Block 4 - 2 Summaries

Section 2

1. Nuclear power generation in reactors results from the accelerated fission of heavy uranium isotopes when bombarded by neutrons. Conventional burner reactors such as Magnox, AGR's and PWR's require the relatively scarce uranium-235 isotope, whereas fast breeder reactors (which have still not been developed on any significant scale) would exploit the more abundant uranium-238. Magnox reactors use uranium metal fuel rods with the natural 235/238 ratio, whereas AGR's and PWR's use uranium oxide fuels enriched in the 235 isotope

2. In the early 1990's there were over 400 electricity-generating nuclear reactors in operation around the world producing 16% of global electricity demand. The main producers are the USA, France, the Former Soviet Republics, Japan and Germany

3. The UK played a leading role in nuclear power developments with its 1950s Magnox programme. During the 1970s, new more efficient reactor designs led to the proliferation of AGR's in the UK and PWR's and other analogous reactors overseas. Progress was slowed in the late 1970's as concern grew over the operational safety of nuclear reactors. Of the ten British PWR's planned in 1980s only one survived (Sizewell B) survived the planning enquiries

4. Even excluding the costs of decommissioning reactors and managing radioactive waste, nuclear over in the UK is probably more expensive than power from fossil fuels. Nevertheless, arguments that nuclear power generation produces virtually no carbon and sulphur gases, combined with technological improvements, weigh in favour of its further development

5. The principal geochemical characteristics that determine the distribution and concentration of uranium to form ore deposits: (a) the large charge and size of uranium ions, which makes uranium an incompatible element that is concentrated by fractional crystallization and partial melting, and so is abundant in granitic rocks; (b) the much greater solubility of $U6+$ than of $U4+$ in surface environments which promotes uranium transport in oxidising groundwaters and deposition from reducing groundwaters.

6. Uranium deposits formed by internal processes (e.g. disseminated magmatic and hydrothermal vein deposits) are termed ‘primary’ those formed by surface processes (e.g. sandstone-hosted and quartz-pebble conglomerate deposits) are termed secondary

7. The relatively high costs of underground compared with open-pit mining for uranium can be off set by differences in ore grade. However, the 1980s slump in uranium prices, consequent on the lower-than-anticipated growth in nuclear power demand, led to many deposits becoming uneconomic and to a stockpiled surplus of uranium

8. Current estimates of reasonably assured and estimated additional uranium resources at less than $130kg-1 total about 3.5 million tonnes. Even if an OECD model predicting expansion of world nuclear power generation to 600GW by the year 2030 was to happen, the fuel required could be supplied from these reserves alone.

9. Public concerns about nuclear reactor safety were exacerbated in 19856 when automated safety procedures at the Chernobyl reactor were overridden during tests, leading to a massive explosion and the widespread atmospheric dispersion of radioactive contamination over most of Europe. The probability of death due to cancers was increased for millions of people

10. The intensity of radiation is greater from radioactive isotopes with short half lives (fission products) than from those with long half lives (uranium and plutonium). The processing and reprocessing of nuclear fuels, and particularly of spent fuels rods, therefore constitute a potential hazard to those living nearby, though as at 1995 this had been tentatively linked to only to increased incidences of childhood leukaemia. The small, but finite risk of accidents at facilities such as the controversial THORP plant on the Sellafield site could be much more serious

11. Plans to dispose of radioactive waste by burial in the UK have had a chequered history, and plans to bury high-level wastes (HLW) have been postponed indefinitely. A succession of NIREX proposals for the burial of intermediate and low level wastes (ILW & LLW) met with stubborn and well-informed local opposition leading, ultimately, to a retreat in favour of ‘nuclear oases’ The

economically favoured solution, a deep repository at Sellafield, suffers from questionable hydrological conditions.

12. The problem of radioactive waste disposal is equally acute in several other countries where spent fuel rods are accumulating rapidly.

Section 3

1. Traditionally, “renewable” geothermal energy has been exploited by drilling wells into high pressure aquifers from which steam can be produced at pressures of a few tens of atmospheres. Steam-dominated systems in hyperthermal volcanic areas are generally more efficient and economic, though water-dominated systems and, increasingly, cooler geothermal fluids on the flanks of hyperthermal areas are used for power generation

2. Electricity generation from hyperthermal areas was 5.8GW in the early 1990s with a further 4.1GW equivalent coming from direct uses of geothermal energy (steam and hot water). Geothermal power currently represents about 0.3% of the worlds electrical needs, a figure that could grow to a few per cent in the next few decades, especially if the relatively non-polluting nature of geothermal technology becomes an important factor

3. Geothermal resources in semi- thermal areas include hot water, used for domestic and industrial space heating etc, which is pumped from aquifers in sedimentary basins, where temperature gradients are enhanced owing to the presence of low conductivity rocks in the sedimentary sequence. Twin production and reinjection wells are used to “mine” the heat and a single system (as in the Paris Basin area) is designed to supply a heat load, typically with 3-5MW of heat energy over 30-50 years

4. Hot rock geothermal resources depend on extracting the energy from granite areas by the creation of an artificial aquifer. HDR technology has been the subject of much recent research and development, but has yet to be perfected to the point where these systems look attractive economically. Key aspects to be investigated

are the stimulation of good long-term heat transfer surfaces underground and the reduction of water losses

Section 4

Table 6 – total annual energy produced globally by alternative energy sources- Page 81

1. Surface energy resources include those derived by exploitation of solar radiation either directly, or indirectly through biomass, wind, hydroelectric and wave sources. The last two depend also on the Earth's gravitational forces. Tidal power depends on only gravitational interaction with the Sun and Moon

2. of the above energy sources, only hydropower was making a significant contribution to global or UK energy supply in the early 1990s, but most of them have considerable potential for power generation at economic rates; wind power in particular has shown rapid development in some regions (as has geothermal power generation; section3)

3. Large scale conversion of solar energy to electricity, whether by means of focusing collectors (heliostats) or by photovoltaic cells, is not likely to be an economic proposition in the foreseeable future. However, the increasing small-scale use of flat-plate solar collectors for water and space heating, and of photovoltaic solar cells to generate electricity for individual buildings and local communities, can raises living standards in developing countries and could significantly reduce dependence on fossil fuels and nuclear power. The biomass energy potential is vast and, with appropriate investment and lead time, growing biomass energy crops to produce storable and transportable fuels could replace much of the demand for conventional energy resources. In industrialised countries there is increasing focus on incineration of biomass and on extracting "biofuels" (especially biogas) from organic refuse.

4. Although the power produced by wind turbines varies as the cube of the wind speed, wind is relatively “dilute” energy source, because air has low density. The largest wind generators can produce about 3MW of electrical power, and are competitive with electricity form conventional sources, but large wind farms are needed to generate electricity on any significant scale.

5. The power output of hydroelectric schemes depends on the working head and the discharge rate; therefore, such schemes are developed ideally in mountainous regions (large head) or through estuarial barrages (exploiting large tidal discharges) The large scale hydropower potential of mountainous regions in the uk and a number of other European countries has already been realised (about $5 \times 10^{16} Jy^{-1}$) but the potential for small scale use of hydroelectricity is enormous.

6. The Severn estuary is one of the few ideal sites on a global scale for developing tidal power, with a peak output potential exceeding 7000MW ($22 \times 10^{16} Jy^{-1}$) However the huge investment and long lead times of tidal barrage schemes has prevented large-scale use of tidal energy.

7. Harnessing wave energy is more difficult technically than tidal or hydropower conversion, requiring complex converters. Because wave energy is a “dilute” energy source, large arrays of converters would be required for significant levels of power generation

<u>Section 5</u>

1. The UK Government’s pit closure plan in late 1992 provided a classic example of how a high value resource can be rendered worthless overnight by economic and political factors that are independent of geological availability. Such abrupt changes make forward planning difficult, especially in the energy industries.

2. Energy planning or forecasting must take into account not only the magnitude of possible future demand but also the availability of energy sources to provide it. In

practice, most scenarios are either *historical,* making use of past trends and extrapolating them, or *technological fix,* having regard to development of more efficient ways of using and conserving energy. They are not mutually exclusive, and optimum forecasting is achieved by making use of both approaches.

3. Forecasting is especially necessary for electricity because of long lead times for building power stations, and because the electricity supply industry must have a range of different types of plant to cope with fluctuations in demand, both daily and seasonal. It must also have excess demand. The base load is normally supplied by nuclear power stations because they are not easily closed down for short periods.

4. No matter how carefully scenarios of future energy (or other resource) use are compiled, unforeseen political, economic and technological developments almost invariably render them inaccurate after a few years. For example, projected large increases in coal and nuclear energy in the UK by the year 2000, made in the late 1970s, could not have anticipated the effects of the miner's strike of 1984-5 or of the Chernobyl disaster in 1986. An earlier forecast of exponential increase in replacement of coal by oil as the dominant fossil fuel, made in the early 1970s, could not have been anticipated the oil price rises of the mid 1970s.

5. Energy demand can be limiting by improving efficiency of conversion if energy (more fuel-efficient engines etc) and by taking energy conservation measures. (e.g. house insulation, vehicle speed limits, more public transport) CHP schemes can be up to 90% efficient, compared with 30% for conventional power stations

6. Available energy sources all have drawbacks which limit their usefulness. Fossil fuels contribute to global warming and acid rain; nuclear fuels produce radioactive wastes; most "alternatives" (renewables) require large areas of land and do not provide transportable fuels. Nuclear fusion and/or an energy economy based on hydrogen could provide almost limitless "clean" energy.

7. Sustainable development in relation to energy resources must eventually mean doing without fossil and nuclear fuels, and relying on renewable energy, including hydrogen. This would entail also massive reductions in energy consumption and great improvements in energy efficiency