Scientists for Global Responsibility

SGR
Promoting ethical science and technology

Career choice and climate change

By Dr Stuart Parkinson

A Scientists for Global Responsibility briefing

This briefing provides an overview of the climate change crisis: its causes, its potential impacts and the economic influences that make the problem harder to solve. Readers will gain insight into ways in which career choice can help alleviate (or worsen) the situation.

Career choice and climate change is of relevance to students and graduates of:

Agricultural science
Chemical engineering
Chemistry
Civil engineering
Computer science
Design
Ecology
Economics
Environmental science
Geography
Geoscience
Marine science
Mathematics
Mechanical engineering
Oceanography
Physics
Politics
Statistics

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This briefing is part of a series entitled ***Thinking About an Ethical Career in Science and Technology***.

Thinking about an ethical career in science and technology

Thinking About an Ethical Career in Science and Technology is intended to give young scientists and engineers an understanding of the wider ethical dimensions of various careers in science and technology. Each briefing focuses on an area in which science and technology can play a major role, either good or bad, and examines the social and environmental controversies in that area. It then gives guidance on how to make an informed, 'ethical' career choice.

The controversy

The threat of global climate change is one of the greatest environmental problems facing humankind. How we apply science and engineering is crucial in determining whether we overcome the problem or whether it overcomes us. Scientists and engineers working in the UK need to take particular care in ensuring their career is part of the solution, rather than part of the problem. The UK is a major fossil fuel producer and user and hence one of the world's top ten emitters of carbon dioxide, the main cause of climate change. Furthermore, the chemicals and process industry, which extracts and processes much of the fossil fuel consumed in the country, is the biggest employer in the manufacturing sector (currently with about 400,000 employees). On the other hand, the UK is home to many of the world's leading research teams on the science, technology and policy of the environment in general, and climate change in particular.

This briefing covers the range of employment options concerned with climate change, from jobs that help to understand the science underlying the problem, to those involved in the development of technological measures, and finally to those which examine the more challenging economic, social and political issues such as how to encourage people to follow low consumption lifestyles. First, though, it introduces the issue of climate change: what it could mean for human society and the environment and how we're causing it.

The consequences

Human activity results in the emissions of huge amounts of greenhouse gases (GHGs). These gases contribute to the natural effect known as the greenhouse effect, which traps a large enough fraction of the heat from the sun to keep the planet warm enough for life to exist. However, the addition of extra GHGs is increasing the amount of heat trapped by the atmosphere and hence the average temperature of the planet. Current estimates suggest that global temperatures will increase by between 1.4°C and 5.8°C by 2100 due to human emissions of GHGs [1]. This may not sound significant but it would represent the fastest rate of global temperature change since the warming that occurred after the last ice age, more than 10,000 years ago.

Such a temperature change will cause sea water to expand and some of the sea ice near the poles to melt, leading to an estimated sea level rise of between 9cm and 88cm by 2100 [2]. Flooding will become an increasingly serious problem with about a seven-fold increase in the number of people affected globally [3]. Most of them will be in southern Asia and many will be forced to migrate, causing a major environmental refugee crisis.

Increased sea levels will also lead to more water shortages as salt water inundates the fresh water table. This, combined with higher average temperatures, will lead to about three billion extra people suffering increased water 'stress' (lack of adequate water supplies) by 2080 [4]. Higher temperatures will also result in more frequent and severe storms. The recent catastrophes in Mozambique show that even storms on today's scale of severity can cause tremendous loss of human life and damage to ecosystems and property in poorer, developing countries.

Although the global picture is quite clear, there is still significant uncertainty about how exactly the climate will change in a particular region. However, there is little doubt that changes will occur and if they do so as fast as predicted, farmers will have major problems adapting their cultivation methods and range of crops to the new climatic conditions. Food shortages will be inevitable. Ecosystems will also find it hard to adapt. Already we are witnessing large areas of coral reefs dying off due to a relatively small increase in sea temperatures.

Disease patterns will also change: research on malaria indicates that in some tropical areas its incidence is likely to decrease – because it will be too hot – but new areas will become susceptible (e.g. southern Europe). The UK Meteorological Office estimates that globally an extra 290 million people will be at risk by 2080 [5].

The causes

Virtually every aspect of our lives, from the food we eat and the clothes we wear to the computers we use and the cars and planes we travel in, leads to emissions of GHGs and therefore contributes to climate change. But it is possible to single out the main contributors.

The GHG that makes the biggest contribution to global warming is carbon dioxide (CO_2). Human activities result in approximately 8 billion tonnes of CO_2 being emitted by every year, and this is growing. The two main culprits are the burning of fossil fuels (roughly 75% of the contribution to CO_2 emissions) and deforestation [6]. Fossil fuels, i.e. coal, oil and natural gas, are burnt to produce electricity, provide direct heating to homes and industrial processes (cement, aluminium and steel production are particularly significant), and drive cars, aircraft and other motor vehicles. Deforestation and other land-use changes are carried out to provide wood for fuel, building materials and paper products, whilst in other areas the reason is to provide land for agriculture, particularly cattle, and expansion of human settlements.

There are a number of other important GHGs: methane; nitrous oxide; and the halogenated hydrocarbons [7]. Methane (CH_4) makes the second highest contribution to climate change, much of which comes from the natural digestion processes in cattle, rice paddy fields, leaks from natural gas pipelines and other agricultural processes. Nitrous oxide (N_2O) is also important, and is emitted by agriculture and industrial processes. A number of other GHGs are emitted in tiny quantities, but are so powerful in their warming effect that they demand consideration. These are halogenated hydrocarbons such as CFCs, HCFCs, HFCs, PFCs and also sulphur hexafluoride (SF_6). CFCs have been banned across the industrialised world and HCFCs will be soon (due to the damage they both cause to the ozone layer); however HFCs and PFCs are used as coolants in refrigeration and air conditioning and, together with SF_6, as solvents in the electronics industry.

Forces at work: the fossil fuel lobby

An important issue regarding career choice in any area of science and technology is the effect of vested interests. Any special interest group can be guilty of putting a 'spin' on the results of scientific research to suit its own interests but this becomes a major problem when one group becomes particularly powerful. Increasingly this group is the industry lobby. In the case of climate change the industries concerned are those involved with fossil fuels, either in extraction (oil, coal and gas companies) or in use (heavy industry, car manufacturers, etc).

These lobby groups are known to have funded a small number of "climate sceptic" scientists to challenge the scientific evidence for global warming [8]. These scientists were particularly vociferous in 1996 in the run-up to the publication of the Second Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), which nonetheless concluded that global warming *did* exist and *was* caused by human activities [9].

Since the agreement of the Kyoto Protocol in 1997, which set international, legally-binding GHG emissions targets for the first time, many of the large corporations that were opposed to action on climate change have shifted their position, realising the potential profit in cleaner technologies (as discussed more fully in the SGR briefing: "Cleaner technologies: a positive choice"). However, a few have remained intransigent, and were instrumental in supporting the well-known opponent of action on climate change, George W. Bush, in his successful campaign to become US president in 2000. The most notable of these corporations is Exxon-Mobil, which owns Esso in the UK.

If you decide to work in industry it's important to consider the political views your chosen company holds and to look into any lobby groups it may fund. Even if you work in academic research, it is important to consider the extent to which your work may be influenced by the fossil fuel industry. The recent report "Degrees of Capture" discusses this aspect in more detail [10].

Careers that affect climate change

There are alternatives to taking a typical job within the fossil fuel industry. While the all-pervading nature of climate change makes it a difficult problem to solve, it also results in a huge variety of career options open to scientists and engineers wanting to help tackle it. For convenience, this briefing describes them in terms of four categories of positive contribution: understanding the problem, technological solutions, economic solutions and social/political solutions. Obviously, some careers may fall within more than one section.

Careers that help further our understanding

There is much scientific research underway geared towards understanding climate change and predicting its effects. A range of computer models have been developed, from the highly sophisticated General Circulation Models (GCMs) which examine the evolution in time of global and regional climatic processes in three dimensions to the simpler (but no less useful) models used to examine specific spatial or temporal aspects of climate change. And, of course, computer models are of no use without reliable data relating to the processes that need to be modelled. A tremendous volume and range of data has to be collected, from atmospheric and ocean temperatures to the nesting patterns of birds and the depth of water tables.

There are a number of specific areas where uncertainties in our undertanding of climate change need to be resolved. The importance of ocean circulation, of cloud formation, of the ozone layer; the effects on disease, agriculture and ecosystems (especially forests), and so on, are still under investigation, leading to a wide range of career options in fields such as the atmospheric and oceanographic sciences, marine and terrestrial ecology, agricultural science and animal and plant biology. These careers are open not just to people directly qualified in those fields but also those with a strong background in mathematics, physics or computer science, particularly where mathematical modelling plays a large role.

The UK has a large number of leading research groups in climate change science, including the Hadley Centre for Climate Prediction and Research, the Climate Research Unit at the University of East Anglia, the Environmental Change Institute at Oxford University, the British Antarctic Survey, based at Cambridge and the Southampton Oceanography Centre. A number of other universities have strong environmental science (or similar) departments active in this area. The UK is also home to one of the world's leading interdisciplinary research centres on climate change, the Tyndall Centre. Based at the University of East Anglia, the Tyndall Centre is a partnership of nine research institutions.

Careers that work towards technological improvements

Since much technological development has taken place without significant concern being given to issues such as energy and material consumption, and their consequent contribution to GHG emissions, there are many opportunities for improvement to existing technologies.

The first and most obvious is efficiency improvements. The more efficiently a product can be produced, the less energy and materials will be used and hence the smaller the amount of GHGs produced. Potential for such improvements can be found in most manufacturing and energy production industries, but there is a catch: if you improve the efficiency with which, say, steel is produced, it becomes cheaper to produce and sell, and so more steel is likely to be sold. The net effect may be no decrease in GHG emissions, just an increase in company profits. So when considering employment that could improve process efficiency, it is important to look at the attitude of the company. Further analysis of this point, together with specific technologies that promote efficient, cleaner energy production are detailed in the SGR briefing: “Cleaner technologies: a positive choice.”

Careers that help to develop new, alternative technologies

Whilst energy-efficiency improvements are important, in the long run, such a path can only be successful if it is combined with a large-scale shift to renewable energy generation, for example from wind, solar, hydro or biomass sources. For a full account of current technological developments relating to renewable energy production and possible areas of opportunity, please again see "Cleaner Technologies: a positive choice."

On another note, there are a number of technologies that have been advocated to help tackle climate change, but which pose particular ethical problems of their own. The most obvious is nuclear power. While this technology leads to much lower emissions of GHGs (the only significant releases being during uranium mining and plant construction), the problems of safety, nuclear waste disposal, plant decommissioning and the inextricable link to plutonium production for nuclear weapons calls into question the desirability of such an option. Even from an economic perspective nuclear power is not very promising.

There are a number of other technological options that would cause ethical problems, for example, CO_2 capture and storage (collecting CO_2 emissions from power plants and injecting them into geological formations or dumping them at the bottom of the ocean) and geo-engineering (modifying the climate system to reduce human effects). All these technologies have the potential to lead to significant environmental damage if they do not work as expected.

Although not a technology, it is also worth mentioning the issue of forestry. Some have proposed large-scale reforestation to tackle climate change, as trees take up CO_2. While it is beneficial to increase the area of forest, this can only ever be a small aspect of a programme to reduce CO_2 levels due to limits on the land area available for re-growth. Nevertheless, there are important career opportunities in this area for ecologists and others.

Careers that promote economic solutions

The role of economic instruments in addressing climate change problems is growing. The most well known of these is probably the carbon tax, in which emissions of CO_2 are taxed. However, other measures include emissions trading (both national and international) and joint implementation.

Carbon taxes, in common with other pollution taxes, are based on the idea that the 'polluter pays'. If carbon taxes are implemented as part of *ecological tax reform*, the effects can be generally beneficial for society (so long as compensatory measures are taken to prevent any negative impact on the poorer sections of society). The process works by reducing taxes on employment (e.g. income tax) while at the same time increasing pollution (carbon) taxes, so that the overall tax burden is kept relatively constant. This means that labour intensive processes become cheaper (helping increase employment) while polluting processes become more expensive (helping decrease pollution/GHG emissions). Unfortunately, ecological tax reform has generally been opposed in much of Europe (including the UK) because the industries that pollute the most also make up a significant part of the European economy. However, things are slowly changing and the UK has recently introduced the Climate Change Levy, a tax on industrial fossil fuel use.

Another economic instrument based on the 'polluter pays' principle is emissions trading, in which a national emissions target is set, and emitting companies are allocated 'fractions' of the target, known as permits, which they can trade. For each period that the scheme operates the emissions of each company must equal the number of permits that they hold. Otherwise they are fined. The UK has recently introduced an emissions trading scheme for certain industrial sectors, which has been integrated with the Climate Change Levy. However, much work remains to be done by economic analysts to ensure that the systems operate properly and lead to the necessary reduction in GHG emissions.

Work is also required to implement a functioning international emissions trading scheme, agreed as part of the Kyoto Protocol. There will be a role for engineers and environmental scientists, as well as economists, in getting these economic instruments to work: reliable measurement of GHG emissions must form the basis of any scheme.

Other economic instruments that require more work include Joint Implementation (JI), which, like its sister the Clean Development Mechanism (CDM), involves a donor country funding an emissions reduction project in a host country and receiving credits for those emissions reductions. There are a number of controversies surrounding these instruments.

Much of the economic analysis of the issues surrounding climate change involves the use of a range of economic models, from those based on macro-economic principles ('top down' models) to those which integrate technological and micro-economic parameters ('bottom up' models). A particular problem here is that many of the underlying assumptions in models are political in nature and hence some of the models have become vehicles for vested interests to influence the policy process. For example, due to underlying assumptions, top down models tend to overestimate the costs associated with reducing GHG emissions, whilst bottom up models tend to underestimate them. It will be unsurprising to many that most economic modelling exercises carried out in the run up to the Kyoto negotiations in 1997 were of the top down type, and hence the alleged costs of reducing GHG emissions were exaggerated [11].

Careers that promote social or political solutions

While the measures for tackling climate change described above are important, they will not succeed if social and political change does not also happen. At least some scientists and engineers should ideally follow career paths in this area. For example, they could play a role in enforcing any legal measures, perhaps working for regulatory authorities such as the Environment Agency. This 'auditing' role is also useful when the targets are voluntary rather than mandatory.

Social and political change is a fertile area for research, both disciplinary and multi-disciplinary. Policy-relevant analysis of possible strategies to reduce GHG emissions is needed. Take food consumption as an example. Research carried out at the University of Surrey concluded that the energy required to transport all the UK's food imports was equivalent to that consumed by a large (1000 megawatt) power station [12]. Since virtually all of this transport leads to emission of GHGs, ways must be found of reducing this value. Clearly the solution will involve examination of a variety of issues, economic, environmental, and social, in order to encourage the consumption of more locally-produced food.

There are other similar examples of complex issues related to GHG emissions. Arguably the most well known is transport itself. Clearly, a large-scale shift away from car travel to public transport, cycling and walking is necessary, but how could such a shift be made acceptable?

Probably the most demanding challenge is that of reconciling economic growth and consumerism with the necessary major reductions of GHGs. While there is no universally agreed 'safe' level of global GHG emissions, a precautionary approach to climate change would require us to make a cut of at least 75% over the next 100 years to avoid most of the potential damage discussed earlier in this briefing [13]. A growing number of economists argue that nothing short of the total restructuring of the global economic system is necessary. However, others argue that this is neither possible nor necessary.

And we must not forget the issue of adaptation to the effects of climate change, which to some extent is already happening. Strategies on how to deal with the various changes are necessary, and once strategies have been formulated, they need to be communicated and discussed, both with policy makers and the public. Scientists also have an important role here, for example in policy formulation, political lobbying, public education, journalism and campaigning.

Concluding comments

Because of the far-reaching nature of the causes and effects of climate change, whatever your background, there is likely to be a job in your field that could help tackle the problem. One particular area of employment that is currently growing fast is environmental consultancy. Companies in this area most commonly employ environmental scientists, engineers and economists. However, as with many of the other employment options discussed in this briefing, it is important to be aware that some organisations you may work for or with will be more interested in presenting an environmentally friendly image rather than taking the steps necessary to become truly sustainable. Hence, it is important remain vigilant to ensure that your employment is helping to tackle the problem, not contribute to it.

References

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[12] Cowell, S & Parkinson, S (2003), Localisation of UK food production: an analysis using land area and energy as indicators, *Agriculture, Ecosystems & Environment*, Vol 94, p221-236.

[13] Taking a precautionary approach to climate change suggests we should try to prevent global temperature from rising by approximately 2°C above pre-industrial levels, which means atmospheric CO_2 concentrations should be stabilised at 450 parts per million. This requires a 75% cut in global emissions from current levels over the next century. For more explanation, see p19-23 (especially figure SPM-6) of IPCC (2001) Climate Change 2001: Synthesis Report, Summary for Policymakers, Intergovernmental Panel on Climate Change, http://www.ipcc.ch/pub/un/syreng/spm.pdf.

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Scientists for Global Responsibility SGR Promoting ethical science and technology

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SGR promotes ethical science and technology, i.e. that which contributes to peace, social justice and environmental sustainability. Our work involves research, education, lobbying and providing a support network for ethically-concerned scientists. Founded in 1992, we are an independent UK-based membership organisation.

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