Renewable Energy: ethical, scientific and technological debate

Energy is at the heart of Creation. Energy supply sustains all aspects of life within our ecological world. This Briefing Paper considers why we need energy supply, the environmental dilemma, and the options. Questions are put for discussion, since the problems are complex and conclusions varied. One conclusion is that ***Renewable Energy*** *must (i)* ***urgently replace most fossil fuel use****, (ii)* ***be increasingly implemented for development, environment and sustainability****. The technology, economics and politics of renewables have equal importance. Perhaps the greatest challenge is for* ***individuals and organisations*** *to make choices within their own responsibilities.*

Middelgrunden, a 40,000 KW wind farm offshore from Copenhagen, provides sufficient annual electricity for about 15,000 homes. Owned by a co-operative of 8,500 members, it has 20 turbines, with rotor diameters of 76 m.

'Let heaven and earth praise God, the seas and all that move in them' Psalm 69 verse 4

The importance of energy

Energy supply has immense benefit, but the sheer scale of present global demand does increasing harm, especially from pollutant emissions and other adverse environmental impacts. Per capita commercial energy use in the USA is twice that in the UK, which is 50 times that of parts of central Africa. Resulting financial benefit and harmful emissions are in similar proportions. Is the disparity an economic imperative or inefficient greed? What is a fair allocation? In fuel poverty people die from lack of warmth; women exhaust themselves obtaining firewood, then breathe the carcinogenic smoke. Transport is essential, but what of the air pollution? Wealth and health require energy supply. Tourism and leisure squander energy with abandon. Should I limit my excess so others with none may have some? But how can I pass my excess to others? Are there clean forms of energy supply? It is often said that such environmental challenges are 'a moral equivalent of war'; only co-ordinated and unselfish commitment can obtain success.

***Discussion**: Of the energy we purchase, how much is wasted through inefficiency and lack of conservation?*

Nothing lives, moves, communicates, cooks, heats, manufactures or produces without a supply of energy. Energy supply is the life-blood of existence. We all have a responsibility to ensure that energy is available, without harm, for our families, our communities and our 'global' neighbours. Likewise governments and commerce must facilitate energy supply for the present and future sustainability of nations. We need not panic however, since ample supplies of clean energy are part of the sustainable processes within creation. If we understand how this occurs 'naturally', we will know how our technological life may operate now and 'for ever'.

Life on Earth depends on the Sun; and on being 150 million km from it! The Sun's surface temperature of 6,300 ^{o}C emits energy as visible and 'nearly visible' light radiation. Such radiation is ideal for initiating moderate electro-chemical processes, so enabling eyes to see and plants to grow. Also, solar radiation heats. So the Earth is kept within the range of temperature necessary for life because of the amount of sunshine and the Sun-Earth distance. Therefore an appreciation of solar energy is vital to understand sustainability and wonder at mankind's place in ecology.

***Discussion**: Read the label of a breakfast cereals packet to discover the energy our bodies need. Compare this with your use of electricity per day. (Clue: 1 kilowatt hour = 3,600 kilo joules = how many helpings of cereal?)*

The essential role of the atmosphere

Control By itself, the Earth's surface cannot provide the controlled environment necessary for our ecology. Life would overheat beyond boiling in daytime and freeze to death at night. It is our atmosphere that moderates the sunshine, controls that temperature regime and provides oxygen for the energy of metabolism and combustion. Moreover, the life that depends on this atmosphere itself maintains essential atmospheric components.

Content Initially, over 4 billion years ago, the Earth's atmosphere was about 99% by volume carbon dioxide (CO_2), with no oxygen gas (O_2). Heat emitted from the Earth's surface as infrared radiation is absorbed by CO_2, and by other molecules with 3 or more atoms, and so this initial atmosphere kept the Earth too hot for life as we know it now. Then, in the next 3 billion years, anaerobic (i.e. not requiring oxygen) microbiological life removed almost all CO_2 from the atmosphere, binding the carbon within solids and solutions. Most carbon was therefore sequestered (removed) from the atmosphere. The previously inert atmosphere was replaced by the present active atmosphere of oxygen (19% by volume), nitrogen (80%) and certain trace gases. CO_2 was drastically reduced from 99% to less than 0.025%, sufficient however to be absorbed by plants in photosynthetic growth and to be a key component in atmospheric temperature control. This renewed atmosphere could then sustain present life, including humans, by controlling temperature, so allowing water to be liquid, providing oxygen for energy and enabling other essential functions. This situation was controlled by ecology, which constantly corrects for changes, but only within limits. It is arguable that mankind today may be causing these limits to be exceeded, so perturbing control mechanisms. For instance, in the last 150 years, fossil fuel use and forest burning has increased CO_2 by 40% to a concentration of 0.035%.

Carbon removed The removed carbon was sequestered mostly as dead plants and micro-organisms to become limestone, chalk and fossil fuels. It is essential for present life that the vast majority of 'buried carbon' remains out of the atmosphere. If just 0.03% of 'buried carbon' is returned to remain in the atmosphere, atmospheric CO_2 concentration would double, with damaging results from climate change. Moreover, the combustion of fossil fuels produces pollutants other than carbon dioxide. It is clear therefore that ecological life, including human, exists because the majority of the Earth's carbon, including fossil fuels, was buried billions of years ago; it is equally clear that returning excess carbon to the atmosphere at present rates (mostly by escalating fossil fuel use, but also by forest burning) is a cause of climate change and a disruption to present life (see JRI Briefing Paper No 2 Global Pollution and Climate Change). The natural ecological control of atmospheric gases is now unable to correct for the rapidity of change through mankind's excesses.

> ***Discussion**: How do we depend on plants and microbiological organisms? Are these a cause for wonder and thanksgiving?*
>
> ***Discussion**: What are the benefits and disbenefits of utilising coal, oil and fossil gas? Have these factors changed over the last 200 years? Who really needs to use fossil fuels and how much?*

What of nuclear power?

Radioactive materials dispersed within the Earth's structure, produce sufficient heat to prevent the inner core from cooling; however this important flux of heat is much less than solar heat. The dispersed and buried nature of the material overwhelmingly prevents the radioactivity from affecting organic life. Likewise the relatively small amounts used so beneficially in medicine and instrumentation may be controlled and used safely. However if the radioactive material has a long lifetime (perhaps many thousands of years) and is concentrated, as with a significant fraction of nuclear ores and wastes, biological organisms cannot continue in its presence. Discarded radioactive material is likely to eventually 'leak' into the biosphere, to be absorbed and concentrated into food chains, with the higher forms of life accumulating radioactivity with subsequent danger of genetic harm. There is no known and certain way to safeguard radioactive waste from ultimately entering and harming the biosphere. To date, no form of containment is reliable against ingress of water over the thousands of years needed before the radioactivity becomes negligible.

When extracted, nuclear energy is used only for nuclear weapons and centralised electricity generation. Usually, as in the UK, these activities have been associated, so causing concern that weapons proliferation and terrorism may stem from nuclear power.

In commercial terms, nuclear generated electricity is expensive and only undertaken with considerable government funding. Nuclear accidents are of major concern. Nevertheless, a significant advantage of nuclear power is the significant abatement of CO_2 and other emissions that might otherwise come from fossil fuels. Continued R&D on the political and technical difficulties and opportunities of nuclear power is justifiable, but only in relation to similar effort on fossil fuel and renewable energy. All such effort should be transparent and open to public scrutiny.

> ***Discussion***: *What are the benefits and disbenefits of utilising nuclear ores? Have these factors changed over the last 20 years? Who needs to use nuclear power; when and how much?*

Brown *versus* Green energy supply

Therefore it is helpful to make two classifications of energy supply (1) *brown energy*, derived from the underground sources of fossil fuels and nuclear ores, and (2) *green energy*, derived from ongoing energy supplies available in the natural environment. One view from ecology is that Brown Energy sources are effectively 'removed pollution', so such fuels are, *ab initio,* already concentrated pollution. Clearly there is a duty to process and use such fuels efficiently with the minimum of adverse impacts (as is indeed is increasingly practised and the declared aim of ethical business). Nevertheless, the final emissions remain pollution, which is didischarged wholly or in part into the air and water of our immediate environment. In contrast, Green Energy supplies at source are intrinsically non-polluting, since life depends upon them. Most categories of Green Energy technology, as explained below, do not emit pollution. Clearly, as we move from Brown to Green energy, the efficient use of present energy and the minimisation of emitted pollution is vital.

> ***Discussion***: *Where does the 'natural environment''start and stop? Is the human economy part of 'nature' or separate from it?*

Renewable (Green) energy

Renewable energy is energy supplied from the natural and persistent flows of energy in the immediate environment. Obvious examples are sunshine that heats glasshouses and hydropower that generates electricity. Such technologies are called 'renewables' and are, by definition, sustainable. The generally benign ecological and environmental impacts of renewables contrasts with the adverse impacts of Brown Energy. By using Renewable Energy instead of Fossil Fuel Energy, buried carbon remains underground (its use is *abated*). Using carbon that is already circulating in the ecology of the biosphere, e.g. in plants, does not produce 'extra carbon' and so does not threaten long-term harm.

The total energy passing through our environment is enormous and predominantly arrives from the Sun; in one hour as much solar energy arrives as is used by the world economy in one year. In addition there are relatively smaller energy fluxes from tides and geothermal heat.

The power of sunshine

Sunshine transforms into most of the renewable supplies. Thus sunshine: ¤heats the surface (*solar water heaters, cookers, dryers, buildings*); ¤causes wind *(wind turbines and pumps*) which in turn causes sea waves (*wave energy devices*); ¤evaporates water giving rainfall (*hydropower*); ¤powers photosynthesis in plants (*biomass, biofuels, gasifiers, landfill gas*) from light (*photovoltaic electricity*); ¤and, via plants, provides animals with food (hence *biogas, sewage gas*).

Other renewables

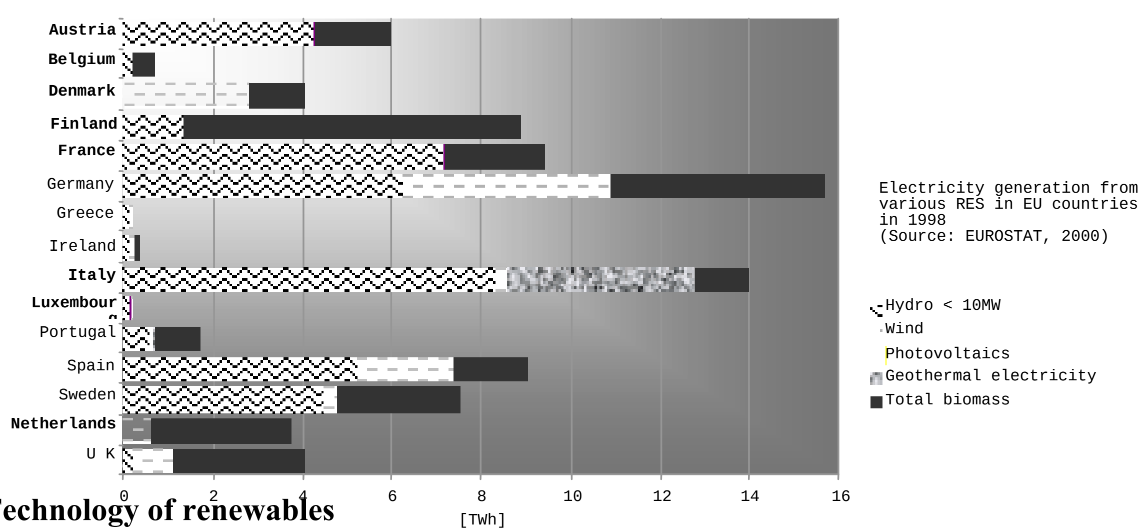
In addition tides (*tidal power*) and subterranean heat (*geothermal power stations, heat pumps*) give occasional and locally important energy supply possibilities. There is no shortage of renewable energy; the challenge is to develop, manufacture, and utilise the associated technology.

Left to rot, biomass decays to CO_2 with slow heat emission. When burnt as fuel, a similar process occurs, but the heat can be used to substitute for Brown Energy, thus abating fossil CO_2 emission. Therefore using sustained biomass for energy does not introduce *extra* carbon into the atmosphere, as does the combustion of fossil fuels.

Compared with brown energy, renewables harness mild forms of energy and so the equipment is relatively large and visible. It tends to require expensive capital items, though the energy harnessed is free. The *visual impact*, in contrast to the ecological impact, can be considered adverse.

The more efficient the renewable energy systems, the smaller the equipment and therefore the cheaper the energy supplied; moreover, the visual impact is reduced. With Brown Energy, both the adverse impacts and the costs are reduced if the systems are efficient. Therefore, *energy efficiency is of prime importance for renewables and non-renewables.*

Discussion*: What benefits have we experienced from forms of renewable energy?*



Electricity generation from various RES in EU countries in 1998 (Source: EUROSTAT, 2000)

Technology of renewables

There are many forms and types of renewables technology; most are now established and with rapidly increasing rates of commercial implementation, often at 30 to 40% growth per year. However, even at these rates, it will be 10 to 20 years before renewables become dominant in energy supplies. 'Renewables' refers to supplies of energy from renewable sources, which in turn is utilised by a wide range of technology.

Renewables are classified by immediate source, and then by technology and purpose. The energy is used for heat, machines, electricity generation and transport. The variability of most renewables requires integration and storage, including amalgamation using electricity and heat grids.

Guide to use of renewables in the UK
This guide gives examples oriented to meaningful household use, either on site or via the purchase of electricity from a 'Green Electricity' supplier. UK benefit is indicated by the number of ✵s; this is only guidance however, since each place has a distinctive environment and opportunities, e.g. with a suitable stream, hydroelectricity can be the best choice, but few places have this.

Solar heating ✵✵✵
Sunshine for heat (a) absorbed directly e.g. passive solar buildings at zero to 10% extra cost of new-build, and opportunistically for building conversions and extensions; saving 50% of conventional heating, (b) transmitted to use e.g. active solar water heaters using 'solar thermal panels' at about £2,000 per house so reducing conventional water heating by 50% in the UK.

> ***Action**: consider adding a solar water heater to the cost of your home; let sunshine enter your otherwise insulated house.*

Solar electricity ✵✵
Sunshine generating electricity (a) immediately
e.g. photovoltaic solar modules or panels interconnected with the grid or using battery storage, at £15,000 per house for 50% annual electricity savings (there are about 10,000 grid-connected installations world-wide), (b) by machines using heat from 'solar thermal' devices, e.g. concentrating mirrors raising steam, though not practical in the UK with cloudy skies.

> ***Action**: buildings can be faced with designer solar panels.*

Wind power ✵✵✵
Electricity from wind turbines. The industry is growing rapidly at 30 to 40% per year; each year world-wide there is more new wind power capacity installed into electricity grids than nuclear or traditional coal power. Electricity generated from wind, e.g. as in the UK, costs less than from new nuclear, oil or coal stations, and about the same as from gas, even without considering the abatement benefits of CO_2 and other pollution. Controversial impacts are mostly visual and sometimes noise. Most machines are large, up to 100m in diameter and commercially grid-connected. Siting is both on land and at sea. Small machines, diameter 1 to 10m, may be used for autonomous electricity supply

with batteries, perhaps integrated with other renewables. Capital costs are about £700/kW for large machines, and more for small machines.

Action: make a conscious decision about the electricity you buy.

Biomass ✵✵✵

This is the generic name for dead and harvested biological matter and its products. There are many opportunities, often complex, for both energy and fertilising nutrients. The use of otherwise waste material, e.g. sewage, gives a cost advantage. Since humans always produce waste, such energy supplies may be considered 'renewable'. However care is needed to optimise systems and prevent inadvertent pollution. Specific examples are below.

Firewood ✵✵

There is a surprising surplus of fallen, waste and scrap wood that can be used dry for domestic, commercial and industrial heating. Purpose-designed stoves and boilers are essential for serious use. Fuel wood and waste is unlikely to be sufficiently 'smokeless' in towns and cities. In the country, up to 100% of heat for water and buildings can be supplied, but the supporting effort is significant.

Action: if permitted, collect and use firewood efficiently.

Urban waste ✵✵

On average, at least 5% of a town's energy supply can come from the combustion of local organic wastes, e.g. from 'rubbish' collection, industry and agriculture. District heating, combined heat and power, energy efficient buildings and environmental taxes enable such strategies to be successful (as in Denmark and Sweden). However, (i) every opportunity should be taken to recycle actual parts and materials before resorting to combustion, (ii) high quality combustion is needed to minimise pollution.

Action: vote for councillors who promote recycling and high-tech use of wastes.

Landfill gas ✵✵

Purpose built rubbish-pits produce a combustible mix of methane and other gases that may fuel electricity generation at megawatt scale or provide commercial process heat. **Sewage gas** is similar. Likewise **Biogas** can be collected from animal manure. All such processes support the proper control and treatment of otherwise unhealthy wastes.

Action: persuade your sewage company to recover the gas.

Energy crops ✵✵

Plants may be harvested commercially, dried and then burnt for heat. The heat is used immediately or to generate electricity, hopefully combined with the use of the rejected heat. Partial combustion, in a gasifier, produces a combustible gas to be used as a convenient fuel. High quality equipment minimises smoke emission and ensures optimum combustion. Crop oils, e.g. rape seed, are a basis for transport biofuels at national scale.

Action: think of agriculture as providing more than food.

Hydro ✵

Falling water turns a turbine for electricity generation. (a) Large systems have stored water behind dams that inundates valleys, e.g. for 10% of Scotland's electricity; (b) 'Run of the river' systems without storage have less impact, but are small and less continuous, e.g. electricity generation at some old mill sites.

***Action**: balance human impact and conservation.*

Wave power ✵

Electricity from sea waves. The energy travelling in large, long-wavelength, Atlantic sea-waves averages about 50 kW/m, and then reduces as the waves become less extreme near to shore. After many years of ongoing research, commercial devices are now operating into the grid and being built in Scotland. Early machines are relatively small (about 150 kW peak electricity), but this capacity will increase with experience.

***Action**: vote for parliamentary candidates favouring research and development of new renewable energy sources.*

Geothermal ✵

Heat from the earth. Hot aquifers, as in Southampton and Paris, may be tapped for district heating, and some for powering turbines for electricity production, as in areas of Italy, New Zealand and California. In principle, but not yet in practice, heat can be extracted from large volumes of granite.

Tidal range ✵

Hydroelectricity from the rise and fall of tidal height, as water flows through a tidal barrier. Potentially 20% of UK electricity could come from tidal-range power stations in the Severn and other estuaries, but the capital costs are large and would require government funding. However the consequent reduction of mud flats, without amelioration, would harm wading and migratory birds. Co-operative benefits can be roads and railways across the barriers, flood prevention, enhanced fisheries and leisure facilities.

Tidal flow currents ✵

These are similar to low-head hydro, but commercially not proven. They would be medium and small scale developments with low impact.

***Discussion**: What forms of renewable energy could we implement (i) at home, (ii) at work, (iii) in our locality?*

So what more can be done?

By governments Most renewable energy technologies have been researched and demonstrated. The need now is for *markets,* linked with ongoing *research and development.* Once there is competitive business from expanding demand, financiers, manufacturers and suppliers can make long term plans, and prices fall. Governments themselves can invest and control appropriate markets by (i) increasing or decreasing taxation, (ii) awarding grants, (iii) legislating obligations, (iv) changing planning regulations, (v) changing building and manufacturing standards, (vii) transport policy, and (vi) environmental legislation. The potential for markets is learnt from research, which governments can facilitate in co-operation with industry.

***Discussion**: What opportunities exist for us to influence government and local authorities about energy developments?*

By individuals Each of us, and our businesses, clubs and churches, can greatly change lifestyle and practice for environmental improvement, especially through our spending and investments. Examples are: insulating homes; contracting with a supplier of green electricity; investing in ethical funds; considering energy use when purchasing white goods, housing, heating plant, lighting, vehicles, travel etc; voting appropriately at elections; studying information; learning from demonstrations of good practice etc. In general it is necessary to quantify and monitor such action so we maintain awareness and responsibility.

***Discussion**: How should energy criteria affect our individual and group purchases?*

By business and industry Obviously commerce requires continued cash flow, which arises from investment and enterprise, and is sustained by meeting market orders. Nevertheless, commerce should not blindly follow others' market practice, but should operate within a code of responsible trade and innovation. Energy purchasing, product and market development are all areas of responsibility, and also opportunity. Such enterprise is essential for best technology and implementation, and for best practice and sustainability. Proper utilisation of renewable energy is at one with efficiency, low overheads, long-term investment and minimum adverse impacts. The world-wide 20 to 30% per year growth of renewable energy implementation and of energy efficiency procedures are market opportunities that sit well with environmental integrity.

***Final discussion point**: Where should money be invested and why?*

FURTHER SOURCES OF INFORMATION

(best obtained using web search engines, such as www.google.co.uk, with key words)

Books and Reports

New and renewable energy: prospects in the UK for the 21st Century (supporting evidence) DTI and ETSU, March 1999.

Renewable Energy, B. Sørensen, Academic Press, 2000.

Renewable Energy Resources, J. W. Twidell and A. D. Weir, Spon Press/Routledge, revised 2000.

Renewable Energy—sources for fuels and electricity, T. Johansson et al (eds), Earthscan, 1993.

General Energy Web Sites

UK Dept Trade & Industry (especially for electricity); key official reports and policies (links to trade associations):
 www.dti.gov.uk/energy
International Energy Agency:
 www.iea.org

General Sustainability Websites

Intergovernmental Panel on Climate Change: www.ipcc.ch
UK Sustainable Development Commission: www.sustainable-development.gov.uk
Royal Commission on Environmental Pollution www.rcep.org.uk

General Renewable Energy Web Sites

Centre for Alternative Energy:
 www.cat.org.uk
European Forum for RE Sources:
 www.eufores.org
International Energy Association, renewables: www.caddet.co.uk; www.caddet-re.org
James & James; RE World (directories, news):www.jxj.com
Canadian RE—'Retscreen': http://retscreen.gc.ca/
International Solar Energy Society - SES:
 http://wire0.ises.org
UK Dept Environment and Transport (including planning, buildings):
 www.detr.gov.uk
UK Dept Trade & Industry (especially electricity) (links to trade associations):
 www.dti.gov.uk/renewable

Other Renewables

Danish wind manufacturers' association:
 www.windpower.org

Related JRI Briefing Papers are The Christian Challenge of Caring for the Earth (No 1); Global Pollution and Climate Change (No 2); Biblical Basis of Creation Care (No 9), *and forthcoming*: Sustainable Consumption *and* Lifestyles.

This briefing has been prepared for the JRI by Professor John Twidell (Director of the AMSET Centre and Visiting Professor in renewable energy engineering, University of Reading). Thanks are due to Sir John Houghton, Professor Colin Russell, Dr John Sale, Mr Peter Bright, Dr Mike Morecroft, Mr David Thistlethwaite and others within the JRI for their constructive comments.

THE·JOHN·RAY·INITIATIVE

The John Ray Initiative promotes responsible environmental stewardship in accordance with Christian principles and the wise use of science and technology. The JRI organises seminars and disseminates information on environmental stewardship.

Inspiration for the JRI is taken from John Ray (1627-1705), scientist and Christian, who pioneered systematic classification of plants and animals.

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