Global Climate Change—The Conflicting Arguments

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The Global Climate Change Committee was formed in 2000 with the following Mission Statement: "To disseminate information which will facilitate balanced dialog on the topic of 'Global Climate Change' in a scientific framework." This article was solicited by Jeff Lund, Global Climate Change Committee Chair and is the latest attempt to fulfill that mission by providing HGS members and other readers of the HGS Bulletin *a current, objective status report on the evidence from an authoritative source. Hopefully, HGS members will be able to use this information to engage and stimulate discussions with the general public.*

Global Climate Change has been a subject of emotive debate over the past two decades. Although there is little disagreement that temperatures in the Northern Hemisphere have been rising rapidly since the 1970s, there are exceptionally polarised opinions over the precise causes of this phenomenon. In this paper we discuss the basic processes involved in the green house effect and critically assess the principal conflicting arguments over what the potential causes of the observed temperature rises may be. In addition potential long term effects of climate change will be considered.

> ***Global climate change is with little doubt the highest profile environmental challenge facing the planet this century.***

1. Introduction and Background.

Global climate change is with little doubt the highest profile environmental challenge facing the planet this century. Although few people are informed of problems that water availability will present the globe in the 21st Century, nearly everyone is aware of global warming. The perceived seriousness of the potential global warming problem at an international level resulted in the establishment of the Intergovernmental Panel on Climate Change (IPCC) in 1988. This body was set up to assess anthropogenic causes of climate change and any potential impacts that would result. IPCC has engaged scientists from a range of appropriate disciplines from the international community. To date, IPCC has prepared three assessment reports in 1990, 1995 and most recently in 2001 (1), that have been used to advise the international community through the United Nations Framework Convention on Climate Change. The Kyoto Protocol to the United Nations Framework Convention on Climate Change of 1997 committed developed countries to reducing their emissions of six greenhouse gases by 5.2% of 1990 levels by 2012. Hence global warming has also been one of the main driving forces behind recent government energy and environmental legislation in the European Union and the United Kingdom. Not all countries, however, signed up to this commitment; most significantly the United States refused to ratify the agreement. Australia has refused to ratify the protocol unless the US and developing countries became fully involved. Russia indicated in September 2002 that it would ratify the Kyoto Protocol but has yet to do so. The United States initially indicated that its unwillingness to comply with the Kyoto protocol is due to a lack of convincing evidence that an enhanced global warming effect is taking place. In June 2002, however, the United States Environmental Protection Agency submitted a report to the United Nations which concluded climate change resulted from human activities (2). The report also recognized that global warming would continue and, in addition, total United States greenhouse gas emissions would increase by 43% over the next 20 years. The US and Russia have indicated that their opposition to ratifying the Kyoto agreement results from concerns that the implementation would result in a serious impact on their economies.

There has been much research carried out on what temperature changes have occurred over the past millennium, together with changes in greenhouse gases and other factors that influence global warming. Geological evidence has shown that, over the planet's lifetime, the climate has changed significantly, as have the concentrations of greenhouse gases such as carbon dioxide and methane. This information provides an important background for the comparison of the effects that have been observed in the past 150 years. Many have argued that the current warming that has been observed is due to the Earth moving into a warmer phase, which has not been influenced by the change in greenhouse gas concentrations. Others claim there is a direct causal link between these two factors. This paper will attempt to look at the evidence presented and discuss the various arguments for and against the case of global climate change.

2. The Greenhouse Effect

2.1 Natural and Enhanced Greenhouse Effect

It should be appreciated that there is nothing unnatural about the greenhouse effect. It is a well-understood phenomenon, which acts to regulate the temperature of the earth's surface, oceans, and lower atmosphere. The only controversy is whether or not emissions of gas resulting from human activities, especially industrially related activities, have already or will, in the future, appreciably influence the global climate. It is this human enhanced greenhouse effect which is the cause of so much debate.

Global Climate Change *continued on page 39*

2.2 Physics of the Greenhouse Effect

2.2.1 Atmospheric Characterisation

Prior to describing the nature of the greenhouse phenomenon, it is important to appreciate the meaning of the terms stratosphere and troposphere. The troposphere is the lower atmosphere, which extends from the surface to an altitude of some 11 km. This is the layer of atmosphere in which our weather occurs, which represents an appropriate phenomenological definition of the troposphere. The stratosphere is the upper atmosphere above the troposphere and is characterised by a positive temperature gradient with altitude.

2.2.2 Energy Exchanges

The earth and its atmosphere are exposed to a mean global solar radiation flux equivalent to approximately $342Wm^{-2}$ (3). It is acknowledged now that the annual global flux does change with time and this figure should be taken as representative only. The radiation frequency of this flux ranges from the ultraviolet to near infrared, which represents wavelengths between 0.1 and 4μm. The short wavelength ultraviolet is largely absorbed by ozone in the stratosphere and, to a lesser extent, in the troposphere.

A proportion of the visible and near infrared radiation is reflected back into space by clouds or atmospheric aerosols. A smaller proportion is absorbed. Overall some $77Wm^{-2}$ of the incident flux is directly reflected from clouds and other atmospheric material. Some $30Wm^{-2}$ is reflected directly from the surface and approximately $67Wm^{-2}$ is absorbed directly by the atmosphere. The remaining $163Wm^{-2}$ is absorbed by the surface of the Earth. The land surface, oceans and clouds, which have absorbed the relatively short wavelength solar radiation, subsequentially emit long wavelength infrared radiation, with wavelengths in the range 4 to 50μm. This radiation is prone to absorption in the troposphere and, therefore, contributes to the warming of the lower atmosphere and, consequentially, the surface.

The proportion of the infrared radiation, which is absorbed rather than escaping into space, is affected by the composition of the troposphere. Gases, which make a particular contribution to infrared absorption include, in order of significance: water vapour (H_2O), carbon dioxide (CO_2), ozone (O_3), methane (CH_4) and nitrous oxide (N_2O).

Figure 1 shows a representation of the global energy fluxes between the surface and atmosphere. It is interesting to notice that the surface radiation is a function of the surface temperature. This temperature is a consequence of "historic" warming and should generally exceed the absorbed direct solar flux. Back radiation incident from the atmosphere, as well as loss from convection and evaporation completes the energy balance. It is this back radiation resulting from the emission of infrared radiation by the warmed troposphere itself, which constitutes the green house effect.

In effect, the troposphere acts as an insulating blanket around the Earth, the effectiveness of which will result in an enhancement of the mean temperature of the surface and lower atmosphere. It should be appreciated that the greenhouse effect should not be expected to warm the stratosphere. Indeed, it can be shown that enhanced greenhouse effects should be expected to cool the upper atmosphere. This is **Global Climate Change** *continued on page 41*

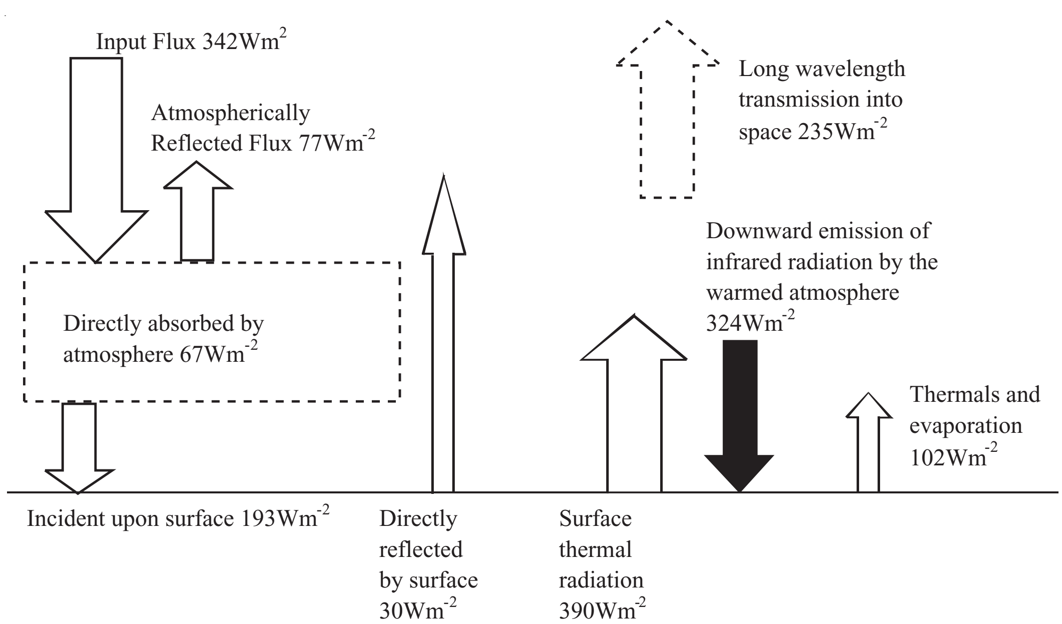

Figure 1. Principal Earth/Atmospheric Energy Exchanges Showing an Overall Balance Between Solar Influx and Long-Wavelength Transmission into Space

because the insulating properties of the lower atmosphere reduces the heating of the stratosphere, which results in a cooler outer atmospheric layer and the emission of less long wavelength infrared radiation to space. There is an analogy here with the effect of insulating a house loft. During snow falls, insulated homes are obvious by the presence of snow lying on the roof, indicating low roof temperatures, while snow will melt rapidly from the roofs of poorly insulated homes.

When considering the influence of the energy balance between the surface and the atmosphere, it is beneficial to consider the overall net radiation flux into the earth atmosphere system because of the very high level of thermal coupling between the surface and the troposphere.

The greenhouse effect maintains the habitability of the Earth. In the absence of the back radiation from the atmosphere, present surface temperatures would induce a substantial imbalance in the input/output fluxes. This would result in rapid surface cooling until a balance was achieved with a considerably reduced surface temperature. This would be substantially below the freezing point of water and insufficient to support life.

As long as the total energy input and output from the earth/atmosphere systems remains in balance, there will be not be any change in the temperature of either the earth surface or atmosphere. There will, of course, be wide short term variations, which are, in effect, manifestations of our short term weather and longer term annual variations.

Modern concerns about the enhanced greenhouse effect relate to changes in the tropospheric absorption of long wavelength infrared radiation emitted by the Earth surface, resulting from changes in atmospheric composition. Water vapour and carbon dioxide occur naturally within the atmosphere and form the primary chemical drivers of the natural greenhouse effect. We now know, however, that the proportion of carbon dioxide, ozone, methane and nitrous oxide have risen substantially as a result of human activity since the industrial revolution.

Radiative Forcing

The term radiative forcing is generally taken as referring to the net change in energy flux into the atmosphere/earth system resulting from a perturbation from a stable state. This makes it a key indicator of changes resulting from modifications in the atmospheric composition, solar radiation or other potential variables. It is a particularly useful concept in assessing the influence of anthropogenic changes in CO_2 levels and other greenhouse gasses.

Somewhat confusingly there are two related representations of radiative forcing. These are:

Instantaneous Radiative Forcing

This refers to the change in net energy flux into the atmosphere/Earth system resulting from a change in state and before any readjustment in temperature within the system.

Adjusted Radiative Forcing

Stratospheric temperatures respond rapidly to any changes in the tropospheric state or the solar energy incidence. An increase in energy absorption in the troposphere, which would result in an instantaneous increase in the overall net energy flux into the earth/atmosphere system, will cause a reduction in stratospheric temperatures. This would then result in a compensating reduction in the overall net flux.

2.3 Factors Influencing the Magnitude of the Greenhouse Effect

The net energy flux into the Earth/Atmosphere system is influenced by a wide range of, frequently interdependent factors, most of which have been discussed in section 3.2. The reflectivity of the atmosphere to the incident short wave radiation is obviously significant, as is the solar intensity. The reflectivity of the surface and clouds is also of direct importance. Much has, for example, been written about the implications of a highly reflective snow covered planet.

The effectiveness of the troposphere as an insulating layer depends upon the concentration of the principal greenhouse active gases and the effectiveness of each of these gases.

Changes in the greenhouse equilibrium of the atmosphere are driven by changes in concentration of greenhouse active gases and the radiative properties of each gas. Similarly, microscopic airborne particles or droplets (aerosols) in the troposphere can reflect solar radiation, which can lead to a cooling in the climate. Changes in aerosol concentrations can also alter quantity of clouds and cloud reflectivity also resulting in cooling.

Volcanic activity can inject sulphur oxides into the stratosphere, which are converted to sulphate aerosols (1). This results in cooling but the effects are usually transitory affecting temperatures for only a few years. Solar activity changes roughly every 11 years (about 0.1% energy change). This may have either a warming or a cooling effect. In addition, over tens to thousands of years, slow variations in the Earth's orbit have led to changes in the seasonal and latitudinal distribution of solar radiation (1).

All of these mechanisms have had a significant influence on climatic variations in the past, for example the glacial and interglacial cycles. When radiative changes occur, the climate responds on a variety of time-scales. The longest of these are due to the large heat capacity of the deep ocean and dynamic adjustment of the ice

Global Climate Change *continued on page 43*

sheets. Consequently the climate response to such changes (either positive or negative) may last thousands of years.

Any changes in the radiative balance of the Earth will alter the hydrological cycles and atmospheric and oceanic circulation. This will affect weather patterns and regional temperatures and precipitation. Any human-induced climate changes will be embedded in a background of natural climatic variations that occur on a range of time- and space-scales. The question to be addressed is, are the observed climate change affects a result of human or natural phenomena?

3. Data on Temperature Rise and Atmospheric Gas Content

Since the late 19th century the global surface temperature has increased by around 0.6C°. The 1990s has been the warmest decade, while 2002 was the warmest year since 1861, when instrumental records began. Global warming has been most pronounced in the Northern Hemisphere, where the temperature increase has accelerated to around 0.1°C per decade since the 1950s. This temperature rise has accelerated further since 1979 with a rise of 0.15 °C per decade recorded (1). While these temperature rises have been observed in the lower troposphere, there have been no significant temperature increases in the upper troposphere while significant cooling has been observed in the stratosphere. As discussed in an earlier section, this apparent paradox is a predicted feature of an enhanced greenhouse effect!

It is difficult to draw any significant conclusions on climate change using data recorded over a relatively short (150 year) period. It is therefore important to consider temperature changes prior to those observed since records began in 1861. Over the past twenty years there has been a significant improvement in the knowledge of temperature trends during the previous millennium. Data have been obtained from a number of sources, primarily gas bubbles trapped in ice cores taken in Greenland and Antarctica (3). From this research it is apparent that temperature in the Northern Hemisphere has been far from stable over this period. In particular the "Medieval Warm Period" occurred between the 11th to 14th centuries. This was followed by what is often referred to as the "Little Ice Age" between the 15th and 19th centuries. Consequently some researchers have argued that the temperature increase observed over the past 150 years is a recovery from the cool period between the 15th and 19th Centuries. What appears to be significant is the fact the rate of temperature increase over this period is significantly greater than any other temperature fluctuations observed over the past millennium.

There would, therefore, appear to be little argument that temperatures have increased since 1861 and the rate of increase is accelerating. The cause of this effect is, however, the subject of this great debate. One of the main arguments presented is the increase in greenhouse gasses over the same period as the temperature rise. The concentrations of greenhouse gases over the millennium were generally stable. Since the 1850s there has been a clear increase in the atmospheric concentration of each greenhouse gas.

The concentration of carbon dioxide (CO_2) has increased from 280 parts per million (ppm) in 1750 to 370 ppm in 2002 (1). This increase in concentration of CO_2 together with the associated radiative forcing contributes around 60% of the effect of all the greenhouse gases. There has also been a significant acceleration in the rate of increase in CO_2 concentration during the 20th century. The increase of CO_2 has resulted from a combination of factors including combustion of carbonous materials such as fossil fuels (1,3). Different fuels output different quantities of CO_2 when combusted, ranging from coal which releases up to 26.6 kg of carbon per GJ of energy released, while natural gas releases around 14 kg of carbon per GJ of energy (3). Deforestation is also associated with the increase in CO_2. This is through a combination of CO_2 released from decaying material, combustion of the forests and the reduction in foliage available to absorb CO_2 through photosynthesis (3).

The atmospheric concentration of methane has also significantly increased over the same period from 700ppb in 1750 to a current level of 1745 ppb (1). This is still increasing; however the rate has started to decrease. Methane is approximately equally produced from natural and anthropogenic sources. The anthropogenic sources include combustion of fossil fuels, biomass combustion, landfill and sewage plant operations and totals up to 615 Tg per year. Farm animals also generate a not insignificant quantity of methane (up to 100 Tg per year) (3) but good taste prevents us from discussing the production mechanism! The direct radiative forcing from methane has been estimated to be in the order of 20% of the total for greenhouse gasses at 0.48 Wm^{-2}.

Nitrous oxide also results from both natural and anthropogenic sources, in particular nitrogenous fertilisers. Over the period 1980 to 1998 the atmospheric concentration of nitrous oxide has increased at around 0.25% per year and the concentration in the atmosphere in 1998 is 16% greater than in 1750 (314 and 270 ppb, respectively) (1). The radiative forcing of nitrous oxide is around 0.15 Wm^{-2} or 6% of the total greenhouse gas radiative forcing.

Halocarbons present a particular problem, as some are extremely effective infra red absorbers (up to 22,000 times that of CO_2) and are exceptionally Global Climate Change continued on page 45

persistent, remaining in the atmosphere for 100 years or, in the case of perfluoromethane, 50,000 years (1). Action taken by many governments as a result of the Montreal Protocol has resulted in a decrease in many of these compounds, in particular chlorofluorocarbons, which have been associated with the depletion of the stratospheric ozone layer. The rate of increase of other compounds has started to decrease. These compounds are almost entirely produced from anthropogenic sources such as refrigerants or cleaning and degreasing fluids. The total radiative forcing of halocarbons has been estimated to be of the order of 0.34 Wm^{-2}, (14% of the radiative forcing from all greenhouse gases) (1).

Ozone is generated indirectly in the atmosphere via photochemical processes involving oxygen with high energy ultraviolet (UV) light. The residence time of ozone in the atmosphere is relatively short (weeks to months). In the past twenty years the reduction of the ozone layer in the stratosphere has resulted in a cooling of the surface troposphere. This cooling is believed to have offset the warming effects of the other greenhouse gases. In addition the thinning in the ozone layer also allows the transmission of more UV light. This UV light can promote the photochemical degradation of species such as methane and halocarbons in the atmosphere (1).

Over the longer term, geological data have indicated that the current concentrations of these gases, with the exception of ozone, are currently at their highest level for 420,000 years (1).

Data on changes in water vapour are more difficult to obtain. The water vapour in the lower atmosphere will increase with increasing temperature. This in-turn will have an additional warming effect (4). Water vapour can also condense forming clouds. Clouds may have either a warming or a cooling effect. The cloud cover will keep heat within the lower atmosphere through reflection. Conversely it can also prevent heat from reaching the surface of the planet by blocking solar radiation. Data on water vapour changes is available only for the past three decades. These data indicates an increase in water vapour of between 3 and 10% per decade (3).

The atmospheric concentrations of aerosols in the troposphere have also increased due to particulate emissions from anthropogenic sources such as combustion, energy generation or vehicle emissions. These aerosols are composed of a combination of particles including sulphate, fossil fuel organic carbon and fossil fuel black carbon, which may have either a warming or cooling effect. The physical/chemical characteristics and spatial distribution of the aerosols will influence the magnitude of the radiative forcing, which will have an overall cooling effect (1).

4. The Arguments Whether or Not Anthropogenic Sources influence the Greenhouse Effect

The consensus among many scientists and policy makers is that the observed temperature rise over the past 150 years is a direct consequence of the rise in greenhouse gas concentration (1,4) There have been other groups that have forcefully expressed their doubts that the enhanced warming is due to these factors and is a natural phenomenon.

A common argument used by sceptics is that the planet is a dynamic environment and that changes in temperature over the past 150 years are insignificant when observed over the lifetime of the planet. Although it is agreed that the planet has gone through phases of significant temperature change, what is significant about the recent observed warming is the rate of temperature increase, rather than just the magnitude of increase.

A criticism that has been used against the argument for human influence in climate change is that the temperature change has coincided with the increase in greenhouse gas emission. It has been argued that there should be a lag between the build up in greenhouse gas concentrations in the atmosphere and the increase in temperature. In addition, it is also claimed that the greenhouse gas emissions have been too small to account for the observed temperature changes. If this argument holds any truth, then the long term consequences could be even more worrying for us, as it implies that we have not yet experienced the full impact of changes in the atmosphere!

The way in which, and the locations where, the data have been gathered have also been criticised. Regrettably, research into global phenomena will always depend on a variety of measurements, many of them indirect by nature. There should now, as a matter of urgency, be an international effort to improve the quality of data measurement. The United States and other developed nations would appear to be the best prepared to fund and implement such a programme. In particular as the energy industry has much of the infrastructure to resource such a programme, this sector should take a leading role in these activities.

Another argument against global warming is the influence of solar activity. It has been claimed that the warming is due to increased solar activity and some models have been presented that match the increase in warming with higher solar activity and this has resulted in a 0.3 °C increase in temperature observed over the past 20 years.

Frohlich and Lean (5) compared the composite total solar irradiance (TSI) record

Global Climate Change *continued on page 47*

measured by space craft over a 23 year period with an empirical model of TSI variations. The authors discussed how, using these records to extrapolate back to around 1650, it could be demonstrated that solar change has resulted in up to a 0.4 °C increase in temperature. This would suggest that the observed warming is a result of changes in solar activity and post industrial greenhouse gas emission would have little effect on climate change.

The way in which much of the solar variability data was gathered has recently been criticised. It has been claimed the drifts in instrument sensitivities were not accounted for when making measurements (6).

5. Potential Long-Term Effects of Climate Change

There are a number of potential effects which may have either a negative or in some cases a positive impact. The predicted effects will vary over different latitudes in the planet and include changes in sea level, precipitation, water availability and food production. It is important to consider that whether or not the temperature increase results from human influence, these changes may result from the warmer climate that we are experiencing. The argument over the magnitude of the anthropogenic influence on climate change is therefore of little consequence when considering such effects.

The major potential consequence is a rise in sea level. This has been predicted to result from a combination of melting glaciers and polar ice caps or more significantly thermal expansion of the sea due to the increased surface temperature. A reduction of Arctic sea ice has been observed in the spring and summer of between 10 and 15%. The annual loss of ice from glaciers in the central Asian state of Kazakhstan has been reported to be nearly two cubic kilometres in the latter part of 20th Century (7). In contrast, no reduction of Antarctic ice has been observed with even a slight increase being reported (1). The rate of global mean sea level increase was reported to be in the range 1.0 to 2.0 mm per annum during the 20th century (1). It should be noted that the increase in sea level is unlikely to be affected by the melting of the Artic ice, since this is floating no net water level rise should result. The rise in sea level may have a number of effects including increase coastal erosion, and flooding of low lying lands and islands. An example would be Bangladesh, where flooding could result in loss of 10% of land. (1,8). In particular, the rice fields could be reduced by 50% affecting the livelihood of over 5 million people (9). Coastal aquifers may be damaged by saline intrusion as salty groundwater rises. The movement of the salt-front up estuaries would affect freshwater pumping plants upriver.

Ironically, large scale climatic change could severely modify the nature of the North Atlantic drift pattern and plunge North West Europe into an extended period of very severe winters similar to those of the equivalent latitudes on the Canadian east coast. The impact of such changes on the heavily populated European Atlantic margin could be regrettable.

An increase in rainfall has also been predicted for several regions in the Northern Hemisphere. As the temperature increases there is an increase in evaporation and the warmer air can hold more moisture. This subsequently leads to an increase in rainfall. The hydrological cycle is however exceptionally complex and how the change in rainfall will affect surface water and vegetation is difficult to predict. During the 20th century an increase in annual land rainfall of around 0.5 to 1% per decade was observed in the middle and high latitudes of the Northern Hemisphere (1).

As a consequence of the changes in precipitation, water availability will be another consequence of climate change. Some models predict that rainfall will be significantly more torrential, leading to more flooding. This may in turn result in less water being taken up by soil which will alter ground and surface water supplies. In addition, while some areas will experience more rainfall others will have less. While there will be increased availability in high latitudes of the Northern Hemisphere, decreases are predicted for southern Europe, the Middle East, central Asia and Africa (1,9). Arid and semi-arid areas, deltas, low-lying coasts, and small islands will be particularly vulnerable. The water availability problems will particularly affect developing countries and add to the demand for water resulting from economic development and population growth. Many of these areas already experience serious difficulties from water shortage so the problems are likely to be exacerbated. The Middle East, for example, currently has 1% of the Worlds available water and 5% of the population (10). The problems with water availability in this region may potentially lead to further political instability in this already very unsettled region of the globe. It has even been suggested that areas such as Ireland may experience water shortages as a result of climate change (10). The Irish Environmental Protection Agency has warned that, although rainfall in the winter may increase by 10%, there may be a summer rainfall reduction of up to 40% in the south and east coast of Ireland (11).

The increase in CO_2 concentration coupled with the warmer climate may increase cereal crop yields in the middle and high latitudes of the Northern Hemisphere (4). Unfortunately in the Middle East, India and Africa crop yields would be reduced. Reduced rainfall and water runoff would cause a reduction in soil moisture which will affect crop growth. The change in water temperature resulting from climate change will affect the ecology of water systems. Nutrient and dissolved oxygen levels may also be affected. A recent report in Nature (12) has also reported a potential link between climate warming and fish harvests in Africa. The sardine harvest **Global Climate Change** *continued on page 49* continued from page 47

in Lake Tanganyika has reduced by around 50% since the 1970s and has been associated with an increase in air temperatures over the lake of 1.5 °C (12). This has resulted in a reduction in the algal growth which is the main source of food for the fish.

6. Conclusions

There is clearly no overall consensus on the human contribution to the greenhouse effect and the relationship between the observed temperature increases over the past century. Much of the disagreements concern the nature of data and the way in which they are gathered and presented by both sides in the debate. A criticism that could be levelled at both sides is that interested parties have a specific bias based on their own viewpoint and, consequentially, interpret data to support their view and criticise data which does not support their position. Environmentalists frequently attempt to use the greenhouse argument to justify the creation of a non-industrial society. Irrespective of whether or not there is an irrefutable link between greenhouse gas emission and global temperature rise, technology has to be the solution to problems created by global climate change. Equally it is not safe to take the attitude that there is no link between atmospheric emissions and climate change.

The evidence that is available at present does suggest a link between anthropogenic gas emission and global warming. What is not known yet is the magnitude of this relationship. It is clear that the potential association between gas emission and climate change can not just be ignored and underlying physics suggests there is a connection. It is vital that society takes steps to implement a comprehensive monitoring programme to establish the extent of the link and any potential future impacts. This will aid governments to undertake any associated planning that might be necessary to accommodate any climatic reaction and subsequent global consequences. This may have a two fold impact to industry. New opportunities for development of technology to address the impacts of climate change may be required, opening up a whole new prospective market. Unfortunately there may be additional financial burdens in terms of more stringent emission control requirements and higher insurance costs. Irrespective of whether there is a proven detrimental consequence of artificial greenhouse gas emissions the energy production industries are not responsible for this. It is the consumers who should be considered culpable; the energy industries only meet their demands. ■

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