WORLD RESOURCES and THE ENERGY CRISIS

Horace Sanders

We are rapidly approaching the position where increases in demand for the fluid hydrocarbons, oil and gas can be met only by discovering new geological sources commercially viable for extraction and refining. The problem is compounded by the necessity to control their combustion and limit the release into the atmosphere of exhaust gases which retard infrared radiation - the greenhouse gases, mainly carbon dioxide but also methane and oxides of nitrogen.

World population has increased six fold in the last hundred years and is expected to increase exponentially. This alone will demand a perpetual increase in all forms of energy. Even more insistent perhaps are the claims for rapid increases in the standard of living in the undeveloped countries, where expectations are being realised on an unprecedented scale. Are the world's remaining mineral and biological resources sufficient to meet these demands, and what limitations will apply?

SALIENT FACTS

On the problem of efficiency, it is useful to consider what takes place in a coal or oil fired power station. High pressure steam is raised in boilers and drives a turbine, the rotor of which is directly coupled to that of the electric generator to maintain constant rotational speed. In the process chemical energy is released in the form of heat, which is then transformed to mechanical force and from that to electrical energy. At each transfer there are inevitable losses. To these must be added transmission losses in the overhead lines and also in the local distribution network with its transformers and underground cables.

By using larger diameter conductors the resistance losses could be reduced, but in the case of overhead lines it would need more rigid supporting masts more closely spaced, with corresponding impairment of the landscape and higher capital costs. All these losses finish up by warming the surrounding atmosphere, known in the engineering trade as "heat for the birds". All engineering is a compromise, with safety paramount, applying equally to the use of power as well as to its generation.

RENEWABLE ENERGY SOURCES

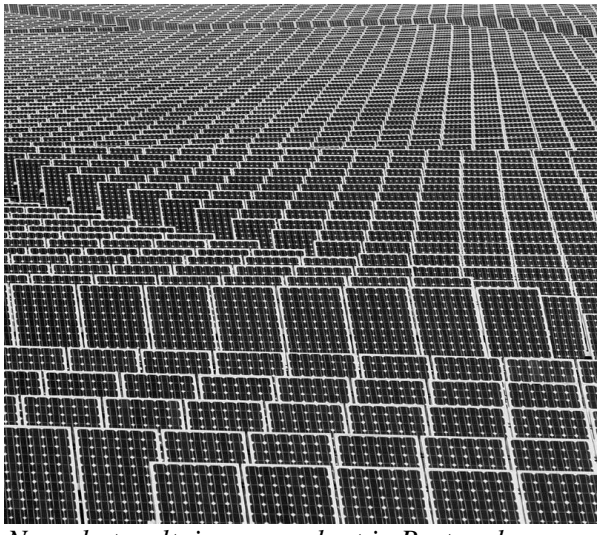
Of these the most reliable is hydroelectric with turbine generators located below storage dams. It provides 5% of total global energy and as much as 90% of all energy from renewables.

Geothermal energy depends upon available hot spots, generally in regions of volcanic activity, as in Iceland. It contributes about 0.4% of world power.

Bio energy is making a contribution for the production of ethyl alcohol as a supplement to petrol but already there is controversy on the extent to which agricultural land for food production is being diverted and whether deforestation is taking place. The opening up of virgin land releases methane and carbon dioxide.

Solar Cells

Solar cells convert less than 15% of the radiation they receive to electricity, and their size is limited to about 8 cm in diameter. In packs they can readily be mounted on buildings to supplement power from the mains. They are expensive, with



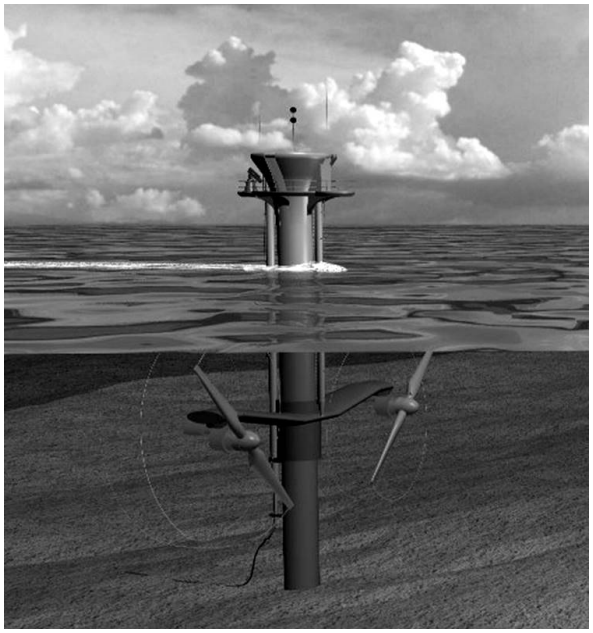
New photovoltaic power plant in Portugal

silicon chip mounts doped with some of the lesser known elements such as Indium, Selenium and Thorium. Further research is needed to reduce their cost to about a fifth before the idea of mounting large arrays of them in sunlight locations such as deserts, and transmitting the current over long distances can be viable. The sun radiates at over a kilowatt per square metre of the earth's surface, vastly in excess of our need. The

energy is there for the taking.

Solar Water Heaters
These are banks of tubes through which water is pumped to supply hot water to a building. Mounted on the roof they are simple and reliable but clearly depend upon the extent of the sun's radiation being received.

Tidal Power
On a more ambitious and enterprising scale we have seriously to consider tidal power, for which we are favourably placed; the Severn Estuary having the second highest tide range in the world. It would mean engineering on a grand scale.



Possible design for capturing tidal energy

There is of course mounting opposition from those concerned with the environment and other interests who claim that it would be both too costly and damaging for the estimated 5% of the UK's total power it would provide.

LIMITATIONS
Of the above power sources only hydroelectric can be relied upon to provide uninterrupted supply, depending upon rainfall and reservoir capacity. The wind is fickle and varies in both strength and direction.

Solar cells can operate only during daylight hours when the sun is at least 15 degrees above the horizon, and not too obscured by cloud.

Tidal power is restricted during the periods of ebb and flow at both high and low tides. These restrictions mean that during the periods when power from renewables is reduced the deficit will have to be supplied from conventional power stations. Steam turbines cannot be brought on load immediately. For this, standby generators can be powered with internal combustion turbines. These are similar to those on propeller driven aircraft.

Nuclear power is carbon free. However carbon costs are entailed in the production and installation of each plant, in the processing of uranium for enrichment, and in the ultimate dismantling, as well as the safe disposal of radioactive waste. The most recent nuclear generator in USA is claimed to be operating at 90% efficiency! In relation to population France leads the world with 59 generators providing 78% of its power. Following the Chernobyl disaster it is claimed that all nuclear generators have built-in automatic shutdown covering operator error or walk-away.

With almost 500 nuclear power stations in operation and more planned (China alone intends to build another 60) there is great demand for pitchblende uranium oxide, the main ore. The main suppliers are Australia, Brazil, and Russia. It seems unlikely that world resources will be unable to meet the demand at the moment, though the mines are deep and radiation is a problem.

Geologists here in the UK, USA, France, Sweden and Finland are cooperating to decide upon the most suitable sites for safe burial of nuclear waste. This requires strata free from tectonic or thermal disturbance and with no possibility of water reaching the surface and for these conditions to be maintained until radioactivity of the waste has fallen to safe levels.

Here our ageing coal and gas fired power stations will have to be replaced to ensure continuity of supply and to meet increasing demand. The decision to go nuclear for at least one station appears to be logical. This avoids commitment to use oil or gas with the now certainty of further price increases. More importantly the power generation will be carbon free.

Opinions on nuclear energy seem to reflect professional background. Most scientists hold the view that it is the only solution if we are to provide the energy the developing world will demand, whilst keeping within the critical limit of 450ppm of carbon dioxide in the atmosphere.

Those in the legal and political professions tend to be more cautious, on the grounds of cost, safety and a general mistrust of technical innovation.

COAL

In a recent issue of the Magazine of The Geological Society of London David Strachan writes under the title of “Cold Comfort", "Depending on your standpoint, coal represents either a massive threat to the climate, or a potentially vital substitute fuel as global oil production heads to terminal decline. Either way it is commonly agreed that the coal will last for well over a century. But a number of recent reports suggest that the coal reserves may be hugely over-inflated, with profound implications for both oil depletion and global warming debates."

The price of coal has quintupled since 2002; one reason being that the industry has already produced most of the easily mined coal. In China for example, the world’s largest producer, much of remaining coal is more than a km below the surface. A recently revised estimate of world coal reserve is 450 gigatonnes.

OIL SANDS

Canada's oil sands are an enormous resource of the heavier hydrocarbons, mainly bitumen. The sands were deposited in the early Cretaceous, the oil having migrated from older rocks far to the west. It is estimated that there are more than one trillion barrels of it, but mostly too deep for mining. Extraction is by drilling wells in close proximity, down which steam or hot water are forced to reduce the viscosity, allowing it to be pumped. It is then treated on the surface by adding lighter oils, bringing it to the grade of marketable crude. Production reached 1.1 million barrels per day in 2006, bringing Canada to seventh place in the world’s largest oil producers. Not generally known is that Estonia produces its electricity from oil sands, mainly by open cast extraction. The deposit is Ordovician as revealed by fossil graptolites and conodonts. Output is about 13 million tonnes a year. It is said that it was first used by shepherds who light fires at night whilst guarding their flock. The oil sands or shales in Canada, Australia, Brazil, USA, China and Russia are a possible source of energy estimated to exceed all known oil reserves: there is every incentive therefore to develop more effective and cleaner methods of extraction.

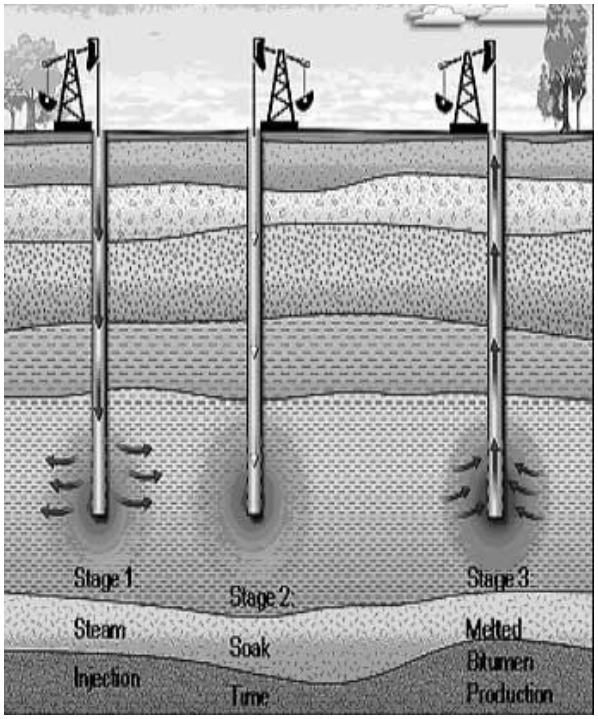


Diagram shows bitumen extraction using cyclic steam stimulation

CARBON CAPTURE AND STORAGE

In the October 2007 issue of Chemistry World the geologist Professor Stuart Hazeldine set out the Fundamental problems of removing carbon dioxide from the flue gases of power stations, particularly those burning coal, the most contaminating of all the hydrocarbon fuels. In addition to carbon dioxide these contain about 80% of nitrogen, residual from the combustion air. Clearly this cannot be stored with the carbon dioxide which must therefore be extracted. A proven method is by dissolving it in organic liquids called amines. After cooling, the exhaust gases are passed vertically up tall scrubbing towers from the tops of which the amine falls as droplets or rain. When the amine solution approaches saturation the unit is taken off stream and the gases are diverted through an identical unit. The amine from the first is then heated to 140°C to expel the carbon dioxide which is then chilled and liquefied under pressure. It will then be transported in special containers to a selected geological site at least 800 metres deep for what is hoped will be permanent storage.

Design layouts of plant of this magnitude reveal its formidable size and complexity, perhaps approaching that of the power station itself, and consuming as much as 30% of the power generated; clearly not commercially viable. Research is being heavily funded, so vital is the need to find an effective solution to the problem.

This is being intensively undertaken in Australia, China, France Germany, Norway, Russia, UK, and USA. A small experimental plant is operating near Bergen at the Norwegian Statoil Refinery. There has been a recent setback in the USA Congress having called a halt to the construction of a CCS plant which was intended to go into service on a new power station in Illinois. Meanwhile coal burning power stations are being constructed worldwide in the expectation that CCS can be "bolted on later". How much later remains to be seen.

Stuart Hazeldine concludes his article referred to above - “It will not be the nuclear plant, or the renewables such as wind or water power, or even the first generation of CCS plants which reduce world carbon dioxide. It will be the improved second generation that begins the process, and the standard deployment of third generation CCS by 2020 at the latest which could make a real impact. By that stage we will surely know if it is too late to avoid unprecedented and unpredictable effects in our living environment".

As an example of the confusion and conflict surrounding the problem, it has just been announced that, with the help of World Bank financing, the world's biggest coal fired power station is to be built for Tata in India. It will be without carbon capture, discharging 25.7 million tonnes/ year of carbon dioxide in atmosphere. Inexplicably it has been cleared by the U.N as “Clean Power" thereby enabling Tata to sell carbon credits to the West.

Failure to keep within the limits of carbon dioxide, as agreed at Kyoto increases the risk of a temperature rise of 3 degrees or more, at which positive feedback can set in, such as the melting of the permafrost in the tundra, releasing vast quantities of carbon dioxide and methane, taking global heating beyond control.

LOOKING AHEAD

Responsibility for the control of climate change rests mainly with the developed and more prosperous nations. What is in doubt is the political will and courage of their governments to confront the people with the harsh facts. These are that climate control will demand effort which will seriously impinge upon the ways in which we live and work and an inevitable reduction in living standards.

Historians of the future may look back on the period from the middle of the nineteenth century to the present day as the era in which the world's geological store of solar energy, in the form of fossilised hydrocarbons, was ruthlessly and irresponsibly squandered and that the approach of their depletion marked the beginning of great changes in energy use. These had profound effects, economically and socially.

Information sources:

The Hot Topic - Gabrielle Walker and Sir David King. A comprehensive review of all aspects of energy and climate change problems. Invaluable as a reference book for all who are actively engaged.

Global Environments Through the Quaternary. D.E.Anderson, A.S.Goudie and A.G.Parker. With strict
scientific discipline they explore every aspect of climate change during the past 2m years.

Journals:

Geoscientist
Geology Today
Chemistry World
The New Scientist

GEOLOGISTS ‘FLAVOUR OF THE MONTH’ in USA

Geologists, it seems are the new superheroes of the American job market. According to Ian Leonard of the daily Telegraph, it’s no longer just oil that has made geologists as valuable as gold dust, but the soaring prices for copper, silver and gold. Geology graduates in the United States it seems are now receiving higher average starting salaries than people with Harvard MBAs. Immigration experts report that if there is any other occupation more guaranteed to speed your entry into America they have yet to hear of it.

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