

# Powering Scotland

## Powering Scotland

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## About Reform Scotland

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Reform Scotland is an independent, non-party think tank that aims to set out a better way to deliver increased economic prosperity and more effective public services based on the traditional Scottish principles of limited government, diversity and personal responsibility.

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## i. Executive Summary

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### Objective

The debate on energy policy in Scotland has too often focused on examining the differences in policy between the UK and Scottish Governments. It is also overshadowed by the debate on nuclear energy. We need a long-term energy policy for Scotland that looks at what sort of energy sector we want for the next generation. This should take into account how we can ensure a stable, diverse, clean and cost-effective supply to meet the needs of households, businesses and industry in the future. Further, we should decide whether we intend to become a net producer, exporting electricity to other countries.

The objectives of this paper are to set out the current state of the energy sector in Scotland, look at the existing policy framework, review the alternative sources of energy and recommend policies that will meet Scotland's future energy needs.

### Findings

- The current mix of energy supply in Scotland, dominated as it is by fossil fuels, is not sustainable in the longer term either in financial terms (as global economic growth increases the demand for and, therefore, price of scarce fossil fuels) or in environmental terms (due to the carbon emissions from fossil fuels and their contribution to climate change).
- Energy policy is largely retained at Westminster, although some elements of energy policy sit at the European Union level and some are devolved to the Scottish Government or to local government. However, the Scottish Government has control over the most effective mechanism for realising energy policy objectives, planning powers for any power station with a capacity of 50 megawatts (MW) or more.
- Scotland is connected to the UK electricity grid and is currently an exporter of electricity. In 2009, Scotland exported 12 Gigawatt hours (GWh) of the 51 GWh generated and so exports were equivalent to 24% of the electricity generated in Scotland.

- With the lives of some of the large power stations being extended, plans for a new gas fired power station to replace the coal fired power station at Cockerzie and substantial further investment planned in renewable energy (in particular wind power), encouraged by the Scottish Government's 2011 and 2020 targets, the risks of an 'energy gap' have receded, at least in terms of the overall annual supply and demand for electricity.
- Renewable energy has made an important contribution to the electricity generation mix in Scotland since the post war investment in hydroelectric power, particularly in the Highlands and Islands. In 2009, hydropower accounted for 12% of electricity generated. Over the last decade there has been substantial investment in on-shore wind power, which contributed 11% of the electricity generated in Scotland in 2009, an almost 20-fold increase in a decade.
- The lesson from other Northern European countries, which have comparable energy requirements, is that all are investing in new, low carbon electricity generation capacity. The energy policies being pursued reflect each country's resources. So, for example:
  - Norway is close to achieving a 100% renewables target, based on its natural hydro resources;
  - Sweden also has extensive natural hydro power resources (although much less than Norway) but in 2009 reversed a previous phase out policy, deciding to replace its nuclear power stations;
  - Finland has decided to invest in new nuclear, in order to meet emissions targets and achieve energy security.

- Electricity generation from renewable sources has price disadvantage when compared to fossil fuel generation. However, with rising fossil fuel prices and economies of scale achievable as renewable energy sectors grow and the technologies mature, the price differentials are narrowing. In any case, the cost of generation is just one of the factors to consider when developing energy policy. Security of supply, environmental impact and economic development potential should also be considerations. There is no single source of generation that is preferable to others across all four of these factors. A decision therefore needs to be based on a balance of these factors. Renewable energy, wind power in the short term and new low-carbon technologies in the medium to long term can provide security of supply and significant economic development opportunities for Scotland, whilst delivering environmental benefits associated with decarbonising the economy. The generation costs are likely to be higher than we have become used to, although with increasing fossil fuel prices and carbon pricing, this is likely to be an issue whatever generation mix is pursued.

## Policy Recommendations

**Devolve energy policy to the Scottish Parliament:** The UK Government has theoretical responsibility for energy policy. However, the Scottish Government has an effective veto through planning powers. Energy policy should be formally devolved to the Scottish Parliament so that the Scottish Government can formulate a clear energy policy that meets Scotland's needs.

**Increase energy exports:** We would support the aim of a substantial increase in energy exports with a target of around half of electricity generated in Scotland being exported because, even using conservative assumptions on prices, this would increase Scottish exports by £2 billion per annum, equivalent to around 17% of Scottish manufacturing exports to the rest of the UK. Given that some of the current fossil fuel and nuclear capacity will still be available in 2020, this is feasible if the 100% renewables target set by the Scottish Government is met.

**Develop the potential of renewable forms of energy:** We support the policy of the SNP Scottish Government and the previous Labour and Liberal Democrat Scottish Executive, which has been to promote renewable energy development. This policy has been successful and it is now the time to go further. The Scottish Government was right to encourage the further acceleration of renewable energy generation by increasing the 2020 renewables target to 100% of Scottish electricity demand. A large proportion of that target can be achieved by wind power (on-shore over the next few years and increasingly off-shore as 2020 approaches) and so to encourage investment and to signal that Scotland is an attractive location for the development and deployment of new and emerging technologies, the Scottish Government should set longer term targets:

- that a significant majority of the electricity generated in Scotland, (between 50% and 75%), is met from low carbon sources by 2030;
- so that enough electricity is generated from renewable sources to exceed Scottish demand, so that Scotland becomes the biggest exporter of low carbon electricity in Europe.

**Move away from a certificate-based system towards a carbon tax:**

As part of the devolution of energy policy, we believe that the Scottish Government should consider a well-designed carbon tax (either particularly targeting the energy sector or as part of a wider carbon tax). This would be a direct tax on negative environmental impact rather than a subsidy for a particular solution such as the main tool currently used to provide an incentive for the growth of renewables in Scotland and the rest of the UK - Renewable Obligation Certificates (ROCs).

The introduction of a carbon tax in Scotland may require the devolution of greater fiscal powers to the Scottish Parliament and a carbon tax should be designed to price-in environmental costs rather than to raise revenue. However, if it did increase net revenue, there should be reductions in taxation elsewhere (e.g. VAT paid on energy by consumers) to maintain Scotland's economic competitiveness.

**Create the policy environment for energy innovation:** Following the devolution of energy policy to the Scottish Government, we would support a policy environment that encourages innovative, 'low carbon' sources of energy to accommodate new and emerging technologies that can make a significant economic development and environmental impact, including carbon capture and storage. This would include:

- increased support for research and development (R&D) and commercialisation so that the excellence in the Scottish academic research base is translated to the market and to encourage both indigenous and international companies to invest in R&D in Scotland;
- a strategy for skills provision to ensure that universities and colleges are aware of future skills needs and have provision in place so that the industry can recruit the staff it will need;
- identification of other areas that could support energy policy. These could include transport, where the introduction of electric vehicles, combined with an increase in renewable energy could help to decarbonise the transport sector;
- set out a framework for the infrastructure provision that might be required to facilitate the further development of renewables. This is likely to include port facilities, development and testing facilities for new technologies and sites suitable for manufacturing facilities. These could be funded by a model such as tax increment financing (TIFs) or by issuing of energy infrastructure bonds, should the increased borrowing powers of the Scottish Parliament allow for such a model;
- accelerated planning arrangements for renewable projects;
- investment in domestic grid to facilitate an increase in new electricity generating capacity, distributed across Scotland;

- support for a wider European grid to facilitate a competitive Europe-wide market in electricity supply;
- access to grid at prices that do not discourage investment, which will require Ofgen to take account of the Scottish Government's energy policy as well as UK policy.

**Phase out nuclear power stations:** We do not think that Scotland's existing nuclear power stations should be replaced and we believe that the sites should be used to develop new energy technologies. New nuclear capacity is one option to meet international obligations and climate change targets set in legislation passed by the Scottish Parliament. This approach would have the advantage of delivering low carbon electricity and some estimates that have been made suggest that the generation costs per unit of electricity for nuclear are competitive with some other generation sources. However, the disadvantages of nuclear electricity generation include cost risks (associated with the risks of capital cost over-run and uncertainty about the long term costs associated with treating and storing waste) and the limited potential for the nuclear sector to contribute to economic development in Scotland, compared to other generation sources. The cost uncertainty and limited economic development potential means that there is not a strong case for nuclear generation in Scotland.

## Conclusion

Energy policy is crucial to Scotland's economic future. The energy sector has the potential to make a major contribution to the development of the Scottish economy. As a result of Scotland's natural energy resources, the strengths of the university research base, the energy companies based in Scotland and a favourable policy environment, Scotland could become a world-leader in new energy generation technologies. Scotland could become a case study in sustainable development and export the technology and know-how around the world. Scotland needs an energy policy that recognises this opportunity and removes the barriers to realising it.

# 1. Introduction and Policy Context

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## 1.1 Objective

The debate on energy policy in Scotland has too often focused on examining the differences in policy between the UK and Scottish Governments. It is also overshadowed by the debate on nuclear energy. We need a long-term energy policy for Scotland that looks at what sort of energy sector we want for the next generation. This should take into account how we can ensure a stable, diverse, clean and cost-effective supply to meet the needs of households, businesses and industry in future. Further, we should decide whether we intend to become a net producer, exporting electricity to other countries.

The objectives of this paper are to set out the current state of the energy sector in Scotland, look at the existing policy framework, review the alternative sources of energy and recommend policies that will meet Scotland's future energy needs.

## 1.2 Global Context

Global demand for energy is growing as a result of population and economic growth with demand predicted to double between 2000 and 2050. How that global demand can be met and the geopolitical and environmental consequences of the potential solutions raise major questions.

An estimated 80-90% of the world's energy demand is currently met from fossil fuels <sup>1</sup> (oil, gas and coal). Increased demand for fossil fuels, driven by the growth in energy demand is likely to lead to higher fuel costs, pushing up the costs of energy. In addition to the energy prices in the market, fossil fuel energy also has a wider environmental impact, as a result of greenhouse gas emissions.

One of the big challenges for society that is being considered at international, national and local level is how the increasing demand for energy can be met, at an acceptable cost to the economy and the environment.

<sup>1</sup> Statistical Review of World Energy\*, BP, 2010.

There is an opportunity for Scotland to make a significant contribution to meeting this challenge by developing energy policies that can be replicated elsewhere and by developing and exporting the technologies that will be required, to the benefit of the Scottish economy.

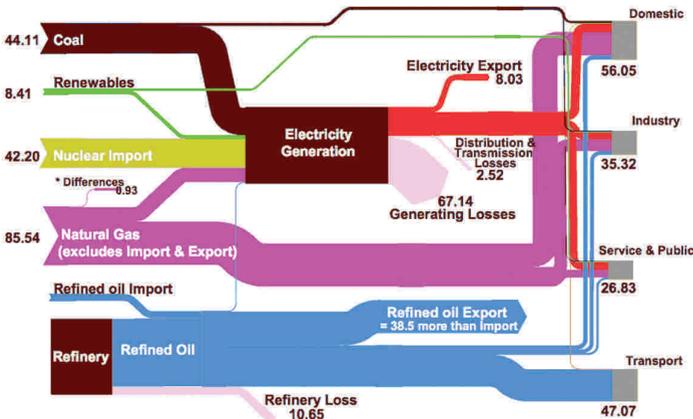
Scotland has already established a reputation for policy innovation, including for example, the world-leading Climate Change Act <sup>2</sup> passed by the Scottish Parliament in 2009, which creates a statutory framework for greenhouse gas emissions reductions in Scotland, by 42 percent by 2020 and by 80 percent by 2050. However, if the ambitious policy targets are to be met they will need to be followed up with practical implementation measures.

This will require the integration of energy policy with other areas of government policy, including, for example, higher and further education, economic development and planning policies.

### 1.3 Energy and Electricity

The energy system is complex, as the figure below demonstrates and can be considered from the perspective of energy sources (the left hand side of the diagram) or final demand (the right hand side), of which the main elements are domestic homes (35% of final demand), transport (28%), industry (21%) and services (18%). In between, the energy flows include fuels, heat and electricity.

Figure 1 - Energy Flows in Scotland (Terawatt Hours, TWh)



Source: Scottish Energy Study, Scottish Government, 2008 <sup>3</sup> (1 TWh = 1 billion kilowatt hours (i.e. standard units of electricity))

<sup>2</sup> Climate Change (Scotland) Act, 2009.

<sup>3</sup> "Scottish Energy Study: Volume 1: Energy in Scotland: Supply and Demand", Scottish Government, 2008.

This paper focuses on the most contentious area of energy policy, electricity generation. However, it is recognised that policy decisions in other areas will have consequences for electricity generation. For example, any significant increase in the use of electrical cars and commercial vehicles will increase the demand for electricity while developments such as enhancements to building standards for insulation will reduce demand for electricity.

#### 1.4 Electricity Sector in Scotland

The electricity sector in Scotland is a diverse sector that includes:

- electricity generation developers and operators (including British Energy which owns and operates Scotland's two operational nuclear power stations, Scottish Power and Scottish and Southern Electricity, both of which operate large power stations and smaller renewable energy developments and a number of smaller renewable energy developers and operators);
- electricity grid operators (Scottish Power in the south of Scotland and Scottish and Southern Electricity in the north);
- suppliers of electricity to households and businesses;
- regulators (including the National Grid and Ofgen);
- providers of the electricity generation technologies;
- construction companies that manage the development of new generation capacity;
- suppliers of fuel, including oil and gas producers and refiners and coal mining companies;
- suppliers of other goods and services to the sector.

## 1.5 Energy Policy

Although the UK Government is ultimately responsible for directing Scotland's energy policy, the Scottish Government has control over granting planning permission for the construction of new power plants over 50 megawatts (MW). As such, the decision-making process relating to energy policy happens at an EU, UK and Scottish Government level, and so Scotland's emission reductions will be defined by whichever body sets the most stringent targets.

### European Union Policy

The central goals for the EU's energy policy, as set out in Article 194 of the Lisbon Treaty, are security of supply, competitiveness and sustainability.

In 2007, the European Council adopted a number of energy and climate change objectives for 2020, to reduce greenhouse gas emissions by 20% (potentially rising to 30% as part of wider international agreements), to increase the share of renewable energy to 20% and to make a 20% improvement in energy efficiency. The European Union's energy strategy <sup>4</sup>, published in 2010, notes that the well-being of the EU's people, industry and economy depends on safe, secure, sustainable and affordable energy and that energy related emissions account for almost 80% of the EU's total greenhouse gas emissions. The new strategy recognises that energy policies taken at the national level have an impact on other member states and that a continent wide market is required for the decarbonisation of electricity generation and to improve security of supply.

The strategy underlines the need to decouple economic growth from energy demand and the creation of market conditions which stimulate higher energy savings and more low carbon investments, to exploit a wide range of centralised and distributed renewable energy as well as key technologies for energy storage and electro-mobility (notably electric vehicles and public transport).

The EU energy strategy focuses on five priorities:

<sup>4</sup> "Energy 2020: A strategy for competitive, sustainable and secure energy", European Commission, November 2010.

- achieving an energy efficient Europe (translating to a 20% saving in energy by 2020);
- building a truly pan-European integrated energy market;
- empowering consumers and achieving the highest level of safety and security;
- extending Europe's leadership in energy technology and innovation; and
- strengthening the external dimension of the EU energy market.

The EU has introduced a number of market based tools to encourage lower emissions, such as an Emissions Trading System, which allows states which emit at levels lower than EU targets to sell their unused emissions to those exceeding the target levels.

Progress has been made towards the 2020 target of 20% emissions reductions. By 2009, in part because of the effects of the financial crisis and lower economic growth, emissions of greenhouse gases had fallen by 14% compared to 1990 levels. Electricity generation is seen by the EU to be the area offering the greatest potential for emissions reductions, mainly through increasing efficiency in the way it is consumed as well as in reducing the investment in carbon-intensive production methods as old technology is replaced.

EU policy recognises that a move to low carbon energy production will reduce concerns about security of supply (54% of the EU's energy needs rely on fossil fuel imports) and encourage employment and economic growth, as well as helping to combat climate change.

### UK Government Policy

Whilst published by the last Government, the framework for the UK Government's overall energy policy is largely set out in the 2007 White Paper <sup>5</sup> which identified two long-term energy challenges:

- reducing greenhouse gas emissions, specifically CO<sub>2</sub> emissions, in light of recent climate change research; and
- ensuring Britain maintains a reliable and safe supply of energy.

<sup>5</sup> "Meeting the Energy Challenge, A White Paper on Energy", UK Government, May 2007.

The current UK Government's energy policy was set out in its first Annual Energy Statement <sup>6</sup> which states that the "mission of this Government is to support the transition to a secure, safe, low-carbon, affordable energy system in the UK, and mobilise commitment to ambitious action on climate change internationally." The Statement makes clear that the rationale for the UK Government's actions is economic as well as environmental and notes the UK's vulnerability to high and volatile oil and gas prices. The large levels of private sector investment needed to develop new low carbon infrastructure are seen as a huge economic opportunity as the UK economy grows out of recession.

The role of the UK Government will be to act as a catalyst for private sector investment in new infrastructure and in energy efficiency, by developing a clear, transparent, long-term policy framework.

The UK Government has also published the 2050 Pathways Analysis <sup>7</sup>, which considers the range of ways in which the UK can meet future energy needs whilst reducing emissions by 80%, over the next forty years. A preferred option has not been identified but the analysis shows that even with substantial reductions in per capita energy demand, a substantial level of electrification of heating, transport and industry will be needed, meaning that electricity supply may need to double, and will need to be decarbonised.

The pathways identified show a significant increase in renewable energy and/ or nuclear generation, as well as a continued role for fossil fuel generation, albeit with carbon capture and storage technologies deployed between 2020 and 2050. There are a wide range of policy measures in place to support the UK energy policy targeting energy demand and conservation, emissions reductions, information provided to consumers, electricity production and investment in demonstrating new technology. Examples include:

- the Carbon Emissions Reduction Target (CERT) which obliges suppliers to encourage the take-up of household energy conservation measures such as insulation;

<sup>6</sup> "Annual Energy Statement", Department of Energy and Climate Change, July 2010.

<sup>7</sup> "2050 Pathways Analysis", Department of Energy and Climate Change, July 2010.

- the Renewables Obligation which places an obligation on UK suppliers of electricity to source an increasing proportion of their electricity from renewable sources – suppliers can either meet the obligation by generating the required proportion from renewable sources or can purchase Renewables Obligation Certificates (ROCs) from others <sup>8</sup> ; and
- Feed-in-Tariffs (FITs), a subsidy to micro and small-scale renewable electricity generators.

The UK Government also publishes an annual analysis of the potential impact of energy policies on future domestic and non-domestic gas and electricity, covering the wide range of initiatives summarised above. The 2010 report <sup>9</sup> shows that, at \$80 per barrel of oil in 2020, domestic energy bills might be expected to increase by 16% with energy policies adding a further 1%. However, if oil prices rise to \$150 per barrel in 2020, domestic energy bills might be expected to increase by 30%, with energy policies reducing that increase by 5% (as a result of the measures to reduce demand and increase energy efficiency). The further development of UK electricity policy was set out in the UK Government's July 2011 White Paper <sup>10</sup> that gives a commitment to "transform the UK's electricity system to ensure that our future electricity supply is secure, low-carbon and affordable." The White Paper anticipates that proposed legislation will receive assent in 2013 with proposed changes taking effect in 2013 and 2014.

The White Paper highlights the scale of the challenge in addressing:

- security of supply as a quarter of the UK's generation capacity will be lost over the next decade as old and polluting capacity closes (while the future system may have more intermittent generation such as wind and inflexible generation such as nuclear); and
- the need to decarbonise electricity generation to meet the 2020 15% renewable energy target by 2020 and 2050 80% carbon reduction target.

<sup>8</sup> The ROCs system works by placing a requirement on electricity suppliers. Renewable energy accounts for a larger proportion of electricity generation in Scotland than elsewhere in the UK and so it could be argued that electricity consumers in England have supported the development of renewable energy generation in Scotland. However, the ROCs system is designed to decarbonise electricity consumption regardless of where the renewable energy is produced. Suppliers of electricity in the rest of the UK would therefore be free to continue to purchase ROCs from Scottish based generators after energy policy was devolved to Scotland (as recommended elsewhere in this paper) provided there was administrative co-operation between the UK and Scottish Governments.

<sup>9</sup> "Estimated impacts of energy and climate change policies on energy prices and bills", Department of Energy and Climate Change, July 2010.

<sup>10</sup> "Planning our electric future: a White Paper for secure, affordable and low-carbon electricity", UK Government, July 2011.

The UK Government estimates that investment of up to £110 billion in electricity generation and transmission is required in the UK by 2020, equivalent to double the current rate of investment.

To encourage investment in new low-carbon generation, the UK Government is proposing a new framework that will have the effect of providing long-term minimum contract prices for electricity generated, in the form of Feed-in Tariffs with Contracts for Difference (FiT CfD). This will be supported by two other mechanisms, a floor price for carbon and emissions standards (that will set a limit on emissions from electricity generation, so that no new coal-fired stations will be built without Carbon Capture and Storage). The details of the FiT CfD system will be developed over the next two years; however, the support will be available to all low-carbon technologies, including nuclear generation.

### Scottish Government Policy

Whilst the UK Government controls Scotland's energy policy and sets the targets relating to emissions reductions, which Scotland must meet, the Scottish Government has the power to set out its own targets, to promote renewable energy and to grant permission for the construction of any power plant over 50MW. The SNP Scottish Government has made clear that it will use its planning powers to ensure that no new nuclear generators are developed in Scotland.

Since its emissions targets are more stringent than the UK's, meeting the Scottish targets will necessarily entail meeting the UK's. The Climate Change (Scotland) Act 2009 sets targets for reducing harmful emissions, by 42% by 2020, and by 80% by 2050, against 1990 levels.

Over the last few years, increasingly ambitious targets have been set for the generation of electricity from renewable sources. The Labour and Liberal Democrat Scottish Executive set what then seemed very ambitious targets to increase the contribution of renewable energy to the generation mix in Scotland, to 31% of electricity demand by 2011 and 40% by 2020. As with subsequent targets, these are expressed in terms of percentage of electricity consumed in Scotland generated from renewable sources.

The SNP Scottish Government confirmed the 2011 renewable energy target (which seems likely to be met) and increased the 2020 target, first to 50% (in 2007), then (in 2010) to 80%. In May 2011, the First Minister announced <sup>11</sup> that the 2020 target had been increased to 100% of Scottish electricity demand to be generated from renewable sources. Given that some of the current fossil fuel and nuclear capacity will still be available in 2020, the 100% renewables target implies a substantial increase in Scotland's exports of electricity, with around half of the electricity generated in 2020 in Scotland being exported. Even using conservative assumptions on prices this would increase Scottish exports by £2 billion per annum, equivalent to around 17% of Scottish manufacturing exports to the rest of the UK.

<sup>11</sup> "Renewables revolution aims for 100%", Scottish Government News Release, 18th May 2011.

## 2. Supply and Demand

This section focuses on the supply of and demand for electricity in Scotland.

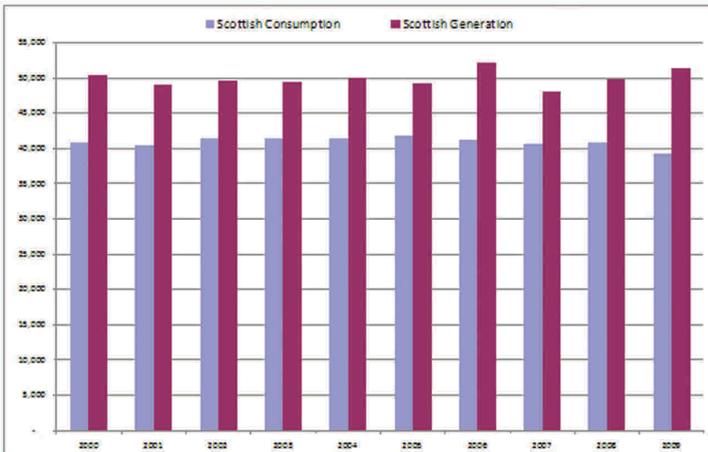
### 2.1 Current Demand and Supply

A unit of electricity on the utilities bills of households and businesses is 1-kilowatt hour (KWh), that is, the one thousand watts of electricity for one hour. The generation and consumption of electricity at the national level is measured in gigawatt hours (GWh), with one GWh equal to 1 million KWh. Over the last decade, Scotland has produced around 50,000 GWh of electricity and consumed around 40,000 GWh each year (Figure 2).

Scotland is connected to the UK electricity grid, to England and Northern Ireland, which means that if, at any given time, generation (supply of electricity) exceeds consumption (demand), electricity is exported and if demand exceeds supply, electricity can be imported.

In 2009, Scotland generated 51,325 GWh and consumed 39,213 GWh, which means that there were net exports over the course of the year of 12,112 GWh, equivalent to 24% of electricity generated or 31% of electricity consumed in Scotland during the year.

Figure 2 - Electricity Generation & Consumption in Scotland 2000-2009 (GWhrs)



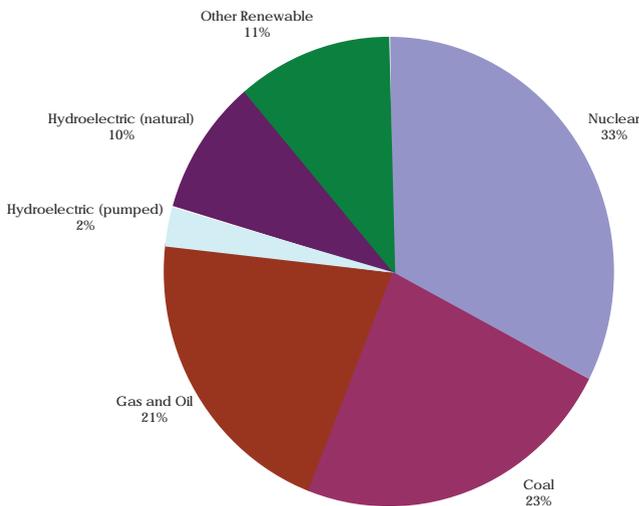
Source: Department of Energy and Climate Change, published by Scottish Government, January 2011

<sup>12</sup> "Scottish Government Business, Enterprise and Energy Statistics", January 2011, including Energy Statistics from Department of Energy and Climate Change.

Electricity generation in Scotland currently comes from a mix of different sources. In 2009, the biggest single contributor was nuclear, accounting for 33% of generation (Figure 3) – there are two operational nuclear power stations in Scotland, Torness in East Lothian and Hunterston in North Ayrshire.

Fossil fuel power stations make a large contribution with coal accounting for 23% of generation (Longannet and Cogenzie Power Stations) and oil and gas for 21% (Peterhead Power Station). Renewables (including hydro) accounted for 21% of generation<sup>13</sup> in 2009. The five big nuclear and fossil fuel power stations produced more than three quarters of the Scottish generation mix in 2009.

Figure 3 – Scottish Generation Mix, 2009 (% of total GWh Generated)



Source: Department of Energy and Climate Change, published by Scottish Government, January 2011

The electricity generation mix in Scotland has changed over the last decade. Generation from coal fell by 28% between 2000 and 2009 and there were also small decreases in the contribution from oil and gas and nuclear (Table 1). In the same decade the contribution of ‘other renewables’ (mainly on-shore wind power) increased almost 20-fold.

<sup>13</sup> In 2009, 21% of generation was from renewables, equivalent to 27% of consumption.

Table 1 - Changes in Generation Mix in Scotland 2000-09

	GWh (2000)	GWh (2009)	%Change 2000
Nuclear	16,918	16,732	-1%
Coal	16,624	11,983	-28%
Gas and Oil	11,275	10,778	-4%
Hydroelectric (pumped)	613	1,087	+77%
Hydroelectric (natural)	4,665	4,877	+5%
Other Renewable	306	5,868	+1,818%
Total	50,401	51,325	+2%

Source: Department of Energy and Climate Change, published by Scottish Government, January 2011

## 2.2 Future Demand and Supply

While Scotland currently generates more electricity than is required for Scottish consumption, investment in new generating capacity will be necessary over the next two decades due to:

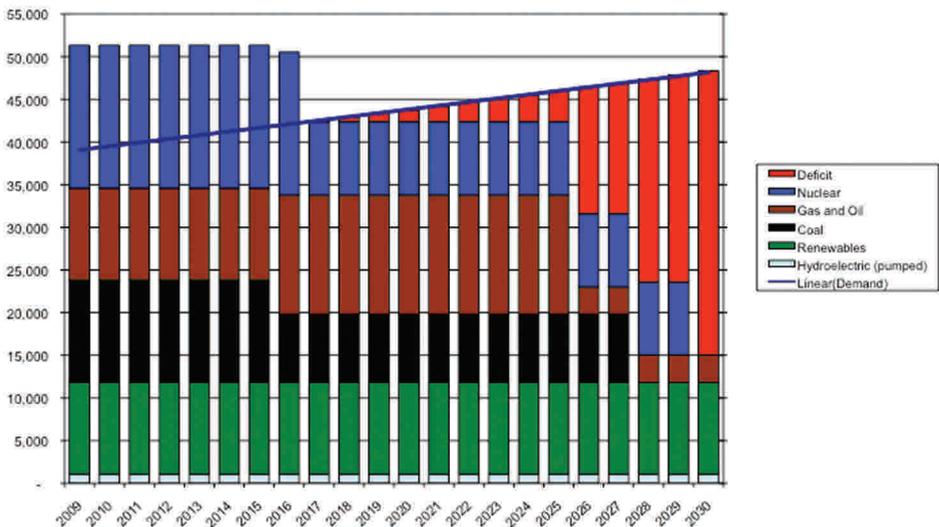
- expected increases in demand, driven by both consumption pressure associated with economic growth and trends (for example, the expected growth in electric vehicles) that are expected to lead to electricity becoming an increasing proportion of energy consumption. The Royal Society of Edinburgh expects a 50 per cent increase in Scotland's energy demand between 2000 and 2050 <sup>14</sup>;
- Scotland is also expected to lose around three-quarters of its generation mix as the five large nuclear and fossil fuel power stations come to the end of their lives, starting with Hunterston B nuclear power station which is due to close in 2016 and Cockenzie coal fired power station, which is due to close in 2016 (although planning permission has recently been granted for a new combined cycle gas turbine power station at Cockenzie, to replace the current coal fired power station).

<sup>14</sup> "Inquiry into Energy Issues for Scotland", Royal Society of Edinburgh, June 2006.

If this generation capacity was not replaced there would be a gap between the future demand and supply of electricity in Scotland, as shown in Figure 3. The blue line in the figure shows the current and expected increase in demand <sup>15</sup> for electricity in Scotland and the columns show the generation supply, based on the current generation mix, taking account of the new Cockenzie power station. So the graph shows that supply will continue to exceed demand until 2017, with the surplus exported from Scotland.

However, from 2018, there could be a deficit (shown in red in the figure below) as demand from Scotland is expected to exceed supply, based on the current generation mix. Investment in new generation capacity is required to fill this gap.

Figure 4 – Future Demand & Generation (No Investment in Replacement Capacity, GWh)



Source: Department of Energy and Climate Change, published by Scottish Government, January 2011 & Information from Generators on Scheduled Decommissioning Dates

The generation mix has changed in recent years and much greater change might be expected over the next decade, as a result of current Scottish Government policy and the patterns of investment in the electricity generation sector.

<sup>15</sup> The figure shows a gradual increase in demand, representing the 50% increase in demand expected between 2000 and 2050. This is a simplified representation since demand is more likely to vary from year-to-year and show a reduction in some years, as has been seen in the recent recession.

There has been growth in renewable energy generation, in particular on-shore wind power and targets have been set for a higher proportion of Scotland's electricity demand to be met from renewables. In 2009, renewable energy generation reached 27% of demand and so it seems reasonable to suppose that the 2011 target will be met. However, the 2020 target represents significant further growth over the next nine years.

In early 2011, the installed capacity of on-shore wind had increased to 2,364 MW, from 1,487 MW in 2009. Scotland has led the UK in the development of on-shore wind and currently has 61% of the UK's operational capacity. If all of those on-shore wind projects in construction and consented and half of those in the planning stage are added, this would increase the installed capacity to 7,297 MW (see Table 2), representing an almost five-fold increase on 2009, and capable of meeting around 57% of the 2009 electricity demand from Scotland.

These figures do not include on-shore wind farm projects being considered by developers (but not yet in the planning system), the offshore wind farms currently being planned, energy from waste, biomass and biofuel generation and new technologies such as wave and tidal power. When all of this is added to current and planned on-shore wind, the 100% target for 2020 seems achievable.

Table 2 – On-Shore Wind Generation Capacity in Scotland, 2011 (MW)

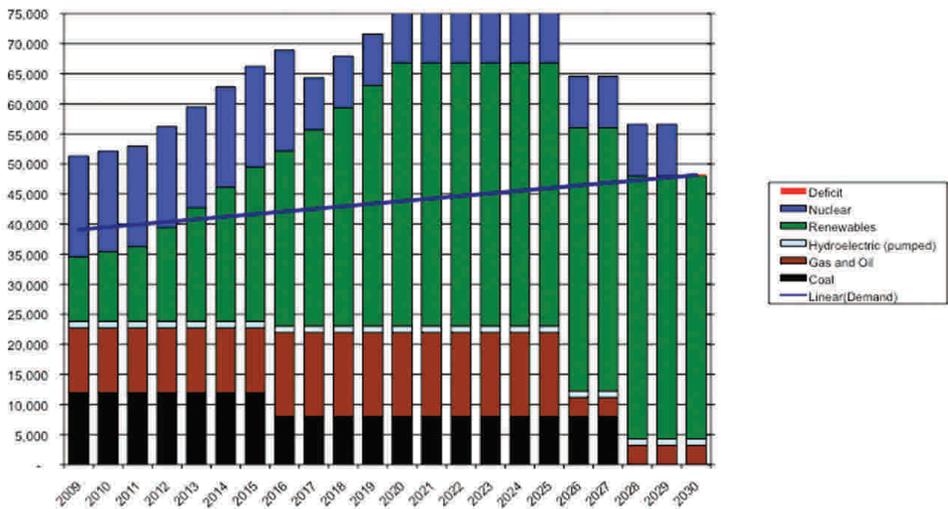
	Wind Farms	Capacity (MW)
Operational	111	2,364.18
Under Construction	18	1,155.72
Consented	79	1,846.95
In Planning	115	3,860.86
Total	323	9,227.71
Total (including 50% of In Planning)		7,297.28

Source: Renewable UK (UK Wind Energy Database, January 2011)

Figure 5 projects the future demand and supply in Scotland to 2030 if four of the five large nuclear and fossil fuel power stations are not replaced (a decision has already been taken to replace Cogenzie) when they come to the end of their operational lives and the Scottish Government's renewable targets are met.

Meeting the renewables target would mean that Scotland would be exporting almost half of the electricity generated in Scotland in 2020. Or, to put it another way, Scotland would be generating almost twice the level of Scottish demand for electricity. Even if there were no further growth in renewables beyond 2020, it would be 2030 until demand exceeded supply.

Figure 5 – Future Demand & Generation (With Renewables Targets Met, GWh)



Source: Department of Energy & Climate Change, published by Scottish Government, January 2011 & Information from Generators on Decommissioning Dates & Scottish Government Renewables Targets

This position is quite different to that found in previous inquiries into Scotland's energy needs. For example, the Royal Society of Edinburgh's Inquiry into Energy Issues for Scotland, published in 2006, raised concerns about a looming 'energy gap' as the existing large power stations closed.

The extension to the generating lives of some of the existing large nuclear and fossil fuel power stations, the growth in renewable energy generation over the last few years and the potential that has been identified for offshore renewable electricity generation means that there are many more options available to fill the electricity generation gap than there seemed to be even five years ago. The options are discussed later in this report.

However, as made clear in the RSE Inquiry a high reliance on renewable energy, particularly wind power and its associated intermittency (wind generators only generate power when the wind blows, typically around 30% of the time where wind farms are located) would require changes to the transmission system and a solution to the need to have enough flexibility of supply to meet the daily and seasonal peaks and troughs in demand. These issues and those associated with alternative strategies are also discussed later in this report.

## 3. Energy and Economic Development

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Energy policy is typically framed on the basis of ensuring the right balance between security of supply (ensuring that the lights don't go out and that energy supply is not reliant on fuel from politically unstable regions), environmental impacts (in particular carbon emissions from burning fossil fuels and finding a solution to the very long-term storage of nuclear waste) and the costs of generation.

Another factor that is worthy of consideration is the contribution that different options might make to economic and social development in Scotland. This is considered in this section.

### 3.1 Demand Side

The cost and reliability of the supply of electricity has important social and economic implications for Scottish households and businesses.

Households on fixed incomes, including many retired people, are particularly vulnerable to increased electricity and gas prices, as has been seen as prices have risen over the last two years, as wholesale oil and gas prices have risen. Households are considered to be living in "fuel poverty" if spending 10% or more of their income on heating their homes. The latest Scottish Government Scottish House Condition Survey <sup>16</sup> found that around a third of all Scottish households were in this position – 770,000 households, up from 618,000 in 2008 and from 293,000 in 2002. The Scottish Government has set a target of eradicating fuel poverty by 2016; a target that seems very challenging given these recent trends. The supply of energy to businesses is also a component of Scotland's competitiveness as a business location, particularly for economic sectors that are relatively high energy users. These sectors are often those thought to have the greatest growth potential, such as life sciences and information technologies. There is a need to ensure a reliable supply of competitively priced energy to businesses if Scotland is to retain its high value and high growth companies and attract new investment.

<sup>16</sup> "Scottish House Condition Survey", Scottish Government, November 2010.

There are also opportunities for new business sectors to emerge if Scotland is seen to have a sustainable, affordable and abundant supply of energy. The most obvious example is of data farm developments where companies require locations with a relatively cold climate and a good supply of energy – in many cases renewable energy.

### 3.2 Supply Side

Scotland has a track record of being at the forefront of research and development in the generation of electricity. The technology on which large-scale wind energy generation has been based was developed in Scotland in the 1970s. However, much of the commercialisation of that technology, and the significant economic impacts associated with it, took place in other countries, notably Germany, the United States and Denmark.

Scotland has had natural resource advantages in carbon-based sources of energy with significant coalfields and then North Sea oil and gas. Scotland still has significant coal reserves and there might be as much in the way of reserves of oil and gas as has been extracted in the last 40 years (if in smaller and more expensive to extract fields).

Scotland's climate and marine environment also gives Scotland significant natural resource advantages in renewable energy and other new technologies. The feasibility of on-shore wind developments is very sensitive to the proportion of the year that the wind blows and the average wind speed. Scotland's windy highlands and uplands explain why Scotland currently has 61% of the UK's operational on-shore wind capacity.

However, it is offshore where Scotland's renewable natural resources are most plentiful. It has been estimated that Scotland could have 25% of the estimated tidal power resource of the European Union (most notably in the Pentland Firth) and perhaps 10% of Europe's potential wave power resource. The offshore wind resource is also substantial.

In January 2010, the Crown Estate <sup>17</sup> announced the results of the bidding process for licences to develop offshore wind farms, which included two sites off the Scottish coast (in the Moray Firth, with an expected installed capacity of 1.3 GW and in the Firth of Forth, with an expected capacity of 3.5GW). These two projects alone would deliver generating capacity more than double the entire current installed on-shore wind capacity.

<sup>17</sup> "The Crown Estate Announces Round 3 Offshore Wind Development Partners - A Quarter of UK Electricity Demand Could Be Met From The Programme", Crown Estate News Release, 8 January 2010.

In addition, the geology of the North Sea means that there may be opportunities for carbon capture and storage including the potential to use depleted oil and gas fields for carbon storage.

Natural resource advantages alone will not deliver economic development to Scotland since if these resources are not developed and exploited by Scottish companies and Scottish employees, much of the economic impacts will be exported.

The Government Economic Strategy<sup>18</sup> sets out the Scottish Government's purpose, "to focus the Government and public services on creating a more successful country, with opportunities for all of Scotland to flourish, through increasing sustainable economic growth." Energy is one of the six key sectors identified in that strategy that are expected to be the drivers of sustainable growth. This is based on the natural resource opportunity and on a number of existing and potential competitive advantages.

### 3.3 Research and Technology

These existing and potential competitive advantages mean that the benefits to the Scottish economy associated with investment in the next generation of electricity generation to meet Scottish demand could be significant.

An example is carbon capture and storage (CCS), with an emerging competitive advantage based on:

- the existing oil and gas sector and associated offshore and pipeline infrastructure and the geology of the North Sea create the conditions for making CCS work in Scotland (particularly if the technology is combined with Enhance Oil Recovery technologies which enhance and extend the life of oil fields);
- Scotland's academic research base, in particular at the University of Edinburgh, has a world-wide reputation for CCS research and is working with major energy companies on how the technology can be scaled up from the lab to an operational power station;

<sup>18</sup> "Government Economic Strategy", Scottish Government, 2007.

- CCS at Longannet and Peterhead – Scottish Power led a consortium bid to the UK Government for major public funding to design and retrofit a CCS demonstration project at the Longannet Power Station. While the UK Government announced in October 2011 that the project would not be supported, the consortium has said that the work done to date has demonstrated that CCS is deliverable. Consideration is currently being given to the development of a CCS demonstration project at Peterhead Power Station.

Scotland is increasingly recognised as a centre for the development of new energy technologies as a result of both academic and commercial research and development activity. This ranges from fundamental research to the testing and deployment of new technologies.

The Scottish universities co-ordinate research in energy through the Energy Technology Partnership which identifies a number of research strengths, including bio-energy, the built environment and demand management, energy conversion and storage, marine energy, power systems and networks, wind energy, solar energy and CCS.

Facilities for the demonstration, testing and deployment of energy technologies include the European Marine Energy Centre in Orkney, the Hydrogen Office at Fife Energy Park and the Power Networks Demonstration Centre.

R&D activity has also been attracted to Scotland by initiatives such as the Scottish Government's Saltire Prize, a £10 million award that will go to the team that achieves the greatest volume of electrical output over the set minimum hurdle of 100GWh over a continuous two-year period, using only the power of the sea.

There have been several major recent investments in the R&D infrastructure, including, for example, the University of Strathclyde's Technology and Innovation Centre, to be built in Glasgow city centre. The academic expertise has helped to attract commercial R&D investment to Scotland and Glasgow is increasingly being recognised as an energy R&D centre, for example by *The Economist* in February 2011<sup>19</sup>. Examples of private sector investments include Scottish and Southern Energy's renewable energy research centre in the city, which has also received investment from Mitsubishi, Iberdrola's offshore wind energy headquarters and Gamesa's wind turbine research centre.

<sup>19</sup> "Green rush: The renewable-energy industry is heading for Glasgow", *The Economist*, 17th February 2011.

### 3.4 Economic Impact Potential of Electricity Generation

The economic potential of the energy sector is much greater, if Scotland can be an exporter of electricity (to the rest of the UK and the rest of Europe) and through the development of new export industries (for example, in products such as tidal and wave generators and also in a range of support and supply services from the deployment of off-shore renewables to operation and maintenance expertise).

The potential economic impacts of different electricity generation strategies for Scotland are difficult to quantify since they will depend on the interaction of a number of factors. Analysis for Scottish Enterprise <sup>20</sup> has made some estimates for the next decade based on a range of assumptions on the scale of capacity installed, the capital costs of installation, the potential Scottish market share, the productivity of relevant sectors and the Scottish content of supply chains. The assumptions used are summarised in Table 3, and Table 4 shows the output (in Gross Value Added) and employment impacts that might be associated with each MW installed of a range of electricity generation methods.

This shows that wave and tidal power could have the greatest economic impact, partly due to expectations that such technologies are likely to be expensive (at least in the next decade while such technologies are in their infancy commercially) but also as a result of the potential for Scotland to secure a large market share.

Hydroelectric power could also deliver high economic impacts but the scale of development is likely to be limited (unless there was political will and public acceptance of flooding large parts of Highland and Upland Scotland).

Carbon capture and storage could also have a significant impact with a large market share possible in some aspects of the supply chain and off-shore wind could have higher economic impact than on-shore wind.

However, nuclear generation (based on a Scottish share of new UK capacity) is expected to have limited economic impact since a low market share is expected.

<sup>20</sup> "Energy Ready Reckoner", CogentSI for Scottish Enterprise, November 2010.

Table 3 – Economic Development Potential of Generation Sources (2010-20): Assumptions

	Annual MW installed	Scottish market share (%)	Annual GVA (£m)	Jobs
Pumped hydro	100	40%	86	2016
Small Hydro	50	70%	36	836
On-shore Wind	560	28%	116	2215
Offshore wind	1,960	9-26%	417-1,213	7,968-23,140
Wave & tidal	300	30-85%	324-918	6,218-17,618
Nuclear	800	11%	85	1658
CCS	800	20-60%	452	6,553

Source: Scottish Enterprise's Energy Ready Reckoner

Table 4 – Economic Development Potential of Generation Sources (2010-20)

	Scottish GVA/ MW installed (£m)	Scottish Jobs/ MW installed
Pumped hydro	0.86	20.2
Small Hydro	0.72	16.7
On-shore Wind	0.21	4.0
Offshore wind	0.21-0.62	4.1-11.8
Wave & tidal	1.08-3.06	20.7-58.7
Nuclear	0.11	2.1
CCS	0.57	8.2

Source: Based on data from Scottish Enterprise's Energy Ready Reckoner

However, the economic development potential discussed above will only be realised if the conditions are right.

These conditions will include an appropriate licensing and planning system and the availability of suitably skilled staff and the physical business infrastructure required to facilitate company growth. The development of an electricity generation sector in Scotland that can generate substantially more electricity than the domestic Scottish demand will also require the grid infrastructure to be in place to export electricity (to the rest of the UK, but also elsewhere if a link to Norway is developed or if a bigger European 'super-grid' is developed).

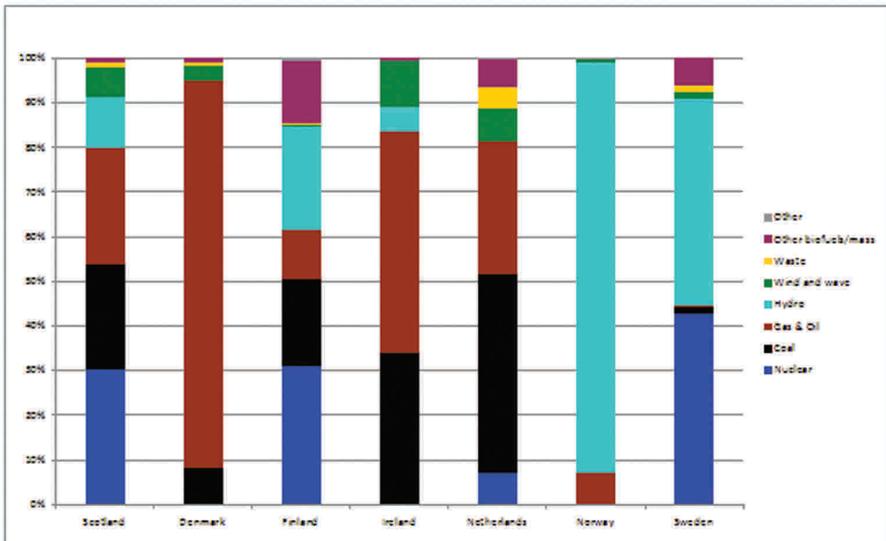
## 4. Experience of Other Countries

While some energy policy has an international dimension, as recognised in the EU 2020 Energy Strategy, a country's energy policy will be influenced by the nature and scale of its energy demand, the policy that has been inherited from the previous generation, its natural resources, its comparative advantages and public and political attitudes.

Given their level of economic development and similar climate, the other Northern European countries are probably the most useful comparators for Scotland's energy policy.

As Figure 6 shows, there are substantial differences in the generation mixes in other small Northern European countries.

Figure 6 – Generation Mix in Small Northern European Countries



Source: International Energy Agency <sup>21</sup>; Department of Energy and Climate Change (All figures for 2008)

<sup>21</sup> International Energy Agency statistics (2008 figures), available via <http://www.iea.org/stats>

The lesson from other Northern European countries is that all are investing in new low carbon electricity generation capacity. The energy policies being pursued reflect each country's resources, so, for example:

- Norway is close to achieving a 100% renewables target, based on its natural hydro resources;
- Sweden also has extensive natural hydro power resources (although much less than Norway) but in 2009 reversed a previous phase out policy, deciding to replace its nuclear power stations;
- Finland has also decided to invest in new nuclear, in order to meet emissions targets and achieve energy security;
- there are no nuclear power stations in Denmark, Ireland or Norway and no plans to develop any.

All these Northern European countries recognise the importance of being connected to a wider grid.

In economic development terms Denmark is a case study in using energy policy to develop competitive advantage in an emerging industry, wind power, and is home to several wind turbine-manufacturing companies, including Vestas, the largest in the world.

## 5. Future Energy Mix

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In deciding the most appropriate future energy mix, there are a range of factors that should be considered, including:

- generation costs, including both the capital costs in developing the capacity and operational costs, including fuel. Given that a generating station will be designed to last for at least 25 years, it is necessary to take account of current fuel and other operating costs and what these costs are expected to be in the future;
- security of supply, including ensuring that the country's electricity demands can be met and that the supplies required for generation, including fuels, can be sourced and are not vulnerable to political instability;
- environmental impact, in particular, the impact of emissions on the climate, generally measured in terms of carbon dioxide emissions; and
- economic development potential, the employment and economic development opportunities associated with creating and operating the generation capacity.

The first three of these factors are commonly highlighted in energy policy documents and are discussed below. Economic development implications of energy policy are considered in broader government economic strategies and were discussed in the previous chapter.

Security of supply, environmental impact and economic development potential are considered separately from generation costs since these considerations are not usually priced into the market. That is, the costs of generating electricity that are usually quoted in debates on energy policy are usually only the direct financial costs. A fuller consideration of costs would also include the social costs associated with security of supply and environmental impacts.

## 5.1 Generation Costs

The (financial) costs of generation arise from a number of sources, including:

- capital costs;
- operation and maintenance costs;
- fuel costs;
- decommissioning costs; and
- waste costs.

Most estimates that have been made of future electricity generation costs also factor in carbon costs, allowing for expectations that a form of carbon tax or carbon pricing will be introduced.

The mix of costs varies for different forms of generation. For wind power, the capital costs make up the majority of costs, since there are no fuel costs. Capital costs also account for the largest proportion of nuclear generation, which also needs to allow for decommissioning and waste costs. For coal, oil and gas, the fuel costs can be a substantial proportion of generation costs – more than half of the costs when fuel prices are low and up to 80-90% when fuel costs are high.

In order to compare costs of different sources of generation, estimates of cost per unit of electricity (in pence per kilowatt hour, p/KWh) can be made. Anyone researching the costs of generating electricity will quickly find that such estimates can vary greatly. This is because the outcome of such calculations will depend on the assumptions made on capital costs, the years of operational life that a generation station will have, the number of hours per year that a generator will be operational, future fuel prices, decommissioning and waste costs and the discount rate that is used to calculate the costs in present values. Any cost estimates are, therefore, likely to be controversial and open to challenge.

Future UK generation cost estimates have been produced by three respected organisations within the last year: PB Power<sup>22</sup>, Wood Mackenzie<sup>23</sup> and Mott Macdonald<sup>24</sup>. The range of future generation costs from these three sources is summarised in the figure below.

<sup>22</sup> "Powering the Nation Update 2010", Parsons Brinckerhoff (PB) Power, 2010.

<sup>23</sup> "The Future of Electricity Generation in Scotland", Wood Mackenzie for the Scottish Council for Development & Industry, December 2008.

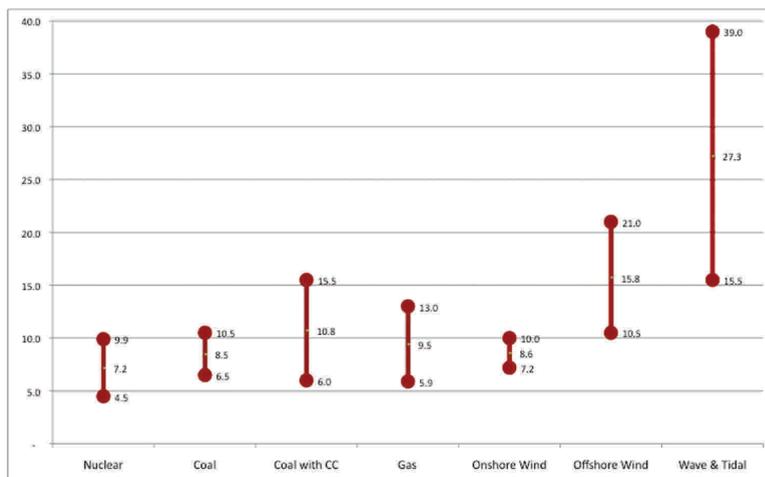
<sup>24</sup> "UK Electricity Generation Costs Update", Mott Macdonald for the Department for Energy and Climate Change, June 2010.

These show a broad range of estimates for many of the generation options, reflecting the uncertainty that exists and, therefore, the assumptions that must be made of the costs associated with a range of factors such as the cost of fuels, the costs of treating and storing waste and the development and deployment of new technologies.

Despite these uncertainties, the ranges in the figure suggest that:

- the range of cost estimates is narrowest in those areas where the technology and construction methods are well established – such as coal and on-shore wind;
- while gas generation is also well established, there is a wider range of cost estimates due to uncertainty about fuel prices (the price of gas usually increases and decreases in similar patterns to the price of oil);
- both nuclear generation and on-shore wind could be cost competitive with coal and gas generation;
- coal generation with carbon capture and storage will be more expensive but there is a wide range of estimates on how much it will add to generation costs;
- there are also a wide range of estimates for off-shore wind, depending on the assumptions that are made on the economies of scale that can be delivered by increasing the size of wind turbines, the average wind speeds at off-shore sites and the cost of deployment in challenging circumstances; and
- there are a very wide range of estimates for the costs of wave and tidal power which reflects the infant nature of the technologies being developed.

Figure 7 – Estimates of Generation Costs (p/KWh)



Source: Cost Estimates from Wood Mackenzie, Mott Macdonald & PB Power, 2010

The above generation cost estimates will not necessarily be reflected in future electricity prices since they do not account for the effects of government policy and do not include wider social costs and benefits such as those related to security of supply, environmental impacts and economic development potential.

## 5.2 Security of Supply

### Gas

Following the development of North Sea gas fields in the late 1980s and the early 1990s, the UK became a net exporter of gas. However, as a result of increased demand (as more gas powered power stations opened across the UK – often referred to as the ‘dash-for-gas’) and the slowdown in production from a peak in 2000, the UK, including Scotland, became a net importer of gas in 2004.

The long-running dispute between Russia and the Ukraine over gas supplies and payments led to Russia cutting off gas supplies through the Ukraine in 2009, impacting on the gas supplies of much of Western Europe. Although the UK imports gas from Norway as well as from continental Europe, this highlighted the security of supply issues associated with gas.

## Coal

Scotland was once a major coal producer with coal supplying the energy needed for the heavy engineering based industrial economy. While Scotland still has significant reserves of coal, the volume of imported coal to the UK has been increasing since the time of the miners' strike in the mid-1980s. There is limited data available for the coal imported and exported between Scotland and the rest of the UK, but the production information available from the major Scottish coal producers suggests that Scotland may be a net exporter of coal. So while the security of supply for coal may be a concern at the UK level, there is less of a concern at the Scottish level, assuming current levels of production continue.

## Nuclear

Nuclear power requires much less fuel in volume terms than fossil fuel generation and the fuel costs are a lower percentage of the generation costs. While uranium is a finite resource, the known reserves are significant, at least in the context of current demand. The UK has no operational uranium mines and so is reliant on imports. However, security of supply can be managed by maintaining sufficient stocks.

## Wind Power

The major advantage of wind power – on-shore and offshore – is that the fuel is free. However, while it tends to be windier in winter when energy demand in Scotland is at its highest, it cannot be guaranteed to meet daily and hourly peaks in demand. The intermittency of wind generation is not a significant concern when wind power is a modest contributor to the generation mix. However, as the proportion of the generation mix that comes from wind power increases, there comes a point when the supply could not be guaranteed to meet peak demand. The level at which the problem occurs is difficult to estimate since the more widespread wind power becomes, the greater likelihood that there will be wind at some of the wind farm sites.

There are a number of solutions to the intermittency challenge including limiting the proportion of generation from wind power, ensuring the network is in place to export and import to and from countries with other forms of generation and the development of storage (which include established technologies such as pumped hydro schemes as well as new battery technologies).

Wind power, and renewable energy in general, also has a security of supply advantage in that the power generation is distributed across many parts of the country and so is less vulnerable to a failure of a large generating station or the distribution system from it.

### Wave and Tidal

Wave and tidal generation also have the significant advantage of free fuel. The problems of intermittency can also be managed since the source of power – wave and tidal flows are more regular and predictable than wind. However, like wind, it cannot be guaranteed that generation will be available to meet peak demand and so storage and import/export systems would also be necessary if wave and tidal generation was to account for a large percentage of generating capacity. This is unlikely in the short to medium term since these technologies are still being developed and scaled up.

### 5.3 Environmental Impacts

Energy supply accounts for a significant proportion of greenhouse emissions. In the UK in 2010, an estimated 37% of carbon dioxide (CO<sub>2</sub>) emissions and 33% of all greenhouse gas emissions were from energy supply (Source: Mott Macdonald for DECC).

In considering the environmental impacts of different forms of generation it is important to consider not just the impacts associated with the fuel being used but the wider life cycle costs which include the impacts associated with construction, decommissioning, processing and transport as well as operational environmental impacts.

Coal is associated with the greatest carbon emissions, measured in grams of carbon dioxide per kWh of electricity generated (gCO<sub>2</sub>eq/kWh), followed by gas (Table 5). Given that 23% of Scotland's current generation mix comes from coal (around 12,000 GWh), this implies that electricity generation from coal in Scotland emits around 12 million tonnes of CO<sub>2</sub> annually. Gas accounts for a further 6 million tonnes of CO<sub>2</sub> emissions.

Carbon capture and storage technologies aim to mitigate these emissions. Emissions associated with hydro, wind and nuclear power are minimal and there is currently limited data on wave and tidal power.

Table 5 – Estimated Life Cycle Carbon Emissions

Energy Type	gCO <sub>2</sub> eq/kWh
Coal	1,000
Gas	500
Biomass	25-93
Solar (photovoltaic)	58
Wave and tidal	25-50
Hydro	10
Wind	5
Nuclear	5

Source: Parliamentary Office of Science & Technology <sup>25</sup>

In addition to greenhouse gas emissions, other environmental concerns include those associated with the processing and storage of nuclear waste. Public opinion in Scotland has been against nuclear power to a greater extent than the rest of the UK. For example, the 2009 Nuclear Industry Association survey <sup>26</sup> found 25% of Scottish respondents favourable to nuclear power, compared to 33% for the UK as a whole.

#### 5.4 Assessing the Options

Figure 8 summarises the advantages and disadvantages of each of the generation options, based on the discussion in this and in the previous chapter. This shows clearly that there is no one generation option that has an advantage over the others in all of the four relevant criteria – generation cost, security of supply, environmental impact and economic development potential.

<sup>25</sup> "Carbon Footprint of Electricity Generation", Parliamentary Office of Science & Technology Note Number 268, October 2006.

<sup>26</sup> "Public Attitudes to Nuclear Survey", Nuclear Industry Association, 2009.

Figure 8 – Advantages and Disadvantages of Sources of Generation (scale of advantage = \*\*\*\*\* to disadvantage = \*)

	Cost	Security of Supply	Environmental Impact	Economic Development Potential
Nuclear	***	***	***	*
Coal	*****	**	*	**
Coal with CCS	**	**	*****	*****
Gas	*****	*	*	**
On-shore Wind	***	*****	*****	***
Off-shore Wind	**	*****	*****	*****
Wave & Tidal	*	*****	*****	*****

## Gas and Coal

Environmental impacts make like-for-like replacement of the large fossil fuel power stations unattractive. These may provide low cost electricity in financial terms, but the market does not cost in the negative environmental impacts. It is also possible, perhaps even likely, that European and international agreements on reducing green house emissions will lead to carbon taxes that will have the effect of pricing in the environmental impacts, removing the financial cost advantages of fossil fuel generation. Rising fossil fuel prices may also reduce or remove any generation cost advantages.

## Carbon Capture and Storage

The development of carbon capture and storage (CCS) technology may provide a future for fossil fuel generation if the technology can be proven and implemented at a competitive cost relative to other generation options. CCS also provides a potential economic development opportunity for Scotland. The distance from market of CCS technologies has meant that developments to date have required subsidy from the public sector. This is likely to be necessary until the development of the technology gets to the stage that it has been proven to work at the power station scale. However, the economic development opportunity means that Government could expect a return on public sector investment in this area as a tax paying domestic sector with tax paying employees is developed.

## Nuclear

While new nuclear power stations could deliver relatively low cost electricity, this depends on the arrangements and costs for the treatment and storage of waste. There is considerable debate about the environmental impacts of nuclear power. Some prominent environmental campaigners (including James Lovelock) who were previously anti-nuclear have concluded that the need to reduce carbon emissions makes nuclear power attractive. However, others remain concerned about the methods and costs of treating and storing nuclear waste. While health and safety and environmental regulations mean that the chances of environmental harm would be a remote risk, the consequences would be significant, as has been demonstrated by the Fukushima nuclear disaster in Japan.

However, the disadvantages of nuclear electricity generation include cost risks (associated with the risks of capital cost over-run and uncertainty on the long term costs associated with treating and storing waste) and the limited potential for the nuclear sector to contribute to economic development in Scotland, compared to other generation sources. While this means that, on balance, there is merit in the current Scottish Government's stance against nuclear, it would be preferable if the policy was based directly on a Scottish energy and economic development policy rather than indirectly, using planning powers.

## Renewables

The major advantage of renewable energy is the limited environmental impact. Where concerns are raised on the sites for individual developments, these can be dealt with in the planning process through the preparation and consideration of an environmental impact assessment.

The main disadvantage of renewables has been the financial costs of generation, relative to fossil fuel generation. Recognising the wider environmental costs not included in the price of fossil fuel generation, Government policy has removed this disadvantage through the Renewables Obligation, which required generators to source a proportion of electricity from renewable sources, directly or indirectly.

This has led to considerable growth in renewable generation, mainly from on-shore wind and to investment in developing the technologies for offshore wind, wave and tidal power. Generally, the costs of renewable generation have been lower than were projected ten or twenty years ago. The cost gap has also been narrowed by the increase in oil and other fossil fuel prices.

On balance, therefore, there is a strong case for Scotland's future energy mix to be increasingly reliant on renewable energy generation, if cost, security of supply, environmental impact and economic development potential are all taken into account.

### Challenges Associated with Reliance on Renewables

Increasing the proportion of renewables in the short to medium term means increased wind power, with large off-shore wind farms now in the development phase to add to the existing and planned on-shore wind farms. In the longer term, other technologies may make a contribution. Significant wave and tidal energy resources have been identified off the Scottish coast and the technologies to exploit these resources are in development. However, the increase in renewable energy generation also presents a number of challenges:

- while wind power is the dominant renewable energy the issue of the intermittency of wind generation needs to be managed since, while it is often windy in Scotland particularly in winter when electricity demand is at its highest, it cannot be guaranteed that wind power will supply the electricity required to meet peak seasonal or daily demand. The solution to the intermittency problem could include one or a mix of the following:
  - **back-up:** the availability of back-up generation from other sources (although any new investment in back-up generation would substantially increase the costs associated with renewables and would significantly increase environmental impacts);

- **storage:** the development of technologies that can efficiently store electricity generated when the supply exceeds demand. Existing technologies that already have this function include pumped storage hydro power (such as Cruachan Power Station in Argyll). Technologies in the development stage (in which there is substantial expertise in Scotland) include battery technology and the use of hydrogen for storage;
- **UK and European grid:** ensuring that the electricity grid includes reliable links for exporting to and importing from, the rest of the UK, Ireland (and possibly in the future Norway if a proposed North Sea link is established as part of a longer term plan to develop a European super-grid) so that renewable energy generated can be exported when supply exceeds Scottish demand and so that electricity can be imported when Scottish demand exceeds supply;
- substantial investment in the electricity grid network will be required to support renewable energy development in areas where there were not previously significant generators. While significant investment in the grid may be required for any future supply mix, a different type of grid will be required for a system that relies on renewable generation distributed across a wide geographic area, rather than the centralised power stations that have dominated the system over the last century;
- ensuring that the skills, infrastructure and finance are available so that Scottish firms can make the most of the opportunity in renewable energy development and operation, maximising the economic development potential.

The increasing cost of electricity is also likely to be an issue for policy makers, whatever the future generation mix. To date, the additional costs of renewables relative to fossil fuel generation have been met using the renewables obligation certificates (ROCs) system, whereby generators have been required either to generate a proportion of electricity from renewables themselves or to purchase ROCs from other renewables generators.

Investment in renewable energy would not be considered to be a good investment without either a continuation of a system like ROCs or unless there was an expectation that future electricity prices will be higher than current prices. Given the increasing costs of fossil fuels and their environmental impact, an increase of electricity costs in the medium to longer term would seem likely whether or not renewables become a more significant part of the generation mix.

The increasing costs will be felt by both businesses and households in Scotland, other countries will also face the same challenges. The key policy issue to be addressed in relation to cost, therefore, is likely to be the consequential increase in fuel poverty.

## 6. Conclusions and Recommendations

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The current mix of energy supply in Scotland, dominated as it is by fossil fuels, is not sustainable in the longer term either in financial terms (as global economic growth increases the demand for and, therefore, price of scarce fossil fuels) or in environmental terms (due to the carbon emissions from fossil fuels and their contribution to climate change).

Scotland's current energy supply is dominated by three fossil fuel power stations (the gas fired Peterhead and the coal fired Longannet and Cockenzie) and two nuclear power stations (Torness and Hunterston). These five power stations account for more than three quarters of the Scottish electricity generation mix.

Scotland is connected to the UK electricity grid and is currently an exporter of electricity. In 2009 Scotland exported 12 Gigawatt hours (GWh) of the 51 GWh generated and so exports were equivalent to 24% of the electricity generated and 31% of the electricity consumed in Scotland.

When the Royal Society of Edinburgh review of Scotland's energy needs was published in 2006 there were concerns that there was a looming 'energy gap' as the five major power stations came to the end of their operational lives over the next decade or two.

However, much has changed in the last five to ten years. The Labour and Liberal Democrat Scottish Executive set what then seemed very ambitious targets to increase the contribution of renewable energy to the generation mix in Scotland, to 31% of electricity demand by 2011 and 40% by 2020. The SNP Scottish Government confirmed the 2011 renewable energy target (which seems likely to be met) and increased the 2020 target, first to 50%, then (in 2010) to 80% and then, following the May 2011 elections, to 100%. Given that some of the current fossil fuel and nuclear capacity will still be available in 2020, the 100% renewables target implies a substantial increase in Scotland's exports of electricity, with around half of the electricity generated in Scotland being exported, which even using conservative assumptions on prices would increase Scottish exports by £2 billion per annum, equivalent to around 17% of Scottish manufacturing exports to the rest of the UK.

Renewable energy has made an important contribution to the electricity generation mix in Scotland since the post war investment in hydroelectric power, particularly in the Highlands and Islands. In 2009, hydro power accounted for 12% of electricity generated. Over the last decade there has been substantial investment in on-shore wind power, which contributed 11% of the electricity generated in Scotland in 2009, an almost 20-fold increase in a decade. With the lives of some of the large power stations being extended, plans for a new gas fired power station to replace the coal fired power station at Cockerzie and substantial further investment planned in renewable energy (in particular wind power), encouraged by the Scottish Government's 2011 and 2020 targets, the risks of an 'energy gap' have receded, at least in terms of the overall annual supply and demand for electricity.

The lesson from other Northern European countries is that all are investing in new low carbon electricity generation capacity. The energy policies being pursued reflect each country's resources, so, for example, Norway is close to achieving a 100% renewables target, based on its natural hydro resources. Sweden also has extensive natural hydro power resources (although much less than Norway) but in 2009 reversed a previous phase out policy, deciding to replace its nuclear power stations. Finland has also decided to invest in new nuclear, in order to meet emissions targets and achieve energy security. There are no nuclear power stations in Denmark, Ireland or Norway and no plans to develop any. All these Northern European countries recognise the importance of being connected to a wider grid. In economic development terms Denmark is a case study in using energy policy to develop competitive advantage in an emerging industry, wind power, and is home to several wind turbine manufacturing companies, including Vestas, the largest in the world.

Electricity generation from renewable sources has price disadvantage when compared to fossil fuel generation. However, with rising fossil fuel prices and economies of scale achievable as renewable energy sectors grow, the price differentials are narrowing.

Cost of generation is just one of the factors to consider when developing energy policy. Security of supply, environmental impact and economic development potential should also be considerations. There is no single source of generation that is preferable to others across all four of these factors. A decision therefore needs to be based on a balance of these factors. Renewable energy, wind power in the short term and new low-carbon technologies in the medium to long term can provide security of supply and significant economic development opportunities for Scotland, whilst delivering environmental benefits associated with decarbonising the economy. The generation costs are likely to be higher than we have become used to, although with increasing fossil fuel prices and carbon pricing, this is likely to be an issue whatever generation mix was pursued. Scotland has the potential to be one of the leading locations in the world for the discovery, commercialisation, manufacturing and deployment of new energy generation technologies, as a result of:

- substantial natural energy resources (including the wind resource available onshore and offshore, wave and tidal energy potential as well as the geology required for storage of carbon associated with carbon capture and storage);
- world-leading university research base in energy and associated engineering and science disciplines; and
- the large and small Scottish companies and international energy companies that have been attracted to locate in Scotland.

### 6.1 Role of Government

A further increase in the contribution of wind power to the generation mix over the next decade also presents a number of challenges, including managing the intermittency of supply (by being part of a wider UK and European grid and through the development of storage technologies), investing in upgrading and renewing the electricity grid and ensuring that the skills, infrastructure and finance are available so that the economic development potential is realised.

All of these have implications for the role of government in energy policy. Energy policy is largely retained at Westminster although some elements of energy policy sit at the European Union level and some are devolved to the Scottish Government or to local government. However, the Scottish Government has control over the most effective mechanism for realising energy policy objectives, planning powers for any power station with a capacity of 50 megawatts (MW) or more.

The starting point for policy recommendations should be to consider why energy markets require Government to be involved at all. A case for Government intervention can be made based on market failure, that is, that the market will not take account of wider geopolitical and environmental issues. Leaving decisions on the generation mix entirely to the market is likely to result in a generating mix that will deliver low electricity prices. However, those prices will not take account of environmental impacts or issues such as the security of supply.

In addition, the structure of the energy sector means that there is a role for government intervention. For example, it would make little sense for competing companies each to operate their own electricity grid. The national grid was publicly owned, as were electricity generators and suppliers, until privatisation transferred responsibility to companies (National Grid in England and Wales and Scottish Power and Scottish and Southern Electricity in Scotland), which operate the grid under regulation. National Grid also has responsibility for managing the overall system to ensure that supply equals demand.

The government also gets involved in issues related to the national interest, such as security of supply, regulating safety issues (for example, standards for storage of nuclear waste), the protection of the interests of particular groups (such as those suffering from fuel poverty) and in spatial planning to ensure appropriate development of generating capacity in the appropriate places.

## 6.2 Policy Recommendations

**Devolve energy policy to the Scottish Parliament:** The UK Government has theoretical responsibility for energy policy. However, the Scottish Government has an effective veto through planning powers. Energy policy should be formally devolved to the Scottish Parliament so that the Scottish Government can formulate a clear energy policy that meets Scotland's needs.

**Increase energy exports:** We would support the aim of a substantial increase in energy exports with a target of around half of electricity generated in Scotland being exported because, even using conservative assumptions on prices, this would increase Scottish exports by £2 billion per annum, equivalent to around 17% of Scottish manufacturing exports to the rest of the UK. Given that some of the current fossil fuel and nuclear capacity will still be available in 2020, this is feasible if the 100% renewables target set by the Scottish Government is met.

**Develop the potential of renewable forms of energy:** We support the policy of the SNP Scottish Government and the previous Labour and Liberal Democrat Scottish Executive, which has been to promote renewable energy development. This policy has been successful and it is now the time to go further. The Scottish Government was right to encourage the further acceleration of renewable energy generation by increasing the 2020 renewables target to 100% of Scottish electricity demand. A large proportion of that target can be achieved by wind power (on-shore over the next few years and increasingly off-shore as 2020 approaches) and so to encourage investment and to signal that Scotland is an attractive location for the development and deployment of new and emerging technologies, the Scottish Government should set longer term targets:

- that a significant majority of the electricity generated in Scotland, (between 50% and 75%), is met from low carbon sources by 2030;
- so that enough electricity is generated from renewable sources to exceed Scottish demand, so that Scotland becomes the biggest exporter of low carbon electricity in Europe.

**Move away from a certificate-based system towards a carbon tax:** As part of the devolution of energy policy, we believe that the Scottish Government should consider a well-designed carbon tax (either particularly targeting the energy sector or as part of a wider carbon tax). This would be a direct tax on negative environmental impact rather than a subsidy for a particular solution such as the main tool currently used to provide an incentive for the growth of renewables in Scotland and the rest of the UK - Renewable Obligation Certificates (ROCs).

The introduction of a carbon tax in Scotland may require the devolution of greater fiscal powers to the Scottish Parliament and a carbon tax should be designed to price-in environmental costs rather than to raise revenue. However, if it did increase net revenue, there should be reductions in taxation elsewhere (e.g. VAT paid on energy by consumers) to maintain Scotland's economic competitiveness.

**Create the policy environment for energy innovation:** Following the devolution of energy policy to the Scottish Government, we would support a policy environment that encourages innovative, 'low carbon' sources of energy to accommodate new and emerging technologies that can make a significant economic development and environmental impact, including carbon capture and storage. This would include:

- increased support for research and development (R&D) and commercialisation so that the excellence in the Scottish academic research base is translated to the market and to encourage both indigenous and international companies to invest in R&D in Scotland;
- a strategy for skills provision to ensure that universities and colleges are aware of future skills needs and have provision in place so that the industry can recruit the staff it will need;
- identification of other areas that could support energy policy. These could include transport, where the introduction of electric vehicles, combined with an increase in renewable energy could help to decarbonise the transport sector;
- set out a framework for the infrastructure provision that might be required to facilitate the further development of renewables. This is likely to include port facilities, development and testing facilities for new technologies and sites suitable for manufacturing facilities. These could be funded by a model such as tax increment financing (TIFs) or by issuing of energy infrastructure bonds, should the increased borrowing powers of the Scottish Parliament allow for such a model;
- accelerated planning arrangements for renewable projects;
- investment in domestic grid to facilitate an increase in new electricity generating capacity, distributed across Scotland;

- support for a wider European grid to facilitate a competitive Europe-wide market in electricity supply;
- access to grid at prices that do not discourage investment, which will require Ofgen to take account of the Scottish Government's energy policy as well as UK policy.

**Phase out nuclear power stations:** We do not think that Scotland's existing nuclear power stations should be replaced and we believe that the sites should be used to develop new energy technologies. New nuclear capacity is one option to meet international obligations and climate change targets set in legislation passed by the Scottish Parliament. This approach would have the advantage of delivering low carbon electricity and some estimates that have been made suggest that the generation costs per unit of electricity for nuclear are competitive with some other generation sources. However, the disadvantages of nuclear electricity generation include cost risks (associated with the risks of capital cost over-run and uncertainty on the long term costs associated with treating and storing waste) and the limited potential for the nuclear sector to contribute to economic development in Scotland, compared to other generation sources. The cost uncertainty and limited economic development potential means that there is not a strong case for nuclear generation in Scotland.

### 6.3 Conclusion

Energy policy is crucial to Scotland's economic future. The energy sector has the potential to make a major contribution to the development of the Scottish economy. As a result of Scotland's natural energy resources, the strengths of the university research base, the energy companies based in Scotland and a favourable policy environment, Scotland could become a world-leader in new energy generation technologies. Scotland could become a case study in sustainable development and export the technology and know-how around the world. Scotland needs an energy policy that recognises this opportunity and removes the barriers to realising it.

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