2.0

Project rationale and project benefits

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2.1 Introduction

This section presents and discusses the current challenges facing the UK energy market. It investigates the rationale behind the need to develop new forms of low carbon energy production and the benefits of the project.

The UK Governments' 4th Carbon Budget, which was published in May 2011, aims to halve Britain's CO_2 emissions by 2027 when compared to 1990 levels. It also has the long-term goal of achieving an 80% reduction relative to 1990 levels by 2050 (DECC, 2011). These ambitious targets are deemed necessary to combat the threat of anthropogenicaly induced climatic change from an increasing national and global population ever more dependant on energy.

2.2 Current Challenges and the Drivers behind Low-carbon Energy Production

The CO_2 reductions proposed by the UK Government compels consideration of the major challenges facing the future of the UK energy market. These include: -

- The role the generation sector will have to play in the reduction of CO_2 emissions in the battle against global climate change;
- The closure of existing nuclear and fossil fuel power stations in the UK and Europe for both safety and environmental reasons;
- The ever increasing demand for electricity by a growing population;
- The increasing dependence on fuel and power imports to meet the primary energy needs of the UK.

2.3 Climate Change

Climate change is widely recognised as one of the most serious environmental problems currently facing humanity and the environments on which it depends.

Climate change results from modifications in the energy balance of the climatic system, driven by both natural processes and anthropogenic activity. In recent years concentrations of atmospheric greenhouse gases and aerosols have increased dramatically. This is in addition to land cover changes, which affects the surface albedo (reflectance) of the planet altering the ratio of incoming and outgoing solar radiation.

The severity of the problem facing humankind has been emphatically described by the Intergovernmental Panel on Climate Change (IPCC) in their Fourth Assessment Report (IPCC AR4, 2007). It states that "global greenhouse gas emissions have grown since pre-industrial times, with the most important of these greenhouse gases, in terms of anthropogenic emissions, being carbon dioxide (CO_2)". The IPCC estimates that emissions of greenhouse gases and specifically CO_2 have increased by approximately 70% and 80% between 1970 and 2004 respectively. The annual mean atmospheric CO_2 levels recorded at Mauna Loa, Hawaii have risen from 0.94 ppm/yr-1 in 1959 to 2.42 ppm/yr-1 in 2010 (Tans & Keeling, 2011).

The IPCC report concludes that confidence is very high that human activities since 1750 has resulted in a warming of the earths climate, and that the measured increase in surface temperature since the mid-twentieth century is very likely to be related to the increase in emissions of greenhouse gases. They highlight records that show 11 of the 12 years between 1995 and 2006 being ranked amongst the 12 warmest years of global surface temperatures since 1850.

Most climate models and trends suggest that future global temperatures are set to rise even further. Most researchers admit that precise figures are difficult to define and there is likely to be considerable spatial variation, but they concur that a global rise of between 1.8°C and 4.0°C is likely to occur by the end on this century.

The impact of a warming climate will have major world-wide consequences which include: -

- A reduction in global ice volumes, further reducing surface albedo, which creates a positive feedback for an additional temperature increase. The resulting influx of fresh water may also have a profound impact on ocean salinity and the thermohaline circulation. This in itself could have important consequence for climatic patterns and weather systems;

- Rising sea levels principally triggered by the thermal expansion of the oceans, this will severely impact on marine ecosystems and the densely-populated low-lying coastal regions. These areas generally contains vitally important infrastructure and generate agricultural productivity;

- Disruption to climatic weather systems and patterns, which potentially could lead to increased areas of drought and desertification in equatorial regions and increased flooding driven by an intensification of monsoonal systems in tropical and temperate regions;

- The increasing global temperature is likely to lead to a reduction in yield and quality of agricultural produce in some of the important food production areas. Any further temperature change and subsequent shift in food production areas will have a negative impact on specie diversity and the availability of habitats.

Thus far, international agreements limiting aimed at tackling the issue of global climate change by reducing CO_2 emissions have had limited success.

The 1992 Earth Summit in Rio de Janeiro resulted in the United Nations Framework Convention on Climate Change (UNFCCC) which identified the earth's climate system as a shared resource and recognised that its stability was affected by industrial and natural emissions of greenhouse gases. It was agreed to gather and share information on greenhouse gas emissions, in addition to developing national policies, strategies and best practice for addressing greenhouse gas emissions. The framework also sought to provide financial and technological support to developing countries in preparation for the impacts of climate change. No mandatory limits on greenhouse gas emissions were included.

However, the framework did lead to the Kyoto Protocol in 1999, which if ratified, would set binding targets for the reduction of greenhouse gas emissions in industrialised countries by establishing mandatory limits. The Protocol came into force in February 2005 and although ratified by 193 countries (UNFCCC, 2011), the USA has refused to sign up, thereby excluding the largest economy in the world.

The Copenhagen Accord of 2009 was drafted by the United States together with China, India, South Africa, and Brazil. While it endorses a continuation of the Kyoto Protocol beyond 2012, recognises the gravity of climate change, and the need to reduce greenhouse gas emissions, it is not legally binding and does not commit countries to agree to a binding successor to the Kyoto Protocol.

The 21st Session of the Conference of the Parties (COP21) to the UN Framework Convention on Climate Change (UNFCCC) took place in Paris in December 2015. In this conference, world leaders came to an agreement to aim at stabilizing the climate and avoiding the worst impacts of climate change. Some parts of the agreement will be legally binding.

The agreement has the aim of limiting the global temperature rise to below 2°C by balancing GHG emissions and their removal, i.e. to realise net zero emissions, in the second half of this century. These aims are covered in the following conference articles: -

Article 2

1. This Agreement, in enhancing the implementation of the Convention, including its objective, aims to strengthen the global response to the threat of climate change, in the context of sustainable development and efforts to eradicate poverty, including by: -

(a) Holding the increase in the global average temperature to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change;

(b) Increasing the ability to adapt to the adverse impacts of climate change and foster climate resilience and low greenhouse gas emissions development, in a manner that does not threaten food production.

Article 4

1. In order to achieve the long-term temperature goal set out in Article 2, Parties aim to reach global peaking of greenhouse gas emissions as soon as possible, recognizing that peaking will take longer for developing country Parties, and to undertake rapid reductions thereafter in accordance with best available science, so as to achieve a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century, on the basis of equity, and in the context of sustainable development and efforts to eradicate poverty.

In the absence of current binding international agreement on greenhouse gas emissions, the current UK Government has proposed the 50% emission cuts outlined in the 4th Carbon Budget and affirmed their commitment for an EU 30% target by 2020. David Cameron stated the need "to combat climate change, secure our energy supplies for the long-term and seize the economic opportunities that green industries hold." adding that "The transition to a low-carbon economy is necessary, real, and global. By stepping up, showing leadership and competing with the world, the UK can prove that there need not be a tension between green and growth".

To help play its part in greenhouse gas reduction, the Welsh Assembly Government published A Low Carbon Revolution in March 2010. The Welsh Assembly Government Energy Policy Statement (WAG, 2010) has three main aims: -

1. To maximise energy savings and efficiency to make producing energy from low carbon sources more feasible and less costly;

2. Energy needs must be met securely from low carbon sources. It pledges to move to resilient low carbon energy production via secure, indigenous renewables, on both a centralised and localised basis;

3. Ensure that the transition to low carbon energy maximises the economic renewal opportunities for practical jobs and skills, in addition strengthen and engage research and development sectors. It aims to promote personal and community engagement to help tackle deprivation and improve quality of life.

2.4 Closure of Existing Power Stations

In 2014, the UK generated 339.0 TWh of electricity, with 29% produced from gas fired power stations, 28% by coal and 17% from Nuclear (see figure 2.1). Although the UK does export some electricity, it remains a net importer – a situation that is likely to continue. In 2014, 46% of energy used in the UK was imported. The UK is now a net importer of all main fuel types though remains a net exporter of some products such as petrol and fuel oil. (DECC, 2015). The majority of electricity produced is still derived from fossil fuels, it is estimated that 642 tonnes of CO_2 are generated per GWh of electricity supplied from fossil fuels (DUKES 2015 Chapter 5).

Electricity supplied by fuel type, 2013 and 2014

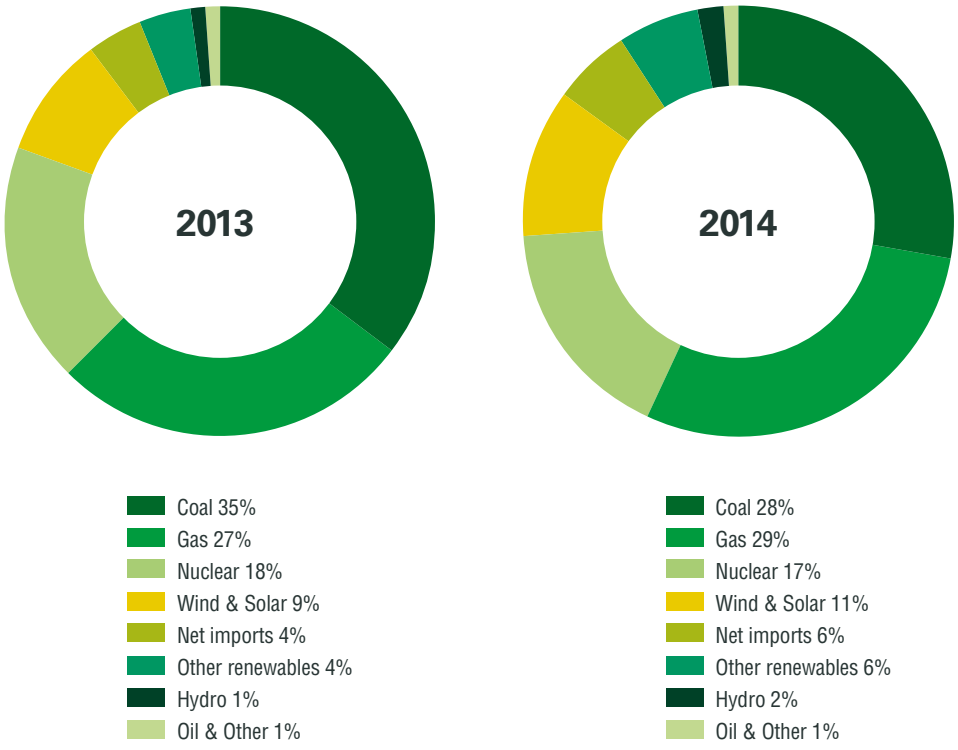

Figure 2.1: (DECC, 2015)

A substantial proportion of the UK's current electricity generating capacity is expected to close over the next decade due to safety issues and new, stricter environmental regulation. The Energy White Paper (2007) estimates that around 30 – 35 GW of new generation capacity needs to be created over the next two decades to replace the planned power station retirements and meet rising electricity demand.

The Large Combustion Plants Directive (LCPD) will lead to the closure of around 12 GW of coal and oil-fired plants by 2016 at the latest. The Industrial Emissions Directive (IED) could also lead to further closures by 2023. Furthermore, according to current timetables, up to 8.86 GW of existing nuclear generating capacity is reaching the end of its operational life and will have closed by 2023 (DECC, 2012). The operating lives of some nuclear power plants may be extended, but only with approval from the Health and Safety Executive's Nuclear Installations Inspectorate.

The Energy White Paper (2007) also confirmed the British Governments commitment to further development of the nuclear fuel industry in Britain, retaining it as a significant element of the low-carbon energy mix. Current new nuclear activity in the UK is being progressed by three consortia (NNB Genco, Horizon and NuGen) that between them have set out proposals to develop approximately 16 GW of new nuclear power in the UK by 2030. That broadly translates into at least 12 new nuclear reactors at five sites currently earmarked for development: Hinkley Point, Sizewell, Wylfa, Oldbury and Moorside. (Nuclear Industrial Vision Statement/Nuclear Industrial Strategy DECC 2013).

However, following the Tōhoku earthquake on the north eastern coast of Japan in April 2011 and subsequent tsunami that overwhelmed vital infrastructure supporting the Fukushima nuclear power plant, renewed concerns regarding the long-term safety of the industry have re-emerged. Consequently, Germany closed 8 existing nuclear powerplants with the rest scheduled to be phased out by 2022. Switzerland has announced that they will close 6 of their nuclear power stations between 2019 and 2034 in response to the incident. Italy has also imposed a permanent ban on the reintroduction of a nuclear power programme following a referendum in June 2011. As of March 10, 2011, nuclear power accounted for 27.26% and 38.01% of the electricity generated in Germany and Switzerland respectively. (World Energy Council 2011 – One Year after Fukushima).

Furthermore, the problems of how and where to store current and future stockpiles of nuclear waste for the longer-term have yet to be resolved. As of 1 April 2010, the UK had 1,620 m^3 of high-level waste and about 94,300 m^3 of intermediate-level waste. These wastes are accumulating in stores as there is no current disposal route for these waste types. (NDA 2010 – UK Radioactive Waste Inventory). These figures are set to increase sharply over the coming decade as the rate of decommissioning old power station escalates.

Deep, geological disposal has been identified by the EU and the UK Government as the most appropriate strategy to deal with the problem. Clearly the indefinite storage of this material will need to be in the most geologically stable areas of the UK, and although a number of potential sites have been identified, no decision has yet been taken. It is not certain how the local communities of any area may react to proposals for the waste to be stored in their locality, and therefore it may be many years before any long-term storage solution is achieved.

Consequently, although nuclear power is pledged to remain an important part of the UK energy mix in the short to medium term, it is uncertain whether in the longer term safety, security and safe waste disposal issues can be addressed to permit the countries' continued commitment to this controversial form of energy production.

2.5 Rising Demand for Electricity

Electricity is integral part of our modern society. It powers an ever increasing array of equipment and services such as computers, lights, household appliances, industrial processes, together with transportation, education and communication networks. This combined with an increasing population exploiting the constant development of new electronic devices in innovative situations and applications has resulted in considerable upward pressure on the demand for electricity.

It is predicted that the demand for electricity will rise substantially over next 40 years. Various estimates of usage range between about 480 and 1,000 TWh by 2050. This rising demand coupled with the closure of existing electricity generating stations means that it is vital that new, clean sources are developed and adopted to maintain security of supply.

The majority of new power stations currently being planned in the UK are Combined Cycle Gas Turbines (CCGT) fired facilities run on natural gas, although it is anticipated that not all the proposed capacity will go on to be developed. One such power station is the Pembroke CCGT power station which was opened on the 19th of September 2013. While these CCGT electricity generators are more efficient and have lower CO2 emissions than older fossil fuel facilities, they still rely on imported gas that is subject to the volatile price fluctuations and pressures of the wholesale world energy market.

2.6 Security of Supply of Fuel Imports

In 1948, coal accounted for around 90% of the total UK energy output. Over the past 60 years this has fallen dramatically, and by 2009 just 28% of the total electricity produced was derived from coal-fired power stations. Over 86% (about 33 million tonnes) of the coal burnt in the UK in 2009 was imported, with approximately half of that figure coming from Russia.

Gas production from the UK Continental Shelf peaked in 2000 and despite some new provision; it is expected to continue to decline over the forthcoming decade. In 2014, UK natural gas production stood at 424.9 TWh – roughly a third the total production during the year 2000. Consequently, since 2004 the UK has been a net-importer of gas to make up the shortfall (~400,000 GWh). Imports of gas are delivered through the Norwegian pipeline, from the Continent through the IUK interconnector with Belgium, the Balgzand-Bacton Line pipeline from the Netherland, and imports of liquefied natural gas (LNG) to the Milford Haven terminal and the Teesside GasPort.

With around 57% of the UK electricity supply coming from coal and gas, it is apparent that the UK is reliant on imported fuel for domestic energy production. Therefore, the UK will be increasingly subject to the fluctuations of world fuel prices and potential disruption to supply based on regulatory failure, political instability or conflict. This case was proven between 2011 and 2012 were the supply of electricity from gas decreased from 41% to 28%, as gas prices increased, particularly in relation to coal. Electricity supplied from coal rose from 29% to 38% during the same period, its highest level since 1996. (DECC 2013 – UK Energy in Brief) The Electricity Market Reform White Paper (DECC, 2011) highlights some of the problems associated with the security of energy supply. To help mitigate a proportion of the UK's exposure, the report concludes that "it is vital that we take action now to transform the UK permanently into a low-carbon economy and meet our 15 per cent renewable energy target by 2020 and our 80 per cent carbon reduction target by 2050."

2.7 Alternative low carbon Energy Sources

There are a number of alternative low-carbon energy sources available, which have the potential to reduce the UK's greenhouse gas emissions. Commonly wind, solar, wave and tidal power, nuclear and hydro electricity are considered to be both renewable and effective at providing low-carbon electricity. Although broadly correct, there are limitations or problems with all these methods of energy generation. In addition, wastes are increasingly being utilised as a feedstock due to favourable calorific values of material, however the potential for contamination and toxic emissions present a risk to the nearby sensitive receptors.

Wind:

In July 2014, the UK had 6546 wind turbines with a generating capacity of 13.3 TW (UKWED). During 2014, wind energy produced 32 TWh of electricity equating to 2,753,000 tonnes of oil equivalent. (DECC 2015, UK Energy in Brief). It is estimated that up to 50,000 MW could be produced in the UK by 2021 from both on-shore and off-shore facilities providing between 44,000 and 115,000 jobs. Increasingly however, wind energy is facing mounting opposition on a range of issues such as efficiency, cost, security of supply and aesthetics.

Solar:

Solar energy is used to directly generate electricity via photovoltaic cells (Solar PV) where a current is generated across the layers of semi-conducting material such as silicon. Although CO_2 is not emitted during the process, solar PV cells are energy intensive to produce, and only generate power for part of the day. Furthermore, due to the UK's variable maritime climate and mid-latitude location, photovoltaic energy production is currently only suitable for micro-scale electricity generation. Only 4 TWh of electricity was generated from Solar PV during 2014, equating to 400,000 tonnes of oil equivalent. (DECC 2013, UK Energy in Brief).

Wave & Tidal:

Wave & tidal power generation is still in its infancy with a number of trials currently being undertaken. In June 2013 the plans for the £30 bn tidal barrage across the Severn estuary estimated to produce 5% of UK's energy was again but on hold due the findings of an Energy and Climate Change Select Committee report which stated the case for the barrage was unproven. The committee was not convinced the economic case was strong enough and that the developer Hafren Power had adequately addressed environmental and economic concerns. However, Britain's extensive coastal waters and large tidal range offers the potential for wave and tidal power to form an important element of the UK renewable energy mix, which is something Tidal Lagoon Swansea Bay Ltd are hoping to achieve in Swansea. A Development Order has recently been granted for the Tidal Bay project.

Nuclear:

The current stock of nuclear power stations generate around 18% of our total electricity output, but as outlined above, a substantial proportion of these facilities are set to close over the next decade. Both the last and current UK Governments have backed plans to allow the development of a new phase of nuclear power stations to be developed. Current new nuclear activity in the UK is being progressed by three consortia (NNB Genco, Horizon and NuGen) that between them have set out proposals to develop approximately 16 GW of new nuclear power in the UK by 2030. That broadly translates into at least 12 new nuclear reactors at five sites currently earmarked for development: Hinkley Point, Sizewell, Wylfa, Oldbury and Moorside. (Nuclear Industrial Vision Statement/Nuclear Industrial Strategy DECC 2013). However, due to problems associated with waste, security and the recent Fukushima nuclear power plant disaster, which is likely to remain the focus of much media attention in the coming decade, the future of nuclear power generation is far from certain.

Hydroelectric Power:

Hydroelectric power is the energy derived from the kinetic energy produced from the flow of water through a turbine generator. The UK currently generates about 2% of its electricity from hydroelectric schemes (including wave schemes). The amount of power generated depends on the volume of water flow and the vertical distance or 'head' that it falls through. Thus, streams and rivers are used to generate relative small amounts of electricity, while upland lakes are utilised for the larger schemes. Nevertheless, there are important environment concerns associated with hydroelectric power and the majority of large, suitable sites within the UK have already been utilised. Therefore, further development of the technology is likely to be concentrated on small-scale and micro-scale generating capacity. During 2014 5.8 TWh of electricity were generated from hydro power, equivalent to 506,000 tonnes of oil equivalent.

Incineration:

Energy from waste by Incineration can provide a method of waste disposal whilst enabling some energy recovery. Whilst incineration can be an acceptable form of waste disposal with energy production, the efficiency of these systems are often limited and that emissions can prove to be problematic to the environment. The residual waste products and concerns about the impacts of these upon public health have led to community resistance in obtaining widespread consent and public acceptance for incineration facilities.

2.8 Gasification

Energy from biomass feedstocks are an increasingly important source of renewable, low carbon fuel. It is often described as carbon neutral as the total amount of CO_2 liberated during combustion is broadly equivalent to the amount assimilated during crop growth.

Renewable energy use grew by 15% between 2013 and 2014. During 2014, plant biomass was the largest single renewable energy source, accounting for 24.2%, with domestic wood accounting for an additional 11.5%.

The proposed project will utilise around 480,000 tonnes per annum of Biomass to generate electrical output up to 49.9 MW together with liquid fuels and gas.

A relatively small proportion of the gas will be used to maintain the plants operation.

2.9 Conclusions

There are a number of challenges facing the energy sector over the coming years. These include: -

- The rate and scale of anthropogenically-induced global climate change;
- Attainment of strict, new national and international targets for the release of CO_2 and other greenhouse gasses;
- The decommissioning of existing nuclear and fossil fuel power stations;
- The role of new nuclear power stations in UK energy market;
- A growing population with an ever rising demand for electricity in a changing climate;
- The increasing reliance on fuel imports to meet the primary energy needs of the UK.

These factors form the main driving force behind the UK Government and Welsh Assembly demands for low carbon energy projects in the UK. They have a clear aim to support such projects and to stimulate research and development in new technologies to enable sustainable growth and create a low-carbon economy. The UK is not alone in the challenges that face electricity generation in the coming years. Indeed every country will inevitably encounter the same issues, but by leading the development of new, clean technologies, the UK has the potential to develop and export its skills and expertise worldwide.