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Report of Working Group 6
Climate Change, Energy and the Environment

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Climate change

Climate changes have occurred in the past naturally, for various reasons. However, currently mankind is modifying the Earth's environment, in various ways, notably because we are changing the climate. Largely as a result of the large-scale combustion of fossil fuels, the atmosphere is at present polluted with particulates, and the balance of the radiation on Earth is being further altered through the emission of anthropogenic greenhouse gases. Among the latter, the most important are carbon dioxide and methane. Global warming and the associated effects of regional and local climate change are expected as a result. In 2001, the International Panel on Climate Change (IPCC) confirmed that "There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities". After a decade of intensified scientific research during the 1990s, there is now no longer doubt about earlier observations that mankind is changing the climate on Earth.

In particular, the magnitude and rate of change of global mean surface temperature over the past few decades is shown to be outside the range of anything deduced from paleo-climate records for the last 1000 years. A global warming has been taken place over the past one hundred years of about 0.7 &Mac176;C, and most projections for 2100 give an increase of global mean surface temperature between about 2 to 4 &Mac176;C. The last decade has been the warmest decade, on average, on record; 1998 has been the warmest year and 2001 the second warmest year ever recorded. Increases in atmospheric greenhouse gas concentrations not only increase mean global surface temperature, but, perhaps more importantly, involve regional and local climate effects, such as increased drought, precipitation, floods, and storms.

Energy supply and economic prosperity

A reliable and affordable supply of energy is critical to maintaining and expanding economic prosperity where such prosperity already exists and to creating it where it does not. But at the same time, the core of the challenge of expanding and sustaining economic prosperity is the challenge of limiting, at affordable cost, the environmental impacts of an expanding energy supply. The worth of today's largely fossil-based world energy system is some 10 trillion dollars at replacement cost. Also because of the equipment turnover time amounting to around a few decades, the current energy supply system cannot be rapidly replaced with non-carbon emitting alternatives, even if they were economically more attractive than conventional fossil-based technologies. Hence, the challenge of transforming the current energy supply system is considerable. This does not imply, however, that the challenge of transforming this energy system into an environmentally friendly one is insurmountable.

A recommendable strategy to address the global warming problem would be to not let carbon dioxide concentrations in the atmosphere increase to more than a stabilization level of about twice as high as the pre-industrial level of 280 ppmv. While the climate change impacts of such an objective could be considerable, to which mankind will need to adapt, there is then at least a good chance that the situation would be manageable. The chance of our ability to manage the impacts would diminish sharply if the concentrations were to rise toward a tripling or quadrupling of carbon concentrations that would be associated with a continuation of business-as-usual. Since we are already well on our way to reaching a doubling, mankind will in any case need to adapt to the climate changes this doubled carbon dioxide concentration will involve. Geotechnical engineering the atmosphere to reduce the effects of greenhouse-gas increases in the atmosphere on climatic variables seems undesirable, but might at some point in the future be needed. Removing from the atmosphere the emissions that have previously been added, for example through afforestation or through enlarging other biological sinks, can contribute to only moderate extent to solving the climate change challenge mankind is currently facing. In addition to these measures, reducing greenhouse gas emissions below levels that would be implied by a "business-as-usual" scenario is therefore imperative.

Reducing carbon dioxide emissions

The determinants of anthropogenic carbon dioxide emissions – the most important greenhouse gas – are population, Gross Domestic Product (GDP) per person, energy use per unit of GDP, and carbon emissions per unit of energy. The available leverage of in principle each of them should be used to reduce carbon dioxide emissions. International support for education, development and family planning are effective measures to slow down population growth and should therefore

receive high attention, also since population control simultaneously involves addressing a spectrum of other problems. However desirable a re-orientation of human wants in terms of material consumption might be, it is unlikely that any political decision-making body will anywhere soon adopt this approach. Industries and individual consumers should be motivated to choose among the available energy options those that are least energy consuming, and to realize savings in an as broad as possible range of energy uses. Equally, incentives should be provided to make low- and non-carbon choices from the menu of energy-supply options available at any given time.

Energy resources and research

The menu from which choices can be made between energy technologies that are both environmentally friendly and economically affordable can be enlarged. To achieve an improved range of energy production options, fundamental research, applied research, development, demonstration and deployment should be imminently accelerated, starting today. International cooperation in energy research is paramount, firstly in order to economize on scarcely available funding. Stimulating collaboration in energy technology development between industrialized countries, countries in transition and developing countries can also be instrumental in the exchange of expertise in technology development and experience in the use of new energy technologies.

At the moment, no single energy resource or technology constitutes a panacea to solve the climate change challenge. Therefore, all available options to address this challenge should be employed and kept open. This involves both increasing energy efficiencies and savings, and keeping a non-carbon energy spectrum as diversified as possible. Among the latter are notably the use of decarbonized fossil fuels (through carbon capture and sequestration), the use of renewables (such as hydropower, wind, solar and biomass energy), and the use of nuclear energy. Also in view of ascertaining energy supply security, maintaining the use of a combination of these options is advisable, since with a diversified energy system nations are better able to hedge against potential energy supply shortages. Meanwhile, the advantages of distributed energy/electricity systems can be exploited to a fuller extent than in the currently largely centralized energy production infrastructure.

Increased fundamental research and R&D into all energy alternatives can mitigate the drawbacks that each of them involves, and can render their favorable properties in terms of global warming accessible. A global framework of commitments should be realized to constraining greenhouse gases in the long run. Many policy options are open to this end, one of which seems to be particularly attractive. All present energy technologies possess detrimental environmental and health externalities, so that there are at present no winners or losers among the energy

options available. By internalizing these externalities, that is, by considering them as real costs that are reflected in energy prices, a fair level playing field of competition can be created. Such internalization of external environmental effects should become the basis for energy decision-making, and should be realized according to an internationally determined set of agreements.

Climate change uncertainties

While the phenomenon of human-induced global warming and the overall effects of associated climate change, such as an increase in global sea levels, have been scientifically well established, many aspects of climate change remain subject to uncertainties. The extent to which, when precisely, and in what parts of the world its effects will become predominant is still difficult to predict scientifically in all its possible dimensions. However, these uncertainties are no reason for inaction. On the contrary, irrespective of these uncertainties, action should be undertaken so as to hedge humanity against some small-probability, but highly adverse, climatic effects, such as a deviation of large ocean currents. Especially the possibility that certain climate effects can be incremental, non-linear, interactive or self-enhancing should make us weary of the risks that could be at stake.

The IPCC seems the appropriate body to analyze climate change uncertainties, as well as summarize them and convey them to a large public. It should continue to inform national governments and individuals that the energy-climate challenge must, and can, be met. Scientific knowledge about why doing so is necessary is abundant, and proposals on how to proceed to address this challenge abound. The costs of the required action are most likely small in comparison to the environmental and economic damages averted, as well as small compared to the investments made globally in maintaining national military forces.
International cooperation and individual responsibility

Today, the poor countries contribute little to the causes of the problem of climate change, while they are likely to suffer most of its consequences, partly because of the stronger dependence of people in the developing world on natural ecosystems, and because they are less able to adapt to the adverse impacts of climate change. Especially in many developing countries the vulnerability to the various effects of climate change is likely to be high. Like with questions of global nuclear disarmament, international cooperation – notably between developing and industrialized countries – is the crux for addressing the many facets of the solutions to problems involved with climate change. International cooperation is in particular essential for establishing global accountability and commitments to reduce carbon emissions. It is also necessary for making energy policy decisions on the basis of the true cost of energy production, including the detrimental effects that may be caused to the environment or to human health as a result of energy production.

Establishing individual responsibility in energy and resource use will also be paramount to solving the climate change problem. Public education and dissemination, notably by scientists, plays a fundamental role in increasing the public understanding that climate change is a problem, which ought to be addressed as of today. Enhancing public awareness of the potential threats to humankind involved with global warming can help creating the political conviction that action is required now. International cooperation, both in energy research and in establishing global greenhouse gas reduction commitments, as well as the promotion of establishing individual responsibility, should be central at the forthcoming Johannesburg Summit. Given the relevance of the global warming problem, and given Pugwash's history in bringing together scientists from different disciplines and backgrounds, convincing policy makers of undertaking action vis-à-vis urgent global threats, and stimulating the realization of international treaties that address these threats, Working Group 6 on "climate change, energy and the environment" recommends that Pugwash should enhance its activities in the climate and energy field, notably through the organization of workshops on this subjects matter, and by including among its Council members experts that are knowledgeable in both the natural scientific and social scientific (e.g. economic) aspects of this multi-faceted challenge.

Concise Summary

- Whereas climate changes have occurred in the past naturally, there is today overwhelming evidence that mankind is modifying the Earth's environment and is provoking an increase of the average global atmospheric temperature and the associated detrimental effects of regional and local climate change.
- In order to minimize the risks induced by substantial climate change, carbon dioxide concentrations should be stabilized, preferably during the 21st century and at a level not exceeding twice the pre-industrial level.
- Adaptation to the consequences of climate change will almost certainly be necessary; geotechnical engineering to counteract the radiative effects of increased levels of greenhouse gases in the atmosphere may at some point be needed; and removal of carbon dioxide from the atmosphere through the employment of large-scale biological sinks (e.g. by afforestation) can only to a limited extent contribute to mitigating climate change.
- Thus, reducing anthropogenic greenhouse gas emissions substantially below levels that would be implied by a "business-as-usual" scenario is imperative; this can – and should – be realized through a reduction in population growth, decreasing levels of energy use per unit of Gross Domestic Product, and decreasing levels of carbon emissions per unit of energy use.
- Reduction in energy demand is essential for addressing the global warming challenge, and measures regarding the end-use of energy, in e.g. transport, building and construction, should be pursued aggressively.

- Since no panacea energy resource exists, all non-carbon emitting energy resources should for the moment remain – and become – part of an energy mix as diversified as possible – also in order to ensure energy security for mankind during the 21st century – at least to allow further mitigating some of the intricacies that available options possess; among these energy resources are decarbonized fossil fuels, renewables and nuclear energy; all of these should be subjected to increased levels of research, development, demonstration and deployment.
- Like with questions of global nuclear disarmament, international cooperation, notably between developing and industrialized countries, is the crux for addressing the many facets of the solutions to problems involved with climate change; among these are establishing global accountability and commitments to reduce carbon emissions and making energy policy decisions on the basis of the true cost of energy production; also establishing individual responsibility in energy and resource use will be paramount to solving the climate change problem.