The climate argument:

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The Climate Argument: should we panic and are we doomed, or what can we do?

(An essay to coincide with the start of United Nations COP21 in Paris, December 2015)

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The evidence that anthropogenic carbon emissions are contributing to the increasing temperature of the Earth grows stronger by the year. Whilst impossible to *prove*, it is suggested that the correlation between CO_2 concentrations and the temperature of the planet is as strong as it ever can be. Therefore, actions both by individuals and governments around the world are needed now to protect everyone against the rising temperatures that are almost inevitable. CH_4 could prove to be as serious a secondary greenhouse gas as CO_2. Possible changes in legislation and adaptions to lifestyle are suggested for the UK. At a global level and in the hope that such subjects are brought into the open, charging for excess use of carbon, food and its production, and levels of population in the world are discussed.

1. ***Introduction, the CO_2 vs. Temperature argument*** A common misconception of science is that it confirms certainty on any issue. This is rarely the case, and therein lies the problem with increasing CO_2 concentrations in our atmosphere and global warming. It cannot be *proved* that the increasing CO_2 concentrations over the last two centuries, which is surely uncontroversial, correlates with what most people believe is an increase in the average land temperature of Planet Earth, +0.8 ^{o}C over the last 130 years (Climate Change Evidence and Causes 2014). Figure 1 shows the data plotted together as a function of time (Stoft 2007), many such figures are available on the web, but there is simply not the *resolution* to prove or disprove a positive correlation between the two sets of data. Indeed, being devil's advocate, if the axes labels were removed and the graphs only were displayed, most scientists would surely say that the two datasets displayed on the *y*-axis might be correlated as whatever the *x*-axis represents changes, but they could not prove it. Therefore, to say that there is a definite correlation between CO_2 concentrations and T_{earth} is displaying unconscious bias.

Despite this provocative opening paragraph, the author is not a climate sceptic. He is a physical chemist researching the vacuum-UV photophysics of gas-phase molecules, and many of the molecules studied recently happen to be long-lived greenhouse gases. He therefore has no vested interest in making the case for or against climate change. Ball wrote two years ago, possibly with tongue in cheek, that the chemistry community has its higher percentage of sceptics than the average (Ball 2013). Whilst disagreeing with this contention, it is understandable why sceptics with a scientific background question the correlation between CO_2 concentration and land temperature; rigorous evidence simply is not there. The purpose of this essay is to present the scientific case that climate change, whilst not proven, is almost certainly occurring.

By the end of this century, the consequences will be serious if we, individually and collectively, do not start to take positive actions now.

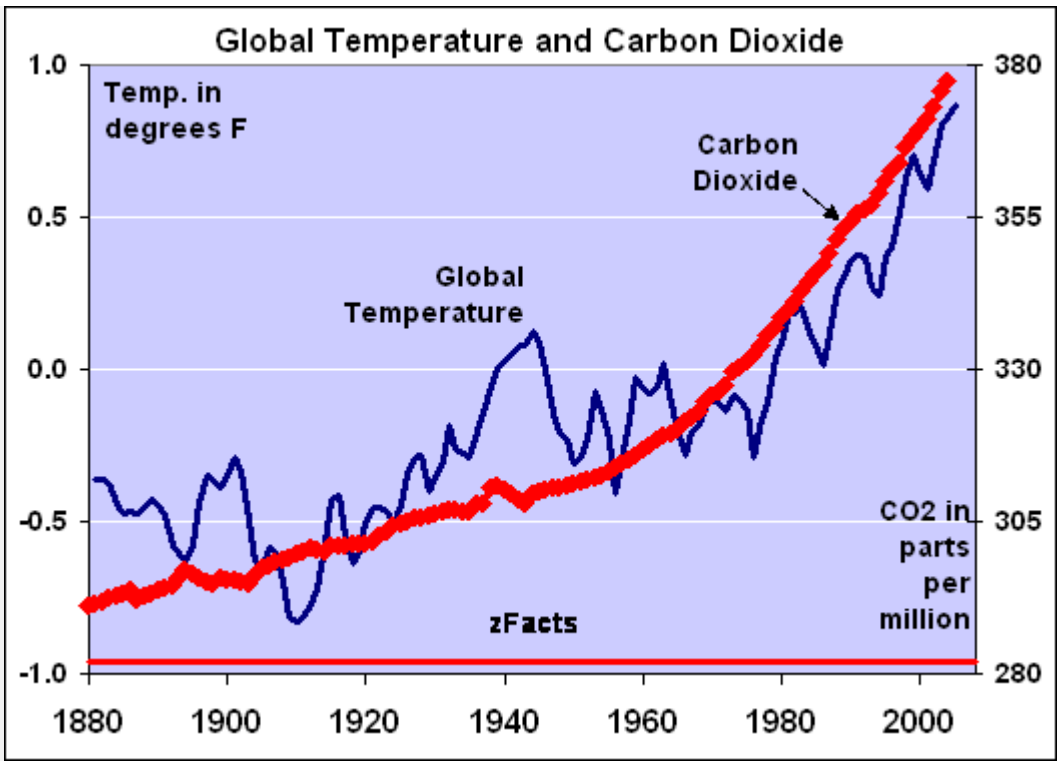

Figure 1. The average temperature of the earth and the concentration level of CO_2 in the earth's atmosphere during the 'recent' history of the last 130 years. See Stoft http://zfacts.com/p/226.html or Hocker http://wattsupwiththat.com/2010/06/09/. A rise of 1 F is equivalent to 0.56 ^{o}C. The latter article even suggests that it is the temperature rise that is causing the increase in CO_2 concentration, not the other way round.

It is suggested that, on this issue, the general public is confused. Some misunderstandings are caused by scientists making increasingly vehement claims on both sides of this argument, some by unwise comments by political leaders who should know better, and some by genuine myths that have grown into the public conscience over decades. Three myths are highlighted. The first is that the greenhouse effect is all 'bad news'. Nothing could be further from the truth. Indeed, without the greenhouse effect, the average temperature of Planet Earth would be that of a Siberian winter, ~255 K or −18 ^{o}C. The reason why the planet is a habitable ~290 K or +17 ^{o}C is due to the *primary* greenhouse effect which has been in existence for thousands of years; the main primary greenhouse gases being water (H_2O) and carbon dioxide (CO_2). The second myth is that the greenhouse effect and ozone depletion, if not quite the same phenomenon, have similar scientific causes and explanations. Again, this is false, but the consequences of this perpetuating myth are not serious. The third myth, perhaps the most serious, is that *weather* and *climate* are the same phenomenon. They are not. The former is a short-term prediction on which daily actions are based, the latter is a long-term prediction of what might happen decades of years in the future.

Two editions of Climate Change (ed. Letcher), an interdisciplinary book of chapters about climate change written by scientists from a range of different backgrounds, have been published (Tuckett 2009, 2015). In the first edition, a chapter written by this author concentrated on the properties of a greenhouse gas that made it effective in the atmosphere: predominantly, its infrared absorption strength, the change in its concentration over the last ~265 years, and its lifetime. It also described how the greenhouse effect should be regarded as comprising two components; the *primary* effect due to the presence of H_2O, CO_2, CH_4 and O_3 *etc.* at steady-state concentrations in the atmosphere for thousands of years, and the *secondary* effect due to increases in concentration of long-lived greenhouse gases since the Industrial Revolution in the mid 18th century. Whilst the primary effect, mainly due to the presence of a constant atmospheric concentration of water vapour absorbing infrared radiation, has maintained T_{earth} at a habitable 290 K, it is the secondary effect that is causing enhanced warming and is the immediate problem. It was stressed that CO_2 was not the only secondary greenhouse gas of concern, but methane (CH_4) potentially could be just as serious. (Indeed, Shine *et al.* continually make the point that long-lived gases other than CO_2 contribute ~40% to the secondary greenhouse effect, so one should not focus exclusively on CO_2 as the only problem (Shine 2007).) Along with others [1], the contention of this author in the second edition is that, whilst absolute proof is not possible, the evidence that person-made carbon emissions *are* the dominant contributors to the increasing T_{earth} grows stronger by the year, and this threat must now be taken seriously.

The World Meteorological Organization Grenhouse Gas Bulletins and the UN Intergovernmental Panel on Climate Change (IPCC) Assessment Reports track the relentless increase in concentration of all long-lived greenhouse gases, and these data surely cannot be challenged. One measure of the seriousness of a secondary greenhouse gas is its *radiative forcing*. It is defined as the microscopic radiative forcing of one molecule of greenhouse gas, effectively a measure of how strongly the molecule absorbs infrared radiation over the range 400–1200 cm^{-1} where the Earth emits its black-body radiation, multiplied by the change in concentration of that greenhouse gas over the ~265 years since the Industrial Revolution. The total radiative forcing of the atmosphere due to such gases (CO_2, CH_4, O_3, SF_6, perfluorocarbons, hydrofluorocarbons, chlorofluorocarbons *etc.*) is positive and growing steadily; 2.43 ± 0.24 W m^{-2} from the 3rd IPCC report of 1998, 2.63 ± 0.25 W m^{-2} from the 4th of 2007, and now 2.83 ± 0.29 W m^{-2} from the 5th of 2013 (Intergovernmental Panel Climate Change 2013), with the predominant contributors being CO_2 (*ca.* 60%) and CH_4 (*ca.* 18%). Furthermore, the increasing concentration of CO_2 shows no sign of slowing down, with the current level at ~400 parts per million by volume (ppmv). Before the Industrial Revolution, the constant level for the previous one thousand years was ~280 ppmv. The view of most climate scientists back in 2005 was that if this value exceeded 550 ppmv the temperature of the earth's atmosphere would likely rise by over 2 ^{o}C since the pre-Industrial era, ~1.2 ^{o}C over present levels (International Symposium Greenhouse Gases 2005). (The 550 ppmv figure is tending to decrease as the modelling improves, with much depending on how the word *likely* is interpreted.) With the atmosphere retaining ~7 % more water vapour for every 1 K rise in temperature (Intergovernmental Panel Climate Change 2013), the primary greenhouse effect will increase, and the

point of no return may be reached because it will be almost impossible to stabilise T_{earth}; this could be the start of what many scientists call the *runaway* greenhouse effect. A recent article has even suggested that the 2 ^{o}C target is non-scientific, and probably was set at this low level for expedient political purposes (Victor *et al* 2015). The Royal Society – National Academy of Sciences report of 2014 suggest that, without drastic action and a 'business as usual' model of carbon emissions, the more likely rise is 3.4 to 5.6 ^{o}C above pre-Industrial levels (or 2.6 to 4.8 ^{o}C above current levels) (Climate Change Evidence and Causes 2014).

The land temperature is not the only criterion for measuring the effect of global warming. The rising of sea levels, and their increasing temperature and decreasing pH are thought by many to be just as, if not more significant (Cheng *et al* 2015), and the analogy of the health of a human being dependent on *many* factors such as blood pressure, weight, and heart rate is now used (Victor *et al* 2015). Gore is perhaps the only world political leader to have been making the same points with some vehemence (Gore 2006), especially now that he has left office. If the above accumulated evidence and predictions are shown to be wrong, then this author suggests that history will judge Climate (Non-) Change to be the biggest scientific hoax of all time.

2. ***Time for action, general points*** This author, amongst many others (Climate Change Evidence and Causes 2014), believes that the evidence is now as strong as it ever can be, and it is time for action. Initially, four general points are made. First, guilt will get us nowhere; it will spiral everyone down into a sea of depression. Second, this is a problem that potentially will affect every individual on this planet. Global solutions are needed, the normal rules of economics cannot apply, so attempts to trade in carbon, *i.e.* 'transfer', through payment, emissions to other countries cannot possibly succeed; it is a short-term solution of dubious morality to a long-term global problem, and will fail. Carbon trading amounts effectively to rich countries buying permission to carry on polluting the atmosphere. Third, scientists and politicians *can* work together; the problems of stratospheric ozone depletion, the Antarctic Spring 'holes' *etc.*, will be solved in the next 40–100 years if the latest predictions are correct (Chipperfield *et al* 2015). In retrospect, the Montreal Protocol of 1987, whereby following scientific advice most of the countries in the first world agreed policies to phase out production of ozone-depleting chlorofluorocarbons, should be regarded as a great success story of modern science. Fourth, out of adversity can come positive solutions; the New Deal in the US after the Depression of the 1920s, and the Marshall plan to rebuild mainland Europe and the formation of the Welfare State in the UK after World War II are examples. It is suggested that Climate Change is the next huge global challenge to be addressed.

If the atmosphere is to be de-carbonised, in simple terms this becomes an issue of *supply* and *demand*. Much of the debate to date, certainly at Governmental level, appears to have been on the supply side; what is the best low-carbon way to provide the energy needed for a growing population? In this essay the advantages and disadvantages of nuclear energy, green energy (and whether sun, wind and tide is 'best') or shale-gas fracking are not discussed. Much less comment has been made on the demand side, and how

lifestyles could adapt to mitigate the worst excesses of climate change. This is understandable because personal choices will then become involved that may be painful.

The author lives in the UK with a population of ~64 million in a world of population ~7300 million. It contributes ~2% of the carbon loading in the atmosphere, and the pessimist believes that anything done here is pointless if the US and China, especially, continue to pollute the atmosphere at current levels. This is true, but should *not* be taken as a reason for small countries to do nothing. Furthermore, despite the diminishing role of the UK in the world, this author does sense that where this country leads others still will follow. What is surely needed is a combination of local country-specific policies, coupled with binding international agreements between blocs of countries (*e.g.* Asia, Africa, the EU and USA/Canada); in the latter category, the upcoming United Nations conference in Paris in December will be crucial. It is also suggested that the current language used by all Governments of expressing reductions needed in carbon emission as xx % by the year yyyy, with the year zzzz being the baseline, is not particularly helpful as such figures do not resonate with the public; eyes simply glaze over.

The author repeats his disclaimer that he is not a member of the atmospheric science community, and is certainly no *policy* expert. Times, however, are believed to be changing, albeit slowly, and there are many examples of excellent practice now emerging in the UK. For example, conservation of energy through double glazing and roof insulation of the housing stock, generation of solar electricity through roof-mounted photovoltaic panels, and the trend to drive more fuel-efficient cars (and perhaps electric cars will be the norm within 50 years) are just three examples. But these examples only scratch the surface, and inevitably it is educated people who are taking these actions. Although it goes against the instincts of politicians of all colours to *'tell people how to live their lives'*, it is feared that is exactly what they must do, and some national policies must be imposed.

3. ***Issues easy to implement and solve*** The challenge for everyone must be to reduce dependence on fossil fuels, yet not reduce standard of living and negate benefits that technology has brought in the last 250 years. Some solutions are obvious. In 2009, MacKay estimated that, on average every person in the UK used 125 kWh of energy per day (Mackay 2009). The Climate Act 2008 mandates that this level must fall to ~25 by the year 2050 (Climate Change Act 2008). Furthermore, modellers predict that to avoid the worst effects of climate change, *i.e.* to limit the increase in global temperatures to less than 2 ^{o}C above that in pre-Industrial times, the *global* average must drop from its current level of ~6 kWh to below 1.5 kWh by the year 2100. Everyone should reflect on these numbers and the enormity of the task ahead. Any policy advocated cannot possibly apply to every person, and in general the young, old and infirm will be exempted. That said, MacKay estimates that wearing more clothes and reducing thermostats by a few degrees might reduce the UK current figure of ~125 by about 20; stopping flying might cause a reduction of 35; modifying short-distance transport within the UK by driving less and biking or walking more might reduce by about

20; avoiding packaging and the buying of clutter, however defined, might cause a reduction of 20; and becoming vegetarian might reduce energy usage by 10 such units. These are all big changes, even though the data come with huge errors. These are *individual* decisions that could be made, but national changes in law could also evolve.

It is suggested that the minimum working temperature for employees could be reduced from its current level of 16 ^{o}C by a few degrees; MacKay effectively is asking whether we must live only in shirt sleeves for our waking hours. In addition, much European health and safety legislation has become sacrosanct and overkill, leading, for example, to un-necessary packaging on much food and 'excess clutter' (Mackay 2009). The UK legislation of 1991 that allowed for Sunday trading for six hours per day could be reversed; Sunday closing remains the law in Switzerland, and it is probably the richest European country. Demand for domestic air travel within a small country such as the UK could be priced out of the market, with a corresponding increase and investment in rail travel. (Hopefully this will happen when the High Speed 2 (and HS3, HS4 …) train routes from London to the north of England / Scotland are completed.) One should ask whether much long-distance air travel for business meetings is really necessary, and whether technology can assist; the Skype principle for 1:1 conversations can surely be extended so that 100+ people can meet remotely, and software is becoming available. Could academia set an example, with remote conferences, especially talks by plenary lecturers, becoming more common?

About fifteen years ago, the UK Government announced that all its major Departments would ensure that future legislation was checked for its impact on the environment. Alas, there is little evidence that anything has changed. Hindsight is so easy, but surely this policy should also have been back-dated to new legislation from the last 30–50 years. For example, nobody clearly thought of the environmental consequences when the provision of compulsory state education was de-regulated by the 1988 Education Act. This decision effectively led to the abolishment of catchment areas in cities for schools to which pupils walked, and the '*school run*', by *car*, became part of the vocabulary.

4. ***Issues moderately difficult to implement*** : The unit of carbon emission that everyone would understand is the cost to their pocket. All developed countries could move to a system of taxation whereby the principle of *'polluter pays'* becomes dominant. A universal carbon credit card would then result where money is charged for excess use of domestic energy, road usage, and certainly air travel. This idea was muted for road travel by the UK Government ten years ago, but was quickly dropped when public reaction was negative, to say the least. The Prime Minister infamously also said around that time that climate change would not be solved by everyone stopping flying. He was surely correct in saying it was inconceivable for all air travel to cease, but it might have helped if he had also said that individuals should review the necessity of all their air travel.

A different issue concerns food production, *what* we eat, and *where* the food comes from. The more anyone looks at the food supply chain, the more baffled s/he becomes. For example, *why* does food often travel such huge distances between source and consumption? Is it necessary? For the last sixty five years since the end of rationing in the UK, the principle that the customer has a paramount right to food at the cheapest price has swept aside environmental consequences. We now understand that this policy comes with a price; excess use of fossil fuels for un-necessary travel. We could then address *what* we eat. Cattle use much limited land for grazing, and there is an argument that we should reduce meat consumption, if not become vegetarians of whatever strictness; a policy effectively advocated by MacKay [11], thereby also reducing methane emissions. (Remember the earlier comment in $1 that CH_4 may be every bit as serious a secondary greenhouse gas as CO_2.) Others will disagree, but this author suggests that the perceived risks of genetically-modified crops have not materialised and this technology, under strictly controlled conditions, should be allowed to expand. The population then may reduce its dependency on cattle as a source of food. Simultaneous with these issues, food wastage could be addressed where the statistics are frightening; about 18% of domestic waste in the UK, over 5 million metric tonnes, is due to food which could have been eaten or re-used (Food Waste UK 2015), and this is independent of wastage from '*out-of-date*' items in supermarkets. The figures from other first-world countries are probably comparable.

CO_2 and CH_4 together contribute ~78% of the total radiative forcing of long-lived secondary greenhouse gases (Intergovernmental Panel Climate Change 2013), but it is naive to say that reduction of CO_2 levels alone will be the complete solution. In simple terms, atmospheric CO_2 levels correlate loosely with lifestyle of the population, and with serious effort, especially in the developed world, huge reductions are possible; examples are given above in $3 and $4. In my opinion, however, CH_4 poses just as serious a threat as CO_2 simply because its level, whilst smaller than that of CO_2, will be much harder to reduce; a major component of methane emissions correlates *strongly* with the number of animal livestock which itself is dependent on the world population.

5. ***Incredibly difficult issues to solve*** The population of the planet dominates this category. The figures are stark (World Population Statistics 2015). Fifty years ago the population was 3.3 billion (3.3×10^9), today it is 7.3 billion and may rise to ~11 billion by the year 2100, with the large majority of growth expected in Africa and Asia. Whilst 75% of the world's population currently live in these two continents, that figure is predicted to grow to 82% by the end of the century. Conversely, the population of Europe, currently ~0.5 billion, is predicted to decrease both in absolute terms and as a percentage of world population. This is an emotive and complex issue, with a range of views whether world population is or is not an issue in the climate argument. The *per capita* usage of energy is vastly smaller in many third world countries, especially Africa, compared to the first world, and therefore it may seem hypocritical for the latter to criticise population levels in the former; they are focussing on the wrong problem (Monbiot 2009). Up to a point this is

true, and a carbon tax ($4) over time should reduce carbon usage in the first world. But the fact remains that, once born, every person will need housing and feeding for their lifetime, as repeatedly pointed out by many pressure groups (Population Matters 2015). A global scarcity of water will also become increasingly serious if population levels grow too much. For these reasons, this author comes down on the latter side of the argument.

If this contentious point can be accepted, population control on a world-wide scale has to be openly discussed and the subject cannot be avoided if carbon emissions are to be controlled. This is one policy area that even the most outspoken politician is reticent to go. The current message from the West is mixed. First-world countries have always believed in the absolute right of individuals to make their choice of family size independent of the State, but their Governments could easily exert influence by limiting financial access to the State for families above a certain size. That said, family sizes in the West decreased significantly once contraception became freely available in the 1960s, and ironically no Government wants population levels to drop too much because of loss of revenue from taxation. To take four current examples, Japan is worried about how few children are being born, thirty years after introducing its one-child-per-family policy China is becoming increasingly concerned who will look after their elderly, whilst Australia and Denmark (to name but two) are almost bribing couples to have more children. Conversely, the leaders of the Catholic Church, comprising ~15% of the world's population and much of it in poorer countries, will not discuss the matter in public, believing in the absolute sanctity of life and refusal to accept any form of contraception. The situation is a mess, but any discussions must surely start with Africa and Asia because projected increases here are the greatest.

Controlling the increase of, let alone reducing, world population levels is a huge policy area that calls for inter-Government agreements at all levels. It calls for patience and understanding of others' lifestyles in different Continents, a '*one size fits all*' policy will not work, and compromises from currently-held positions will be needed. For all its faults and decreasing respect with which it is viewed, the United Nations is surely the only global organisation that could lead on this issue; it could become their major policy directive for the next few decades. World leadership is surely needed to bring about this step change in public perception and subsequent action.

And so, we return to the title of this essay which was deliberately provocative. To quote three of the most famous lines from the UK comedy show Dad's Army (available worldwide on YouTube to those outside the UK not familiar with it), '*don't panic*', guilt will get nowhere, but yes, '*we're doomed*' if we do not wake up, '*stupid boy*', start to think, and act fast.

Acknowledgements : *I thank Dr Harriet Martin of the Quaker Living Witness, http://www.livingwitness.org.uk, for enlightening discussions, and Dr Simon Cotton (University of Birmingham) and Professor John Dyke (University of Southampton) for a preliminary reading of this manuscript and useful suggestions.*

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