Shaping Our Energy Future: Electricity Infrastructure

1. Introduction

The UK has a privatised electricity market. The electricity supply industry currently comprises: generation capacity; a transmission network (the National Grid) that transmits electricity across Britain from where it is generated via high-voltage overhead lines; and regional distribution networks (overhead lines and underground cables that deliver lower voltage power from Grid 'supply points' to customers, owned by distribution network operators (DNOs)). Ofgem is the regulator for Britain's electricity market.

Scotland currently has 2 nuclear power stations; 2 coal-fired power stations; 1 gas-fired power station; and almost 3,000 MW of installed wind capacity (see map at Appendix 1). Energy policy is reserved to the UK Government, which sets the policy framework for electricity generation, transmission, distribution and supply. Scotland has devolved responsibility for planning and environment policies.

Existing coal and nuclear plants are reaching the end of their lives, reducing generation capacity. At the same time electricity demand is projected to rise gradually. As a result, spare capacity in the GB electricity market is due to reduce rapidly over the next few years[1]. Figure 1 shows predicted generation capacity changes through to 2017. The result is a higher risk of occasional electricity shortfalls; however, customers are expected to feel little or no impact [1].

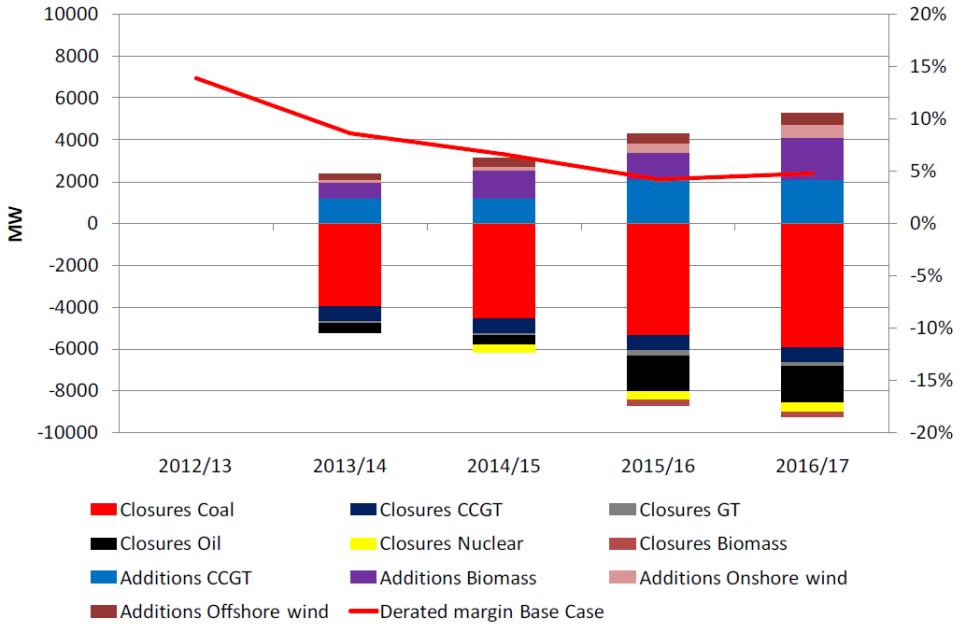

Figure 1. Electricity generation capacity changes in the GB market and de-rated margin, base winter case (source: Ofgem, 2012 [1]).

[1] Ofgem showed the de-rated capacity margin was to fall from 14% to 4% by 2016 [1]. This is the percentage ratio of excess available generation capacity to peak demand, where capacity of each generator is de-rated using the historical availability for that technology.

Given impending plant closures and gradually rising demand, there is a gap between future electricity supply and demand that investment in new infrastructure must seek to fill. The UK and Scottish Governments will set the overall framework for this investment – notably through the UK Energy bill and its Electricity Market Reform and the Scottish Government's renewables and planning policies. It is private sector actors that will then determine where and when that investment will occur.

2. Current infrastructure

2.1 Nuclear

Two nuclear power stations (Hunterston and Torness) currently operate in Scotland, producing a significant proportion of the electricity generated in Scotland (30.6% in 2010 [2]). They are due to close in 2016 and 2023 respectively, though their operator EDF Energy hopes to extend the life of each by a minimum of 5 years. The Scottish Government's policy is for no new nuclear build to take place in Scotland, but does not oppose extensions to the operational life of existing installations.

2.2 Coal and gas

Scotland currently has 2 coal-fired power stations, at Cockenzie and Longannet, and one gas-fired station at Peterhead. Together these have an installed capacity of over 4,500 MW.

Air-quality standards set by the Large Combustion Plant Directive mean that a number of UK coal- and oil-fired power stations are scheduled to close by 2015. Cockenzie is due to close in 2013. Longannet plans to comply with the directive and continue operating.

Under the provisions of the UK Energy bill, an Emissions Performance Standard (EPS) set at 450g CO_2/kWh will reinforce the requirement that no new coal-fired power stations are built without Carbon Capture and Storage (CCS – see below). The proposed level for the EPS will allow new gas-fired plant to be built.

2.3 Carbon Capture and Storage (CCS)

Carbon Capture and Storage refers to a process whereby the carbon dioxide produced from the fossil fuel-fired power plant is trapped and stored so that it is unable to escape to the atmosphere. Two proposed Scottish CCS projects, at Hunterston and Longannet, have failed to get off the ground [3] [4]. Other CCS projects are under consideration, such as at Peterhead. However, setbacks to date leave doubts as to how rapidly CCS could be widely deployed. Issues with CCS are replicated internationally with the International Energy Agency describing the slow progress as particularly worrisome [5].

2.4 Renewables

Renewable generation in Scotland from 2000 to 2010 is shown in Figure 2, with the percentage of gross consumption on the right axis. The graph shows the growth in wind output with wind generating more electricity than hydro for the first time in 2010 [6].

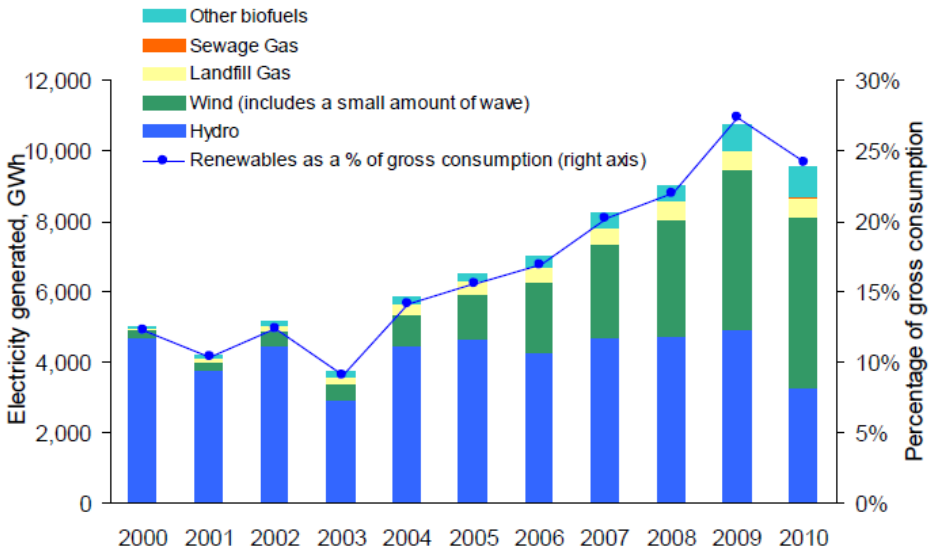

Figure 2. Electricity generated from renewables in Scotland by technology (source: The Scottish Government, 2012 [6]).

Appendix 1 provides a map of wind developments in Scotland. Wind is an intermittent resource, varying across seasons and also during the day. Wind-generated electricity output can therefore be relatively low at times of high demand or vice versa. As wind speeds vary between areas, having a range of wind farm locations reduces the overall variability of output [7]. Nevertheless, in isolation, wind power has limited capability to provide an adequate source of on-demand electricity [7]. Ways of tackling this include the use of additional fossil fuel plant capacity or other on-demand source, increased interconnection and storage capacity, the introduction of smart grids, and improved load management [7]. The Scottish Government's approach is primarily focused on retaining fossil fuel capacity for base-load and balancing, and installing interconnectors for load balancing [8]. Despite its intermittency, wind provides an abundant resource for generating low carbon electricity, and in the case of on-shore wind, may be the cheapest renewable technology for the UK [7].

3. The evolving policy framework

Scotland's energy infrastructure is in transition. Changes are being driven by a combination of ambitious targets for greenhouse gas emissions reduction and renewables, and planned end-of-life decommissioning of existing coal and nuclear capacity. Table 1 shows the 2020 renewable energy targets and the levels achieved in 2010.

Table 1. Scottish 2020 renewable energy targets and actual 2010 levels (sources: The Scottish Government [9] [6] [10]).

	2020 Target	2010 levels
Heat	11%	2.8%
Transport	10%	3.6%
Electricity [1]	100%	24.1%
Overall	30%	

[1] **Renewable electricity figures are stated in equivalent term to gross consumption.**

3.1 Interconnection and transmission

The existing system links between Scotland and England are being used to their maximum capacity and a number of reinforcements are required to accommodate the increased transfers predicted by 2020 [11]. However Ofgem analysis [1] suggests that until 2016 the link between Scotland and England will not be a significant constraint on electricity security of supply for GB due to the planned investment in upgrading; notably a West Coast link between Hunterston and North Wales, and an East Coast link between Peterhead and Humberside [8]. Significant other reinforcements are required within Scotland, including a new subsea link from the Scottish Islands to the mainland. Figure 3 shows these and other works.

The total cost for these links has been estimated at £6.06 billion in 2010 terms [11]. Doubt has been expressed as to the feasibility of completing the installation of further subsea interconnectors by 2020, potentially constraining achievement of Scotland's 2020 renewable targets [12]. Longer term developments may include a North Sea grid and a sub-sea grid in the Irish Sea [8]. Increases in interconnection would be expected to improve security of supply because of the benefits gained from being a part of a larger and more diverse electricity system [1].

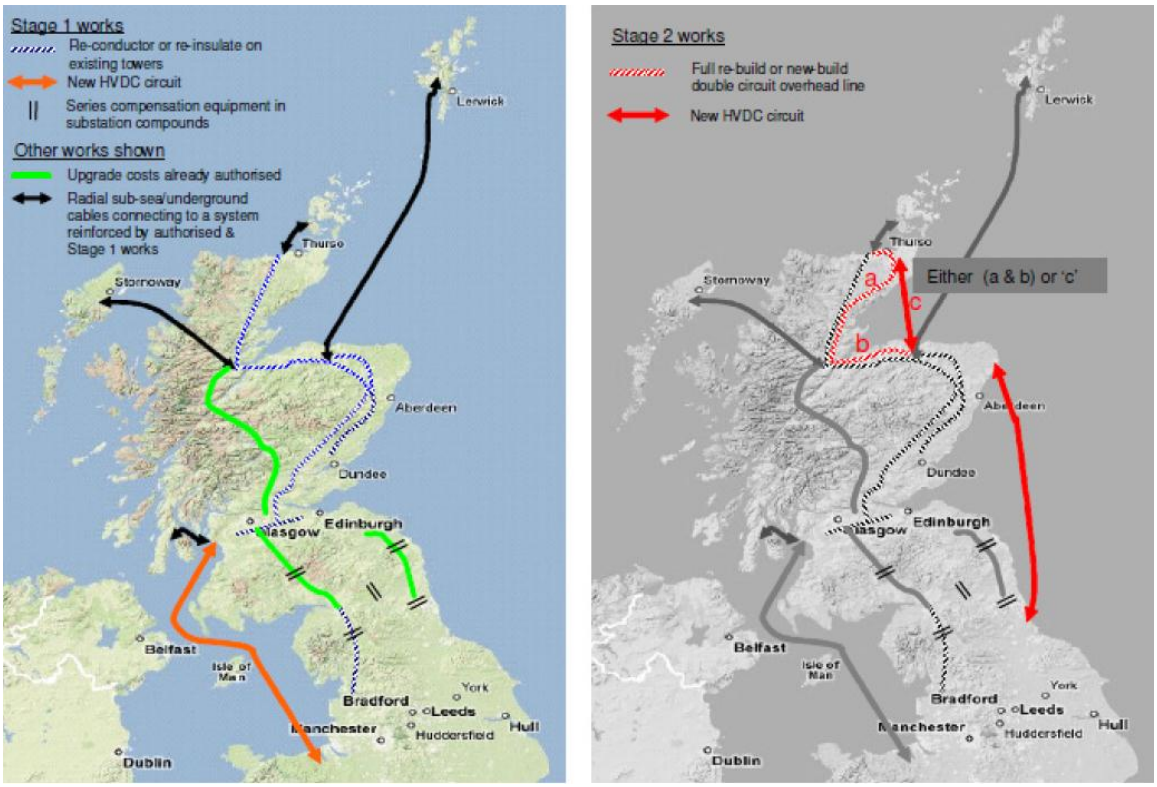

Figure 3. Transmission reinforcements for Scotland (source: The Scottish Government, 2012 [8]).

3.2 The Trajectory for Scotland?

The Scottish Government commissioned analysis to outline a plausible generation mix that could achieve its 2020 renewable electricity target. The results put renewables in 2020 at 72% of generation capacity and 64% of output. This equates to a little more than Scotland's total electricity consumption [8]. The rest of the electricity would be available for export, in line with the Scottish Government's policy to export half of electricity generated by 2020 [10]. The analysis identified wind as the principal generator, accounting for 55% of supply, 32% from onshore and 24% offshore wind [8]. To achieve the targets, renewable deployment needs to occur more rapidly than historically [10]. It is widely accepted that this is a challenging goal, but some are sceptical that it is technically or financially achievable [13].

4. References

1. **Ofgem.** Electricity Capacity Assessment. 2012.
2. **Department of Energy and Climate Change.** Energy trends. 2011, December.
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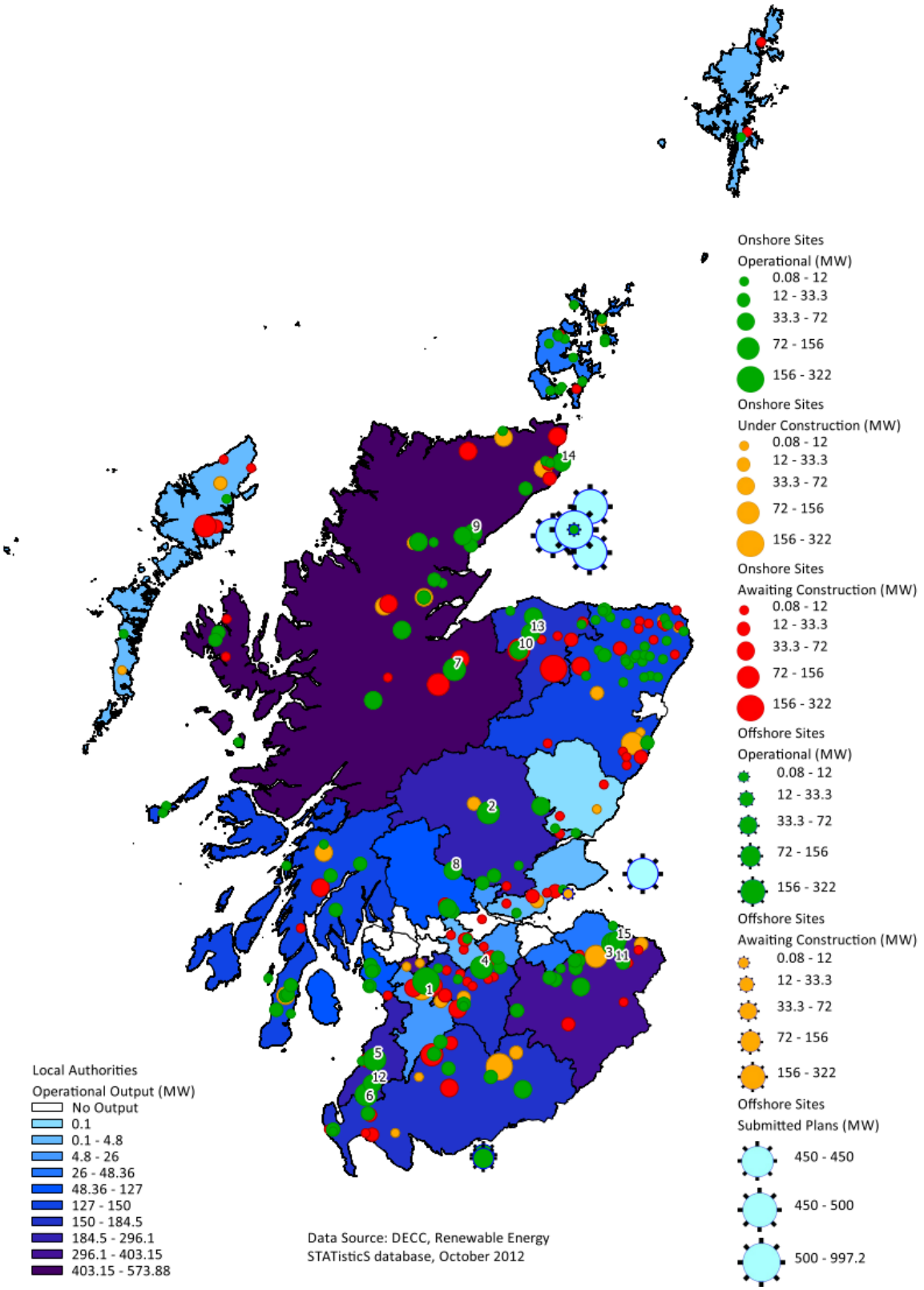
12. **Sinclair Knight Merz.** Scottish Generation Scenarios and Power Flows. 2011.
13. **Institution of Mechanical Engineers.** Scottish Energy 2020? 2011.
14. **Department of Energy and Climate Change.** Digest of United Kingdom Energy Statistics 2012, Chapter 5. 2012.

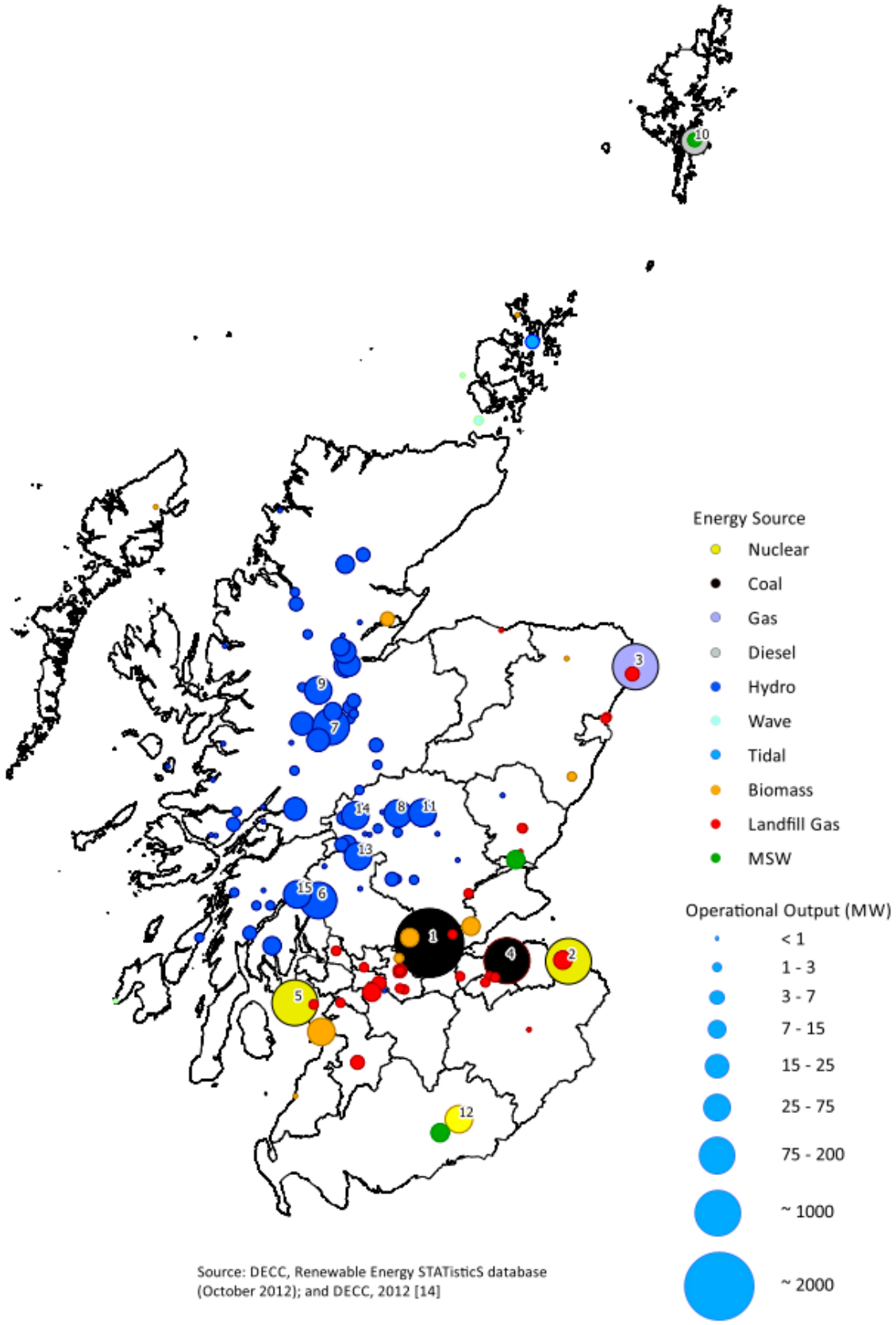
Appendix 1 – On-shore and Off-shore wind developments in Scotland



Key:

Ranking	*Site Name*	*Installed Capacity (MW)*
1	Whitelee	322
2	Griffin	156
3	Crystal Rig Phase 2a	138
4	Black Law	124
5	Hadyard Hill	120
6	Arecleoch	120
7	Farr	92
8	Braes O'Doune	72
9	Gordonbush	70
10	Paul's Hill and Extension	65
11	Crystal Rig Phase 1	62.5
12	Mark Hill	56
13	Rothes Wind (Cairn Uish)	50.6
14	Causeymire	48.3
15	Aikengall	48

Appendix 2 – Electricity generation in Scotland, excluding wind



Source: DECC, Renewable Energy STATisticS database (October 2012); and DECC, 2012 [14]

Key:

Ranking	*Site Name*	*Technology*	*Installed Capacity (MW)*
1	Longannet	Coal	2304
2	Torness	Nuclear	1190
3	Peterhead	Gas / Oil	1180
4	Cockenzie	Coal	1152
5	Hunterston B	Nuclear	890
6	Sloy	Hydro	153
7	Glendoe	Hydro	100
8	Errochty	Hydro	75
9	Fasnakyle	Hydro	69
10	Lerwick	Diesel	67
11	Clunie	Hydro	61
12	Steven's Croft	Biomass – Dedicated	50.4
13	Lochay	Hydro	46
14	Rannoch	Hydro	45
15	Clachan	Hydro	40

Appendix 3 – Transmission network infrastructure

Source: DECC, 2012 [14]

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Source: DECC, 2012 [14]