Renewable and alternative sources of electricity

This briefing note has been prepared in consultation with experienced engineers and scientists to try to bring some perspective to the many exaggerated claims made for renewable and alternative sources of energy, in particular electrical energy on which the world is becoming increasingly dependent. Another SONE briefing note, under the title of micro-generation, deals with a supposed alternative means of providing electricity supply.

SONE welcomes the development of renewable and alternative sources of energy so long as they provide a reliable source of energy or electricity that, taking everything into account, is environmentally acceptable, substantially free of greenhouse gases and is affordable, so allowing the nation to continue to be able to compete in the world.

We do not regard any existing or plausible future source of renewable energy as a competitor with nuclear power; nor do we see nuclear as the solution to all our energy supply problems. Common sense dictates that we aim for the greatest possible security of supply at competitive cost. That is likely to be provided by a portfolio of sources, with nuclear power continuing as a major or dominant supplier of baseload electricity, thereby minimising the use of fossil fuels.

The Outlook

The world is heavily dependent on fossil fuels – predominantly coal, oil and gas – as the primary energy source, including electricity generation. It is likely to increase its dependence as China, India, much of the rest of Asia, European Russia and eventually Africa develop their economies. This has immense implications for greenhouse gas emissions and the cost of energy as rising demand depletes oil and gas resources.

The International Energy Agency (IEA) World Energy Outlook in 2006 said: "Oil and gas consuming countries will be increasingly vulnerable to severe supply disruption and price shock if rising demand is left unchecked".

Currently, there are no alternative sources of energy on the massive scale with which fossil fuels are used, or with their versatility. In short, it is unrealistic to suppose that we can eliminate or even vastly reduce their use in the foreseeable future.

Nuclear power, with 442 reactors across the world, currently provides about 17 per cent of the world's electricity as compared with two per cent for renewables. Hydro-electricity, also regarded as a renewable in the UK, supplies 16 per cent but in the UK is marginal and virtually fully developed. Nuclear's global contribution is growing and its growth, along with that of reasonably reliable and competitive renewables, offers the possibility of avoiding undue reliance on fossil fuels.

Nuclear power is fuelled by uranium that is abundant, widely distributed and free from supply constraints – see SONE's briefing on uranium availability. Uranium has the ability, through reprocessing and the development of the fast reactor, massively to increase the efficiency with which it is used. Some authorities suggest there is enough nuclear fuel to power the world for the next 1,000 years.

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So, common sense requires the immediate development of nuclear power across certainly the technologically developed world along with the more reliable and competitive renewables, plus – and this we advocate strongly – a serious global drive to improve the economy with which we use energy.

The UK Position

The latest UK figures underline the global problem. They show that nearly three quarters of the UK's electricity supply is derived from fossil fuels (coal 37 per cent and gas 34 per cent). The split varies with the price of fuels. Gas generated as much as 40 per cent before the 2006 price increases as a result of which coal made a comeback.

Nuclear is responsible for about 20 per cent. The contribution from renewables is four per cent, most of it from biological sources and hydro. We also import nuclear electricity from France, equivalent to the output of two large power stations totalling around 2000 MW. But the indigenous nuclear contribution to British supply is falling with the progressive closure of ageing power stations and will be down to three per cent in 15 years' time.

If, as the IEA advises, prudence and the need at least to avoid exacerbating global warming require the **world** to reduce its dependence on fossil fuels, Britain should take heed. And if global common sense requires the immediate development of nuclear power along with the more reliable and competitive renewables, again it applies to Britain. The situation also underlines the urgent need for a vigorous British energy economy programme.

What is Possible?

After 50 years' experience of generating electricity from uranium, the nuclear industry has a solid base for major expansion. But what is the potential contribution of renewables to British electricity generation?

It is claimed that Britain has a wide range of renewable **potential** – waves, tides, hydro, wind, solar, geothermal and biofuels - and that it exists in various forms within a source: e.g. onshore and offshore in the case of wind; passively, actively and photovoltaic in the case of solar, and biofuels from waste, crops or landfill gas for combustion or conversion.

Biofuels

Unfortunately, biofuels are, among other things, limited by the vast area of land they require for growing, as demonstrated by the table below showing the area of land required to feed and maintain a single 1000 MW power station in operation:

Fuel	Area required
Biomass (wood)	a forest the size of North Wales
Bio-oil	a rapeseed field the size of the Highlands of Scotland
Bio-alcohol	a sugar beet field the size of Devon or a cornfield the size of Yorkshire
Biogas	800 million chickens on a farm a third the size of Dartmoor

The fact that we need not just one 1000 MW power station but 60 of them to maintain heat and light and keep industry going in the coldest weather puts renewables in perspective. So does the amount of oil products required to cultivate such large areas and transport the crops to market. Such land-hungry sources also raise the question as to how much would be left for food production.

By contrast, a 1000 MW nuclear power station would require only ten soccer pitches and emit next to no greenhouse gases.

"Huge potential"

Nonetheless, the Sustainable Development Commission (SDC), a publicly funded body tendering advice to the Government, argues that the **potential** of renewables is huge. In a report on nuclear power in March 2006, it asserted that "the data on UK renewable resources suggests that the total practical resource is at least 87 per cent of current electricity production. It is therefore reasonable to state that it is theoretically possible to supply all of the UK's electricity from renewable sources in the long term, especially when combined with energy efficiency".

Indeed, it claimed that there is "widespread agreement by respected analysts that a viable energy future is possible for the UK without new nuclear power". This is such a sweeping claim, based as it is on **theoretical potential**, that it needs critical examination.

There is certainly no shortage of **potential** sources of energy. Sources in outer space present one **theoretical** possibility. The problem is to harness them at affordable cost. So how do the SDC's claims pass muster with experienced engineers and scientists?

Theory and Practice

The SDC based its conclusions on a 2003 report by the Tyndall Centre for Climate Change Research which showed that this "practical resource" represents 334 TWh of electricity generation – i.e. 87 per cent of the current total production of 382 TWh. Unlike coal, gas and nuclear (which can be available for 80 per cent of the time at full power), renewables generally suffer from being very dilute or erratic sources of energy. A wind turbine generates about 25 per cent of its theoretical maximum over a year, during which time output will repeatedly and unpredictably swing between zero and maximum.

So, taking the Tyndall Centre's estimates for energy available as a base, we have to work back through the load factors of the various sources to establish the respective installed capacities needed to deliver the expected energy.

The Tyndall Centre did this in its 2003 report on renewable energy in the UK and the table opposite shows how much installed capacity would theoretically be required to generate cumulatively the 334 TWh of electricity:

Renewable resource	Expected energy TWh*	Typical load factor	Capacity GW**
Municipal solid waste	13.50	0.66	2.3
Hydro	4.90	0.35	1.6
Wind onshore	58.00	0.30	22.1
Wind offshore	100.00	0.35	32.6
Energy crops	31.00	0.66	5.3
Wave	52.00	0.35	17.1
Tidal stream	36.00	0.35	11.6
Tidal barrage	50.00	0.35	16.1
Photo-voltaic	7.20	0.35	2.3
Totals	**334.00**		**111.00**

* Tyndall Centre estimates, as published by the SDC. The figures add up to more than 334.

** Implied gross (nameplate) generation capacity calculated here

Expensive and uncontrollable

In other words, to generate 87 per cent of existing electricity output would require 111,000 MW of renewables plant. That is nearly twice the plant required by the UK's current mix of conventional generating sources to keep the country going in cold weather. That shows just how dilute or intermittent, or both, renewable energy is and how expensive it can consequently be.

But that is not the end of the story. Most renewable energy is uncontrollable – i.e. it cannot be produced to order. The wind does not blow, the tides do not flow and the sun does not shine when we want them to. They are subject to other influences over which we have no control, so that power is not produced when we want it. Alternatively, they produce electricity when we do not want it – e.g. outside peak hours or at night.

All this presents a formidable problem because electricity cannot be stored in bulk, except in the form of hydro-power, a marginal contributor in Britain where it is more or less fully developed. It would mean that those managing the National Grid would have, minute by minute, to balance fluctuating demand with erratic supply.

The consequences of this physical constraint are dramatically illustrated in Denmark, which has a relatively large installed wind power sector. It has to dump 80 per cent of its wind energy on to the Euro-grid at knock-down prices because it is produced at times when it is not needed. Because Britain does not have access to such a dump, a surge in wind power, if it were developed on any substantial scale, could make the system collapse.

Restricted access to market

In other words, on the assumption that we installed 111,000 MW of renewable energy in line with the above table, none of that power would – or could – have unrestricted access to the electricity market. The very nature of the electricity supply system means that it would be grossly uneconomic. Electricity cannot be generated profitably if access to the market is as chancy as winning a lottery.

In 2005, daily demand in Britain varied by 37,000 MW – from a minimum of 23,000 MW over the 24 hours of July 17th to a maximum of 60,000 MW over the same period of November 28th. If the National Grid is to balance supply and demand, especially with this scale of variation, it has to know where its power is coming from and when.

Conclusion

It follows that the national power demands between these maximum and minimum levels restricts the power from renewable energy sources to well below the 111,000 MW necessary to supply 87 per cent of demand. The SDC's claim, therefore, simply does not stand up. Nor is it credible that, hiding in the wings as it were, there is a major renewable power source waiting to be discovered, immediately exploitable on a massive scale without resource constraints, reliably available, free of greenhouse gases and economic.

Naivety Unbounded

The claims of a massive renewables potential imply some astonishingly naïve views about electricity supply. It is as if there is a grand assumption abroad that the market will take any old power, anywhere at any time. Unfortunately, it won't. The National Grid has not merely to match supply with demand; it has also to maintain good quality electricity, essential these days when so much depends on computers and other sensitive instruments, with tight control over voltage, frequency and the avoidance of surges, dynamic instabilities and disruptions.

Yet what characterises all the loose talk about renewables and micro-generation etc. is an amazing ignorance of the physical limitations and engineering requirements.

Just take Scotland, for example. The Scottish Executive plans to make Scotland the "Renewables Capital of the World", aiming to provide 40 per cent (some even say 100 per cent) of its electricity from renewable sources by 2020. In this case, some 14,270 MW of wind power were, at the end of 2005, either operating, under construction, awaiting approval, planned or proposed. This was on top of its total conventional generating capacity of 9500 MW and a maximum Scottish demand of some 6000 MW.

It is, of course, true that this rated capacity of 14,270 MW would produce (intermittently) only at best the equivalent of around 5000 MW of conventional capacity since, as the Renewable Energy Foundation has shown, wind turbines in Scotland produce only one third of their rated output. Nonetheless, that adds up to 5000 MW looking for a consumer since there is next to no high-voltage transmission network over much of the North of Scotland. And the cross-border transmission capacity to England, where consumers are concentrated, is at best 2200 MW.

The assumption must be that consumers will be required to pay not merely for wind power, which they already heavily subsidise, but also for a brand new transmission system to indulge this Scottish passion for unreliable power in the name of world environmental leadership. Some estimates suggest that, if we go on like this, wind power will have cost the British consumer £30bn by 2020.

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Incidentally, there is an astonishing inconsistency in the arguments of renewables and energy conservation protagonists - for example, the SDC. It advocates the development of micro-generation to avoid transmission losses of power on the distribution system when, at the same time, it encourages wind power generation in North West Scotland for consumers 600 miles away in London.

Greenhouse gas reduction

All this might not be so bad if wind power's main justification – the avoidance of greenhouse gases – were substantial. Unfortunately, because of the need for mostly fossil-fuelled power stations to chip in when the weather is calm or blowing a gale (when turbines have to be shut down for safety), wind power's avoidance of CO_2 emissions is much less than claimed by enthusiasts. It is further reduced by the fact that, in order to chip in as required, these conventional stations have to be running on reduced load, so emitting proportionately more CO_2 than on full power. The amount of CO_2 avoided by wind also depends on whether it happens to replace gas or coal generation since coal is twice as carbon-intensive as gas. Nuclear power emits next to no CO_2.

This limitation on greenhouse gas avoidance would also apply to a greater or lesser degree to other intermittent renewables – e.g. waves, tides, solar.

Dispensing with conventional plant?

If it is impossible for renewables to produce 87 per cent of British electricity, could they, as the SDC also claims, nonetheless dispense with nuclear power in the UK? Indeed, how much conventional plant (coal, oil, gas and nuclear) could be rendered redundant by increasing levels of wind power (or for that matter other intermittent renewables) without risking load-shedding or blackouts?

A number of studies suggest that the answer is approximately the square root of the rated capacity of the wind power installed, measured in GW (1000 MW). Thus, if we had 16,000 MW (16 GW) of wind we could, theoretically, dispense with 4000 MW of conventional capacity. But we may soon need 64,000 MW to make sure we can keep Britain going in cold weather. So 64,000 MW of renewables would theoretically dispense with only 8000 MW of conventional power.

Every little helps, you may say. But at what cost? How can we afford to maintain 56,000 MW of conventional capacity where the market for its output has been reduced by that taken by wind? Ofgem, the current electricity regulator, has not yet worked out how to induce existing generators to provide an adequate reserve against arctic weather.

In fact, every study on security of electricity supply in Britain has shown that the conventional power station capacity needed for the National Grid will always exceed the peak demand, regardless of the wind capacity installed. In short, renewables may not close a single coal, oil, gas or nuclear power station. Germany, with 10,000 wind turbines, still has to keep all its conventional power stations connected to the grid.

Conclusion

The inevitable conclusion is that the Sustainable Energy Commission and others who make claims for renewables do not know what they are talking about. This, you may well think, is not conducive to the general well-being if the Government heeds their advice.

As Professor Michael Laughton, Emeritus Professor of Electrical Engineering at the University of London, put it: "We need energy strategies based on sound engineering, not the fantasies of Non-Governmental Organisations, environmentalists or policies promoted by trade associations. Otherwise energy policy will reflect the priorities of lunatics running the asylum".

It follows that nuclear power, as a means of delivering greater security of supply, cleanly and at competitive prices, is not just an option but a NECESSITY.

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