Expanding renewable energy in the UK

Dave Andrews and Martin Quick give two perspectives on the potential for expanding the deployment of variable or intermittent renewable energy in the UK. In the first article (below), Andrews argues that the disadvantages of these types of technologies are much less than detractors claim while, in the second article (opposite), Quick outlines some innovative ways of expanding their deployment.

Variable renewables and the base load issue

Proponents of nuclear power stations often argue that this technology's ability to supply near-constant levels of electricity give it a clear advantage over, especially, variable or intermittent renewables, whose output varies according to local conditions. However, there are numerous reasons why this is not the case.

The basics

Power stations connected to the national grid are generally classified as supplying 'base load' or 'peak load'. Base load is the minimum amount of electricity that is supplied during a 24 hour period, while peak load is the maximum.

Currently in the UK, base load is mainly provided by a combination of coal-fired and nuclear power stations. These plants take hours or days to start up and hence are utilised most effectively to supply this minimum continuous level of electricity (indeed, it is very hard to use these nuclear power stations in any other way), whereas plants that can start up much faster, e.g. gas-fired, are more suited to supplying peak load.

Dealing with variable renewables

Variable renewables obviously supply electricity according to their natural resource – the wind, sun, tides etc. Nuclear proponents often argue that, accordingly, variable renewables are 'ineffective' in providing base load electricity.[1]

Serious study suggests that this is incorrect. During, for example, a period of low winds, the electricity supply sector would do what it did in December 2007 – when many of the nuclear power stations in this country were out of action for various reasons – and simply start up existing gas- or coal-fired stations, which are held in readiness for this purpose.

Other techniques, all currently used to a greater or lesser extent in this country and around the world, routinely deal with the loss of power stations (planned or unplanned) or with power surges. These include:

- Load shedding – where large, non-urgent industrial consumers are automatically disconnected from the grid.
- Energy storage – common current examples include 'pumped storage' where excess electricity is used to pump water back up into a reservoir serving a hydro-electric dam.
- Inter-country connection of power grids – used to redistribute electricity between countries (especially in Europe) in response to demand.
- Tariffs and 'smart' meters – these are increasingly being used to influence consumer consumption patterns.
- Privately-owned small diesel generators – there are very large numbers of small diesel generators in countries such as the UK and these can be called to help deal with the increased variability due to a large amount of (e.g.) wind power.

In fact, the largest potential cause of sudden power loss in the UK would be an emergency stoppage of the Sizewell B nuclear power station. Indeed, it is the size of that station – 1.2 gigawatts (GW) – that sets what is called the 'fast reserve generation margin' – the amount of electricity that would need to be brought online quickly to deal with such a power loss. Nuclear power stations – like all electricity plants – need back-up as they stop both in an emergency and for regularly for planned maintenance and/or re-fuelling.

The future

Obviously, the future development of the electricity supply system in the UK must be considered in the context of overall energy provision, subject to rapid reductions of greenhouse gas emissions and the maintenance of energy security. This has a range of implications given the discussion above.

Firstly, the rapid expansion of renewables should not be held up by the flawed arguments of the nuclear lobby. A recent Irish study has shown that close to 50% of electricity could be supplied to a national grid by wind energy.[2] A much more optimal approach would obviously be to complement wind power with other renewable energy generation (such as tidal, wave, biomass, and solar photo-voltaic) and energy storage, in tandem with a massive programme of energy-efficiency measures.

Secondly, we should construct many more combined heat and power (CHP) plants. These are considerably more efficient than conventional electricity supply plants (80-90% compared with 30-55%) since they divert their waste heat to supply local users. Such schemes are common throughout Denmark and Germany. These can be built rapidly and, in particular, would help use natural gas much more efficiently given the current concerns over security of supply and cost. The flexibility of CHP plants mean they work very well in tandem with variable renewables.

Thirdly, there should be a large-scale expansion of interconnectors with mainland Europe to allow more efficient expansion of renewable energy across the continent.

Fourthly, we need to retain enough large, flexible, fossil-fuel power stations for managing peak demand, especially during infrequent periods of (e.g.) widespread low winds.

A recent study at University College London[3] has modelled in detail the yearly operation of the entire UK energy system hour by hour and claims that it would be technologically possible to provide up to 95% of power from a mix of renewables and CHP at a reasonable price of about 5 pence per kilowatt-hour (p/kWh).

So, should nuclear have a role in this future energy system? The fact that nuclear power stations need to run (almost) continuously at near their peak output raises serious questions about their compatibility with variable renewable energy technologies. If we want to have a large amount of renewable electricity, then the fewer large inflexible producers like nuclear, the better – the two types of technology are simply not a good mix.

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References

1. For example, "For base load power – the irreducible minimum electricity use, which runs to more than 20,000MW in the UK – intermittent sources of power, including most of the renewables, are ineffective." From: Grimston et al (2007). Letters. The Guardian, 7 January.
2. Department of Communications, Energy and Natural Resources and Department of Enterprise, Trade and Investment (2008). All Island Grid Study: Study Overview. Dublin, Ireland.
3. Barrett M. (2007). Green Light – A UK electricity scenario. Bartlett Faculty of the Built Environment, University College London. http://www.bartlett.ucl.ac.uk/markbarrett/Energy/UKEnergy/GreenLight_220607.ppt

Innovating to exploit variable renewables

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The limit of how much of the UK's energy could be provided by renewable sources depends on the size of the resources, their affordability and – for variable renewables – the ability of the grid to cope with a given degree of intermittency.

How much intermittency?

Recent research has shown the costs of integrating variable renewables into the grid to be quite modest for a contribution of up to 20% of the UK's electricity supply. For example, the UK Energy Research Centre,[1] following an analysis of a large number of international studies, showed that the extra cost of such a proportion would be 0.5 to 0.8 p/kWh, i.e. less than 1% on customers' electricity bills. Above this, more stand-by capacity would be needed to cope with periods of low electricity production. However, a wide geographic spread of wind and tidal power systems would minimise the likelihood of a very high proportion of these generators being unavailable at one time. Hence the amount of time this stand-by capacity would be called upon would be small, and the objectives of reducing carbon emissions and reducing dependence on imported fuels would not be seriously compromised.

This contrasts with the need for 'spinning reserve' – power stations operating at low power (and obviously using some fuel) – which is needed to respond rapidly to a sudden loss of generating capacity. The amount of spinning reserve is determined by the largest unit on the grid, currently the nuclear power station, Sizewell B.

New technologies to harness a variable electricity supply

The potential to use higher proportions of variable or intermittent renewables on the grid could be substantially increased if greater use were to be made of energy storage technologies and controls that can switch off certain appliances and equipment at times of low supply.

In terms of energy storage, new possibilities arise from the use of electric vehicles and plug-in hybrid (PIH) vehicles. PIH vehicles have sufficient battery capacity to cover most typical daily journeys – with charging being mainly from the grid – together with an internal combustion engine for providing energy on longer distances between charging points. These plug-in vehicles could generally take their power at times of surplus, e.g. at off-peak times when excess electricity is being generated by variable renewables. This would not only decrease the carbon emissions that such vehicles were responsible for, but also reduce costs due to the cheaper price of off-peak energy. In the very rare case of a prolonged shortage of (e.g.) wind-generated power, PIHs would be able to operate using their internal combustion engine. Some such vehicles are scheduled to be marketed soon.[2]

Another technology that could take advantage of a situation with a high proportion of renewable energy is the electric heat-pump. These pumps draw heat energy into a building from the external environment – mainly from the surrounding atmosphere (air-source heat pumps) or using pipes laid underground (ground-source heat pumps). Air-source pumps are generally cheaper, but ground-source tend to be more efficient, so the latter are generally preferred. Together with heat storage, these technologies could help make optimum use of variable renewables. Heat-pump and heat storage schemes become more economic if carried out on a community scale rather than just at the level of individual households. Indeed, with oil and gas prices likely to remain high for the foreseeable future, the economics of carefully designed heat-pump systems are becoming significantly more attractive.

Exploiting the renewable potential

The UK has a very large potential for offshore wind power and different types of marine energy – and harnessing this potential could contribute energy far in excess of the 20% contribution discussed above. Floating wind turbines – which make use of well-developed technology for floating oil rigs and can be positioned in much deeper water than fixed turbines – are being developed and tested now by a number of firms.[3] Because of the stronger and more consistent wind in the open sea and easier installation (if grouped in large clusters to ease the electric connection to the shore), the cost of power from these is claimed to be comparable with onshore turbines. Hence, at present wholesale electricity prices, this would be a competitive electricity source. This development could provide very large amounts of energy in relation to the UK's needs.

The UK government's recently released proposals for a renewable energy strategy[4] are an encouraging start for the medium term (up to ~2020), but to meet the very demanding greenhouse gas reductions needed in the longer term, preparations for an even larger programme of renewables is required, and this should include promoting demand-side infrastructure that can make optimum use of intermittent and variable renewables.

A huge effort to develop, manufacture and install a large capacity of renewables is needed urgently to tackle climate change, to ensure security of the UK's energy supply and to minimise economic problems due to an unfavourable balance of trade in energy. This will need a major upgrading of skills at all levels. But above all, there is a need to reduce energy demand through a combination of energy efficiency and behavioural change.

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Note: these issues are discussed more fully in a recent SGR submission to the House of Lords Economic Affairs Committee – available from <MartinQ@sgr.org.uk>

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