IPENZ Informatory Note Six

Climate Change and the greenhouse effect

October 2001

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This Note should be read in conjunction with IPENZ Informatory Note Four *"Sustainability and Climate - An Engineering Response, July 2001"*. It provides a more in-depth discussion of some of the issues raised there.

The context

It is easy to forget that 99% of the earth's atmosphere is within 32km of its surface. This compares with the earth's radius of about 6350km. The atmosphere, through the "greenhouse effect" of this relatively very thin layer, keeps the earth's surface temperature in the livable range by reflecting back a proportion of the outward thermal radiation from the earth, thus retaining the heat and raising the average temperature of the atmosphere. The natural effect from the greenhouse gases already in the atmosphere is to make the earth about 33ºC warmer than it would otherwise be and also to minimise temperature swings between night and day.

The risk

Human activities have increased the concentration of these atmospheric greenhouse gases, and although the changes are relatively small, the equilibrium maintained by the atmosphere is delicate, and so the effect of these changes is significant.

The world's most important greenhouse gas is carbon dioxide, a by-product of the burning of fossil fuels. Since the time of the Industrial Revolution about 200 years ago, the concentration of carbon dioxide in the atmosphere has increased from about 280 parts per million to 370 parts per million, an increase of around 30%.

On the basis of available data, climate scientists are now projecting an average global temperature rise over this century of 2.0 to 4.5ºC. This compared with 0.6ºC over the previous century – about a 500% increase. (The full range of the projections is between a 1.4ºC and 5.8ºC increase by 2100). This could lead to changing, and for all emissions scenarios more unpredictable, weather patterns around the world, less frost days, more extreme events (droughts and storm or flood disasters), and warmer sea temperatures and melting glaciers causing sea levels to rise. The rise in sea level around New Zealand by 2100 is mostly likely to be in the range of 0.31 to 0.49m by 2100, with a full range covering all scenarios of 0.09 to 0.86m by 2100.

Well informed individuals have quite correctly drawn attention to gaps in the science of climate change and some leading scientists have questioned some of the assumptions being made and whether observed signs of climate change are being caused mainly by natural processes rather than by human activities. Yet professional engineers commonly deal with risk, and frequently have to make judgments based on incomplete data. The available evidence suggests very strongly that human activities have already begun to make significant changes to the earth's climate, and that the long-term risk of delaying action is greater than the cost of avoiding/minimising the risk. On the other hand, if these changes are later found to be caused mainly by natural processes, then there is a risk involved in committing large scale resources to greenhouse gas reduction which might be better directed elsewhere.

Little imagination is needed to envisage the effect of a nationwide increase in average temperature in New Zealand of (say) 2ºC by the year 2100, or a nationwide change of total rainfall by a significant percentage. Worldwide, the effects are even greater, with high and low latitudes experiencing major changes in their usability by humankind. Scientists are now confident that global temperatures are in fact rising. There is new and stronger evidence that most of the warming over the last 50 years is attributable to human activities and that global average temperature and sea levels are projected to rise under all emissions scenarios.

Equity issues

Global warming is not a local or a national problem but a global problem which can only be resolved internationally. Climate change will affect every single person in the world, yet a disproportionate amount of the increase in greenhouse gas emissions is being generated by the more developed countries while the greatest impact of climate change is likely to be on the less developed countries.

Many of the best potential mitigation options for greenhouse gas emissions lie within the developing countries which need to avoid the mistakes made in the developed world as their energy use expands. Technology transfer, both to achieve low emission or sustainable energy production and to achieve efficient energy use, are key elements here.

Some figures may help to illustrate the issue. The USA produces about 25% of global greenhouse gas emissions (and 36% of developed country greenhouse gas emissions) with just over 4% of the world's population. Dividing the total annual USA carbon dioxide emissions by their population, these emissions are 24 tonnes of CO_2 per person per year.

By comparison the figure for a typical European country (Holland) is 11 tonnes per person per year, for Australia 9 tonnes, for New Zealand 8 tonnes and for China 2.2 tonnes. However, because China has a population of over 1.2 billion, it is the world's second largest emitter of greenhouse gases (after the USA).

In order to ultimately keep the global climate in balance it has been estimated that a world-wide production of 1.7 tonnes of CO_2 per person per year is the maximum allowable. Equity considerations suggest that eventually the USA will have to reduce annual CO_2 emissions from 24 to 1.7 tonnes per person, while many developing countries should be able to increase their emissions as a consequence of economic growth which they consider to be essential.

The USA (and many other countries) are adamant that it is not possible to accept such a massive reduction in CO_2 emissions and hence the present compromises in the Kyoto Protocol which are initially politically acceptable targets but certainly nowhere near enough to achieve equilibrium.

Delivering the New Zealand response

New Zealand is planning to ratify the Kyoto Protocol by about mid-2002. If the Protocol is implemented (with or without the USA) when sufficient countries have ratified it so that it becomes operational, New Zealand must then respond nationally and it is likely that a range of policy measures will be set in place.

The Minister of Energy has recently (September 2001) released a National Energy Efficiency and Conservation Strategy prepared by the Energy Efficiency and Conservation Authority (EECA) which has been developed to assist New Zealand in meeting its obligations under the Kyoto Protocol.

Measures to reduce the extent of climate change

Much of the political and business concern over the effects of the Kyoto Protocol, both within New Zealand and internationally, may relate to a lack of confidence that acceptable technical solutions are available.

Professional engineers will need to take key roles, not only in identifying these solutions, but also in assessing the opportunities which they present and barriers to development and uptake. Life-cycle analysis of products and processes are likely to play an increasingly important role in evaluating alternatives.

Minimising energy consumption

Small vehicles with small engine size are more fuel efficient than vehicles with larger engine size. This suggests a considerable potential saving in energy consumption nationally by minimizing engine size for the load to be carried. New types of vehicle which use fuel more efficiently including hybrid vehicles and fuel-cell powered vehicles (operating on hydrogen, methanol or natural gas) have great potential to reduce energy use. Better road design and construction will improve safety and reduce fuel use.

Urban planning that encourages bicycle and public transport usage represents only a small-medium opportunity in New Zealand because of our small population density and relatively long commuting distances. Methods of avoiding travel including more working and shopping from home will need to be actively promoted.

Passive solar design of new houses and better control of energy use in domestic, commercial and industrial buildings represents a small-medium opportunity (although retrofit costs may be high).

The development of new low-energy technologies for industrial processes represents a future opportunity as new industrial plants are brought into operation.

Energy generation and distribution

There are a number of possible ways in which engineering can reduce future greenhouse gas emissions. More efficient thermal power generation technologies are already being implemented in New Zealand and further advances are expected. We also need to maximise the usage of renewable energy installations.

In future there is also significant potential for developing a biomass to liquid fuel conversion capability and also a biomass to electricity capability in New Zealand.

Concern over political and safety issues has made nuclear power from fission sources an extremely unlikely future energy source for New Zealand, but the future possibility of nuclear power from fusion sources should not be disregarded.

Re-sequestration of fossil-fuel derived CO_2

There are several proposed methods, for re-sequestering carbon dioxide produced from fossil fuel combustion in electricity generation or industrial plants, but their future economics are still in doubt.

Reducing agricultural methane and nitrous oxide emissions

In New Zealand agricultural methane and nitrous oxide emissions together comprise two thirds of our total greenhouse gas emissions. Reducing these emissions is a challenging issue but is within the capability of our research scientists and agricultural engineers to find solutions.

Summary

Delivery on an obligation (through ratification of the Kyoto Protocol) to reduce greenhouse gas emissions will be a major challenge for New Zealand, since these emissions are caused by behaviour woven into our social fabric.

Greenhouse gas emissions can be reduced and the efforts of the engineering profession will be essential in delivering technologies to bring these reductions about.

Professional engineers will also be presented with new challenges in designing for the effects of climate change which is already occurring.

Contributors

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Other Informatory Notes

Note One: The Role of Engineers in Developing National Wealth
Note Two: Policy and Leadership Framework for Wealth Creation in New Zealand
Note Three: The Role of Technology Education in New Zealand's Future Prosperity
Note Four: Sustainability and Climate – An Engineering Response
Note Five: Wealth Creation in New Zealand Improving Intellectual Property Realisation

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