

# the **power** of Scotland Renewed

Clean, green energy for the nation's future.



## **A summary for policy makers**

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## Introduction and summary

**Decarbonising our energy supply is at the heart of the challenge to prevent the worst impacts of climate change. This report shows that it is possible to have a clean, green energy supply in Scotland. By 2030 renewable energy can meet between 60% and 143% of Scotland's projected annual electricity demand, depending of the level of investment in energy saving and new renewables. The analysis also demonstrates that it is entirely plausible that no large-scale fossil fired generating capacity would remain online by 2030.**

Climate change has been identified as the greatest threat facing humanity during the twenty-first century. To prevent the worst impacts of climate change, annual global emissions of greenhouse gases such as carbon dioxide urgently need to be reduced if we are to stay below the widely recognised dangerous threshold of 2 degrees warming. Scotland's Climate Change legislation commits us to cutting overall greenhouse gas emissions by at least 80% by 2050 and interim emissions reductions targets of at least 42% by 2020<sup>i</sup>.

Given that the power generation sector is the largest single source of carbon dioxide<sup>ii</sup>, it is vital that Scotland's electricity generating capacity is almost completely 'decarbonised' over the coming decades. The Scottish Government's Climate Change Delivery plan promises a "largely de-carbonised electricity generation sector by 2030, primarily using renewable sources for electricity generation with other electricity generation from fossil fuelled plants utilising carbon capture and storage"<sup>iii</sup>.

This summary paper outlines five scenarios developed in our full report, from 'business as usual' to alternative, low carbon futures for electricity generation in Scotland. Using these cases, we have sought to:

- Develop likely and practical scenarios for the supply of Scotland's electricity needs up to 2030;
- Assess the likely need for large-scale conventional nuclear or Carbon Capture and Storage (CCS)-equipped fossil fired thermal plant to deliver security of supply in such scenarios;
- Identify and assess alternative means of delivering security of supply by 2030 without reliance on nuclear or fossil-fired thermal plant.

Decommissioning large, centralised generation capacity at Cockerzie, Hunterston B and Torness will not compromise Scotland's energy security, and the projected supply mix in 2030 will ensure that Scotland's electricity needs will be met even if the supply of electricity from variable sources of renewable energy falls to zero during a period of peak demand.

The base scenarios assume increased energy consumption and stable peak demand. However, this should be viewed as a worst case situation as it is now recognised that a sustainable approach means we must reduce our energy consumption and manage peak demand. Additional security of supply, reduced carbon emissions and significant financial savings can be achieved by taking action to manage and reduce our demand for electricity through energy efficiency measures, and by electrification of some degree of heat and transport demand.

While the bulk of Scotland's electricity will be supplied from sustainable, low-carbon sources by 2030, some scenarios include a role for fossil-fuelled power generation for the foreseeable future. If Scotland is to achieve the carbon emissions reductions targets embedded within the Climate Change (Scotland) legislation under these scenarios, it is essential that by 2020 a significant share of existing fossil capacity must be closed or fitted with CCS; and by 2030 virtually all existing, and any replacement fossil capacity must feature full CCS. In these circumstances new unabated fossil capacity, especially coal-fired, would severely compromise the likelihood of delivery of our climate targets.



However, combining increased development of offshore renewables with a realistic programme of demand reduction means that Scotland's renewable resource can meet, and exceed, our annual electricity demand, even when a significant proportion of heating and transport demand are electrified. Under such a scenario, it is entirely feasible for all centralised thermal generation to be closed by 2030, with our security of supply relying on interconnectors, storage and deferrable demand. Investment in new or replacement thermal plant with CCS could provide additional security and increase export capacity, but would be primarily justified by the global need for the development of such technology.

## Summary of cases

1. Even the 'business as usual' case where we meet existing policy targets in Scotland (Case 1) does not require any new fossil or nuclear capacity (other than replacement for Peterhead or Longannet if required) to maintain security of supply. However, it does not deliver the required degree of decarbonisation without the deployment of CCS, and requires significant investment in interconnection, and potentially new storage, after the other existing thermal stations are closed.
2. If there is continued growth in renewables capacity during the 2020s (Case 2), primarily in the offshore wave and tidal sector, net exports are maintained and two large fossil-fired generating stations could remain on the system. To achieve high levels of decarbonisation requires either closure of these stations or the implementation of fully operational CCS. Analysis suggests that in this Case, closure would be technically feasible, albeit reliant on increased interconnector capacity to allow significant short-term imports.
3. If neighbouring administrations were also pursuing similar policies (Case 3), then substantial investment in storage, deferrable demand and dispatchable renewables would be needed.
4. In scenarios where energy efficiency and demand management lead to Scotland's annual energy demand falling significantly (Case 4) security of supply is much more easily maintained. When combined with the additional offshore generating capacity of Case 2, it enables renewable sources to generate up to 143% of Scotland's annual electricity demand. As a result, Scotland could export significant amounts of clean energy each year.
5. The electrification of a proportion of Scotland's heat and transport demands (Case 5) would add a notable amount to Scotland's annual electricity demand. However, the storable and deferrable nature of such loads, and the fact that periods of high heat demand tend to coincide with high renewables output, mean that security of supply is unlikely to be compromised.
6. Under Cases 4 and 5, Scotland's renewable output comfortably exceeds our annual electricity demand. While some thermal plant may be retained as peaking capacity, it is entirely plausible that no large-scale fossil fired generating capacity would remain online by 2030. Security of supply would be maintained by moderate and practical investments in grid upgrades, interconnectors, deferrable demand and storage.



## Relevant policy targets and positions

The following have been taken into account in the development and analysis of the cases:

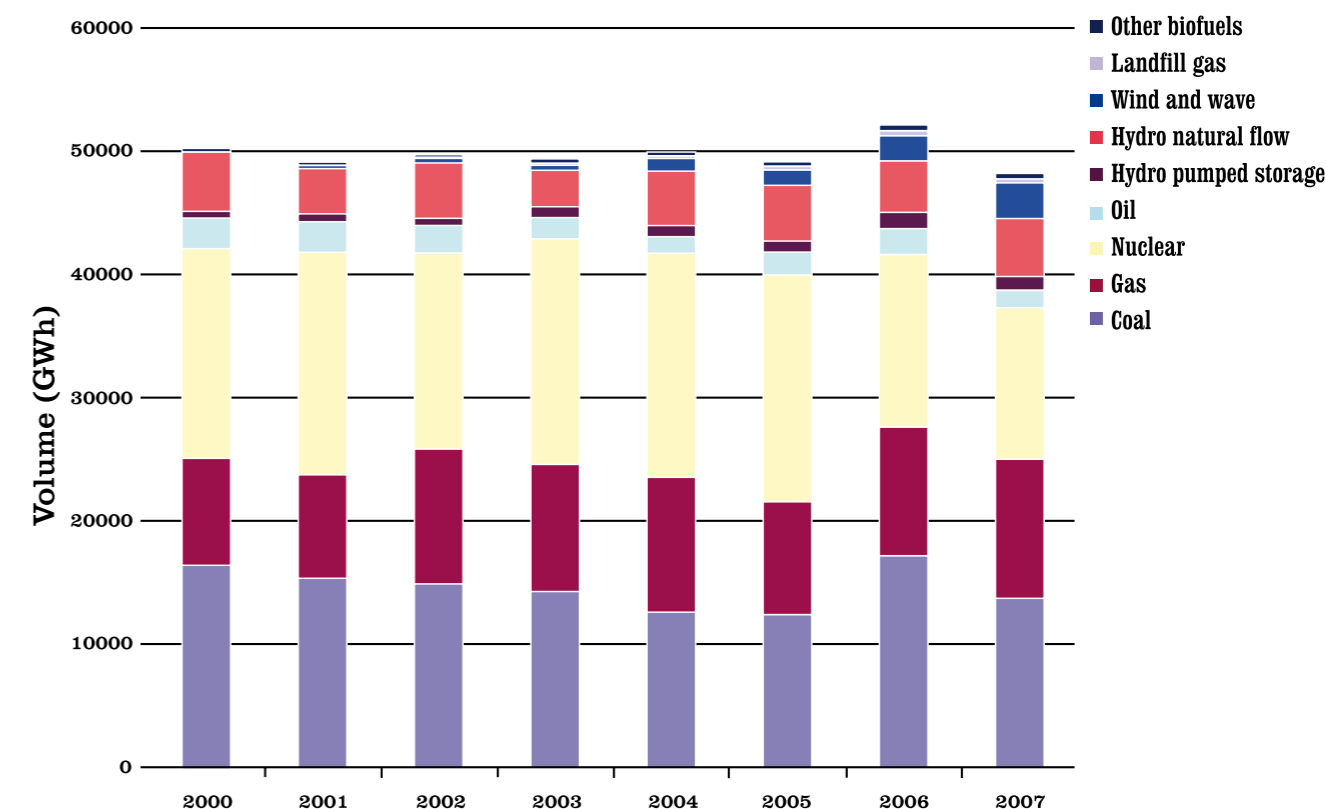
- Climate Change (Scotland) Bill includes targets for Scotland to cut its emission of greenhouse gases by at least 42% by 2020 and at least 80% by 2050<sup>iv</sup>.
- Renewable electricity targets: the Scottish Government has increased the 2020 renewable electricity target to 50% with an interim target of 31% by 2011<sup>v</sup>. In September 2008, the Government announced that it was on track to achieve the 2011 milestone target<sup>vi</sup>.
- The European Union has set a 2020 target for 20% of final consumption of energy to come from renewable sources and for a 20% reduction in projected energy consumption through energy efficiency.
- The current SNP Government has made clear its opposition to the construction of new nuclear power stations.
- The UK National Energy Efficiency Action Plan produced in 2007 includes targets for an 18% reduction in delivered energy by 2030<sup>vii</sup>.
- The EU policy also asks all member states to work towards having CCS technology deployed in all new fossil fuelled power plants by 2020. Both the UK and Scottish Governments are currently consulting on CCS requirements.
- Phase three of the EU Emissions Trading Scheme (2013 to 2020) requires electricity generators in all but a small number of member states to buy all their emissions permits at auction. This is intended to stimulate the development of low-carbon electricity generation.
- Both the UK and Scotland are committed to 'the almost complete decarbonisation' of electricity by 2030.
- Scottish Government policy to deliver renewables without environmental harm.

## Electricity generation and consumption today

At the beginning of the 21st century, the conventional model of large, remote electricity generation had led to Scotland being dependent on just five power stations – coal-fired Cogenzie and Longannet, gas fired Peterhead, and nuclear stations at Hunterston and Torness - for the overwhelming bulk (around 90%) of its electricity needs.

But Figure 1 shows how by 2007 (the last year for which we have reliable data), the mix had begun to shift quite dramatically. Large-scale conventional and nuclear generation was still dominant, but its share had fallen to 80% while the proportion of our electricity coming from renewables had almost doubled to around 20%. Most significantly, non-hydro renewables had seen their contribution rise from 0.6% to 7.3%, virtually all of which was from onshore wind farm developments encouraged by the Renewables Obligation (Scotland).

The overwhelming bulk of the reduction in large-scale generation was in the nuclear sector – its share of electricity generation fell from over 33% in 2000 to 25% in 2007<sup>viii</sup>. This was largely due to planned and unplanned outages and reductions in nuclear generation. To deliver Scotland's climate change targets, if fossil-fuelled stations are to continue to operate rather than be replaced by renewables, carbon capture and storage technology will be essential.



Note 1: 'Wind and wave' is virtually entirely wind generation.  
Fig 1 Electricity generation in Scotland subdivided by source, 2000-2007

## Case 1: Meeting current targets

This case sets out the likely course of events under plausible 'business as usual' assumptions, meeting those current targets or aspirations in EU, UK and Scottish policies that are receiving significant investment and political attention.

Analysis by Garrad Hassan shows that by 2030, in such a scenario, renewable electricity sources are likely to make up:

- 68% of Scotland's generating capacity
- 58% of our total electricity generation and
- 64% of our domestic electricity demand.

The Scottish Government's renewable electricity targets for 2011 and 2020 are met, with more than 7GW of additional capacity bringing the total to over 10GW in 2020. However, this case assumes, very conservatively, that very little further renewable capacity is built after 2020, with the total in 2030 being just 10.8GW. Moreover, in this scenario it is assumed there is continued growth in demand, despite aspirations to the contrary. In practice, demand reduction could have a significant effect on targets for 2030, and this is examined in more detail in Cases 4 and 5.

Even in this 'business as usual' case which meets only some existing policy targets, Scotland does not require any new fossil or nuclear capacity (other than replacement for Peterhead or Longannet, if required) to maintain security of supply. However, it does not deliver the required degree of decarbonisation without the deployment of CCS, and after the closure of Cockenzie, Hunterston, and Torness it would require significant, although entirely practical, investment in transmission, interconnections and potentially new storage capacity.

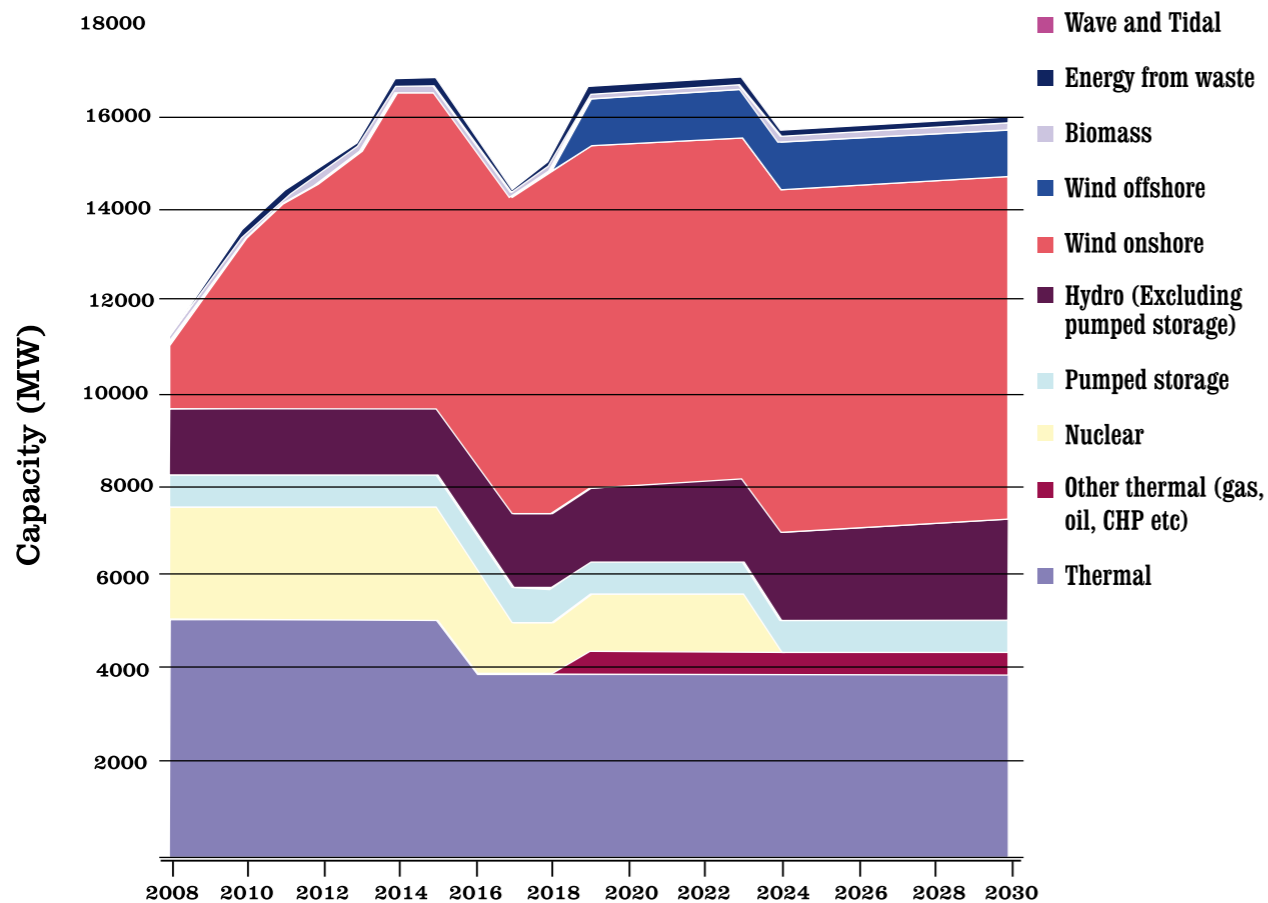


Figure 2 Electricity production to 2030, Case 1

## Case 2: Continued growth in renewables

This scenario assumes that renewable energy generation capacity continues to increase further beyond 2020. For purposes of analysis an assumed target for 2030 is adopted for renewable electricity production in Scotland to meet 90% of gross domestic consumption.

If this additional generating capacity were to come from technologies such as onshore wind, offshore wind, wave and tidal, then additional renewable capacity of the order of 4.1 GW would be required – at an annual rate of construction similar to that required in the 2010s. This brings the total renewable capacity in 2030 from 10.8 GW to 14.9 GW. This volume of renewable capacity is well within Scotland's identified renewable resource potential, even when avoiding development on sensitive wildlife, landscape areas and MOD low fly zones<sup>ix</sup>. Garrad Hassan's analysis assumes that additional capacity is made up of wave and tidal generation, but it may also include a wider mix of sources, including significant additional microgeneration capacity.

This alternative case developed by Garrad Hassan would mean that renewables make up:

- 75% of Scotland's generating capacity
- 67% of our total electricity generation and
- 93% of our domestic electricity demand.

Comparing 2014 and 2030 in Figure 3 above, it can be seen that total Scottish electricity production is very Figure 3 also makes it clear that Case 2 assumes that thermal generation output remains unchanged from 2019 onwards. In effect, as renewables would meet 90% of Scottish gross consumption by 2030, it is assumed that virtually all this thermal generation output would be exported. In reality, it is likely that the thermal generation output would be reduced to some extent. It is possible that some or all of the thermal generation would close. This would not affect achievement of the 2030 renewable electricity target but would help meet carbon emissions reduction targets. To achieve high levels of decarbonisation requires either closure of these stations or the implementation of fully operational CCS. Analysis suggests that in this Case, closure would be technically feasible, although in those circumstances there would be periods in which Scotland would be a significant short-term importer of electricity. In this case substantial interconnector capacity would be required.

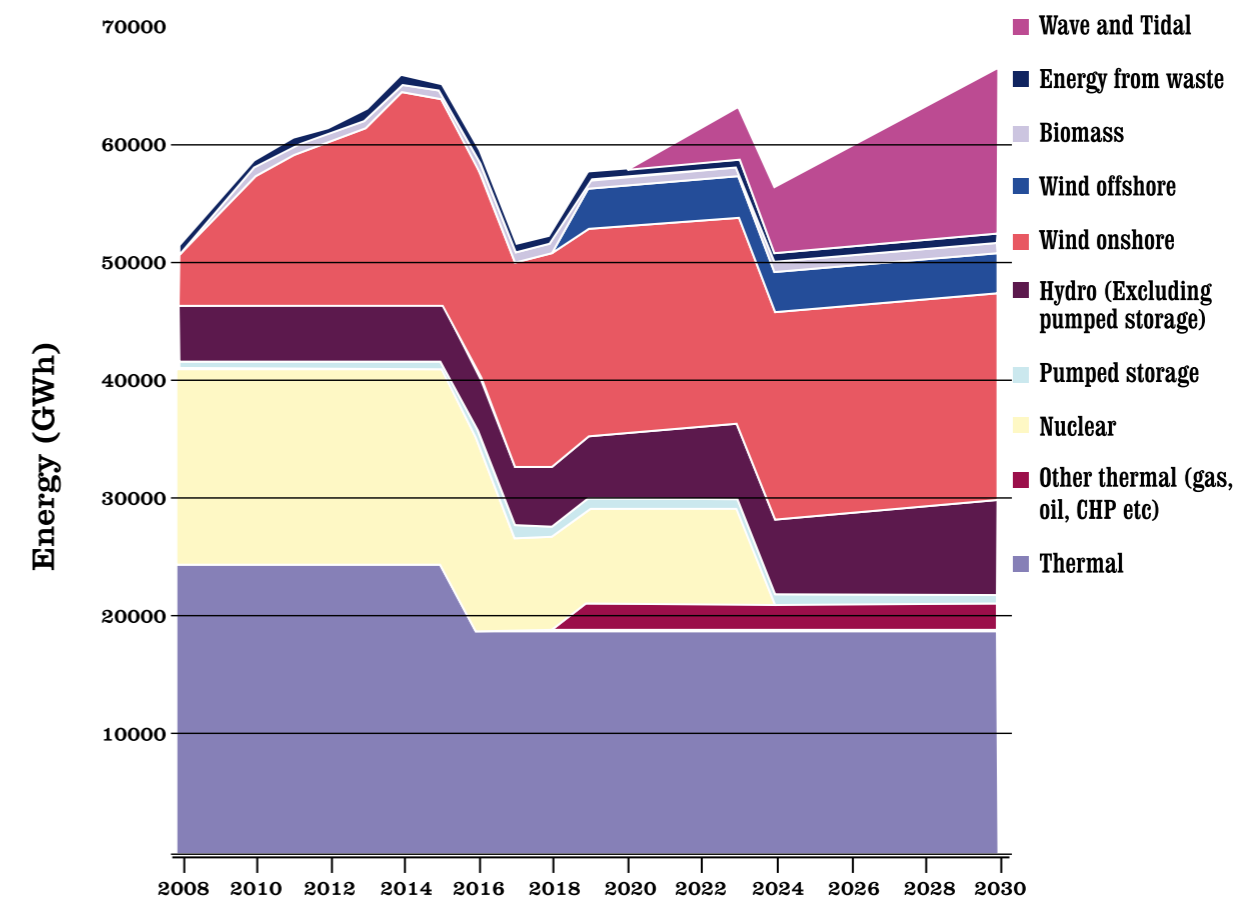


Figure 3 Electricity production to 2030, Case 2

### Case 3: Growth in renewables outside Scotland

Case 3 differs from Cases 1 and 2 in that it assumes that the electrical systems to which Scotland is connected will be following a similar path, i.e. decarbonising their electricity supply via a rapid expansion of renewable capacity. Should this be the case, the assumptions made for the first two scenarios, that Scotland would be able to export significant amounts of electricity during periods of excess supply, and rely on imports when demand exceeds domestic supply, can no longer be relied upon to the same extent.

Instead, measures such as additional peaking capacity (probably gas-fired) or developing renewables that are either dispatchable (e.g. biomass) or which incorporate a storage function (e.g. tidal barrage) would be required alongside investment in deferrable demand in order to provide security of supply. However, there is no reason to suppose that the rest of the UK is in fact pursuing a generation scenario identical to Scotland; instead, the generation mix in England and Wales is more likely to be based upon a combination of renewables, thermal generation with CCS, and baseload nuclear.

### Case 4: Reducing demand

Previous cases were based on the assumption that Scotland’s annual electricity consumption would increase significantly to 2030. This assumption could be seen as unduly pessimistic; both Scottish and UK energy policy aims for a significant reduction in electricity demand, and the Scottish Climate Change Act puts Scotland’s energy efficiency action plan on a statutory footing.

Rather than the increased demand of earlier scenarios, Case 4 adopts projections of electricity demand reduction and compares them with projected supply. The Department for Business, Enterprise and Regulatory Reform (DBERR) in 2008 predicted an 8% reduction in demand to 2020, which then remains constant to 2030. This relatively unambitious or ‘modest’ scenario puts the annual demand at 38.6 TWh/y in 2030. Modelling by Pöyry Energy Consultants in 2008 analysed three scenarios, of which the medium scenario is adopted here. This assumes an elevated level of action delivering a demand reduction of 20% by 2020 and 26% by 2030. This would give an annual demand of 31.1 TWh/y in 2030.

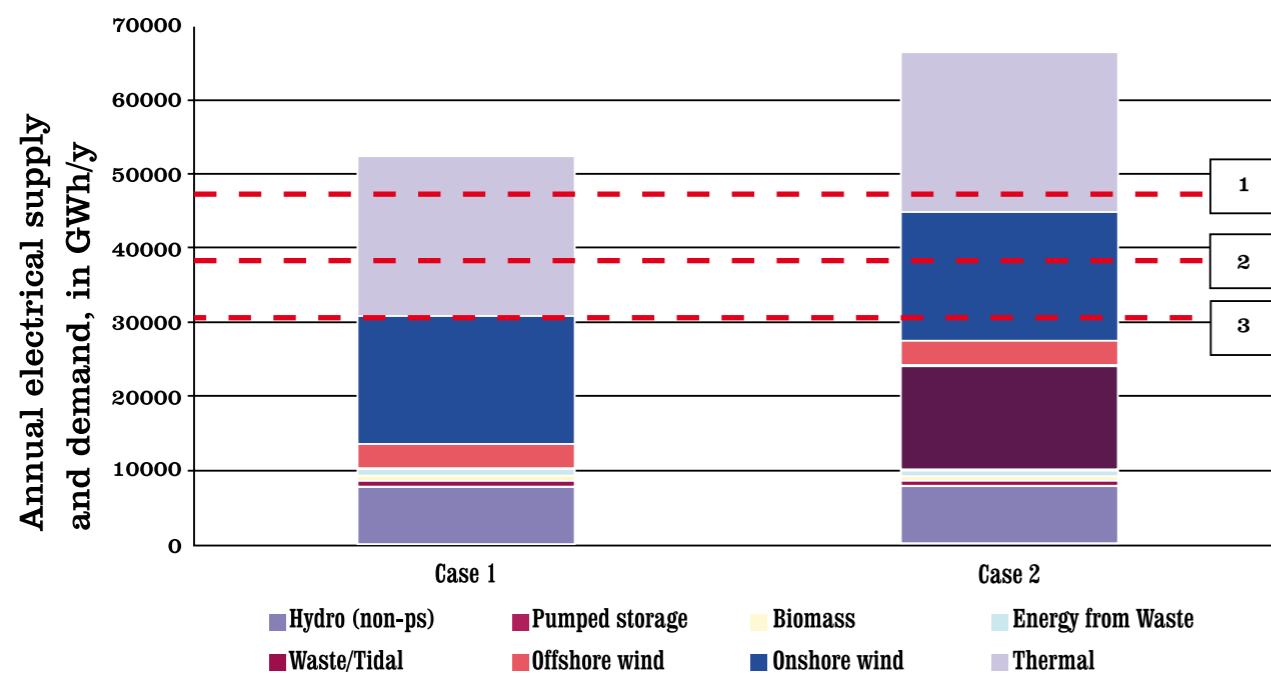


Figure 4: 2030 electrical output scenarios from Cases 1 and 2 compared with three different demand scenarios



In figure 4 opposite the three demand projections (the increase assumed for Cases 1 and 2 (line 1), and the modest and more ambitious reductions considered in Case 4) are shown as numbered horizontal dashed lines against the Case 1 and Case 2 generation scenarios.

It can be seen that for Case 1, that even with modest demand reduction, we would still require a certain amount of thermal generation capacity, while the more ambitious demand reduction more or less coincides with the renewable output. However, Case 2 provides enough output to comfortably meet annual demand in either of the demand reduction scenarios.

While it is possible that some thermal generation might be retained to provide peaking capacity, it is more likely that operators would not find this economically viable under such demand reduction scenarios. Even so, security could be maintained with moderate investments in deferrable demand and storage, and Scotland would be able to make substantial net exports.

## Case 5: Electrification of heat supply and transport

Electricity generation is responsible for only a small proportion of energy related greenhouse gas emissions. Transport and, to a greater extent, heat make up the majority of Scotland's greenhouse gas emissions. Thus many advocate a transition to increase use of low carbon electricity to substitute for fossil fuel in heat and transport uses.

Case 5 examines the implications of electrification of 10% of the current demand for heating. This would add between 2.5 and 7.8 TWh/y to Scotland's projected electricity demand, depending on the extent of uptake of heat pumps and the level of home energy demand reduction. While electrification of heating demand places an additional burden on the electricity supply, it is both storable and deferrable and generally coincides with periods of high renewables output. For these reasons, it should act to improve the security of supply.

This case also examines electrification of 10% of transport. While this currently represents some 5 TWh of energy each year, electric transport is many times more efficient than that powered by fossil fuels, so the additional electricity demand is only in the region of 1 TWh per year. This relatively modest addition to Scotland's annual demand should present little difficulty to our system of electricity supply, and the storage function provided by a fleet of electrical vehicles provides both for deferrable demand and for a reserve function in the event of capacity loss elsewhere on the system.



## Conclusions

The analysis carried out by Garrad Hassan demonstrates that there is enormous potential to increase the generation of electricity from renewable sources during the next two decades, and that by 2030 renewable energy can meet between 60% and 143% of Scotland's projected annual electricity demand, depending on the level of investment in energy saving and new renewables.

As the proportion of electricity derived from variable energy sources such as wind, wave and tidal power increases, care must be taken to ensure that security of supply is not compromised. Measures to increase the proportion of demand that can be deferred, such as smart meters and smart appliances are expected to be rolled out, with the effect that in no scenario is peak demand expected to rise, even when overall consumption rises. The analysis indicates that under either the base case or Case 2, the worst-case situation (minimal output from variable sources of renewable energy coinciding with a period of peak demand) would not result in power shortages, although Scotland might be forced to rely upon imports of electricity from elsewhere in the UK.

The system can be made more secure by increasing the capacity of interconnectors to England and Wales, Northern Ireland and elsewhere in Europe, enabling electricity to be exported during periods of excess production and imported when very low (or extremely high) winds mean that Scotland's variable renewable sources are not operating. This remains true, although less effective, even if the rest of the UK pursues a decarbonisation strategy.

Achieving the considerable potential to manage and reduce electricity demand (Case 4) would result in an even greater margin of safety. In these cases the adoption of deferrable demand measures could reduce peak demand even faster. And, somewhat counter-intuitively, a moderate level of electrification of heat and transport would most likely enhance security by increasing the proportion of demand that can be deferred.

Decommissioning large, centralised generation capacity at Cogenzie, Hunterston B and Torness will not compromise Scotland's energy security, especially if Scotland takes measures to reduce our demand for electricity through energy efficiency measures, and by electrification of some degree of heat and transport demand.

However, combining increased development of renewables with a realistic programme of demand reduction means that Scotland's renewable resource can meet – and exceed – our annual electricity demand, even when a significant proportion of heating and transport demand are electrified. Under such a scenario, it is entirely feasible for all centralised thermal generation to be closed by 2030, delivering almost complete decarbonisation, with our security of supply relying on interconnectors, storage and deferrable demand.

This report shows for the first time that a truly sustainable energy future is achievable for Scotland. Rather than burdening future generations with an inefficient, uneconomic and carbon intensive model of electricity production, we can demonstrate that a healthy, modern economy can be powered by electricity that doesn't cost the earth.

## Reference:

<sup>i</sup>Targets in the Climate Change (Scotland) Bill, as passed on 24 June 2009. Available online at: <http://www.scottish.parliament.uk/s3/bills/17-ClimateChange/index.htm> [Accessed 2nd July 2009]

<sup>ii</sup>AEA Technology, 2008. Greenhouse Gas Inventories for England, Scotland Wales and Northern Ireland: 1990-2006. Available online at: [http://www.airquality.co.uk/reports/cat07/0809291432\\_DA\\_GHGI\\_report\\_2006\\_main\\_text\\_Issue\\_1r.pdf](http://www.airquality.co.uk/reports/cat07/0809291432_DA_GHGI_report_2006_main_text_Issue_1r.pdf) [Accessed 24th May 2009]

<sup>iii</sup>Scottish Government, 2009, Climate Change Deliver Plan. Available online at: <http://www.scotland.gov.uk/Publications/2009/06/18103720/0> [Accessed 19th June 2009]

<sup>iv</sup>In comparison with 1990 levels; the baseline year for some of the Kyoto gases is different, but for the majority it is 1990.

<sup>v</sup>Scottish Government, 2007. Renewable energy potential

(News release). Available online at: <http://openscotland.gov.uk/News/Releases/2007/11/27095600> [Accessed 15th April 2009]

<sup>vii</sup>Scottish Government, 2008. Renewable energy targets (News release). Available online at: <http://openscotland.gov.uk/News/Releases/2008/09/09103722> [Accessed 15th April 2009]

<sup>viii</sup>Department for Environment, Food and Rural Affairs, 2007. UK Energy Efficiency Action Plan 2007. Available online at: [http://ec.europa.eu/energy/demand/legislation/doc/neeap/uk\\_en.pdf](http://ec.europa.eu/energy/demand/legislation/doc/neeap/uk_en.pdf) [accessed 30th May 2009]

<sup>ix</sup>Note that figures for capacity can differ from generation in any given year, as different types of electricity generation can be utilised for varying percentages of their capacity.

<sup>x</sup>Scotland's Renewable Resource 2001 Garrad Hassan & Partners Ltd. Scottish Executive 2001

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The full **Power of Scotland Renewed** report is available at  
[www.foe-scotland.org.uk/energy](http://www.foe-scotland.org.uk/energy)