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postnote

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RENEWABLE ENERGY IN A CHANGING CLIMATE

Concerns over climate change (see POSTnote 295) have led to an increasing focus on the renewable energy sector. The EU has agreed a binding target of 20% of renewable energy by 2020, with a proposed UK target of 15% of energy from renewable sources. This POSTnote looks at UK options for meeting this target, and discusses how climate change could affect both the UK capacity to produce renewable energy and demand for energy in general.

Background

The current government sees renewable energy as a substantial part of the UK plan to tackle climate change. The Climate Change Bill sets a target of a 60% reduction in CO_2 emissions by 2050; this could be achieved by a substantial expansion of renewable capacity.[1] In 2007, only 1.78% of energy used in the UK was from renewable sources such as hydro and wind.[2] The British Isles have the highest potential for wind energy in Europe. Their location next to the Atlantic Ocean means there is also capacity for marine power.

Renewable energy policy

Renewable Energy Strategy (RES)

The government has outlined potential measures to meet the EU target in the RES consultation (June 2008). This sets out a possible breakdown of the target into 32% of electricity from renewable sources, 14% of direct use heat and 10% of road transport. The electricity share is high due to low current levels of renewable capability in heat and transport. The majority of renewable electricity will most likely come from wind due to the maturity of the technology. The Renewables Obligation (RO) is the government's main policy instrument to increase renewable electricity (see Box 1). The Devolved Administrations have also each set their own targets:

- Scotland plans to achieve 50% by 2020.
- Northern Ireland has a target of 40% by 2025.
- Wales has an aspiration for around 100% by 2025.

Box 1. Renewables Obligation

The Renewables Obligation (RO), and equivalents in Northern Ireland (NIRO) and Scotland (ROS), place an obligation on suppliers to source a specific and annually increasing percentage of their sales from renewable sources or to pay a buy-out price. Currently, a Renewable Obligation Certificate (ROC) is issued by Ofgem (the gas and electricity market regulator) for each MWh of eligible renewable electricity generated. The generators sell the ROCs, with or without each MWh of electricity, to traders or electricity suppliers. At the end of the obligation period, suppliers demonstrate they have met their obligation by presenting ROCs to Ofgem or paying a buy-out price. The money in the buy-out fund is recycled to suppliers who presented ROCs, rather than paying the buy-out price, encouraging further renewables generation.

A consultation on "Reform of the Renewables Obligation" was published in June 2008 setting out the detailed changes announced in the 2007 Energy White Paper including "technology banding" (as listed below).

- 0.25 ROC - landfill gas;
- 0.5 ROC - sewage gas, co-firing of biomass;
- 1.0 ROC - onshore wind, hydro, energy from waste with Combined Heat and Power (CHP), co-firing of energy crops, co-firing of biomass with CHP;
- 1.5 ROC - offshore wind, co-firing of energy crops with CHP;
- 2.0 ROC - wave, tidal stream, tidal barrage, tidal lagoon, solar PV, micro-hydro, dedicated energy crops, dedicated biomass with CHP.

The aim is to provide more support to technologies that are currently further from commercial deployment to drive development and maintain diversity. The reformed RO aims to deliver around 13.5% of renewable electricity by 2015.

Currently only 0.6% of the UK direct heat demand is met by renewable energy. Most of any expansion achieved would most likely come from biomass.

Transmission network

The UK electricity transmission grid is currently a centralised system and faces a number of challenges when integrating renewable energy (see POSTnote 280). The best renewable energy sources are found in remote locations with limited grid connections, such as the Shetland Isles. The Crown Estate 2020 vision lays out a design for an offshore transmission network running down the eastern UK, including interconnectors. This would accommodate substantial offshore wind generation and allow for exploitation of onshore and offshore renewable energy potential in northern Scotland.

Planning

The current Planning Bill proposes an Infrastructure Planning Commission (IPC) to review large scale projects, including all electricity generation projects over 50 MWe onshore and 100MWe offshore in England and Wales.[3] Planning decisions are intended to be made more quickly, which would allow for faster deployment of large-scale renewables. The National Planning Framework has comparable aims under the Planning etc.(Scotland) Act 2006. Microgeneration rule changes in 2008, in England (similar measures are in place in Scotland and Wales), allow householders to install solar panels and wind turbines without explicit planning permission.

Energy efficiency

The key to reducing overall energy demand is increased energy efficiency. The RES states that the amount of renewables required to meet the 2020 targets will fall by 7% if the 2007 Energy White Paper energy efficiency proposals were introduced.[4]

A changing climate

Climate change in the UK is projected by the UK Climate Impacts Programme (UKCIP) to lead to the following effects:[5]

- **Temperature** – the annual mean temperature may rise by up to 1.5 °C by 2020. The largest increases will occur in summer, and in the south and east of the UK. Heat waves may become more frequent and severe. The growing season for plants has increased by about a month since 1900 and this trend is expected to continue.
- **Precipitation** - southern parts of the UK could experience up to 20% less precipitation during the summer months by 2020. Total winter rainfall has increased in almost all regions of the UK and this trend is expected to continue. Intense winter precipitation could become more frequent, increasing the risk of flooding. Snowfall is likely to decrease and large parts of the country may experience increased periods without snow.
- **Wind speed and direction** may also be affected but are difficult to model because small scale features, such as hills or cities, can create localised wind climates. A major complication is the uncertainty involved in projecting the position of the North Atlantic storm track (see Box 2), an important driver of UK winds. The wave climate is linked to the wind climate and predictions are therefore uncertain.
- **Storminess** is a measure of the number and frequency of storms (wind speeds greater than 89 km/h). Studies show no clear change in storminess over the past 100 to 200 years, despite increasing temperatures, and any variation due to climate change is likely to be small compared with natural variability.
- **Cloud cover** - increasing temperatures and decreasing precipitation in summer, particularly in the southern UK, suggest a decrease in cloud cover. However, projections must be treated with caution due to complexities involved in modelling cloud cover.
- **Sea level** rise accelerated over the latter half of the 20th century and this is expected to continue. This change will not be constant across the UK as the northern UK is rising while the south is sinking mainly due to glacial isostatic adjustment since the last Ice Age. The UKCIP projections, accounting for land movement, indicate a rise in sea level of up to 12 cm in southern England by 2020.[6] Storm surge heights are projected to increase, further threatening low lying coastal areas.

Box 2. The North Atlantic Storm Track

The North Atlantic storm track is the path along which most mid-latitude storms travel. It is highly variable in strength (number of storms) and position (the most common path of the storms) from winter to winter. This variability is associated with a pattern in sea level atmospheric pressure known as the North Atlantic Oscillation (NAO). When the pressure difference between Iceland and the Azores is high, the storm track is strong and orientated over the UK. This brings mild, wet and windy weather. When the pressure difference is small, the storm track is weaker and shifted southwards leading to colder, calmer UK winters. As the NAO and storm track are so variable they are very difficult to forecast.

Climatic effects on renewable energy

Climate change could affect the potential of renewable energy in two ways, by;

- **affecting electricity generation capacity and operation**, and
- **changing the UK energy demand profile.**

Effects on electricity generation

Wind

Commercial turbines will start generating electricity at around 13 km/h, generate maximum power between 47 km/h and 89 km/h, and cut out at wind speeds (excluding gusts) exceeding 89 km/h to prevent damage to the blades. Offshore wind turbines are more exposed to wear and tear especially during storms. Vestas, the world's largest turbine manufacturer, has encountered some "technical incidences" with offshore turbines in some of its earlier projects. However, current development is incorporating measures to counter such problems. The Met Office is working with UK energy companies to establish whether and how future wind speeds and directions could be affected by climatic changes. Little is known, although current projections show relatively small changes. The lifetime of a wind turbine is between 20 and 25 years. Any sites could also be reassessed at the end of their lifetimes to determine their continuing viability, including use of any newly developed technologies.

Wave

Wave power technologies are at the prototype stage. Survivability against storm damage is the number one criterion for design (see Box 3). It is unlikely that the present wave technologies will contribute significant amounts of energy at current scales. The wave energy sector is confident that climate change adaptation can be readily incorporated into the ongoing design and development process if sufficient funding for early stage research and development is in place.

Box 3. Examples of wave energy converters

Wave power devices must be designed for much harsher conditions than wind turbines. Examples include:

- the Pelamis Wave Energy Converter is the first wave power device to reach commercial deployment. It was tested successfully, and supplied power to the grid in 2004, at the European Marine Energy Centre (EMEC) in Orkney. To protect against the most extreme conditions the Pelamis goes through the waves rather than over the top of them.
- the Archimedes Waveswing is an underwater device, so is not exposed to damaging surface waves.
- the 'Limpet' is a shoreline energy converter currently in testing on the Isle of Islay. A shoreline device is easier to access and maintain in inclement weather.

Tidal

There are two forms of tidal energy:

- Tidal range, which uses the difference between high and low tide to generate electricity. A tidal barrage spans an estuary whereas tidal lagoons enclose a smaller area of water in shallow coastal locations. A Severn Barrage could meet 4% or more of the UK's current electricity demand.[7]
- Tidal stream, which uses the flow of water created by tides and accelerated by coastal topography. Some of the best sites are in sheltered locations (estuaries, sea lochs and straits) reducing exposure to storm damage.

Tidal power generation is very predictable and largely unaffected by any climate changes. Sea level rise will be small compared with the scale of the proposed barrage, or over the lifetime of a tidal stream device. Additionally a tidal barrage could be designed to provide flood defence for areas at risk from rising sea level.

Hydro electric power

In Scotland 10% of electricity demand is met by hydropower, which may also provide means of storing energy to meet any sudden demands by "pumped storage" (see POSTnote 306). Changes in precipitation type, amount and intensity may impact hydro generation. Snow melts at higher altitudes and reaches the reservoir slowly allowing ease of reservoir regulation. In contrast, intense rainfall results in high surface run off and large volumes reaching the reservoir in a short period. Using water for generation may be limited by the Environment Agency (SEPA in Scotland) due to downstream flooding risks or drought. Higher temperatures will increase evaporation rates, especially in the southern UK. In a recent drought, hydro generation in the South West fell by 10% but an average generation level was maintained in Scotland and Wales, showing that the effects on hydropower are likely to be region dependent.

Biomass

Changes to the temperature and precipitation patterns across the UK will have an impact upon all plant life including biomass crops. An extension of the growing season would allow the cultivation of species at more northerly latitudes, where, in particular, forestry may provide the greatest potential.

Energy crops use a lot of water and may struggle with drier summers. However, Southampton University researchers have modelled the effect of climatic changes which, when coupled with increasing atmospheric concentrations of CO_2, acting as a 'fertiliser', lead to a 10-20% increase in yields. They also suggest that although building in climate resistance is not occurring at present, there is huge potential for development of highly water efficient crops.

Increasingly intense rainfall episodes, sea level rise and flooding could seriously affect agricultural land which might be used for energy crops.

Solar

There are two main types of solar power technology: solar thermal is primarily used for supplying domestic hot water, while solar photovoltaics (PV) convert energy from daylight into electricity. Any increase in cloud cover may reduce the output of current solar systems. A decrease in cloud cover, particularly in the summer period, would increase power output and improve cost competitiveness.

Operation and maintenance issues

Maintenance of offshore wind installations can be challenging as it involves sending boats and crew offshore. While storminess forecasts are uncertain, any increase in the number of gale days would reduce the time available for maintenance and repair. This could potentially result in a turbine being out of operation for days or possibly weeks. Most wave technologies are designed to be brought to shore for maintenance to minimise the required weather windows. Remote Operated Vehicles can be used for routine tasks allowing for a faster return to operation.

Sea level rise and more intense storm surges are likely to increase coastal erosion affecting offshore transmission cables and coastal substations. However, the oil and gas industry has been operating in the offshore environment for over 30 years and this experience can be transferred to the offshore renewable sector.

Changing energy demand

The changing profile of UK energy demand

Traditionally, energy demand in the UK has peaked in winter but this may alter as the UK climate becomes warmer. Between 1961 and 2006 there were an additional 30-35 days per year where buildings in the Greater London area required cooling. Cooling days are expected to increase greatly, especially in the urban areas of SE England. National Grid has already witnessed a growing electricity demand in response to higher temperatures, which it attributes to an increased use of air conditioning and fans.[8] For instance, in July 2006, the warmest month on record, National Grid issued an 'insufficient margin warning' due to air conditioning demand. Such events are likely to change from a 1 in 20 year event to almost yearly by 2050. An increase in winter temperatures will reduce the number of days that buildings require heating. In the 1961 to 2006 period, the number of heating days reduced by about 20 days across the UK.

Matching generation with demand

Wind and wave energy is more plentiful in autumn and winter which fits with the current UK energy demand profile. However, with increasing temperatures adaptations will be required.

Wind power has load factors (the percentage of time at which the turbine is working at the theoretical maximum capacity) of around 70% in winter. Therefore there could be times when supply is greater than demand. One option is the use of storage technologies (see POSTnote 306) but these remain costly. Energy-intensive industries, such as aluminium smelting could provide a profitable use of excess supply

Lower wind speeds in summer reduce load factors, although at west coast, island and offshore locations they remain around 25 to 30%. The impact of climate change on sea breezes is unknown but could potentially either adversely or favourably alter load factors in coastal wind farms.

Onshore wind is concentrated in upland Scotland, Wales and NW England but the large expansion in offshore capacity will be sited largely around the English coast. Such geographical diversity will help to smooth out the variability of the UK wind supply. Indeed, a study by the Environmental Change Institute found that at no point in the last 35 years did the wind speed drop below the level required for generation over the whole UK.[9] The same is true for wave power generation, and there is often a time delay between the highest winds and highest waves.

Electricity generated from an individual tidal power project may be mismatched to the daily peak energy demand. However, the variation in generation capacity is dependent on daily and fortnightly tidal cycles, rather than seasonal, and is again highly predictable. A Carbon Trust commissioned report noted that the daily tidal cycle varies according to location so developing the tidal resource at a range of sites would result in low daily variability.[10]

Small-scale generation

Solar power technologies, particularly in the south and east where demand for cooling is expected to be greatest, could play an important part in summer. Solar thermal can meet all domestic hot water needs at this time and PV systems can be integrated into homes as tiles or facades and are suited to urban environments where space is limited and cooling needs are highest.

Other small-scale generation options include:

- biomass Combined Heat and Power (CHP), which can provide cooling, as well as heat and electricity, on a community scale. Such year-round use makes CHP more economic;
- small scale biomass heating systems, especially in rural properties;
- vertical axis wind turbines which are better suited to urban areas than traditional 'windmill' designs; and,
- small scale hydropower, with particular potential at old water mill sites. This technology has a high load factor (>50%) and little effect on the environment.

Overview

- Renewable energy sources are varied and will be affected by a changing climate in different ways.
- Climate change is likely to increase energy demand for cooling in summer and decrease demand for heating in winter, especially in urban areas.
- A diverse renewable energy industry, both in type and geography, will limit the impact of the effects of climate change.
- An efficient transmission network and development of interconnectivity and storage technologies would ensure a secure energy supply from the renewable sector.

Endnotes

1 Climate Change Bill [Bill 129 0708]
2 BERR*, Digest of UK Energy Statistics, 2008,* table 7B, HMSO, 2008
3 Planning Bill [HL Bill 69 0708]
4 BERR, *Meeting the Energy Challenge: A White Paper on Energy*, May 2007
5 *UKCIP02 Climate Change Scenarios* (funded by Defra, produced by Tyndall and Hadley Centres for UKCIP) , 2002
6 *UKCIP06 Guidance note on the UKCIP estimates of sea level change* and Defra's new supplementary guidance to support planning policy statement 25 (PPS25), 2006
7 Sustainable Development Commission, *Turning the Tide: Tidal Power in the UK*, October 2007
8 National Grid, *Summer Outlook Report 2008*, April 2008
9 Sinden, G., *Energy Policy*, 35(1), p112-127, 2007
10 Carbon Trust, *Variability of UK Marine Resources*, July 2005

POST is an office of both Houses of Parliament, charged with providing independent and balanced analysis of public policy issues that have a basis in science and technology. POST is grateful to Eleanor O'Rourke for researching this briefing, to the Natural Environment Research Council for funding her parliamentary fellowship, and to all contributors and reviewers. For further information on this subject, please contact Dr Michael O'Brien at POST.

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