumulate in the atmosphere at decadal to centennial timescales, and their effect on climate hence persists for decades to centuries after their emission. On timescales of decades to a century already emitted emissions of long-lived climate forcers can only be abated by greenhouse gas removal (GGR). [IPCC]
Methane (CH_4)	One of the six greenhouse gases (GHGs) to be mitigated under the Kyoto Protocol and is the major component of natural gas and associated with all

	hydrocarbon fuels. Significant emissions occur as a result of animal husbandry and agriculture, and their management represents a major mitigation option.
Model (ensemble)	A group of parallel model simulations characterising historical climate conditions, climate predictions, or climate projections. [IPCC]
Mole	One mole is defined as the amount of substance containing as many elementary entities (atoms, molecules, ions, electrons, radicals, etc.) as there are atoms in 12 grams of carbon-12 (6.023 x 1023). The mass of one mole of a substance equals its relative molecular mass expressed in grams.
Monsoon	A monsoon is a seasonal change in the direction of the prevailing, or strongest, winds of a region. Monsoons cause wet and dry seasons throughout much of the tropics. Monsoons are most often associated with the Indian Ocean. [wikipedia.org]
Negative emissions	Removal of greenhouse gases (GHGs) from the atmosphere by deliberate human activities, i.e. in addition to the removal that would occur via natural carbon cycle processes. For CO2, emissions can be achieved with direct capture of CO2 from ambient air, bioenergy with carbon capture and sequestration (BECCS), afforestation, reforestation, biochar, ocean alkalinisation, among others. [IPCC]
Net-zero CO2 emissions	Conditions in which any remaining anthropogenic carbon dioxide (CO2) emissions are balanced globally by anthropogenic CO2 removals. Net-zero CO2 emissions are also referred to as carbon neutrality. [IPCC]
Ocean acidification (OA)	Ocean acidification refers to a reduction in the pH of the ocean over an extended period, typically decades or longer, which is caused primarily by uptake of carbon dioxide (CO2) from the atmosphere, but can also be caused by other chemical additions or subtractions from the ocean. Anthropogenic ocean acidification refers to the component of pH reduction that is caused by human activity. [IPCC]
Ozone layer	The ozone layer is the common term for the high concentration of ozone that is found in the stratosphere between 15 and 30km above the earth's surface. It covers the entire planet and protects life on earth by absorbing harmful ultraviolet-B (UV-B) radiation from the sun. *www.environment.gov.au/*
Paris Agreement	The Paris Agreement under the United Nations Framework Convention on Climate Change (UNFCCC) was adopted on December 2015 in Paris, France, at the 21st session of the Conference of the Parties (COP) to the UNFCCC. [IPCC]
Particulate matter	Particulate matter is the sum of all solid and liquid particles suspended in air many of which are hazardous. This complex mixture includes both organic and inorganic particles, such as dust, pollen, soot, smoke, and liquid droplets. These particles vary greatly in size, composition, and origin. *www.greenfacts.org*
Permafrost	Ground (soil or rock and included ice and organic material) that remains at or below 0°C for at least two consecutive years. [IPCC]
pH	pH is a dimensionless measure of the acidity of a solution given by its concentration of hydrogen ions ([H+]). pH is measured on a logarithmic scale where pH = -log10[H+]. Thus, a pH decrease of 1 unit corresponds to a 10-fold increase in the concentration of H+, or acidity. [IPCC]
Plug-in hybrid electric vehicle (PHEV)	A vehicle whose propulsion is mostly electric with batteries re-charged from an electric source but extra power and distance are provided by a hybrid internal combustion engine.
ppm; ppmv	Parts per million/ Parts per million by Volume (of CO2 in atmosphere),
Precautionary principle	"Look before you leap!"

Pre-industrial	The multi-century period prior to the onset of large-scale industrial activity. The reference period 1850-1900 is used to approximate pre-industrial global mean surface temperature (GMST) in this report.
Projection	A projection is a potential future evolution of a quantity or set of quantities, often computed with the aid of a model. Unlike predictions, projections are conditional on assumptions concerning, for example, future socio-economic and technological developments that may or may not be realized. [IPCC]
Radiation	In physics, radiation is the emission or transmission of energy in the form of waves or particles through space or through a material medium. This includes: electromagnetic radiation, such as radio waves, microwaves, infrared, visible light, ultraviolet, x-rays, and gamma radiation (γ). www.wikipedia.org
Radiative forcing	In accordance with the basic laws of thermodynamics, as Earth absorbs energy from the sun, it must eventually emit an equal amount of energy to space. The difference between incoming and outgoing radiation is known as a planet's radiative forcing (RF). In the same way as applying a pushing force to a physical object will cause it to become unbalanced and move, a climate forcing factor will change the climate system. When forcings result in incoming energy being greater than outgoing energy, the planet will warm (positive RF). Conversely, if outgoing energy is greater than incoming energy, the planet will cool. www.climate.gov/maps-data/primer/climate-forcing
Radiative forcing	Radiative forcing is the change in the net, downward minus upward, radiative flux (expressed in W m2) at the tropopause or top of atmosphere due to a change in a driver of climate change, such as a change in the concentration of carbon dioxide or the output of the Sun. [IPCC]
Renewable energy	Renewable energy is electrical energy produced by sources other than by burning fossil fuels. It is produced mainly from wind, solar and hydro power but may come from other sources such as the tides, wave action, geo-thermal wells and certain types of bio-mass. Not all bio-mass should be considered as a renewable source, e.g., old-growth forests. Nuclear energy may be considered to be renewable, seeing that it does not release CO2 or pollutants into the atmosphere, but all power generated by nuclear sources is ultimately released into the atmosphere as heat. Use of the term 'renewable' may be seen as incorrect from a semantic point of view, given that we do not create new energy but simply convert it from one form to another, without affecting the overall energy content of the Earth System.
Runaway	The runaway greenhouse effect is used in astronomical circles to refer to a greenhouse effect that is so extreme that oceans boil away and render a planet uninhabitable, an irreversible climate state that happened on Venus. [IPCC]
Sea surface temperature (SST)	The sea surface temperature is the subsurface bulk temperature in the top few meters of the ocean, measured by ships, buoys, and drifters. [IPCC]
Short-lived climate forcers (SLCF)	Short-lived climate forcers refer to a set of compounds that are primarily composed of those with short lifetimes in the atmosphere compared to well-mixed greenhouse gases, and are also referred to as near-term climate forcers. This set of compounds includes methane, which is also a well-mixed greenhouse gas, as well as ozone and aerosols, or their precursors, and some halogenated species that are not well-mixed greenhouse gases. These compounds do not accumulate in the atmosphere at decadal to centennial timescales, and so their effect on climate is predominantly in the first decade after their emission, although their changes can still induce long-term climate effects such as sea-level change. Their effect can be cooling or warming. [IPCC]
Sink	A reservoir (natural or human, in soil, ocean, and plants) where a greenhouse gas, an aerosol or a precursor of a greenhouse gas is stored. [IPCC]

Small Island Developing States (SIDS)	Small Island Developing States (SIDS), as recognised by the United Nations OHRLLS (Office of the High Representative for the Least Developed Countries, Landlocked Developing Countries and Small Island Developing States), are a distinct group of developing countries facing specific social, economic and environmental vulnerabilities [IPCC]
Soil carbon sequestration (SCS)	Land management changes which increase the soil organic carbon content, resulting in a net removal of CO2 from the atmosphere. [IPCC]
Solar radiation modification (SRM)	Solar radiation modification refers to the intentional modification of the Earth's shortwave radiative budget with the aim of reducing warming. Artificial injection of stratospheric aerosols, marine cloud brightening and land surface albedo modification are examples of proposed SRM methods. [IPCC]
Southern Annular Mode (SAM)	The Southern Annular Mode, or SAM, also known as the Antarctic Oscillation (AAO), is a mode of variability which can affect rainfall in southern Australia. The SAM refers to the north/south movement of the strong westerly winds that dominate the middle to higher latitudes of the Southern Hemisphere. The belt of strong westerly winds in the Southern Hemisphere is also associated with the storm systems and cold fronts that move from west to east. [Australian BOM]
Stratosphere	The highly stratified region of the atmosphere above the troposphere extending from about 10 km (ranging from 9 km at high latitudes to 16 km in the tropics on average) to about 50 km altitude. [IPCC]
Sudden Stratospheric Warming (SSW),	When the stratosphere high above the South Pole rapidly heated, began at the end of August, and was the strongest SSW event since 2002. This induced a negative phase of the Southern Annular Mode (SAM) from late October to late December, shifting the belt of westerly winds over the Southern Ocean northwards towards the equator. [Australian BOM)
Sustainable development (SD)	Development that meets the needs of the present without compromising the ability of future generations to meet their own needs (WCED, 1987) and balances social, economic and environmental concerns. [IPCC]
Temperature-air	According to the American Meteorological Society's Glossary of Meteorology, temperature is the quantity measured by a thermometer. In gaseous fluid dynamics, temperature represents molecular kinetic energy, which is then consistent with the equation of state and with definitions of pressure as the average force of molecular impacts and density as the total mass of molecules in a volume. Air temperature is measured in a shaded enclosure (most often a Stevenson Screen) at a height of approximately 1.2 m above the ground. Maximum and minimum temperatures for the previous 24 hours are nominally recorded at 9 am local clock time. Minimum temperature is recorded against the day of observation, and the maximum temperature against the previous day.
Tipping point	A level of change in system properties beyond which a system reorganizes, often abruptly, and does not return to the initial state even if the drivers of the change are abated. For the climate system, it refers to a critical threshold when global or regional climate changes from one stable state to another stable state. [IPCC]
Transient climate response to cumulative CO2 emissions	Transient climate response to cumulative CO2 emissions (TCRE) The transient global average surface temperature change per unit cumulative CO2 emissions, usually 1000 GtC. [IPCC]
Troposphere	The lowest part of the atmosphere, from the surface to about 10 km in altitude at mid-latitudes (ranging from 9 km at high latitudes to 16 km in the tropics on average), where clouds and weather phenomena occur. In the troposphere, temperatures generally decrease with height. [IPCC]
Uncertainty	A state of incomplete knowledge that can result from a lack of information or from disagreement about what is known or even knowable. It may have many types of sources, from imprecision in the data to ambiguously defined concepts

	or terminology, incomplete understanding of critical processes, or uncertain projections of human behaviour. [IPCC]
United Nations Framework Convention on Climate Change (UNFCCC)	The UNFCCC was adopted in May 1992 and opened for signature at the 1992 Earth Summit in Rio de Janeiro. It entered into force in March 1994 and as of May 2018 had 197 Parties (196 States and the European Union). The Convention's ultimate objective is the "stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system". The provisions of the Convention are pursued and implemented by two treaties: the Kyoto Protocol and the Paris Agreement.
Vested interest	Political parties, rent-seekers and lobby groups.
Water (clouds)	Water molecules in liquid or frozen state suspended within clouds.
Water (precipitation)	Rain, hail, snow or combinations falling from clouds.
Water (vapour)	Water molecules in a gaseous state in the atmosphere

Acronyms/Abbreviations

Acronym/ Abbreviation	Definition
AAQ	Antarctic Oscillation
ACCESS	Australian Community Climate and Earth System Simulator
AI	Artificial intelligence. Computer systems able to perform tasks normally requiring human intelligence, such as visual perception and speech recognition.
ANU	Australian National University
AOGCM	Atmosphere–ocean general circulation model
BAU	Business-as-usual
BAU	Business-as-usual
BC	Black carbon
BCA	Business Council Australia
BECCS	bioenergy with carbon capture and sequestration
BEV	Battery electric vehicle
CCI	Climate Change Institute (ANU)
CCS	Carbon capture and storage
CCS	Carbon dioxide capture and storage
CDCS	Carbon dioxide capture and storage
CER	Certified Emissions Reductions
CFC	Chlorofluorocarbons
CFC	Chlorofluorocarbons
CH4	Methane
CH4	Methane
CO2	Carbon dioxide

CO2e	Carbon dioxide equivalent
COAG	The Council of Australian Governments
CSIRO	Commonwealth Scientific and Industrial Research Organisation
ECS	Equilibrium Climate Sensitivity
EMR	Electro-magnetic Radiation
ENSOR	El Nino Southern Oscillation
ERF	Emission Reduction Fund
ESM	Earth system model
ESM	Earth system model
ESS	Earth System Sensitivity
ETS	Emission Trading Scheme
EV	A vehicle whose propulsion is powered fully or mostly by electricity.
GHG	greenhouse gases
GHG	greenhouse gas
GISS	Goddard Institute for Space Studies
GMST	Global Mean Surface Temperature
GMST	Global mean surface temperature
GwH	*Giga watt-Hours, millions of watts power generated/consumed for H hours.*
GWP	Global Warming Potential
H2	Hydrogen
HCFC	Hydrochlorofluorocarbons
HCFC & HFC	Hydrofluorocarbons
HELE	High Efficiency Low Emission (HELE) coal-fired power generation. Nuclear power generation
IOD	Indian Ocean Dipole
IPCC	Intergovernmental Panel on Climate Change
IRR	Infra-Red Radiation
Km	Kilometre
KwH	Kilowatt-Hours, ie thousands of watts power generated/consumed for H hours
LCA	Life cycle assessment
LCC	Life Cycle Cost
LLCF	Long-lived climate forcers (LLCF)
LULUC	fossil fuels, deforestation, land use and land-use changes
N2	Nitrogen
N20	Nitrous oxide
NASA	National Aeronautics and Space Administration

NO2	Nitrous Oxide (laughing gas)
O2	Ozone
O2	Oxygen
pH	pH is a dimensionless measure of the acidity of a solution given by its concentration of hydrogen ions ([H+]). pH is measured on a logarithmic scale where pH = -log10[H+]. Thus, a pH decrease of 1 unit corresponds to a 10-fold increase in the concentration of H+, or acidity. [IPCC]
PHEV	Plug-in hybrid electric vehicle
PHEV	Plug-in hybrid electric vehicle
ppm	Parts per million (of CO2 in atmosphere)
ppm; ppmv	Parts per million/ Parts per million by Volume (of CO2 in atmosphere),
REDD	Reducing Emissions from Deforestation and Forest Degradation
SAM	Southern Annular Mode
SCS	Soil carbon sequestration
SLCF	Short-lived climate forcers
SSW	Sudden Stratospheric Warming
TCR	Transient Climate Response
Twi	Increment in average world temperature
UNFCCC	United Nations Framework Convention on Climate Change
UNSW	University of NSW
UVR	Ultra-Violet Radiation