CHRISTIAN STEWARDSHIP AND ENERGY SUSTAINABILITY

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REFLECTING UPON HUMAN PROGRESS AND INTERACTION WITH THE WORLD ENVIRONMENT UP TO THE END OF THE TWENTIETH CENTURY, A NUMBER OF THINGS ARE EVIDENT. Last century the world population increased from 1.6 to 6.0 billion people, while on average we each became four times better off.[1] This was enabled by increased food production, the availability of cheap energy, giving a thirteenfold increase in energy use, and the ready availability of fresh water in population centres. At the same time we changed the surface of the planet more than ever before, mainly through agriculture. We also caused massive pollution in many parts of the world but responded and reversed much of it.[2] A lot remains to be done and many challenges are before us.

A major test for Christians today is how we should use the Earth's resources – understood as God-given, part of his wonderful creation – in a virtuous, practical and sustained way to meet human needs. In this article I will focus on those resources that can be developed and deployed to meet people's energy needs.

Christian insights on stewardship of God's creation have much to contribute in enlightening the secular mindset, which tends to greed and selfish exploitation. These insights can also help counter narrow and extreme agendas that purport to protect the planet from the ravages of humans. But let us not overreact! God's provision is unbelievably abundant.

The sheer abundance of his provision for humankind cannot simply be enjoyed by us sitting back and being waited on. In fact, it furnishes us with many challenges in how we access and use the resources available to us. In relation to energy, it is clear that we need constraints on fossil fuel use if we are to reduce greenhouse gas emissions. Such constraints narrow the possibilities for electricity generation, which, worldwide, is the fastest growing form of energy, even though some two billion people have none and another two billion or more have very inadequate supplies.

WHAT ARE THE MOST SUSTAINABLE ENERGY OPTIONS?

Coal is abundant and reasonably widespread in the upper parts of the Earth's crust. It remains an important source of energy. Much of the known coal reserve, although accessible with current technology, is uneconomical to mine under foreseeable economic conditions, and concerns remain about the level of carbon dioxide emissions, although current proposals for clean coal technologies may change this outlook.

Natural gas is also abundant in some parts of the world. Present knowledge suggest that it is not as plentiful as coal. Scope for storage of gas is limited and its distribution through long pipelines means that increasingly there are the same sort of political and security of supply considerations as we have seen with oil since 1970 – countries located at the end of long pipelines that depend significantly on gas are very vulnerable.

Oil has been under the exploration spotlight more than any other mineral resource, and it is likely that the peak of its rate of usage will occur before 2020. There is no suggestion or plan to increase oil usage in any major area; rather, there is intensive effort to substitute other fuels for it as prices either rise or threaten to do so in the medium term. Hydrogen is the main candidate as a transport fuel, but many technical challenges remain before it can be widely available as a substitute for oil.

Uranium is ubiquitous on the Earth and has no other uses than concentrated energy production. The world's present-known resources of uranium, used only in conventional reactors, are enough to last for almost eighty years, and that is simply a statement about knowledge, not geology. Further exploration and higher prices will certainly, on the basis of present geological knowledge, yield further known economic resources as present ones are used up, and probably well in advance of that. Currently about one-fifth of uranium use is from recycled military warhead inventory – it lights one in ten US light bulbs.[3]

Nuclear energy is a fascinating area for Christian reflection. Little creativity was required for humans to learn how to burn fossil fuels, but learning how to 'burn' uranium controllably was a technological feat of some magnitude, accelerated by wartime priorities focused on explosives. Yet, in creating the universe, God had done it already.

While the genesis of nuclear technology in weapons of war confers ongoing moral ambiguity in the eyes of some people, a more basic consideration is the proposition that there is nothing worthless in all of creation, and if anything seems superfluous it may be because we are yet to work out its true purpose. With uranium, we clearly have an important purpose,[4] so in the context of God's creation provision it is obviously not redundant.

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NOTES

1 Measured by average per capita Gross Domestic Product.

2 John R McNeill, *Something New Under the Sun: An Environmental History of the Twentieth Century* (London: Penguin, 2001) provides an excellent environmental overview of the last century.

3 There is an interesting echo here of Ezekiel 39, where the people of God utilise as fuel the figurative enemy's weapons of war after God acts to remove the military threat: 'For seven years they will use them for fuel. They will not need to gather wood ... because they will use the weapons for fuel' (vv. 9–10).

4 The focus here is on energy, notably electricity, but uranium used in nuclear reactors is also the basis of most nuclear medicine and a host of industrial radioisotope uses.

5 Only Russia is currently operating a commercial-scale reactor of this kind, but future international plans give this technology a major role.

6 From a typical 1000 MWe power unit operating for one year the quantities of wastes are about 200 m3 of low-level wastes (requiring no shielding to be handled), about 70 m3 of intermediate-level wastes (requiring shielding) and 10 m3 of used fuel (requiring shielding and cooling) or 2.5 m3 if as vitrified high-level waste from reprocessing that used fuel.

7 It is much more in UK due to British Energy's contracts with British Nuclear Group which were part of the privatisation set-up in 1996.

8 The UK historical situation is unique, at least outside of Russia.

9 This and the 158 MWe Nysted offshore wind farm project are the survivors of cutbacks from five such wind farms by the new Danish government early in 2002.

►ELECTRICITY

Returning to the focus on electricity, most demand is for continuous, reliable supply on a large scale. More than half of this worldwide is now provided by fossil fuels, notably coal. If we turn away from these because of concern about greenhouse gas emissions, the possibilities are largely nuclear and hydro, with wind providing a useful supplement when it can. There is little scope for increasing hydro capacity, so the focus shifts to nuclear power as an important part of the energy mix. Providentially, this is a mature technology right when we most need it, with a fifty year history and more than 12,000 reactor-years of civil operational experience (plus about the same in naval experience, which is relevant).

Like fossil fuels and renewable sources, nuclear power and uranium are a God-given resource. The question is how, not whether, we use them. Faithful stewardship of God's creation (not merely the 'green' parts) involves more than climbing aboard bandwagons that are based more on neo-romanticism than theology. Both nuclear fission and radioactivity (the decay of certain kinds of atoms) are part of God's creation. The first nuclear energy appears to have been generated naturally about two billion years ago in a uranium deposit in West Africa (now Oklo, Gabon). Some natural kinds (isotopes) of a number of elements forming part of the Earth are radioactive, also many which result from the fission process are radioactive as they decay towards stable forms.

At the level of the uranium atom one discerns the remarkable fact that when one fissions, some of the energy release is delayed, enabling very sensitive and precise control of the reaction in a power station (otherwise it would be more suited to bombs). Nuclear fission produces a lot of energy from a small amount of material (20,000 times as much if comparing natural uranium with coal, or 160,000 times as much for the actual respective fuels). It is hard not to see God's provision in all of this!

The dynamics of the Earth's crust largely depend on radiogenic decay, and the primary source of energy driving convection in the mantle beneath is radioactive decay of uranium, thorium and potassium (today, mostly the first). Hot rocks a few kilometres underground are the latest focus of attention as renewable energy; again, it is radiogenic decay that produces that extra heat, making it a potentially usable resource. Of course, the Sun is a large nuclear reactor, albeit fusion, not fission!

The resource base in the Earth for long-term use of nuclear power is excellent. The development of well-proven but currently uneconomic fast neutron reactors means we will be able to get about 60 times as much energy out of the raw uranium as we do today.[5] This is another extraordinary aspect of God's provision.

The wastes from nuclear power are contained and managed, not dispersed to the environment, and this is a significant ethical feature of the technology. The amounts concerned are modest, and from newer reactors, they are less again. Compared with any other process involving the conversion of fuels to energy the quantities of hazardous residues are very small.[6] In Europe, radioactive wastes (including those from medicine, etc.) comprise about 1 per cent of all toxic industrial wastes, and the other 99 per cent do not become more benign with age – the radioactivity of spent fuel diminishes to 0.1 per cent of original after about 40 years, providing a strong incentive to store it for this period. There have been no significant problems from storage, handling and transport of civil nuclear wastes in the first 50 years of industry experience, which provides some basis for confidence in the future, given that waste management is very straightforward. A petrol or industrial chemical tanker on a British road is more of a public safety hazard than any nuclear waste in transit anywhere in the world.

Waste management and disposal cost is internalised at about one fortieth of generation cost.[7] Technically, storage and disposal are straightforward. Decommissioning costs are also normally met from a levy on current production, and in most cases the amount of that has been found more than adequate as experience has caught up with projections.[8] Political problems regarding sites for geological disposal do hamper the industry though – 'not in my backyard' being a ubiquitous social reflex, especially in the UK. That is a challenge for people of principle and integrity in the political process, and one which merits attention from Christians.

Considering the whole nuclear fuel cycle, from mining through enrichment to waste disposal, there are some carbon emissions, but they are usually less than two per cent of those from coal. Nuclear is essentially carbon-free. Audited life cycle figures are available for several plants and range from 3 to over 20 g/kWh CO_2. Energy inputs to the whole fuel cycle are less than two percent of output (up to 3 per cent if postulating very low grade ores).

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Renewed attention to nuclear power is driven by three factors: improving the basic economics (due both to higher fossil-fuel prices and improvements in nuclear technology), the prospect of carbon emission costs on fossil-fuelled alternatives, and energy security. The last two considerations apply also to renewables, but wind and sun cannot provide the continuous reliable supply available from nuclear and coal-fired plants, so require substantial backup capacity to be built, typically gas-fired. Also, above a modest level, their input is very difficult to manage in a grid system.

A major challenge for our future use of energy is to stabilise carbon dioxide concentrations in the atmosphere. This will require reducing emissions during this century to a fraction of present levels. Reductions must be global, and should be equitable. The Kyoto Protocol is an important first step in this, but developing nations must also become involved. International trading in rights to emit carbon dioxide will be one step in this.

Harnessing renewable energy is an appropriate first consideration in sustainable development, because apart from constructing the plant, there is no depletion of mineral resources for fuel and no direct air or water pollution. In contrast to the situation even a few decades ago, we now have the technology to access wind on a significant scale, for electricity. But harnessing these 'free' sources cannot be the only option. For one thing they are heavily subsidised, and as their use grows such subsidies will become less affordable. This was brought home in 2002 in Denmark, when subsidy arrangements for the development of further wind capacity beyond two particular offshore wind farms were terminated. More fundamentally, renewable sources other than hydro – notably wind and solar, are diffuse, intermittent, and unreliable by nature of their occurrence.

Wind is the fastest-growing source of electricity in many countries, albeit from a low base, and there is a lot of scope for further expansion. While it has been exciting to see the rapid expansion of wind turbines in many countries, capacity is seldom more than 30 per cent utilised over the course of a year, which testifies to the unreliability of the source and the fact that it does not and cannot match the pattern of demand.

A further, and rapidly increasing constraint, is the aesthetic acceptability of numerous wind turbines on landscape (often scenic areas including national parks and similar). In the UK this is already placing severe, and perhaps terminal, limitations on the expansion of wind generation on land. In Europe large new wind farms are offshore (e.g. Denmark's 160 MWe Horns Rev wind farm, with 80 turbines covering 20 square kilometres[9]).

Returning to the need to limit carbon dioxide emissions, doubling the world's nuclear contribution would eliminate a quarter to a third of the carbon dioxide emissions from power generation. Furthermore, this could be achieved relatively quickly. In 1984, 39 nuclear reactors came on line in a single year, so it is not hard to imagine that over a decade, plus a bit of lead time, the present nuclear capacity could be more than doubled.

If the newly announced Global Nuclear Energy Partnership, led by the USA, attracts full international support we will see this expansion occurring at the same time as weapons proliferation concerns are sharply reduced – Iran's two decades of evasion under the Nuclear Non-Proliferation Treaty and its subsequent intransigence will have achieved a major paradigm shift towards greater security and better use of resources.

Ten years ago the environmental lobby was noisy in opposition, today you have some of the world's highest profile environmentalists speaking very clearly for nuclear power, not because they love it, but because it represents much less of a problem or threat than global warming. The great question before us is not whether nuclear energy will grow, but whether it will grow rapidly enough to play its needed role. For example, Patrick Moore, a founder of Greenpeace, says, 'we need not 440 nuclear reactors but maybe 5000 … to really make a dent in (consumption of) fossil fuels'.

Today's concerns about global warming from a build-up of greenhouse gases simply underline the felicitous coincidence of virtue and necessity regarding the future of nuclear power, not only for electricity and uses such as desalination, but also probably for hydrogen production. This underlines the need to approach with intelligent respect what God has provided and work out what faithful stewardship means in practice to meet the needs of six billion people.