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ABSTRACT:

“Engineering the Global Thermostat!” is presented in two Parts: Part A and Part B. The complete paper involves itself in the emerging debate concerning engineering the global climate to counter global warming. Can we do it? Is it wise? What has happened in the past? Under what circumstances would we do it and what could go wrong? Part A reviewed our knowledge of a changing climate over the ages and commented on the uniqueness of the last 10,000 years. Using the Milankovitch mechanism an attempt was made to forecast the future “predestined”

climate change (next 50,000 years) and then to predict a more complicated state, by superimposing the anthropogenic effects on such global changes using the findings of the Intergovernmental Panel on Climate Change Assessment Report. Part B, this paper, “Creating a Permaclimate” deals with deciding to what temperature to set the ‘Thermostat’, considers the ‘Double Threat’ and what existing and proposed ‘Geo-Engineering’ are economically feasible and ethically possible.

1. INTRODUCTION

This paper is effectively written in two parts. The first part considers the changing climate over the ages and the relevance of a stable climate, particularly over the last 10,000 years, for the development of our current civilisation. The major factors forcing the climate on earth are used to understand future predictions with and without the anthropogenic effects. The second part considers the need for the creation of a ‘Permaclimate’ and ‘Thermostat’ for Earth and discusses how geo-engineering is now necessary to stabilise rising average global temperatures until greenhouse gas emissions are reduced.

2. SETTING THE ‘THERMOSTAT’ - CREATION OF A ‘PERMACLIMATE’

The earlier sections of this paper have illustrated how the temperatures of the Earth are capable of great variation over the past 650 million years. During the last 440,000 years the glacial/interglacial periods have demonstrated temperature variations forced by the Earth's elliptical orbit around the Sun. More recently, in the last 10,000 years, the variations in temperature have been smaller enabling the current civilisation to become fully established and the last 1000 years, as presented in Al Gore’s book, “An Inconvenient Truth” (Gore, 2006) Homo sapiens have “never had it so good”. Refer to figure 1 below.

Figure illustrates the relatively small temperature variation of plus or minus 0.5⁰C to which modern sophisticated agricultural systems are now reliant to continue to produce food for an ever increasing world population in times of climate change.

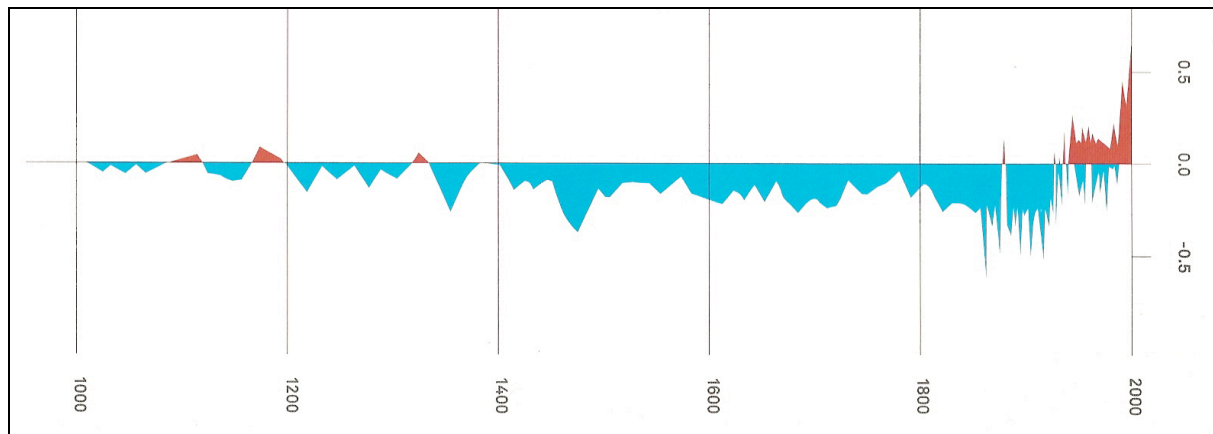


Figure 1 1000 years of Northern Hemisphere Temperatures in a Degrees Centigrade. (Gore, 200?) Note. The last 160 years of temperature records have been measured not inferred.

It is this small variation of plus or minus 0.5°C, that previously we had never questioned and have become accustomed to, that we should adopt as the temperature thresholds for the setting of the thermostat and use the means at our disposal to create a 'Permaclimate' for Earth. The adoption of such a setting alleviates any future squabbles over what is the 'ideal' setting for global thermostat.

3. HOW TO DEAL WITH THE THREAT OF GLOBAL WARMING

Undeniable evidence exists that the Earth has been warming since the industrial revolution. Over the last 30 years there has been a marked increase in the rise of the temperature of the sea and the land together with increasing rates of the melting of the ice masses. Questions still remain as to the extent of warming caused by anthropogenic activities and arguments are presented in this paper, based on climate studies, that we could be entering a new ice age or that the interglacial warm periods could be extended for another 50,000 years. Initially this author was hopeful that a new ice age would correct the present global warming dilemma and that our coal reserves (and other techniques) might have to be used to keep Homo sapiens from freezing, however, on the basis of the evidence presented by Berger and Loutre in Part A, it would seem in all probability that an exceptionally long interglacial period is ahead. If this is the case or not it, would seem prudent that every attempt should be made to maintain greenhouse gases at pre-industrial revolution levels.

Currently there appears to be three ways of addressing projected global warming. (Miller, 2005)

1. Do more research before acting - a wait-and-see strategy
2. Act now to reduce the risks from climate change brought about by global warming - applying the precautionary principle and
3. Act now as part of a no regrets strategy.

There is now another strategy being discussed in the public arena – GEO-ENGINEERING.

4. GEO-ENGINEERING

The accelerated release of carbon dioxide through the burning of fossil fuels, at the rate of one million years of stored carbon in one year, has unbalanced the rhythm of the seasons and temperatures of the last thousand years to the extent that there is now global warming and severe climate change. The predictions for the future global climate are dire, since, with the application of the best science the IPCC targets of stabilisation levels are not achievable within the necessary time frames. Refer Part A.

The above situation creates two overwhelming problems: overheating and the acidification of the oceans.

4.1 Definition of Geo-engineering

An article in the New York Times entitled, "How to Cool a Planet (Maybe)" described *geo-engineering* as the deliberate modification of the Earth's environment on a large-scale to suit human needs and promote habitability. (New York Times, 2006)

Geo-engineering ideas and concepts have been mooted for many years and until recently had been considered in the realm of science fiction. It was Noble Prize winning scientist, Paul Crutzen, who wrote in Nature, "Our future may well involve internationally accepted, large scale geo-engineering projects ... to optimise climate, " (Crutzen, 2002) that legitimised the application of geo-engineering for the current climate dilemma. Currently there is a raft of proposals being considered including agricultural char/bio-char, mirrors in space, Lovelock's deep ocean pipes, adding iron to oceans, covering oceans, optimising contrails and using sulphur aerosols as global dimmers. It is the tried agricultural char and sulphur aerosols used as global dimmers that are further considered in this paper.

4.2 Addressing the Double Threat

4.2.1 Overheating Threat

The rapidly rising temperatures as identified in the IPCC Assessment Report (plus 0.7⁰C) indicate that the level of incoming solar radiation must be reduced to within the thermostat setting of plus or minus 0.5°C. It would appear that this rapid temperature rise exceeds the ability of world nations to reduce the greenhouse gas emissions rapidly enough to thwart this temperature increasing further and so avoid a liturgy of climatic and ecological disasters. Refer to Part A. **Urgent action must therefore be taken.**

4.2.2 Acidification of the Oceans Threat

The unprecedented rise in carbon dioxide levels over at least the last 150 years threatens to decrease the pH level of the oceans and so increase its acidity. As a consequence the reproduction of Krill, which is a critical building block of oceans' food web, will be severely inhibited. **Urgent action must continue to de-carbonise, as much as possible, the world's energy production systems.**

4.3 Replacing Fossil Fuels by Knocking in the Wedges - a positive response

Professors Robert Socolow and Stephen Pacala of Princeton University in New Jersey, USA presented a proposal of using a number of existing and new technologies in combination to achieve the world goal of emitting no more CO₂ in 2055 than today. (Socolow and Pacala, 2004) They defined a wedge as being capable of an annual reduction in CO₂ emissions of 1giga tonnes of carbon by the year 2055. To meet the world goal seven wedges would be required. Socolow and Pacala claimed, "Humanity can solve the carbon climate problem in the first half of this century simply by scaling up what we already know how to do".

The seven wedges are as follows. Increase the fuel economy of all vehicles from 30 to 60 miles per gallon. Halve the distance travelled in each vehicle during a year. Improve the efficiency of both buildings and electricity generation. Increasing the number of gas fuelled electricity generating stations by a factor of four to replace coal generating stations. Build 700 gigawatt gas-

powered electricity generating stations and install geo-carbon-sequestration to 800 coal generating plants worldwide.

Mark Lynas in his book, *SIX DEGREES*, makes the comment that, "Socolow and Pacala's approach is especially useful because it illustrates the importance of scale. This is particularly daunting for the renewable -- for wind power to achieve one wedge, 2 million 1-megawatt turbines would be needed, a fifty-fold increase from today's deployment. The turbines would cover over 30 million hectares, equivalent to 3% of the total land area of the United States. A wedge of solar photovoltaic electricity generation would need a 700 fold increase from today's total, covering 2,000,000 hectares of land -- or around three square metres per person." (Lynas,2007) the scale of the infrastructure replacement and renewal is gigantic but achievable, given that China is currently building one coal electricity generating station per week. (Russell, 2008)

4.4 The Moral Question of Geo-engineering - "Beating the Greed"

The answer to the moral question of geo-engineering is, 'One is dammed if you do and dammed if you don't.'

Tim Flannery in his book, "The Weather Makers", offers three possible outcomes in response to, "... the great game of climate modification that humanity is engaged in." (Flannery, 2005)

The first possible outcome would lead to global conflict since, "Our response to limiting emissions is too slow or uncoordinated to avert great climate shifts, which destroyed Earth's life-support systems and stabilise our global civilisation... and to make peace, will have been swept away. These changes could commence as soon as 2050 ". This outcome is morally reprehensible. The second possible outcome is that, "Humanity acts promptly... and so avoids serious climatic consequences." This is a highly desirable but increasingly remote possibility since achieving global agreement is fraught with delays. E.g. after seven years of negotiations on World Trade the current DOHA round of negotiations appear to have irretrievably failed. And the third possible outcome, "Emissions are reduced sufficiently to avoid outright disaster, but serious damage to Earth's ecosystems results... during which period the carbon cycle will need to be strictly controlled, by large and small geo-engineering projects alike."

In this final scenario Flannery proposes the establishment of an "Earth Commission for Thermostat Control, something that could easily grow from the Kyoto Protocol. " Which would inevitably need to address the root cause of the current issue, "the total number of people on the planet." This Flannery claims could transform the Earth Commission for Thermostat Control into... an Orwellian-style world government... As horrific as such an outcome is, if we delay action to combat the climate crisis, the carbon dictatorship may become essential for our survival."

4.5 The Economic Question

The cost of the stabilisation of greenhouse gases to levels that will restrict the average global temperature rise to about 2°C is achievable. The sooner the activity starts to stabilise the level of greenhouse gases to this level the lower will be the cost. Sir Nicholas Stern put the cost at about 1% of global product per year which is approximately \$US350Billion in 2005 dollars. (Stern,2006) The following example puts the annual cost in perspective. The average annual cost of replacing the world's coal generating power stations over 10 years with 1,334,000 wind turbines (capacity = 1.5 MW per turbine) is \$US223 billion/year and the total annual world non-renewable energy subsidies are of the same order.(Danish Wind Association,2007) The real challenge is not the economics but being able to decide in an equitable way in distributing the macro economic costs in

a timeframe that can achieve reasonable stabilisation targets. I.e. There being overall global targets with each nation meeting their particular target for their current level of development.

Australia, with one of the highest per capita emissions of carbon dioxide, could transform its situation by devoting three annual surpluses of about \$20 billion to the replacement of all existing coal-fired electricity generating plants with decarbonised power generating systems. The limitations in achieving this target (apart from the lack of will) are the availability of resources and suitably trained engineers. Also, a suitable 'future fund' would need to be created to part compensate for the existing coal-fired power stations.

4.6 Interim Measures - for immediate application – known technology

There are two existing potential geo-engineering technologies that could satisfy the two threats of overheating and acidification of the oceans. Both technologies could have an immediate effect on reducing the incoming solar radiation to Earth. The first technology is the sequestration of atmospheric carbon dioxide to soil humus and/or agricultural char as was done in ancient South American civilisations. This technology is fully proven and could be applied extensively over the Earth especially in the tropical regions. They have the capability of capturing more atmospheric carbon dioxide than any other processes. The second technology is associated with the injections of sulphur aerosols into the atmosphere.

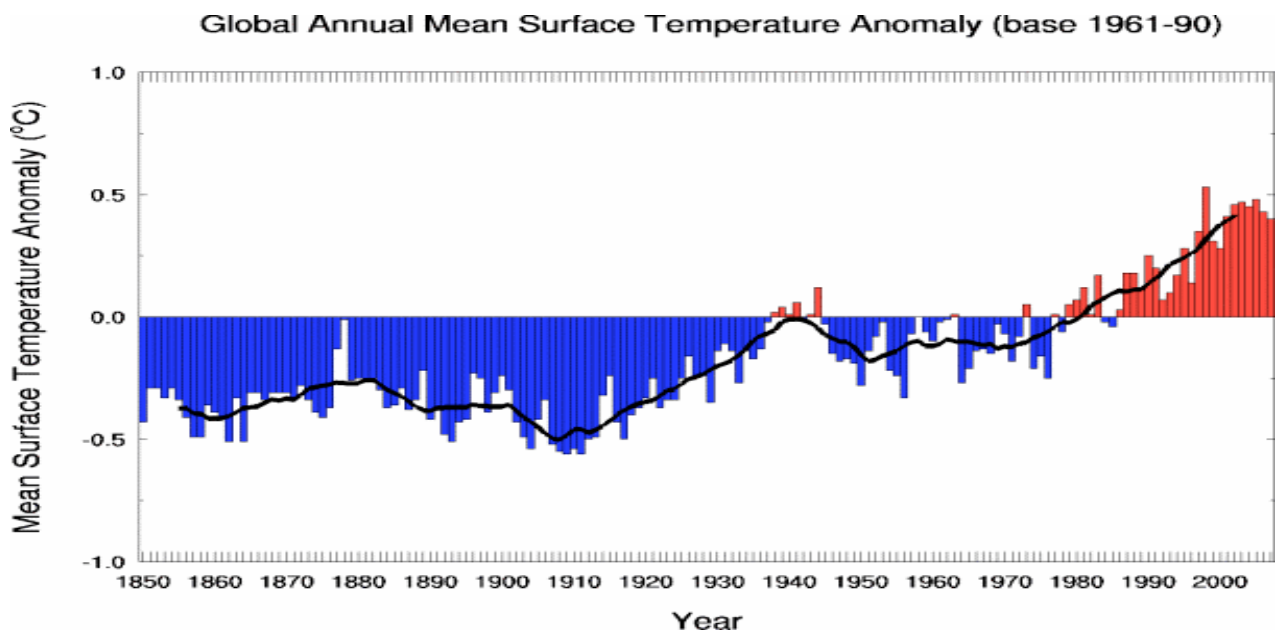


Figure 2 Depicts the increase global annual mean surface temperature since the onset of the industrial revolution. Note: After the Second World War the temperature dropped for approximately 40 years. This drop is attributed to global dimming attributed to the release of sulphur into the atmosphere from 'dirty coal' burning. (The acid rain phenomena.)

In his book, "The Weather Makers", Tim Flannery attributes the discharge of sulphur dioxide from dirty coal burning that caused the acid rain in the Northern Hemisphere and the discharge of large quantities sulphur dioxide from the eruption of Mount Pinatubo in the Philippines in 1991 to measured lowering of the average global temperature. (Flannery, 2006). Figure 2 depicts the drop in average global temperature for approximately 40 years from 1940. Burning 'dirty coal' could be trialled for a limited duration in the Southern Hemisphere where the land masses are minimal and the Southern Oceans extensive. Australia, New Zealand, South Africa and South America would be ideal sites to conduct such trials in the lower atmospheres, where existing coal burning electricity generating power stations could be used to burn sulphurous coal under controlled

conditions. However, since the relatively number of coal burning electricity generating power stations in the Northern Hemisphere is much higher a trial of switching off the chimney stack scrubbers could be contemplated in the Northern Hemisphere where the outcome is known and valuable time could be accrued.

5. Reducing INSOLATION for ‘immediate’ temperature reduction - sulphur injection to atmosphere INSOLATION (INcoming SOLar radiATION = INSOLATION). Refer Part A.

It was Noble Prize winning scientist, Paul Crutzen, who wrote in Nature, "Our future may well involve internationally accepted, large scale geo-engineering projects ... to optimise climate, " (Crutzen, 2002) that legitimised the application of geo-engineering for the current climate dilemma. It would seem that Crutzen wrote his paper out of his frustration with the inability of the international community to settle on significant greenhouse emission reductions that would stem global warming.

Since that time there had been numerous meetings of climate scientists and engineers around the world to consider the geo-engineering proposal of injecting sulphur aerosols into the stratosphere. The literature shows that the renowned scientists are concerned about the prospect of geo-engineering, meddling with the climate, and only now consider the prospect because there needs to be plan B in the event of runaway temperature increases and no adequate international agreement in place on greenhouse gas emissions.

The current urgency of the situation would seem to override the concerns that are raised for such a proposal. Now, reluctantly, many climate scientists and engineers are prepared to seriously contemplate sulphur injections trials into both the lower and upper atmospheres as a stop-gap method in reducing average global temperature increases until greenhouse gas emissions are abated to stabilized levels as per the IPCC stabilization levels. Two such methods could be the switching off sulphur scrubbers on coal-fired power stations in the Northern Hemisphere and firing sulphur aerosols into the upper atmosphere in the Southern hemisphere using existing US marine artillery guns.

Given the urgency being faced and the inability of the international community to conclude the Kyoto Protocol, the author proposes that the Scandinavian nations be entrusted with overseeing the conduct of the trials as it is these nations that have demonstrated the highest level of social awareness and responsibility in the past. It is proposed the upper atmosphere trials be conducted in the Southern Hemisphere where the oceans are large and the land mass is relatively small compared to the Northern Hemisphere and the ‘acid rain’ dimming trials be conducted in the Northern hemisphere.

6. THE BIGGEST CHALLENGE - THE DESTINY OF MAN

The biggest challenge is whether we regard life on Earth as ‘a business opportunity’ or as ‘a spiritual experience with obligations’.

7. SUMMARY

1. The climate of the earth has changed over the ages and will continue to change.
2. The last 1000 years has seen the most stable temperature conditions and has given rise to a current civilisation.
3. Anthropogenic effects are destabilizing these constant temperature conditions and the current civilization.

4. For our current civilisation to survive a 'Permaclimate' not different from the current climate is essential. Adjustment of the 'Thermostat' to plus or minus 0.5⁰C of the current average global temperature would remove conjecture between nations.
5. The IPCC worst-case stabilisation level scenarios projections have been exceeded.
6. Urgent intervention in the form of geo-engineering is critical as it is the last resort to contain average global temperatures at or below 2.0⁰c until greenhouse emissions abatement is at appropriate stabilization levels.
7. Humankind is capable of intentional geo-engineering since unintentional geo-engineering has been practised over many years.
8. Scandinavian countries to be entrusted with the initial trials of geo-engineering the climate.
9. Initial geo-engineering trials to be commenced in the Northern Hemisphere with sulphur dioxide trials in the lower atmosphere (switching off chimney stack scrubbers) and sulphur aerosols-injection trials in the upper atmosphere (Stratosphere) to commence in the Southern Hemisphere.

8. CONCLUSIONS

It is concluded that;

1. Unless there is a demonstrated WILL by the nations of the world to drastically reduce carbon dioxide emissions within a very short time-frame the world community will have to consider desperate measures if billions of people are not to perish and the species is to survive.
2. Decarbonisation of our civilisation continue at an accelerated pace using wind, solar, wave and soil/vegetation carbon sequestration.
3. Resource conservation and population limitations become major foci.
4. Emergency measures are trialled to reduce the incoming solar radiation (INSOLATION), particularly over the next 20 to 30 years.
5. Geo-engineering trials are commenced in the Southern and Northern Hemispheres under the auspices of the Scandinavian nations to create a Global "Permaclimate".

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