Envisioning the Future

Considering Energy in Northern Ireland to 2050

Main Report – Final Version

Developed by Ricardo-AEA with

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Report for DETI

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Contact:

Colin McNaught
e: colin.mcnaught@ricardo-aea.com
Ricardo-AEA is certificated to ISO9001 and ISO14001

Author:

Colin McNaught, Duncan Kay, Nikolas Hill, Mark Johnson, Heather Haydock, Michael Doran, Alan McCullough

Approved By:

Heather Haydock

Date:

24 July 2013

Signed:

Executive Summary

Introduction

DETI wish to develop a vision for energy supply and demand in Northern Ireland in 2050. This vision will inform thinking and further analysis of the decisions and policy needed in the period to 2050. The focus of the study is on the three key parts of the energy sector: electricity, heat and transport.

The outcomes are a vision of what might happen by 2050, they are neither a prediction nor a plan. With any long term view, there is very significant uncertainty in many of the variables. So two separate scenarios for 2050 have been developed, the use of different views of what might change by 2050 highlight the uncertainty inherent in any long term vision.

Amongst the uncertainties are:

- how global energy supply and prices will change, factors that have changed significantly over the previous four decades;
- the Directives that may be introduced by the EC on greenhouse gas (GHG)[1] and energy targets post 2020;
- how global and EC influences will be experienced in the UK and transposed into UK law and devolved to Northern Ireland;
- how all of these influences change the behaviour and decisions of individual consumers in Northern Ireland and hence affect energy demand;
- how all of these influences affect the decisions of investors in energy projects in Northern Ireland and hence affect energy supply.

As a result, it is important to emphasise that this vision study does not propose a strategy, nor an action plan. Instead, the energy vision study is intended to guide thinking on:

- what can be achieved in 2050 and what early decisions and activities may be needed to support development towards 2050;what may not be achieved in 2050 and hence the areas that may need greater emphasis or additional assessment in future.

This vision does build on previous work that examines how the energy system in Northern Ireland may develop over the period to 2020, e.g. the Strategic Energy Framework and plans for renewable electricity and renewable heat to 2020.

Approach

The approach used to develop the energy vision for Northern Ireland in 2050 has been to:

- draw upon existing studies and strategies that consider energy supply and demand for 2050. As no studies for Northern Ireland cover the period to 2050, the main study used is DECC's pathways to 2050 as this already covers the whole of the UK and is in line with EU level targets on GHG emissions, energy efficiency and renewable energy;
- adjust the assumptions used in the DECC pathways to reflect circumstances in Northern Ireland. These adjustment factors included:
  - energy use and fuel mix in 2010;
  - population growth projections to 2050;
  - economic growth projections to 2050;
  - the scale of renewable energy resources;
  - barriers and opportunities specific to Northern Ireland.

[1] GHG emissions include six different gases that contribute to man-made climate change. In this report the unit used for GHG assessment is kilo tonnes CO_{2e}, or 1000 tonnes carbon dioxide equivalent. This includes the equivalent climate change impact of all six gases.

- verify the assumptions made by holding three stages of stakeholder workshops during the project to enable adjustments to be made to the sector level assumptions. The details of the sector level assessments are provided in a separate report, the Sector Annexes;
- integrate the outcomes in a spreadsheet model to deal with fuel switching once sector level assessments are complete, – e.g. changing from oil to gas or renewables for heating, and to assess the overall outcomes in 2050.

Scenarios

Over a long term period, such as the 4 decades to 2050, a very wide range of events and developments could take place. In the preceding 4 decades the energy system in the UK has moved from a coal dominated system, through a boom in hydrocarbon production and use, to a recent trend to decarbonisation.

Over the coming 4 decades it is likely that the pace of change will be even more rapid than in the past. So new policy directions may emerge, new technologies will be introduced and behaviours and attitudes will change. Hence creating a single view of energy supply and demand in Northern Ireland in 2050 would create an impression of being a prediction, while in reality it is impossible to predict events that far ahead.

The response to this challenge is to create more than one view of the long term future for energy in Northern Ireland. Most studies that consider the long term view use a number of scenarios. Each scenario shows a different possible pathway to 2050, often using four or more scenarios. The DECC pathways study allows users to create their own pathways, this allows a very wide range of ideas to be tested out.

In this study for Northern Ireland we have developed two scenarios:

- **Scenario 1**: This considers a continuation of trends from 2020 in the move toward increased security of supply and decarbonisation[2];
- **Scenario 2**: This considers a more aggressive change towards higher security of supply and greater decarbonisation, with higher levels of energy efficiency and greater moves to renewable energy.

Again emphasising that these are not predictions, but illustrations of two pathways for energy supply and demand in 2050, the key outcomes envisaged for 2050 include:

Security of Supply

Under both scenarios the levels of imported fuel change, with imported fuel in 2010 accounting for 96%, this falls to 68% under Scenario 1 and 41% under Scenario 2.

In 2010 fuel imports are dominated by oil, in the 2050 scenarios the majority of imports are for gas (for electricity generation, space heating and industry), significant oil imports remain, but the main use is for transport.

There is potential for local supplies of gas, if the development of shale gas proves commercially attractive and obtains the necessary consents. Section 5.3 provides the details on security of supply.

GHG Emissions

Under both scenarios for 2050, energy related GHG emissions fall significantly, to 45% of 1990 levels under Scenario 1 and to under 20% in Scenario 2. Given that Scenario 2 pushes the levels of energy efficiency and renewable energy harder, this produces a more significant reduction. These estimates cannot be compared directly with the EU and UK targets for an 80% reduction by 2050, as this study does not consider the non-energy GHG emissions, e.g. from agriculture, forestry and land use. Section 5.4 provides the details on GHG emissions.

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[2] Decarbonisation includes the reduction of all six types of GHG, not just CO_2.

Energy Costs

Energy costs for consumers are the product of the volume of energy consumed and the price of energy.

The Scenarios for 2050 suggest that fossil fuel consumption may fall, particularly so under Scenario 2. This is a consequence of assumptions of higher energy efficiency, higher use of renewable energy and a switch to electricity from fossil fuels. While energy efficiency does reduce electricity demand this is counterbalanced by increased use of electricity for space heating and transport. So electricity use rises in Northern Ireland, increasing in total use and use per household.

The past history of energy costs shows that energy prices can change significantly, and tend to show a rising trend. Energy price projections are not available post 2030. However electricity prices post 2030 may be influenced by the further investment in electricity generating capacity needed to reach the GHG reductions indicated for the 2050 scenarios.

So the net change in energy costs in 2050 may be a reduction in costs for fossil fuels which could be counterbalanced and exceeded by increases in electricity costs. The additional costs to upgrade and reinforce the electricity network will further increase the pressure on the costs of electricity.

Decisions over which type of electricity generating plant is developed in the 2030s and 2040s will have a large influence on electricity costs in 2050. By this time period there will be greater certainty over the costs of different options and there may be new options such as energy storage that can replace the most expensive generation, flexible open cycle gas turbines,

Section 5.5 provides the details on energy costs.

Pathway to 2050

A workshop was held with DETI and DRD staff to identify the most significant events in the pathway towards the energy vision in 2050. This workshop set out to examine when key activities were likely to take place, for example:

- major investment in new systems for energy supply or energy demand;
- major investment in energy related infrastructure;
- work on the policy needed to support or encourage the investments envisaged.

This process highlights where early decisions or policy development may be required, e.g. further assessment which may be needed in the near term.

This also shows that some of the decisions that have a large influence on the 2050 outcomes will not take place until the 2030s or 2040s. So final policy and practical actions for these later decisions can wait until energy prices, technology costs and other factors have become more certain.

Conclusions

The energy vision developed for Northern Ireland in 2050 suggests that significant progress towards decarbonisation could be achieved, especially under the more ambitious Scenario 2. Reduction of 55% to 80% in energy related GHG emissions could be achieved through:

- a switch to renewable electricity as the main form of electricity generation;
- a move to renewable heat;
- improved efficiency of buildings, industry processes, light and appliances;
- uptake of electric vehicles, plug in hybrid vehicles and fuel cell vehicles.

The scenarios for 2050 also envisage a significant change in energy security of supply for Northern Ireland. For fossil fuels the reliance on oil for heating is expected to be very significantly reduced, replaced by gas, renewable heat and electricity. For transport oil will continue to dominate the fuel mix, making transport the main sector that will be exposed to international energy cost fluctuations. The scenarios suggest that fossil fuel imports could fall from 96% in 2010 to between 68% and 41% in 2050. From a net importer of electricity, Northern Ireland could be a significant net exporter.

Energy costs are the product of volume of energy used and the price paid per unit of consumption. The scenarios suggest that fossil fuel use may fall, potentially significantly, whereas electricity consumption may increase. Long term energy price projections are often overtaken by events in the global energy sector. In addition there are no UK energy price projections for 2050. In general fossil fuel and electricity prices are expected to rise, so the main concern on energy costs is for electricity. A trend in rising electricity costs could be managed by considering how to deploy lower cost electricity generation options. In particular, the use of smart grid solutions or energy storage, as an alternative flexible technology to open cycle gas turbine generation. A move to these technologies would also reduce the costs of wider reinforcement of the electricity network. So these technologies would reduce costs and reduce GHG emissions.

To achieve these changes in GHG emissions and security of supply would require a sustained and concerted effort to deliver and this would also require all sectors of the economy to play their part in making the changes envisaged.

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1 Aims of the study

1.1 Overview

DETI wish to establish a long term vision to 2050 for energy in Northern Ireland covering electricity, heat and transport.

Comprehensive roadmaps and analysis have already been developed for the UK or internationally. These include reports produced for:

- European Commission (e.g. EU 2050 energy roadmap, European transport roadmap);
- Department of Energy and Climate Change (DECC) (e.g. 2050 pathways analysis, 2020 Renewables Roadmap);
- Committee on Climate Change (e.g. Building a Low Carbon Economy);
- Scottish Government (e.g. 2050 Policy Options, Energy Storage Study);
- Welsh Assembly Government (e.g. 2050 Policy Options Study);
- International Energy Agency (e.g. Energy Technology Perspectives, World Energy Outlook).

DETI commissioned this study to understand the implications, (including constraints) of these (and other relevant) studies for Northern Ireland (NI). This will help DETI to understand:

- the potential energy mix in Northern Ireland in the years to 2050;
- how far Northern Ireland can progress towards decarbonisation;
- the cost implications for Northern Ireland

1.2 Thinking over the long term

It is crucial to state that the results are a vision of what could happen by 2050. Hence the vision is **not:** a prediction for 2050 nor a strategy to reach 2050 or an action plan for 2050.

Long term predictions for the energy sector can be infamously wrong, with two examples below:

> ***"Already the output of natural gas has begun to wane. Production of oil cannot long maintain its present rate."***
>
> ***US Coal Commission, 1922***

> ***"I will drink all the oil there is in the North Sea"***
>
> ***Peter Kent, Chief Geologist for BP***

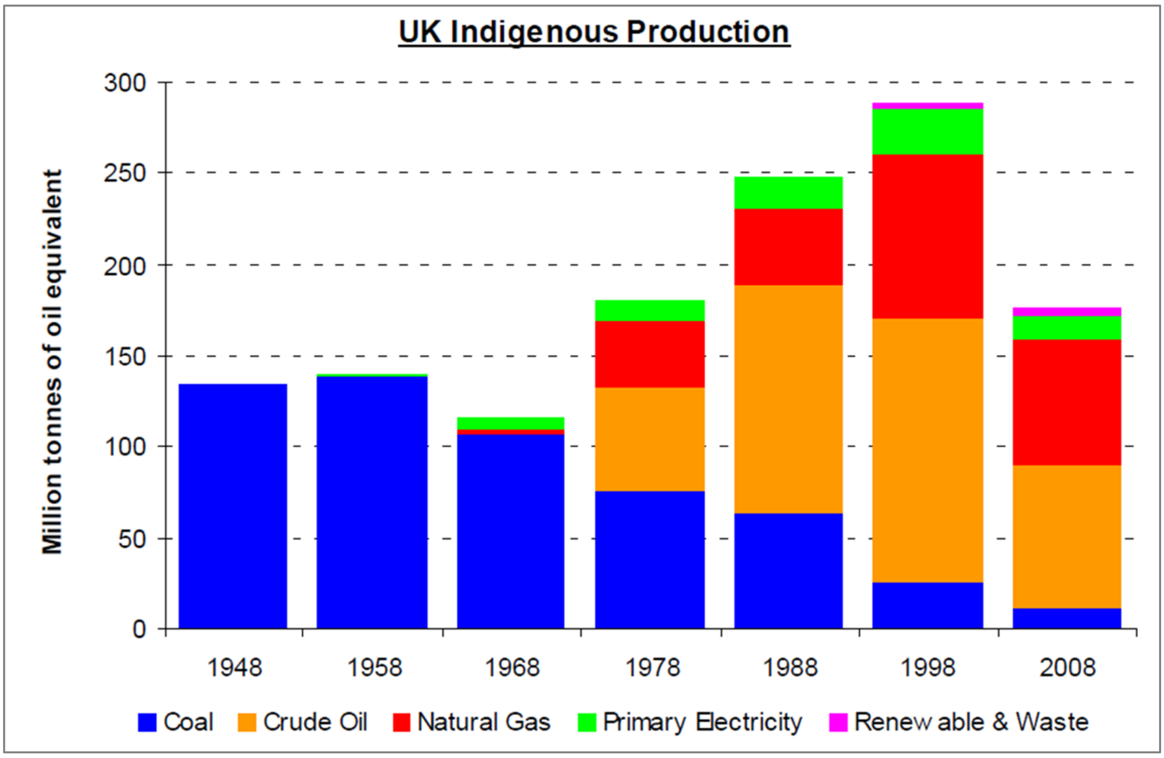
This is a key reason why two scenarios are developed, as a single scenario would appear to be a prediction, rather than a vision which cannot be predicted with certainty. There are many routes by which Northern Ireland could reach key energy goals in 2050. This study illustrates two possible routes to 2050, many other routes are possible.

It is often difficult to break away from the immediate future and consider the degree of change that may be possible in the next four decades to 2050. One way of obtaining some perspective on the degree of change that is possible, is to consider the degree of change that has occurred in the past.

The following chart shows two long term cycles of energy production in the UK:

- prior to the 1970's coal was the dominant form of energy produced, providing fuel for heating, power generation and for conversion to town gas;
- from the 1970's North Sea oil and gas production increases, rising such that the UK can be a net exporter of hydrocarbons;
- by 2008 North Sea production has fallen significantly, but with no significant coal production the UK becomes a net importer of hydrocarbons. The move to renewable energy has started, but is at a low level.

Figure 1 UK indigenous production of energy[3]



So two major energy transformations took place over the previous four decades. In general terms the pace of technological and economic change is much quicker now than previously. So the degree of transformation possible in the next four decades may be much higher than seen over the last four decades.

[3] DECC: 60th Anniversary: Digest of United Kingdom Energy Statistics

Consideration of the lifetime of different elements of the energy system helps to shape thinking about the changes that may take place over the coming 4 decades. Some energy systems have a very long operating life. So the decisions on the long life and infrastructure investments that will be operating in 2050 will be made soon. While decisions about short life items will be made in the 2040's. This is shown in the following table:

Table 1 Timeframe for decisions that will influence energy use in 2050

	2010's	2020's	2030's	2040's
Infrastructure	Infrastructure decisions on grid, road and rail in all 4 decades will continue to operate until 2050			
Long Life	Power stations will be built to replace the existing fleet and will continue in operation to 2050			
Medium life			Most of the renewable energy capacity built from 2000 onwards will have been retired and replaced or superseded in the 2030's or 2040's. So key decisions are made in the last 2 decades	
Short life				Lighting, appliances, private vehicles will have been bought in the 2040's and hence influenced by the technology and energy policy in this decade

While there is a natural focus on the hardware that makes up the energy system, the decisions about how energy is used and how energy is produced are made by people.

Attitudes affect decisions about the purchase of appliances, use of energy in the home and at work and choices over transport mode and types of vehicle owned and used. In addition public views have an influence on the larger energy decisions via the planning system.

A review of the projections for population in Northern Ireland in 2050 showed that:

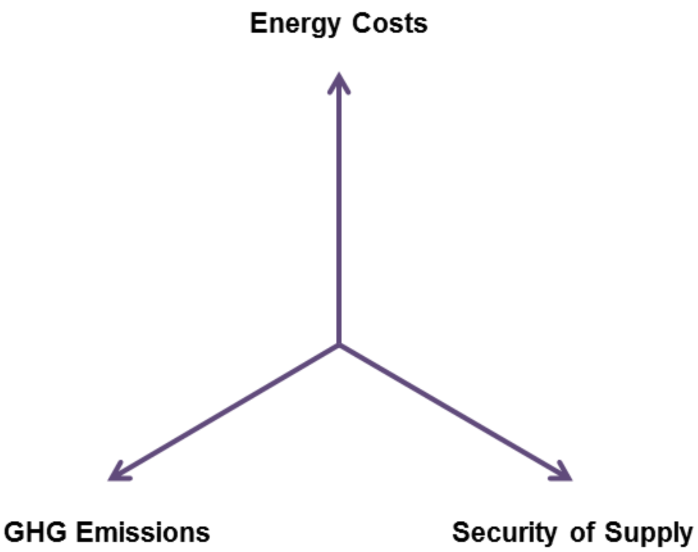
- 36% of the population of Northern Ireland in 2050 have not yet been born.
- 19% of the population of Northern Ireland in 2050 were born since 2000.
- 45% of the population of Northern Ireland in 2050 were born before 2000

So the individual and collective decisions that affect energy use in Northern Ireland in the 2040s will be made, or influenced, by a majority of citizens whose views are not yet known.

1.3 Key Energy Policy Outcomes

Northern Ireland's energy policy is strongly influenced by EU policy, market forces and other events. The aim of this study is to identify pathways to 2050 that have the best overall outcomes for Northern Ireland, in terms of energy costs, security of supply and GHG reduction. The tension between these three main aspects of energy policy is often represented as a trilemma, shown below:

Figure 2 Energy Trilemma



The trilemma concept is used to represent how different energy supply and energy demand changes might contribute to the achievement of these three key energy policy objectives.

1.4 Influences on Energy Outcomes

1.4.1 Market Events

Market events can have a profound and rapid influence on energy prices and energy security and hence energy supply and demand. Market events can be sudden such as:

- loss of gas supplies in Europe, e.g. from Russia;
- storm damage to energy infrastructure;
- diversion of fuel tankers to alternative markets.

Some changes can be more gradual or can be anticipated:

- reductions in fossil fuel extraction, e.g. the UK becoming a net importer of gas and oil;
- closure of fossil and nuclear power stations, e.g. due to the Large Combustion Plant Directive;
- increase in shale gas production in the US and knock on impacts on international LPG markets.

A key point for the Scenarios is that some of the gradual changes can be anticipated but sudden events are by their nature unpredictable.

1.4.2 Technology

Technology development tends to happen more gradually than market events. It can take years for a new technology to progress through R&D and testing to full commercialisation. This cycle is shorter for demand side technologies which are driven by consumer demand.

For supply side technology, particularly large scale ones, the cycle is much longer. Even when the technology is ready for market, at a project investment level it can take 10 years to get grid, planning and construction completed.

Nevertheless, over a four-decade time period, technology changes can be profound.

1.4.3 Policy

Many of the environmental aspects of energy supply are influenced by EU policy on greenhouse gas emissions, air quality, renewable energy and energy efficiency targets, and other environmental controls. It is likely that in the years between now and 2050 that the EU will continue with its focus on policies (expressed in the form of Directives) on greenhouse gas reduction, energy efficiency and renewable energy, including mandatory targets for Member States. Because of this focus from Europe, which requires mandated action within Member States including Northern Ireland as part of the UK, the focus of policy and programmes in Northern Ireland may focus on the cost and security of energy, the other two aspects of the trilemma.

There are many existing policy documents that explore the three key issues of cost, security and GHG for 2020 and some studies that consider the further changes to 2050. However, none of these is specific to Northern Ireland and therefore they do not take into account the specific features, geography and resources for energy in Northern Ireland.

Accordingly, the aim of this study is not to duplicate the body of work in EU and UK studies, but to interpret these for the context and energy situation, creating a vision for energy supply and demand in Northern Ireland in 2050.

A selection of key EU and UK policy papers for 2050 is reviewed in Section 2.

1.4.4 Uncertainties in the long term

As emphasised earlier, there are significant uncertainties in producing quantified results for 2050. Significant changes can occur in markets, technology and policy, these changes have occurred in the past and they will occur again in the future.

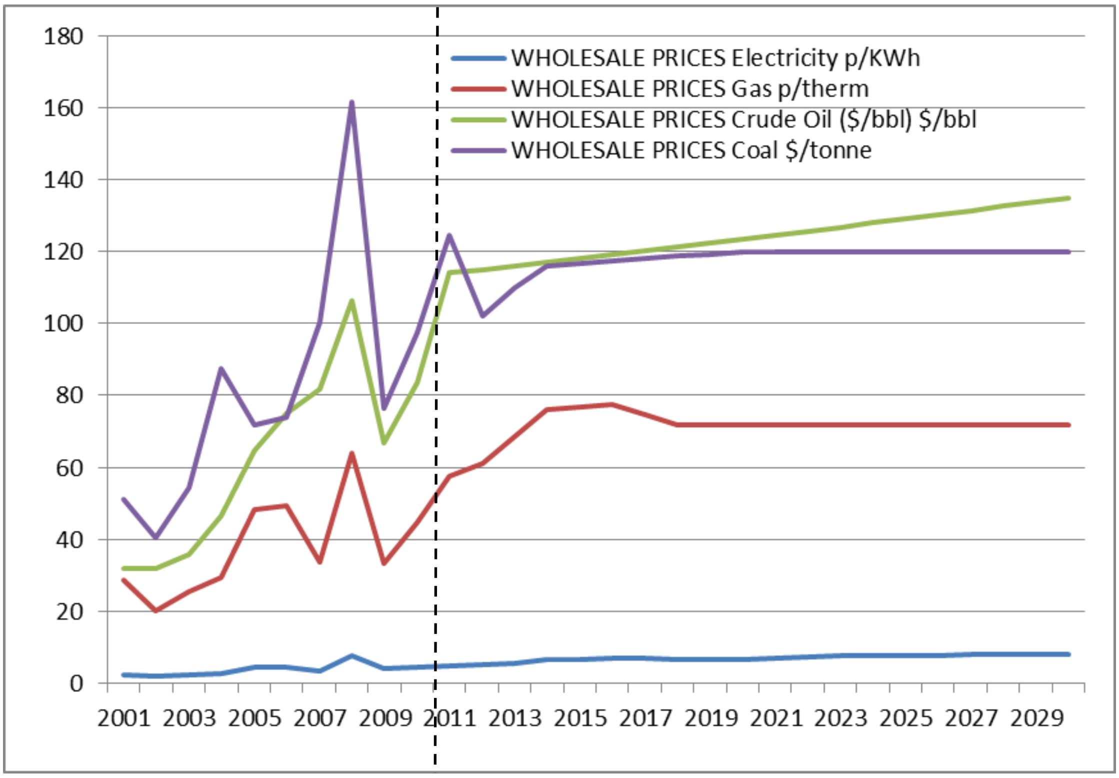
In developing a vision for 2050, there is an inherent bias on the part of those involved to create a logical and consistent picture. This assumes that perfect decisions are made by investors and policy makers – in reality this does not always happen.

A useful example of this is the Inverkip power station on the Clyde. This 1,900 MW oil fired power station started construction in 1970, but by 1973 the oil crisis led to fuel prices so high that it was uneconomical to operate. This station operated very infrequently before being mothballed in the 1980s.

Another example of this is in the short term changes in energy market prices: prices can radically change operating profits of power stations and hence change operating profiles and stymie investment decisions.

The following chart shows DECC's central energy price projections published in October 2012[4]. The historical prices show spikes and troughs – prices reacting to market events. The future projections show smooth progressions in price levels. It is certain that future prices will show just as much fluctuation as seen in the past – but such fluctuations are impossible to project forward.

Figure 3 DECC central energy price projections



[4] DECC: Updated Energy & Emissions Projections - October 2012

2 EU and UK policy context

Energy policy and hence changes to the supply and demand of energy, are strongly influenced by international and European events and policy. The previous section has highlighted how world events affect energy supply and hence energy prices. This section considers EU and UK perspectives.

A number of previous studies consider how energy supply and demand may change over the period to 2050. Key examples are:

- EU Energy Roadmap 2050 - the ten structural changes for energy system transformation, and the challenges and opportunities in moving from 2020 to 2050;
- European Transport Roadmap – the ten goals for a competitive and resource efficient transport system;
- DECC 2050 Pathways Analysis – the six illustrative pathways.

These are considered in the following sections as they:

- include policy and targets that may influence the 2050 vision for Northern Ireland;
- assess different energy system options for 2050.

In each case these EU and UK policy documents have decarbonisation of energy systems as a core objective. In the case of Northern Ireland the key resource to achieve this is renewable energy. Hence the scenarios with high levels of renewable energy are likely to be the most relevant to Northern Ireland.

2.1 EU Energy Roadmap 2050

Published in December 2011, the EU Energy Roadmap[5] reports on a range of scenarios that all lead to decarbonisation of the energy system by 2050. This goal is a key long term objective, to reduce GHG emissions by 80% by 2050.

A number of overarching comments are included in the Roadmap:

- that the EU policies and measures to achieve the Energy 2020 goals and the Energy 2020 strategy are ambitious;
- current polices will continue to deliver beyond 2020, helping to reduce emissions by about 40% by 2050;
- they will however still be insufficient to achieve the EU's 2050 decarbonisation objective as only less than half of the decarbonisation goal will be achieved in 2050;
- there will be a need for continued action after 2020.

The Roadmap recognises that forecasting the long-term future is not possible, so a scenario approach is developed, with two reference scenarios and five decarbonisation scenarios.

The decarbonisation scenarios explore different routes towards decarbonisation of the energy system. All imply major changes in, for example, carbon prices, technology and networks.

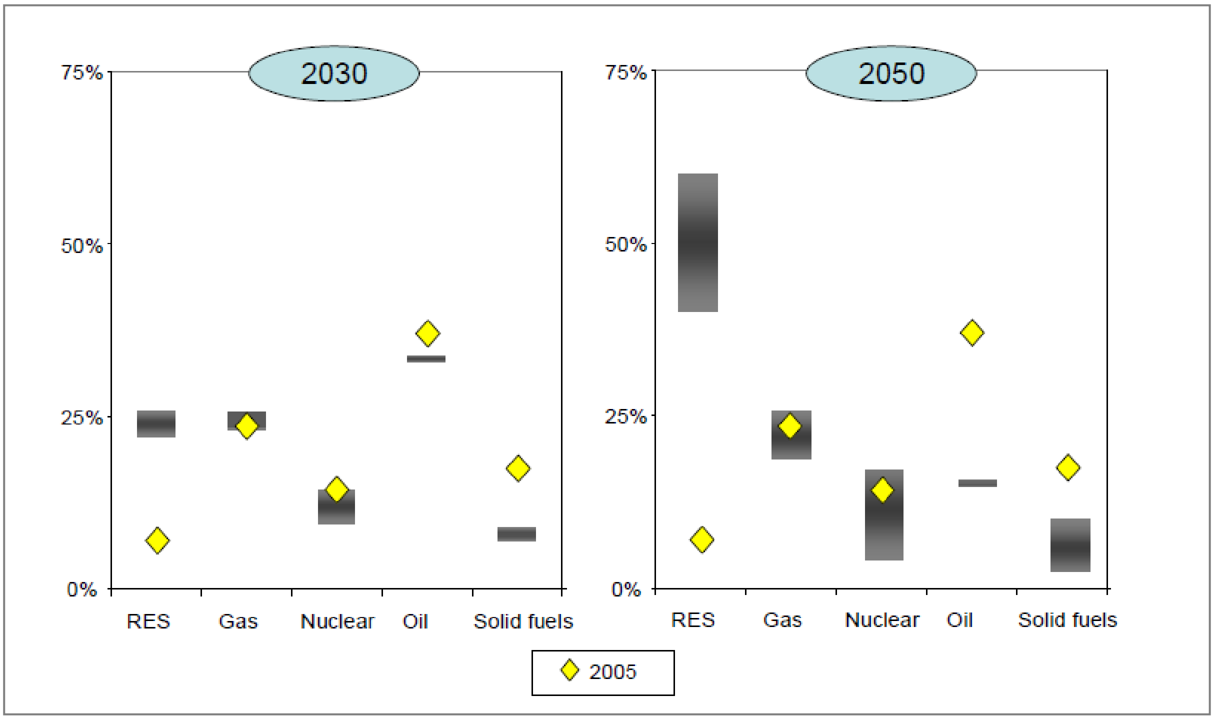
[5] See; http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2011:0885:FIN:EN:PDF

Table 2: EU 2050 Roadmap scenarios

EU 2050 Reference Scenarios
The Reference scenario includes current trends and long-term projections on economic development (gross domestic product (GDP) growth 1.7% pa). The scenario includes policies adopted by March 2010, including the 2020 targets for RES share and GHG reductions as well as the Emissions Trading Scheme (ETS) Directive. For the analysis, several sensitivities with lower and higher GDP growth rates and lower and higher energy import prices were analysed.
This scenario updates measures adopted, e.g. after the Fukushima events following the natural disasters in Japan, and being proposed as in the Energy 2020 strategy; the scenario also includes proposed actions concerning the "Energy Efficiency Plan" and the new "Energy Taxation Directive".
EU 2050 Decarbonisation Scenarios
Political commitment to very high energy savings; it includes e.g. more stringent minimum requirements for appliances and new buildings; high renovation rates of existing buildings; establishment of energy savings obligations on energy utilities. This leads to a decrease in energy demand of 41% by 2050 as compared to the peaks in 2005-2006.
No technology is preferred; all energy sources can compete on a market basis with no specific support measures. Decarbonisation is driven by carbon pricing assuming public acceptance of both nuclear and Carbon Capture & Storage (CCS).
Strong support measures for RES leading to a very high share of RES in gross final energy consumption (75% in 2050) and a share of RES in electricity consumption reaching 97%.
Similar to “Diversified supply technologies” scenario but assuming that CCS is delayed, leading to higher shares for nuclear energy with decarbonisation driven by carbon prices rather than technology push.
Similar to “Diversified supply technologies” scenario but assuming that no new nuclear (besides reactors currently under construction) is being built resulting in a higher penetration of CCS (around 32% in power generation).

The following figure show the EU 2050 Roadmap’s view of the situation in 2005 and the range of changes for each fuel type in 2030 and 2050.

Figure 4 EU Decarbonisation scenarios, 2030 and 2050 fuel mix compared with 2005



So renewable energy across the EU has a share around 25% in 2030 but rises to around 50% in 2050, but with a much greater range of outcomes in the different scenarios. This range reflects the wide range of assumptions made in the different scenarios.

Across the scenarios the roadmap identifies 10 structural changes for energy system transformation, these are summarised below:

(1) Decarbonisation is possible – and can be less costly than current policies
The scenarios show that decarbonisation of the energy system is possible, plus the cost of this transformation does *not* differ substantially from the Current Policy Initiatives (CPI) scenario: with decarbonisation, total energy system costs increase from 10.5% of European GDP in 2005 to 14.6% in 2050.

(2) Higher capital expenditure and lower fuel costs
All decarbonisation scenarios show a transition from an energy system with high fuel and operational costs, to an energy system based on higher capital expenditure and lower fuel costs.

(3) Electricity plays an increasing role
All scenarios show electricity will have to play a much greater role, almost doubling to 36-39% of final energy demand in 2050). Electricity will have a key role to play in the decarbonisation of transport and heating/cooling.

(4) Electricity prices rise until 2030 and then decline
Most of the scenarios suggest that electricity prices will rise to 2030, but fall thereafter. Most of the cost increase is present in the reference scenario, due to the replacement of older generation capacity. In the High Renewables scenario, with a 97% share of renewable electricity, electricity prices continue to rise but at a decelerated rate.

(5) Household expenditure will increase
In all scenarios, including current trends, expenditure on energy and energy-related products (including for transport) is likely to become a more important element in household expenditure.

(6) Energy savings throughout the system are crucial
Very significant energy savings need to be achieved in all decarbonisation scenarios. Achieving significant energy savings will require a stronger decoupling of economic growth and energy consumption.

(7) Renewables rise substantially
Renewable energy (RES) rises substantially in all scenarios, achieving at least 55% in gross final energy consumption in 2050.

(8) Carbon capture and storage has to play a pivotal role in system transformation
If commercialised, CCS will have to contribute significantly in most scenarios.

(9) Nuclear energy provides an important contribution
Nuclear energy remains a key source of low carbon electricity generation.

(10) Decentralisation and centralised systems increasingly interact
Decentralisation of the power system and heat generation increases due to more renewable generation. In the new energy system, a new configuration of decentralised and centralised large-scale systems needs to emerge and will depend on each other, for example, if local resources are not sufficient or are varying in time.

Many of these transformations are relevant to Northern Ireland, especially the energy efficiency and renewable energy actions. However, it is important to note that some of these options are not as relevant to the Northern Ireland case, and this may therefore restrict the options for and scope of the vision available to Northern Ireland. These restrictions are explored further in this report.

2.2 European Transport Roadmap

Published in 2011 this EU transport roadmap[6] covers the period to 2050. This roadmap:

- recognises that mobility is vital for internal and external markets and quality of life;
- notes that Oil will become scarcer in future decades, from increasingly uncertain sources;
- highlights the need to reduce GHG emissions by 80% to 95% by 2050, with transport providing a reduction of at least 60%;
- observes that transport has not changed significantly since the first oil crisis 40 years ago.

The vision presented in the roadmap includes:

- breaking the dependence of transport on oil;
- new patterns for freight and passenger transport;
- the phasing out of conventionally fuelled vehicles from urban areas by 2050;
- aviation using 40% sustainable fuels.

[6] See: http://ec.europa.eu/transport/themes/strategies/doc/2011_white_paper/white_paper_com(2011)_144_en.pdf

2.3 DECC 2050 Pathways Analysis

The DECC pathways[7] for 2050 include:

- sector level assessments for energy supply and demand, using four different levels of change by 2050. Level 1 has the least change, whereas Level 4 has the greatest change;
- a series of seven scenarios that set the level of change in each sector at different levels, in some scenarios there is a very high level of change in some sectors but no change in others.

The pathways report is accompanied by a web site and spreadsheet which allows users to develop their own pathways.

The following table summarises the seven scenarios.

Table 3: DECC Pathways

DECC Pathways
This pathway assumes that there is little or no attempt to decarbonise, and that new technologies do not materialise. This pathway does not meet the UK emissions targets and would not ensure that a reliable and diverse source of energy was available to meet demand – it would leave the UK very vulnerable to energy security of supply shocks.
DECC Pathways
Illustrates a pathway with largely balanced effort across all sectors, based on physical and technical ambition. In this pathway, there would be a concerted effort to reduce overall energy demand; an equivalent level of effort from three large scale sources of low carbon electricity (renewables, nuclear, and fossil fuel power stations with carbon capture and storage); and a concerted effort to produce and import sustainable bioenergy.
Looks at what could happen if we were not able to generate electricity using carbon capture and storage technology.
Looks at what could happen if no new nuclear plant were built
Looks at what could happen if only minimal new renewable electricity capacity were built.
Looks at what could happen if supplies of bioenergy were limited.
Looks at what could happen if there were little behaviour change on the part of consumers and businesses.

[7] See: https://www.gov.uk/government/publications/2050-pathways-analysis

3 Study Methodology

The aim of the study is to create a vision of how energy supply and demand might look in Northern Ireland in 2050. Any long-term vision for energy has the challenge that changes in the energy sector occur every week. So over a period of 4 decades it is impractical to predict what will happen. In addition, providing a single view of energy in Northern Ireland in 2050 has a risk of being interpreted as a prediction.

So, two separate scenarios for 2050 were developed, to represent two different pathways for energy supply and demand in Northern Ireland. These are:

- **Scenario 1**: This considers a continuation of trends from 2020 in the move toward increased security of supply and decarbonisation;
- **Scenario 2**: This considers a more aggressive change towards higher security of supply and greater decarbonisation, with higher levels of energy efficiency and greater moves to renewable energy.

To inform the development of the two scenarios for Northern Ireland and number of other studies and scenarios for 2050 were reviewed (see Section 2).

Of the previous 2050 studies reviewed, the DECC pathways is the most detailed and the most relevant to the context in Northern Ireland. Hence this study takes the sector level DECC pathways and edits these to match the energy, economic, infrastructure and geographic situation in Northern Ireland.

The results of these interpretations of the DECC pathways were the subject of several stages of workshop sessions:

- an initial workshop in January 2013 – to discuss preliminary ideas for key sectors;
- these revisions were then reviewed with DETI in an internal workshop;
- a second phase of more detailed workshops took place on 25th and 26th January, with half day stakeholder workshop sessions on Electricity, Heat and Transport.

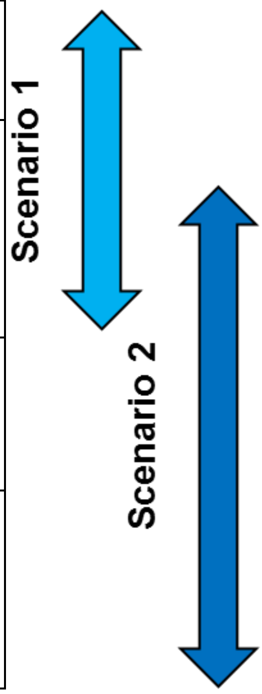
The details of the workshops and attendees are included in Appendix 1.

3.1 Use of the DECC Sector Pathways

In the DECC 2050 pathways, four separate levels of development are set out for each sector. The narrative for each level is shown in the table below:

Table 4 DECC narrative for the 4 levels

Level	Description
Level 1	Assumes little or no attempt to decarbonise or change or only short run efforts; and that unproven low carbon technologies are not developed or deployed.
Level 2	Describes what might be achieved by applying a level of effort that is likely to be viewed as ambitious but reasonable by most or all experts. For some sectors this would be similar to the build rate expected with the successful implementation of the programmes or projects currently in progress.
Level 3	Describes what might be achieved by applying a very ambitious level of effort that is unlikely to happen without significant change from the current system; it assumes significant technological breakthroughs.
Level 4	Describes a level of change that could be achieved with effort at the extreme upper end of what is thought to be physically plausible by the most optimistic observer. This level pushes towards the physical or technical limits of what can be achieved.



For the two scenarios for Northern Ireland:

- Scenario 1: Draws most from DECC Levels 1 and 2, as these have less ambitious levels of change.
- Scenario 2: Draws more from DECC's Levels 2 to 4, as these have the highest elements of change.

3.2 Approach

The steps taken in this project are shown below:

Figure 5 Overall approach

The review of studies and the sub-sector results were developed using:

- a review of the current situation in Northern Ireland;
- an assessment of the status and prospects for development in each sector;
- a review of the DECC 2050 pathways results for the sector;
- an interpretation of the DECC 2050 pathways for Northern Ireland;
- two scenarios for energy supply and demand in Northern Ireland for 2050;
- a qualitative assessment of the contribution of changes in each sector to the key policy objectives using the Trilemma approach.

The results have been reviewed at external workshops twice, with further review by DETI and DRD at internal meetings. The external workshop stages are described in Appendix 1.

3.3 Sector Annexes

The final results for each supply or demand sector are presented in a separate Sector Annexes report. The Sector Annexes present the details of a series of sector level analyses for the most important energy supply, energy demand and energy infrastructure sectors. Each sector is considered separately and independently, without interaction or constraint from the other sectors.

Once the potential changes in each sector are established and agreed, the interactions can be assessed and analysis and judgements made as to the impact of the interactions in scaling back supply or increasing demand. These interactions are dealt with and described in this main report.

Table 5: Sector listing for the Sector Annexes

Section No	Title
2	**Energy Demand Sectors - Overview**
2.1	Appliances & Lighting
2.2	Heating and Cooling
2.3	Industry
2.4	Transport
2.5	Agriculture
3	**Conventional Energy Sources**
3.1	Fossil Generation & Carbon Capture and Storage
3.2	Nuclear
3.3	Shale Gas
4	**Renewable Energy Overview**
4.1	Onshore wind
4.2	Offshore wind
4.3	Tidal Stream
4.4	Wave
4.5	Large scale biomass
4.6	Anaerobic Digestion
4.7	Solar PV
4.8	Hydro
4.9	Renewable Space Heating
4.10	Solar Thermal
5	**Energy Infrastructure Overview**
5.1	Electricity Interconnection
5.2	Electricity Storage
5.3	Electricity Networks

4 Energy Demand and Supply

The following sections draw together the individual sector level results for energy demand and supply. Each demand sector and each form of electricity supply is reviewed in detail in the Sector Annexes. Each Annex provides:

- analysis on the current situation
- reviews of the DECC 2050 pathways for the UK
- adaption of the UK pathways to produce two scenarios for Northern Ireland

The results of each of the demand and supply assessments are combined in this section of the Main Report.

4.1 Electricity Demand

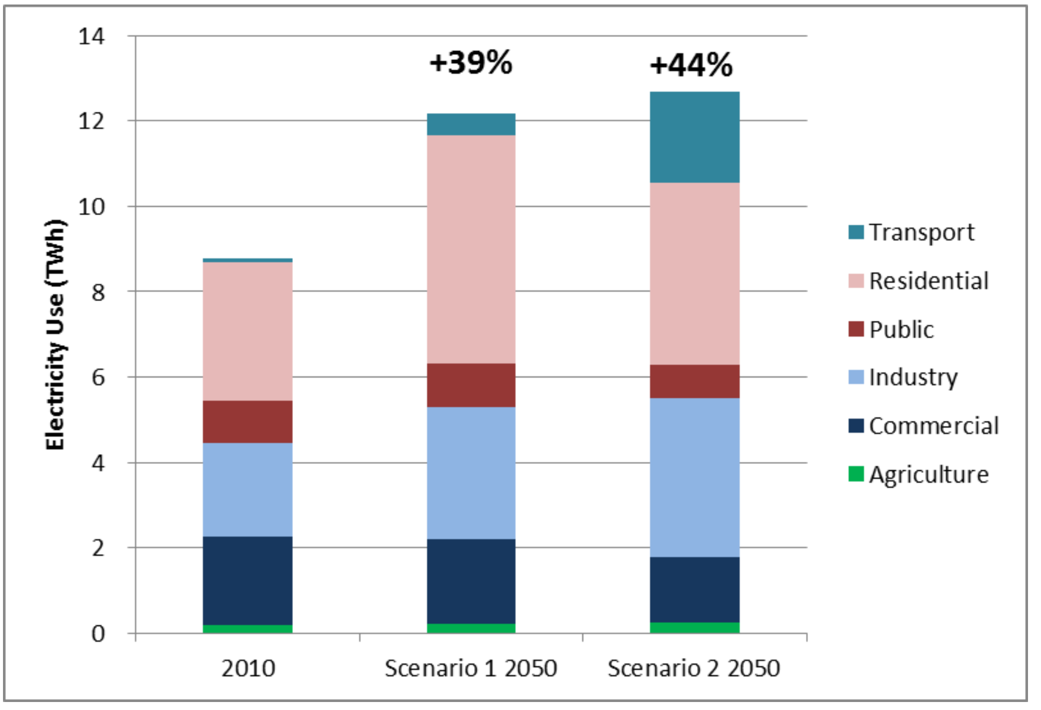
Electricity demand in 2050 changes significantly, as the amounts of electricity used for appliances changes and new uses for electricity such as electric vehicles increase. The key factors are:

Table 6 Key changes in electricity demand

	Scenario 1 2050	Scenario 2 2050
Decreases use of electricity in lighting and appliances, as these become more efficient and controllable.	A significant level of change	A much more significant change
Increases in the population and the number of homes. Increasing numbers of appliances.	Same in both scenarios	
Switching from fossil fuels to electricity for heating, either as direct resistive heating or for heat pumps.	A significant level of change, particularly uptake of resistive heating and some heat pumps	A much more significant change, particularly uptake of heat pumps
Switching fossil fuels to electricity for transport, for plug in hybrid vehicles, electricity vehicles or to produced hydrogen for fuel cell vehicles.	A significant level of change, 20% of passenger km are in cars fuelled by electricity (direct).	A very significant change, 80% of passenger km are in cars fuelled by electricity (direct or via hydrogen).

Overall electricity use in Northern Ireland increases significantly, by 39% in Scenario 1 and 44% in Scenario 2. .

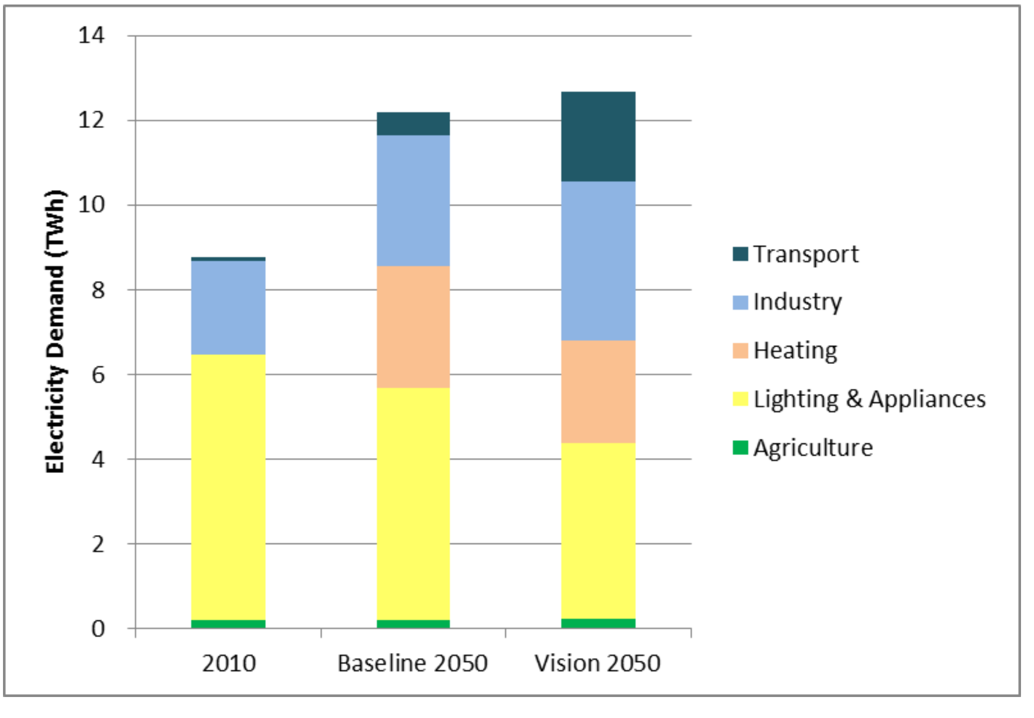
Figure 6 Electricity demand by sector (TWh)



The way that electricity is used also changes significantly, with:

- falling electricity use for lighting and appliances, see Sector Annex Section 2.2;
- a very large increase in electricity for heating see Sector Annex Section 2.3;
- an increase in electricity use in industry, moving to less heat intensive sectors and using electricity in processes which would have used fossil fuels, see Sector Annex Section 2.4
- a very large increase in electricity for transport, see Sector Annex Section 2.5.

Figure 7 Electricity use by end application



4.2 Electricity Supply

Electricity supply in 2050 sees a large shift to renewable energy generation, in line with EU and UK expectations for 2050. Given the renewable energy resources in Northern Ireland, the main potential increases are for onshore and offshore wind, with important increases in tidal stream, solar PV and large biomass. The details of the assumptions are presented in Sections 3 and 4 of the Sector Annex. An overview is shown below:

Table 7 Key changes in electricity supply

	Scenario 1 2050	Scenario 2 2050
Fossil Generation & Carbon Capture and Storage	Combined Cycle Gas Turbine (CCGT) and Open Cycle Gas Turbine (OCGT) replace the current fleet of power stations	CCGT and OCGT replace current fleet. More OCGT in Scenario 2
Nuclear	None	None
Shale Gas	None	Developed, main impact is on security of supply
Onshore wind	Increases, post 2020, but not at the same rate	Increases, post 2020, but not at a slightly higher rate
Offshore wind	Current proposed schemes replaced like to like by 2050	Current proposed schemes replaced by increased capacity by 2050
Tidal Stream	Current proposed schemes replaced like to like by 2050	Current proposed schemes replaced by increased capacity by 2050
Wave	None	None
Solar PV	Large increase, based on lower costs.	Larger increase, based on lower costs.
Hydro	Increases, but not a significant capacity	Increases, but not a significant capacity
Large scale biomass	Several schemes at ports	Larger schemes at ports, with a large scheme with District Heating in Belfast

Two electricity generation technologies, coal (with carbon capture and storage) and nuclear were discussed extensively in the workshops and are covered in the Sector Annexes. Both are important options at EU and UK levels.

Coal with CCS if focused on larger coal fired power stations, which are located on coastlines that have an economical route to a sub-sea geological store of CO_2. The costs of the CO_2 pipeline and infrastructure are best accommodated if the power station is large, or is used by a cluster of power stations. This spreads the cost of the infrastructure over a higher quantity of electricity generated. Northern Ireland has smaller scale conventional power stations, and in smaller numbers, than the rest of the UK. So coal with CCS is less likely to be economically attractive in Northern Ireland.

Coal with CCS would provide some carbon reduction compared to the current use of gas fired generation, but has higher emissions than renewables. Unlike the rest of the UK coal fired generation in Northern Ireland has already fallen very substantially, so adding coal fired generation would not improve security of supply. The costs of coal with CCS are currently high, early projects need significant EU or UK government support. Costs of coal with CCS will fall over the next 4 decades, but coal with CCS is likely to remain a more expensive option in Northern Ireland, compared to the rest of the UK, because of the smaller scale and greater distance to the CO_2 store.

Nuclear has an important role to play in carbon reduction and can contribute to security of supply. Hence DECC have produced a strategy to develop and build a new tranche of nuclear power stations in the UK. Nuclear power stations have historically been large (1,000 MW or more) and have needed to operate as baseload. Baseload means 24 hour a day operation and in the UK the pumped storage schemes were built to enable this. New designs of nuclear will allow more flexible operation of nuclear plant, though the degree of flexibility will not be as great as OCGT. It is also technically possible that smaller scale nuclear plant could be built in future. The development costs (planning applications, safety case, public inquiries etc.) for nuclear are high. These costs do not reduce for smaller plant. So any developer will tend to aim for a larger plant, and for a fleet of similar plant, so that the development risks and costs are spread over more stations and higher income. For Northern Ireland these factors do not apply as the likely scenario would be a single smaller scale nuclear power station, which does not allow spreading of development risks and costs. Hence any developer would need a high level of confidence over the success of the planning application and the income from electricity sales.

The changes in electricity generating capacity envisaged are shown in the following table and figure.

Table 8 Electricity generating capacity (MW)

	2010	Scenario 1 2050	Scenario 2 2050
Coal	440	0	0
Oil	232	0	0
Gas CCGT	900	900	600
Gas OCGT	330	500	700
Biomass / Biogas	50	75	260
Anaerobic Digestion	3	50	75
Hydro	10	10	20
Tidal Stream	1.2	200.0	400.0
Onshore Wind	402	1,600	2,000
Offshore Wind	0	600	1,200
Solar PV	1	600	800
Totals	**2,366**	**4,485**	**5,980**

Figure 8 Electricity generating capacity (MW)

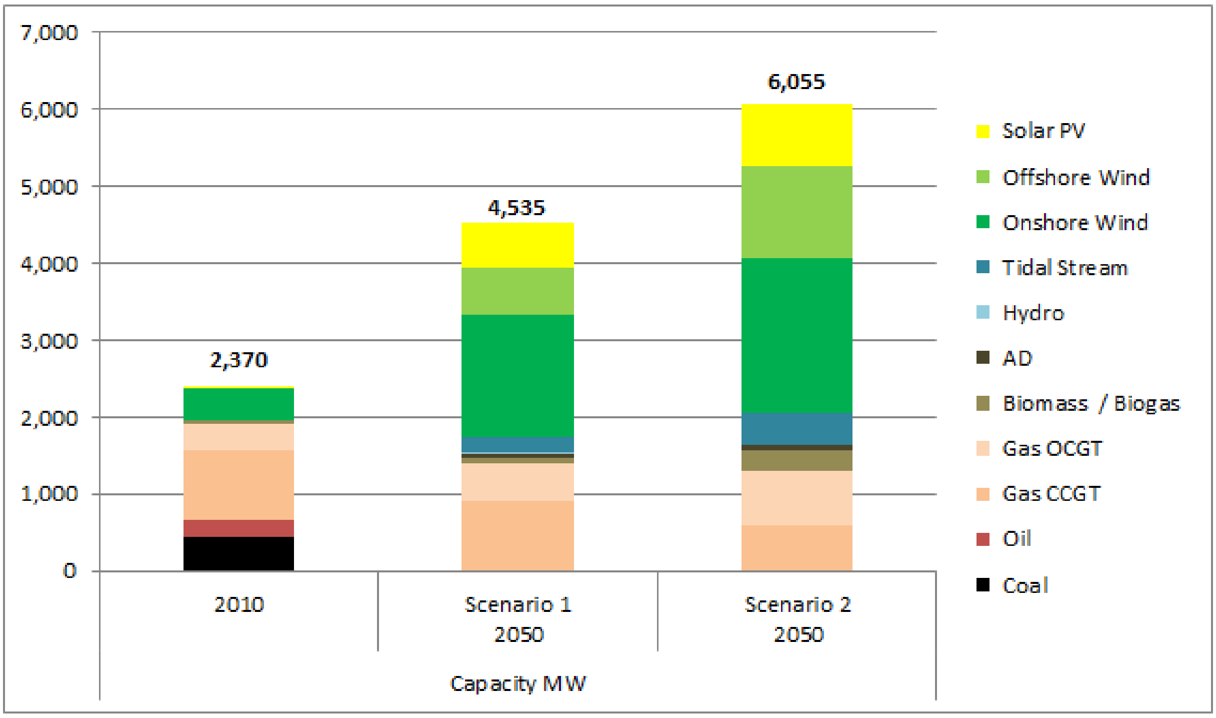
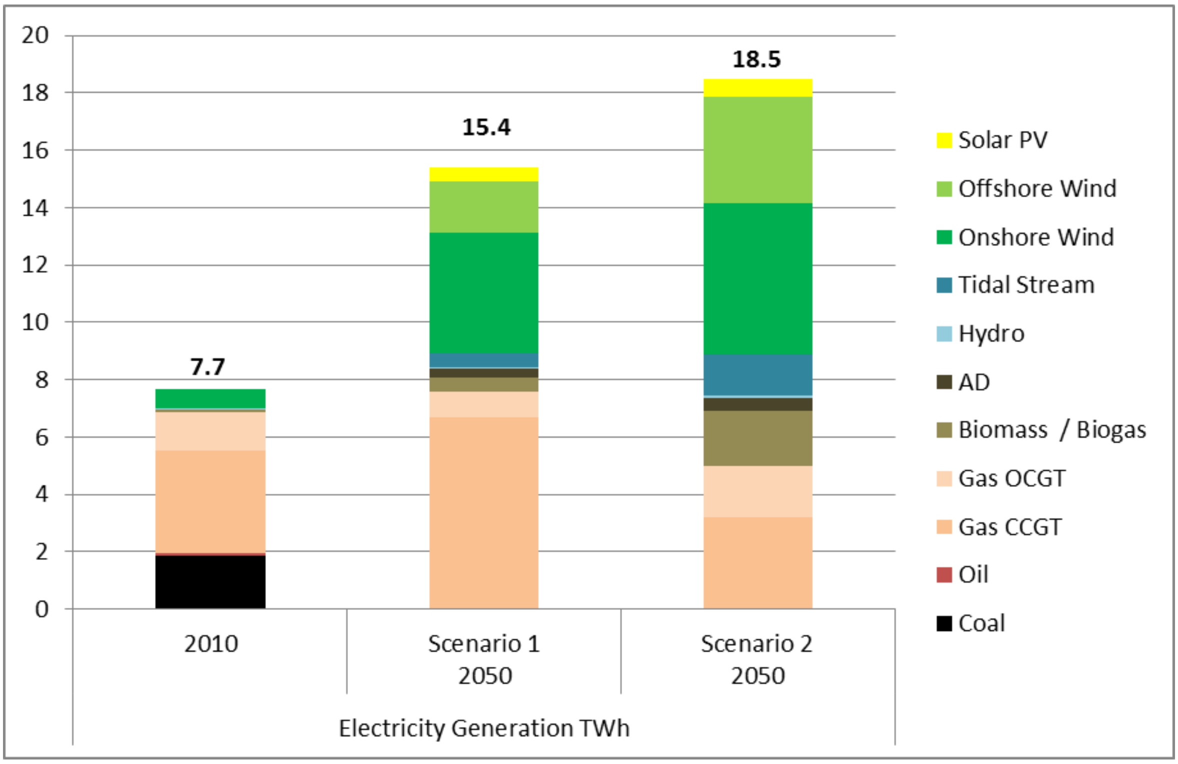


Table 9 Electricity generation output (TWh)

	2010	Scenario 1 2050	Scenario 2 2050
Coal	1.9	0.0	0.0
Oil	0.1	0.0	0.0
Gas CCGT	3.6	6.7	3.2
Gas OCGT	1.3	0.9	1.8
Biomass / Biogas	0.1	0.5	1.9
Hydro	0.0	0.0	0.1
Tidal Stream	0.0	0.5	1.4
Onshore Wind	0.6	4.2	5.3
Offshore Wind	0.0	1.8	3.7
Solar PV	0.0	0.5	0.6
Totals	**7.6**	**15.1**	**18.0**

Figure 9 Electricity generation output (TWh)



4.3 Electricity Imports/Exports

Interconnectors allow the transfer between separate electricity markets. Hence the only interconnector is the Moyle sub-sea connection to Scotland. The lines to Ireland are classified as tie-lines, these allow trading within the Single Electricity Market (SEM) and also allow technical system support.

The distinction between an interconnector and an internal transmission level tie-line is important because:

- Ireland and Northern Ireland may take a similar path in terms of investment in future electricity generation. Both may have significant amounts of wind and other renewable energy generation supported by gas fired conventional generation. As both regions will experience similar weather conditions, it is likely that peaks and troughs in generating margin will occur at similar times. Hence the cost and security of supply benefits of trades of electricity will be of less commercial and strategic value in this scenario;
- it is likely that the GB market will also have significant renewable generation capacity, but will also have significant nuclear, coal with CCS and gas capacity. Hence interconnection between the SEM and the GB markets offers access to a more diverse range of generating capacity and hence a greater likelihood for trading to be commercially attractive;
- in addition to the different prices in the two markets, interconnection with the GB market also offers higher security of supply benefits. In part this is an issue of scale, having access to a much larger electricity system increases security of supply. In addition the weather conditions, and hence renewable energy output, will be more diverse over the entire British Isles. This offers the prospect for trading of renewable energy surpluses and shortfalls.

Northern Ireland imports significant amounts of electricity from the GB market via the Moyle interconnector. So this is a key element in the electricity mix for Northern Ireland. The scenarios for 2050 suggest this position will reverse, leading to significant electricity exports to GB and Ireland:

Table 10 Electricity imports & exports (TWh pa)

	2010	Scenario 1 2050	Scenario 2 2050
Net Imports	2.1		
Net Exports		2.77	6.18

This would require additional interconnection to GB and tie-lines to Ireland. The details of the assumptions on interconnection are presented in Section 4.1 of the Sector Annexes, a summary is shown below:

Table 11 Key changes in electricity interconnection

	Scenario 1 2050	Scenario 2 2050
Replacement	Moyle (500 MW)	Moyle (500 MW)
New interconnection	Northern ISLES (500 MW) Heysham (1,000 MW)	Northern ISLES (1,000 MW) Heysham (1,500 MW)

4.4 Heat Demand

Heat use includes:

- space heating in homes, public buildings, commercial buildings and industry;
- water heating in homes, public buildings, commercial buildings and industry;
- process heating in industry and agriculture.

As discussed in the Sector Annexes, there are no complete data sets for energy demand in Northern Ireland. Hence fossil fuel use for heat in 2010 has been estimated using:

- back calculation from the GHG Inventory for Northern Ireland, using emission factors to estimate fuel use;
- data on percentage fuel use from a wide range of sources to estimate the emissions factors at sector level;
- cross checking against a number of previous studies.

The results are not to the level of accuracy available for similar studies in the rest of the UK, as these can draw on official energy statistics.

Table 12 Fossil Fuel Use for Heating in 2010 by sector

	Fossil Fuel Use in 2010 (GWh)
Agriculture	200
Commercial	1,070
Industry	6,399
Public	919
Residential	14,208
Total	**22,796**

Clearly fossil fuel use in homes dominates with over 60% of fossil fuel use, followed by industry with 28%. Hence measures to reduce heat use and to introduce renewable heat need to be focused on the residential sector.

Changes to heat demand in 2050 are described in detail in the Sector Annexes, under the heating and cooling section and the industry section. The factors that influence heat demand and which were considered and adjusted for Northern Ireland, include:

- economic Growth;
- shift to less energy intensive industry;
- increasing population;
- new homes;
- smaller homes;
- building standards.

4.5 Heat Supply

In terms of fuel type, oil dominates with 75%, gas use has increased to 16% and coal use is falling:

Table 13 Fossil Fuel Use for Heating in 2010 by fuel

Gas	3,640	16%
Oil	17,102	75%
Coal	2,054	9%
Total	**22,796**	**100%**

Changes to heat supply in 2050 are described in detail in the Sector Annexes, under the heating and cooling section and the industry and agriculture sections. The factors that influence heat demand and which were considered and adjusted for Northern Ireland include consideration of switching of fuels used for heating including:

- switching to gas;
- shift away from coal;
- switching to renewables.

The DECC model does includes a wide range of scenarios for the mix of fuels and technologies. These are reviewed in the Sector Annex for this study, see Section 4.9: “Renewable Space Heating”. A selection of these assumptions is used in this analysis. These take into account the specific circumstances in Northern Ireland, e.g. the amount of gas vs. oil used and the limits to supply of biomass.

The assumptions used are shown in the following table. The assumptions show the percentage of heat demand that is supplied by each heating technology in 2050. This is heat demand after energy efficiency improvements have been taken into account. So in Scenario 1 for 2050 new gas boilers provide 30% of space heating, falling to 20% in Scenario 2.

Table 14 Switching of fuels and technologies for heating

Heating Technology	Scenario 1 2050	Scenario 2 2050	Comments
Gas boiler (old)			None: all retired
Gas boiler (new)	30.0%	20.0%	Some continue in areas served by gas.
Resistive heating[8]	14.5%	20.0%	Higher than UK scenarios. Has the potential for storage and through SMART energy systems to use electricity when renewable electricity output is high
Oil-fired boiler	20.0%	10.0%	Some left, higher in Scenario 1
Biomass boiler	10.0%	10.0%	Modest levels, recognising limits to the biomass resource in Northern Ireland
Stirling engine micro CHP (µCHP)			Not included as it would increase reliance on gas and the use of fossil fuels in heating
Fuel-cell µCHP			Not included as it would increase reliance on gas and the use of fossil fuels in heating
Air-source heat pump	15.0%	22.3%	CoP of 3.0
Ground-source heat pump	5.0%	10.0%	CoP of 4.0
Geothermal	0.5%	0.5%	Limited potential of around 5 to 10 MWth
Community scale gas CHP	5.0%	5.0%	Small number
Community scale solid-fuel CHP			Included as DH from biomass power station
District heating from power stations		2.2%	Belfast scheme

In most cases these assumptions do not change the total amount of energy supplied, however the treatment of heat pumps requires additional steps:

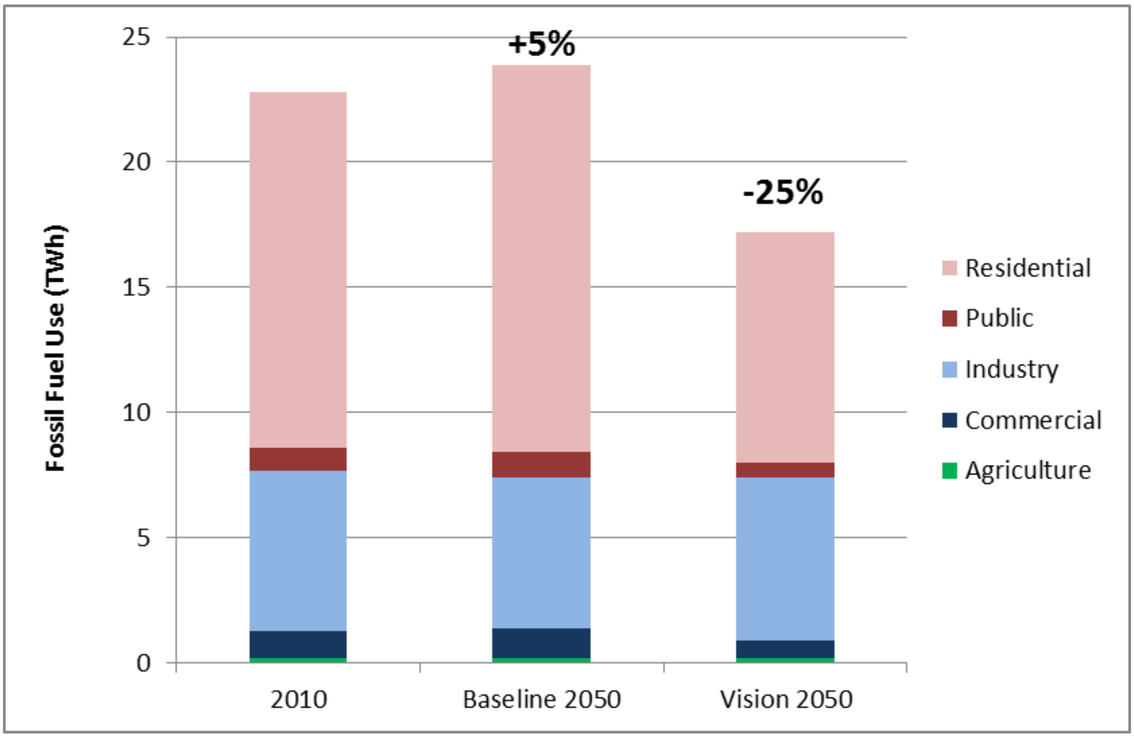
- assessment of the heat demand that is supplied by heat pumps;
- assessment of the electricity demand using the assumed CoP stated above;
- addition of the electricity demand to total electricity demand.

[8] Resistive or ohmic heating, is produced by electric current passing through a heating element, the heat produced by the current can be used immediately, or can be stored and used later (e.g. as used in economy 7 systems).

4.6 Heat Summary

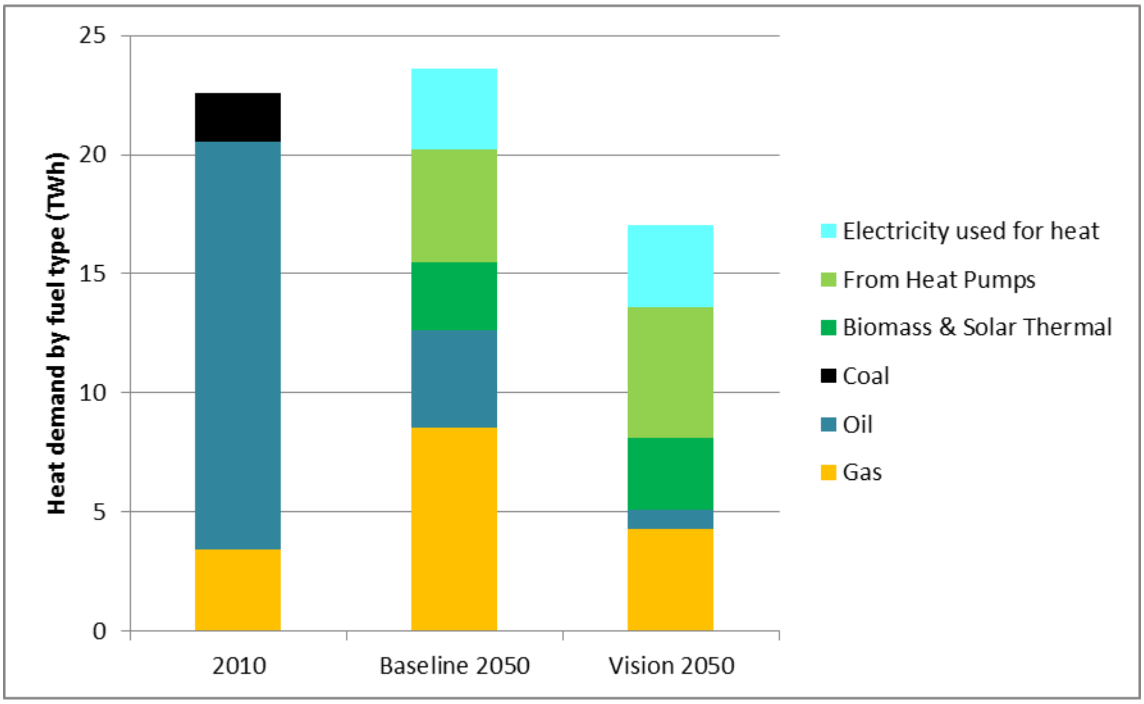
The overall result is a small increase in the heat demand of 5% for Scenario 1 and a 25% decrease in Scenario 2 for 2050.

Figure 10 Heat demand (TWh)



However, the picture when seen by the type of fuel is much more dramatic, with fossil fuel use falling in both scenarios. The following chart shows which fuel supplies the heat demand.

Figure 11 Heat demand by fuel type (TWh)



Importantly:

- renewable energy is the direct use of renewable energy: e.g. biomass, solar thermal;
- the output of heat pump systems is shown separately, this electrical energy used to provide this heat is also shown in the electricity section, but the figures are lower when the CoP of the heat pumps are taken into account. Heat from heat pumps is deemed to be a renewable source of energy under the Renewable Energy Directive[9];
- direct electrical heating is resistive heating, with or without storage;
- by 2050, the carbon emissions from electricity generation have fallen very significantly, especially in Scenario 2. So the carbon emissions associated with the direct use of electricity have also fallen. So while this is not deemed renewable, it is a low carbon form of heating in 2050.

The major changes in fuels used for heat in 2050 are:

- phasing out of coal completely;
- very significant reductions in use of oil, especially in Scenario 2;
- increasing use of renewables;
- increasing use of electricity, in heat pumps and for direct heating;
- increased use of gas in Scenario 1.

Gas use is lower in Scenario 2 as heat demand is lower and more or the remaining heat demand is switched to renewable sources.

Table 15 Fuel use for heat (TWh)

	2010	Scenario 1 2050	Scenario 2 2050
Gas	3.4	8.6	4.3
Oil	17.1	4.1	0.8
Coal	2.1	0.0	0.0
Biomass & Solar Thermal		2.9	3.1
Heat Pumps		4.8	5.6
Electricity used for heat		3.5	3.4
Total	**22.60**	**23.81**	**17.19**
% Renewable		**32%**	**50%**

[9] Provided that the Coefficient of Performance (CoP) is sufficiently high

4.7 Transport Demand

The DECC pathways study assesses changes in transport demand in the following categories:

- Passenger transport activity
- Technology
- Efficiency
- Freight

The assumptions and assessments made in the DECC study for the UK were adjusted to reflect the content in Northern Ireland. DECC level 1 assumptions were used as a basis for Scenario 1 and elements of DECC level 3 and level 4 assumptions were used as the basis for Scenario 2.

Each element of the two 2050 scenarios has been assessed using 2010 transport data and earlier trends for Northern Ireland as the starting point. For road transport, numbers of vehicles by type are based on actual Northern Ireland vehicle licensing data and distances travelled are based on data from the Northern Ireland GHG inventory. Hence the results are specific to the transport context in Northern Ireland.

The following four tables set out the key assumptions for Scenarios 1 and 2 in each of the categories identified above.

Table 16: Key assumptions - passenger transport activity

Category	2010	Scenario 1	Scenario 2
Key assumptions		Travel activity in terms of overall mobility and mode shares is consistent with past trends broadly continuing but with growth in demand slowing over time. Department for Transport (DfT) estimates of future road transport forecasts to the year 2035 are used as a basis.[10] These were extrapolated to 2050 and adjusted to remove the influence of London and reflect the very different split of urban / rural travel to be found in Northern Ireland in comparison to England. Adjustment was also made for the lower expected population growth in Northern Ireland when compared to England. Note that any estimate of future transport demand out to the year 2050 will inevitably be subject to potential error.	10% reduction in passenger transport demand compared to Scenario 1 as people take advantage of alternatives such as teleconferencing instead of domestic flights, home-working replacing commuting, and internet shopping replacing shopping trips. Car and van use accounts for 94% of passenger kilometres in 2050 with public transport, walking and cycling accounting for only 5%. Due primarily to population growth this still results in substantial increases in number of passenger kilometres travelled for rail and for buses. These figures are based on extrapolation of projected future trends for rail[11] and growth in bus passenger journeys (assumed as 1.3-1.4% per year from 2012-2050). This would require around an 88% increase in numbers of buses and 58% increase in number of trains.
Total pkm (bn)	31	43	39 (10% reduction versus scenario 1)

[10] DfT, Road transport forecasts, 2011. Available online at http://assets.dft.gov.uk/publications/road-transport-forecasts-2011/road-transport-forecasts-2011-results.pdf

[11] See Figure 7, page 25 of DRD, FUTURE RAILWAY INVESTMENT: A CONSULTATION PAPER (Jan, 2013)

Category	2010	Scenario 1	Scenario 2
Car pkm (bn)	29	39	35 (12% reduction versus scenario 1)
Bus pkm (bn)	0.54	0.43 (20% reduction versus 2010 – based on an assumed slight annual decline of 0.56% following current trends).	0.91 (69% increase versus 2010 – based on investment leading to growth rates of 1.3-1.4% per annum from 2012-2050).
Rail pkm (bn)	0.19	0.26 (36% increase versus 2010 – based on expected future trends to 2035 and no further increase).	0.27 (41% increase versus 2010 – based on expected future trends to 2035 and 0.26% growth per year to 2050).
Domestic air pkm (bn)	0.16	0.40 Based on Committee on Climate Change's "likely" scenario (developed December 2009).	0.38 (5% reduction versus scenario 1)
Walk/cycle pkm (bn)	0.44	0.50 (14% increase versus 2010 – in line with population growth)	0.76 (74% increase versus 2010 – based on investment in infrastructure / travel behaviour change measures)

Table 17: Key assumptions - technology

Category	2010	Scenario 1	Scenario 2
Key assumptions		The assumptions on technology match DECC Level 1. Internal combustion engines (ICEs) continue to dominate car and van fleets.	The assumptions on technology match DECC Level 4: A substantial switch away from ICEs so that by 2050 these account for only 20% of distance by cars and vans (and are mostly hybridised). Big uptake in distance by PHEVs assuming breakthroughs in battery and fuel cell technology to improve performance and reduce costs. PHEVs are assumed to run on petrol or diesel for only 38% of mileage. Assumes provision of sufficient recharging and hydrogen refuelling infrastructure.
Car & van % distance by PHEV	0%	20%	32%
Car & van % distance by EVs	0%	2.5%	28%
Car & van % distance by FCEVs	0%	0%	20%
Bus % distance by diesel-hybrid	0%	40%	78%

Category	2010	Scenario 1	Scenario 2
Bus % distance by EV	0%	0.5%	22%
Rail electrification	0%	0%	50%

Table 18: Key assumptions - efficiency

Category	2010	Scenario 1	Scenario 2
Key assumptions		Efficiency improvements include some engine advances, hybridisation and other vehicle improvements such as light-weighting and downsizing. ICE cars and vans show an ambitious average efficiency improvement by 2050. The use of hybrid technology is included in this assumption. Levels of biofuel use are assumed at 10% (by energy) for all other modes.	Cars, vans and buses are assumed to have the same efficiency improvements as for scenario 1. For aviation, 20% biofuels penetration by 2050 is on the assumption that biofuels which met required sustainability aims are available in these volumes. Levels of biofuel use are assumed at 20% (by energy) for all other modes.
ICE efficiency improvement		54% (versus 2010, including use of hybrid technology)	54% (versus 2010, including use of hybrid technology)
EV efficiency improvement		37% (versus 2010)	37% (versus 2010)
PHEV efficiency improvement		50% (versus 2010)	50% (versus 2010)
Bus efficiency improvement		31% (versus 2010)	31% (versus 2010)
Rail efficiency improvement		0% (versus 2010)	20% (versus 2010)
Aviation efficiency improvement		0.8% improvement per year / 10% biofuel penetration. Based on Committee on Climate Change's "likely" scenario (developed December 2009).	1.0% improvement per year / 20% biofuel penetration. Based on Committee on Climate Change's "optimistic" scenario (the middle of three scenarios).

Table 19: Key assumptions - freight

Category	2010	Scenario 1	Scenario 2

Category	2010	Scenario 1	Scenario 2
Key assumptions		Levels of freight activity are assumed to grow at the same rate as expected growth in GVA per head of population. All road haulage operations use internal combustion engines. Uptake of readily available lower carbon technologies such as aerodynamic fairings or low rolling resistance tyres is minimal. Empty running is assumed to remain at current levels.	Levels of freight activity are assumed to grow at half the rate assumed in scenario 1. This approach is consistent with the European Commission's reference scenario for the 2011 White Paper modelling analysis, which includes an increase in freight transport demand (excluding maritime shipping) that is roughly half that of the projected increase in EU GDP/head). Since freight activity derives from demand for goods and raw materials (for example, for construction), this assumption may not be accurate if activity in other sectors of the economy entails the building of significant new infrastructure. For road freight there is a significant increase in the use of less readily available lower carbon HGV technologies such as ICE hybrids, which offer substantial carbon savings.
Freight growth		As per expected growth in GVA (2.5% per year) per head of population (14% increase by 2050).	Half the rate assumed in scenario 1
HGV efficiency improvement		10% by 2050 (based on Department for Transport projections).	53% by 2050
HGV - % distance by alternative powertrains		0%	50% Diesel-hybrid 20% BEV (for small rigid HGVs)
Biofuel usage		10% by energy	20% by energy

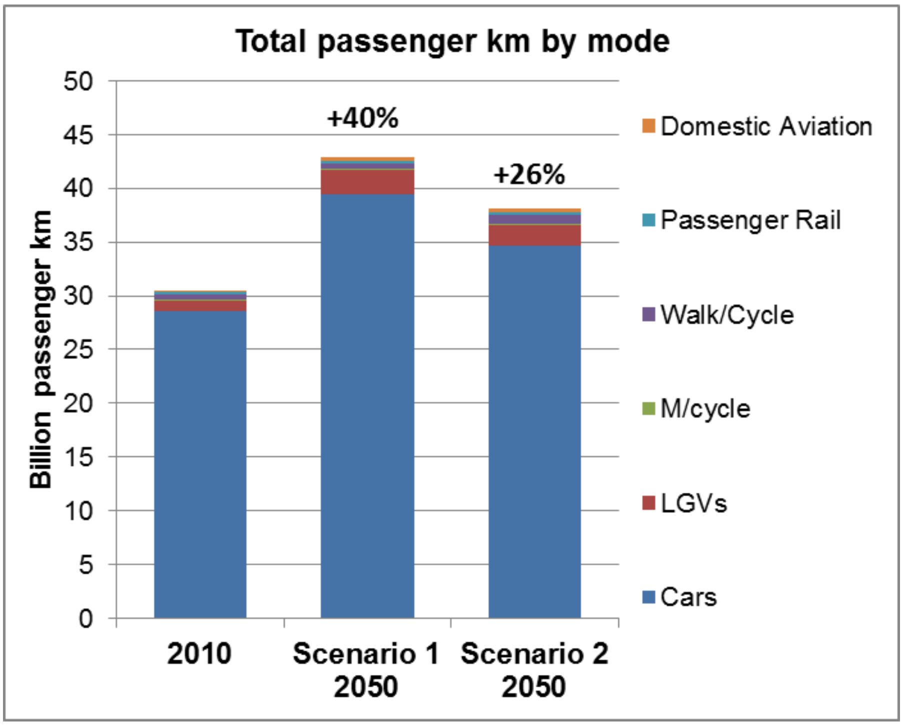
The following charts show the key results:

Passenger transport – amount of travel and mode chosen

The most important element remains passenger transport. In the 2050 scenarios, total distance travelled increases, by 40% for Scenario 1 and 26% for Scenario 2.

The modal split for Scenario 1 is very similar to the 2010 situation, but the modal split shifts to significantly increased bus and passenger rail use in Scenario 2. In addition, walking and cycling also increase.

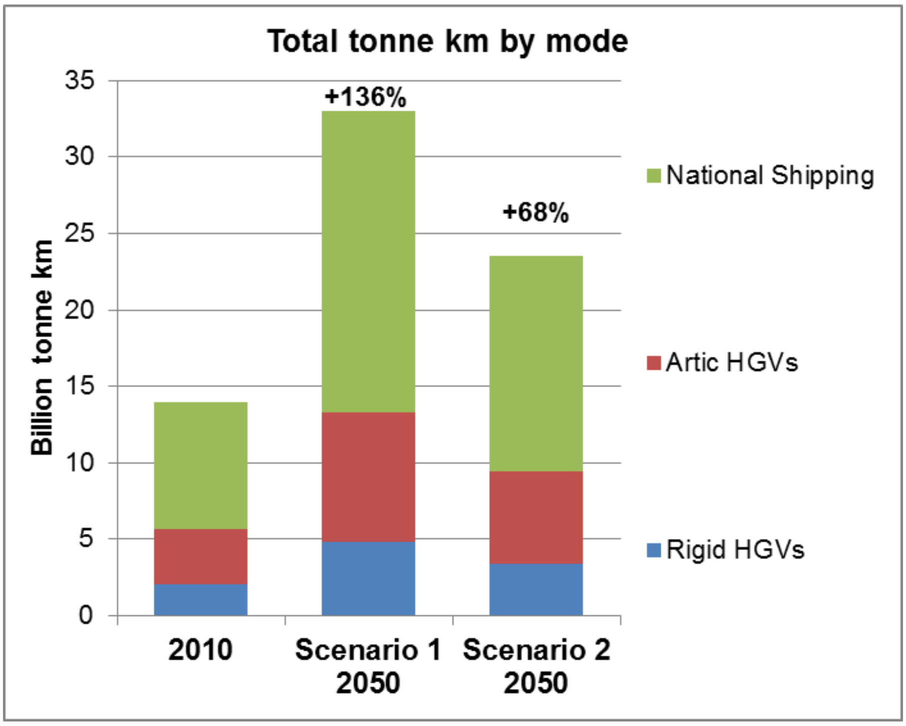
Figure 12: Passenger transport use and mode



Freight transport – amount of travel and mode chosen

Freight tonne-km is also assumed to grow – by higher percentages than passenger-km. The growth is highest for national shipping.

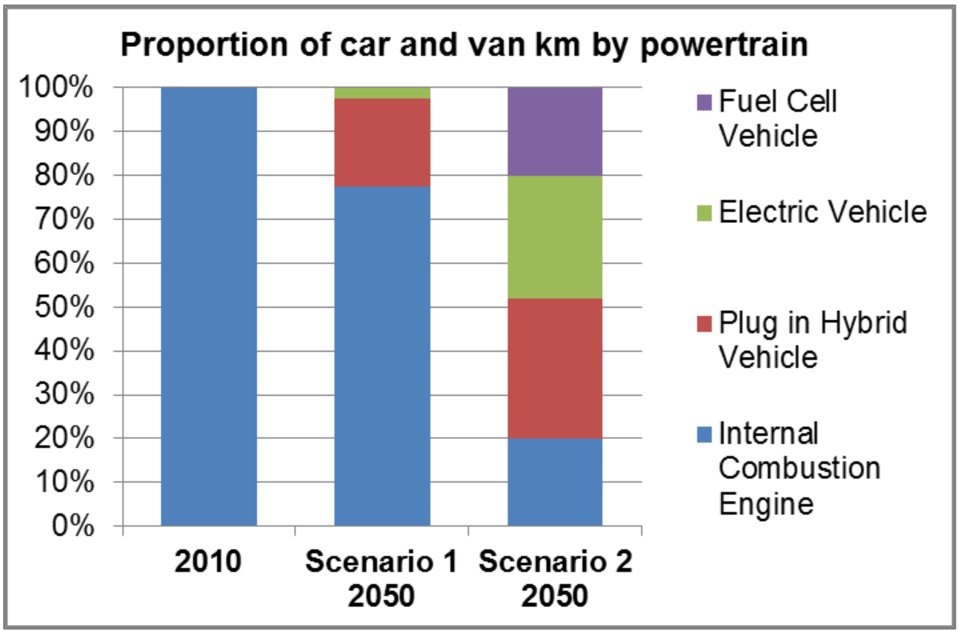
Figure 13: Freight transport use and mode



4.7.1 Technology – which type of vehicle

The following chart shows the complete dominance of internal combustion engine vehicles in 2010. In Scenario 1 20% of cars and vans have switched to plug in hybrid electric vehicles with a further 2.5% switch to full electric vehicles. In Scenario 2 this switch is much more profound, with 20% of the distance travelled by internal combustion engine vehicles, and 80% using new vehicle technologies. The new vehicle technology is split between plug in hybrid (32%), electric vehicles (28%) and fuel cell vehicles (20%)

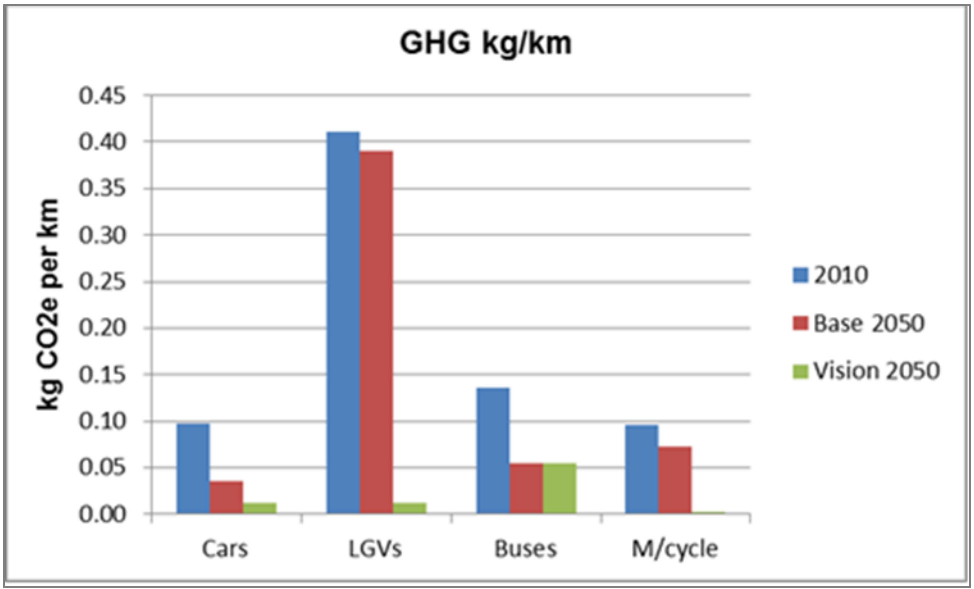
Figure 14: Car and van km by powertrain



Efficiency – of the vehicle and how it is used

It is clear from figure 16 that the new technologies that are expected for road transport vehicles, in combination with improvements in efficiency of existing ICE technology should result in substantial reductions in GHG emissions per passenger kilometre travelled.

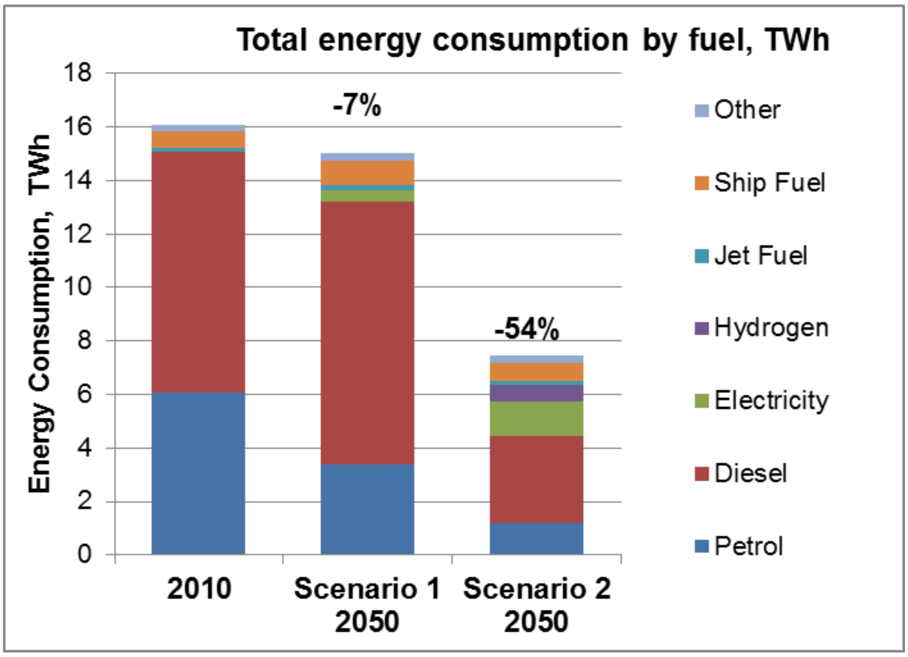
Figure 15: Total transport energy use in Northern Ireland 2050



4.7.2 Overall transport fuel use in 2050

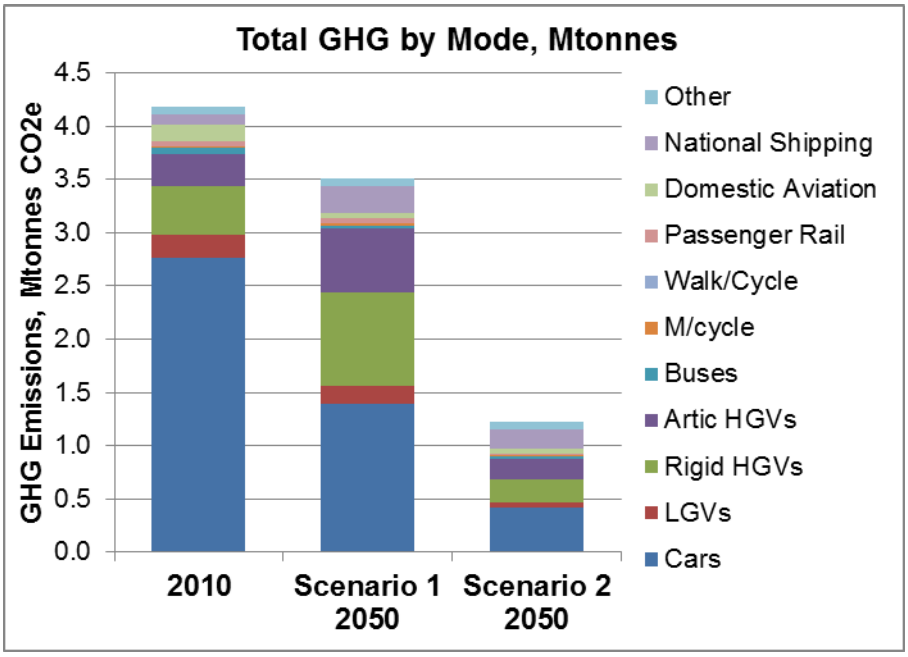
The results of the shift to increased use of public transport, walking and cycling, in combination with the introduction of much more energy efficient vehicle technologies result in total transport energy consumption being more than halved in Scenario 2 compared to 2010. Despite the substantial shift to plug-in hybrid and electric vehicle use, petrol and diesel still account for the majority of total energy consumption. This is due to the much greater energy efficiency of electric vehicles.

Figure 16: Total transport energy use in Northern Ireland 2050



Looking at GHG emissions, Scenario 2 achieves a 63% reduction in 2050 versus 2010. Due to the assumed decarbonisation of the electricity generation sector, these emissions result almost entirely from petrol, diesel and kerosene use.

Figure 17: Total transport GHG emissions in Northern Ireland 2010 versus 2050



4.8 Transport Supply

Unlike electricity, the supply of transport fuel is assumed to match demand, with no surplus or deficiency such as can occur in electricity.

The key changes for transport fuel supply are shown below, drawing on DECC 2050 Pathways for 2050. For Scenario 2 there is a significant uptake in distance by PHEVs (32%), EVs (28%) and FCVs (20%). This assumes breakthroughs in battery and fuel cell technology to improve performance and reduce costs. PHEVs are assumed to run on petrol or diesel for only 38% of mileage.

Table 20 Key changes in transport supply

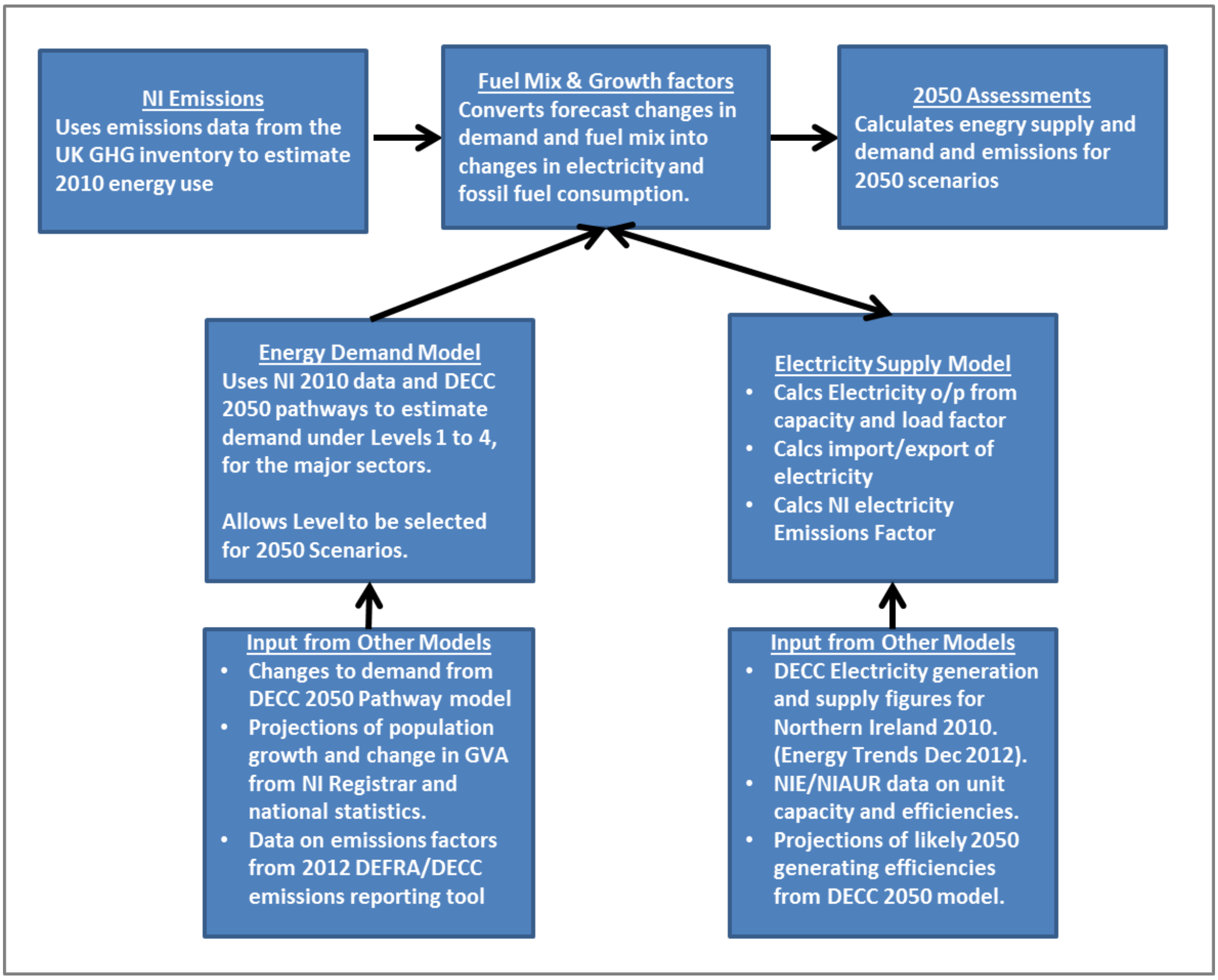
	Scenario 1 2050	Scenario 2 2050
Fossil fuel	Decline	Very significant decline.
Electricity	Increasing as around 20% of passenger miles are in electric vehicles	Very significant increase as over 60% of passenger miles are in electric vehicles
Hydrogen	None	Required for fuel cell vehicles, 20% of passenger miles. Assumed to be provided by electrolysis of water.

5 Overall Energy Supply and Demand

5.1 Analysis Approach

In order to estimate the change in Northern Ireland's GHG emissions under the two scenarios, a top down model (Figure 18 was developed based on the analysis of the traded and non-traded share of Devolved Administration GHG emissions, 2008-2010. The source data for GHG emissions was the UK national air emissions gas inventory (NAEI)[12] using data for 2010.

Figure 18 Overview of the overall model of NI Emissions



The NAEI inventory data provides an estimated breakdown according to top level economic sectors, and this was used to estimate the carbon emissions associated with each area being modelled. One sector (business) was subdivided into industry and public and commercial (P&C), using data from the Strategic Energy Scenario Planning Model for Northern Ireland (ESRI, 2011), to allow the change in demand in these two sectors to be modelled separately. The major non-energy related emissions were separated out using inventory data to bring the top down estimates of GHG emissions from fossil fuels closer to the bottom up estimates.

[12] http://uk-air.defra.gov.uk/reports/cat07/1208241153_DA_GHGI_report_2010_Issue1_r.pdf

Figure 19 Diagram of emissions by source and end use in Northern Ireland

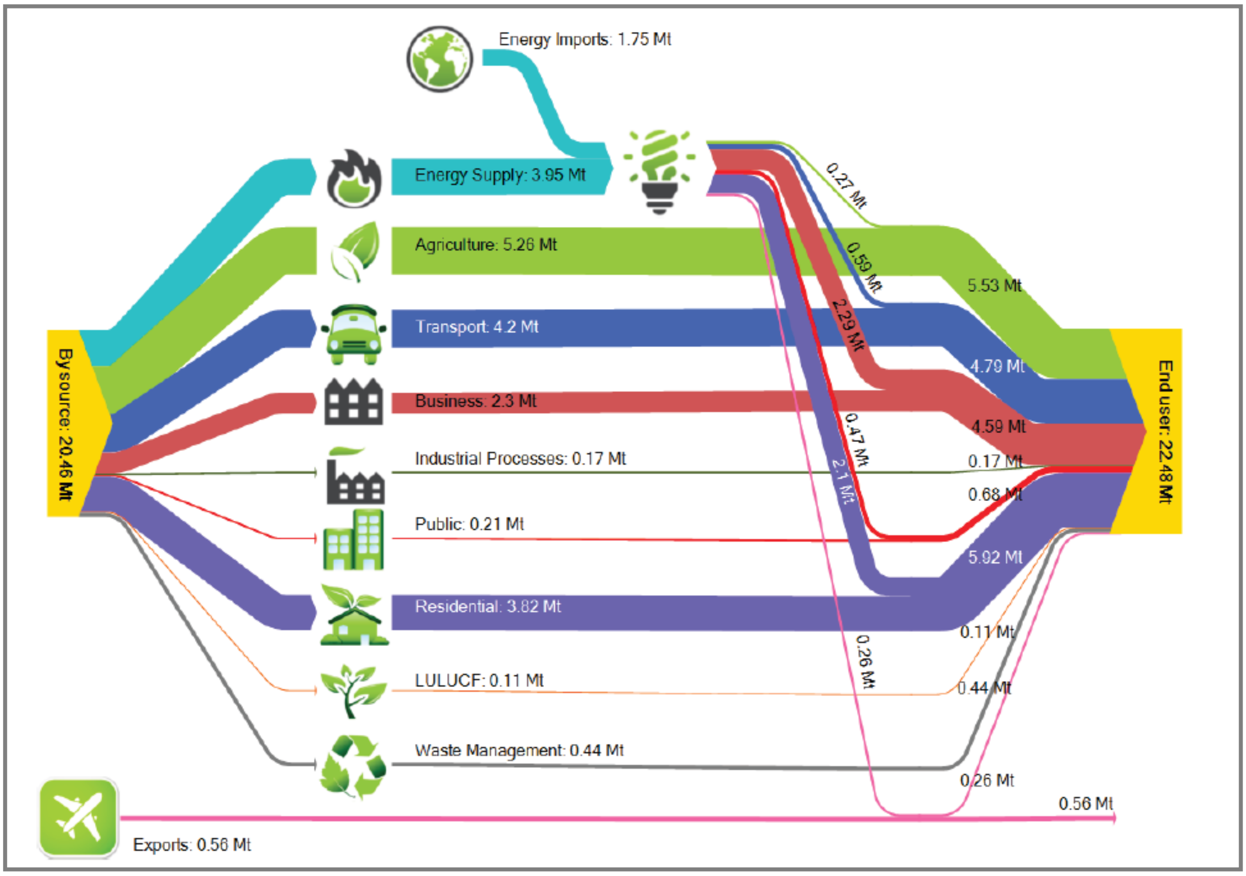


Table 21 Estimated breakdown of NI GHG Emissions by Economic Sector for 2010 (By End Use)

Northern Ireland 2010	Total 1990 kt CO_{2e}	Total 2010 kt CO_{2e}	Electricity 2010 kt CO_{2e}	Fossil Fuel 2010 kt CO_{2e}	Non Energy 2010 kt CO_{2e}
Agriculture	6,073	5,420	101	573	4,746
Commerce	5,131	1,640	1,061	264	315
Industry	0	3,011	1,125	1,885	0
Public	1,124	727	500	227	0
Residential	6,742	5,916	1,660	4,133	123
Transport	3,838	4,786	56	4,730	0
Total	**22,908**	**21,500**	**4,503**	**11,812**	**5,184**

This data was used to estimate the energy demand by economic sector based on the fossil fuel mix of each sector set out in Table 22, Renewable Space Heat section, and Northern Ireland electricity generation by fuel type published by DECC in Energy Trends December 2012.

This approach provided a good fit to the 2010 final electricity demand published by DECC in Energy Trends December 2012, but fit between the top down or bottom up estimates of energy consumption and carbon emissions due to fossil fuel was less good. To resolve this, the data used to derive the top down and bottom up estimates was cross-checked against other data sources and adjustments made to improve the level of model accuracy.

The remaining differences were resolved by translating the forecasted energy demands for 2050 under Level 1 to Level 4 conditions into a relative change in electricity and fossil fuel demand in GWh between 2010 and 2050. The carbon footprint of Northern Ireland under the 2050 scenarios was then calculated allowing for forecast changes in fuel mix.

The resulting estimate of the total change in electricity demand was then fed into a model of the electricity supply sector that estimates the GHG intensity of Northern Ireland electricity in 2050, using the bottom up estimates of likely generation capacity and electricity supplied by technology.

This model balances electricity supply and demand by assuming that any difference is addressed by importing or exporting electricity through the interconnectors to the UK, although in practice, balancing is likely to involve some transfer of electricity with Ireland. The GHG emissions associated with these balancing transfers are also assumed to be imported or exported on the accounting basis of the average GHG intensity of the originating grid.

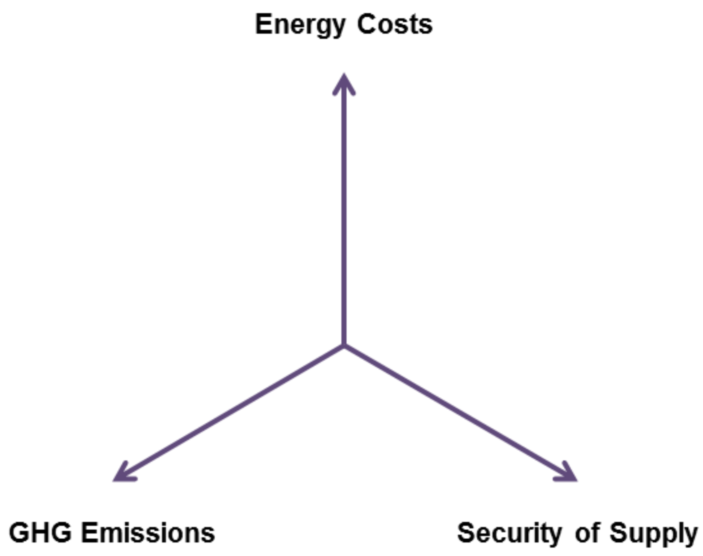
Table 22 Top down estimate of Northern Ireland Final Energy Demand by Economic Sector in 2010

Northern Ireland 2010	Electricity GWh	Fossil Fuel GWh	Total Demand GWh
Agriculture	0.20	2.00	2.19
Business (P&C)	2.07	1.07	3.14
Business (Industry)	2.20	6.40	8.59
Public	0.98	0.92	1.89
Residential	3.24	14.21	17.45
Transport	0.11	18.19	18.30
Total	**8.78**	**42.78**	**51.56**
	17.0%	**83.0%**	**100.0%**

5.2 Overall Outcomes

As discussed previously the three key aims of energy policy are to achieve improvements and balances in the three elements in the trilemma:

Figure 20 Trilemma energy policy aims



Again emphasising that these are not predictions, but illustrations of two pathways for energy supply and demand in 2050, the key outcomes envisaged for 2050 are summarised in the following sections.

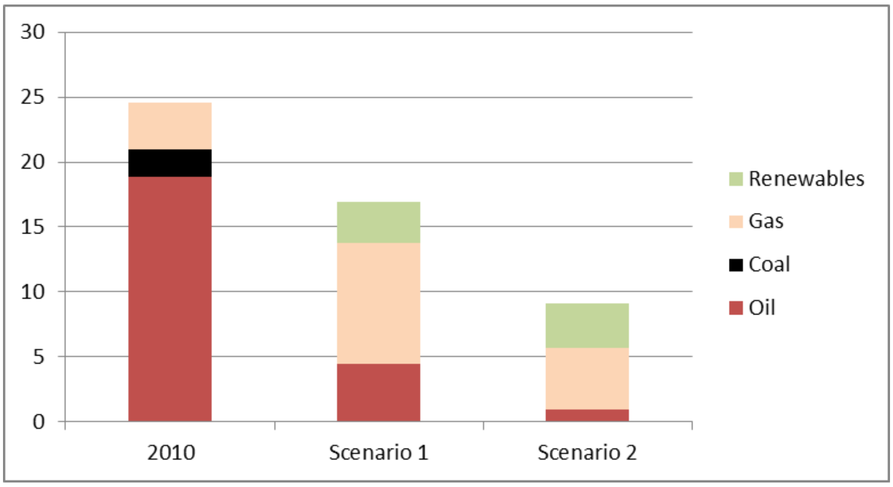
5.3 Security of Supply

At present almost all energy used in Northern Ireland is imported, mainly oil and gas, along with smaller quantities of coal and other fuels.

Under the two Scenarios developed for this study there are major changes to the amounts of fuel used, and to the types of fuel used.

For heating, the use of imported fuels falls to 56% of 2010 levels in Scenario 1 and falls to 23% of 2020 levels in Scenario 2. The main imported fuel becomes gas rather than oil, though at a much lower level than the current levels of oil use for heating. Future imports of gas would reduce if the potential for shale gas extraction in Northern Ireland proves commercially attractive and is consented.

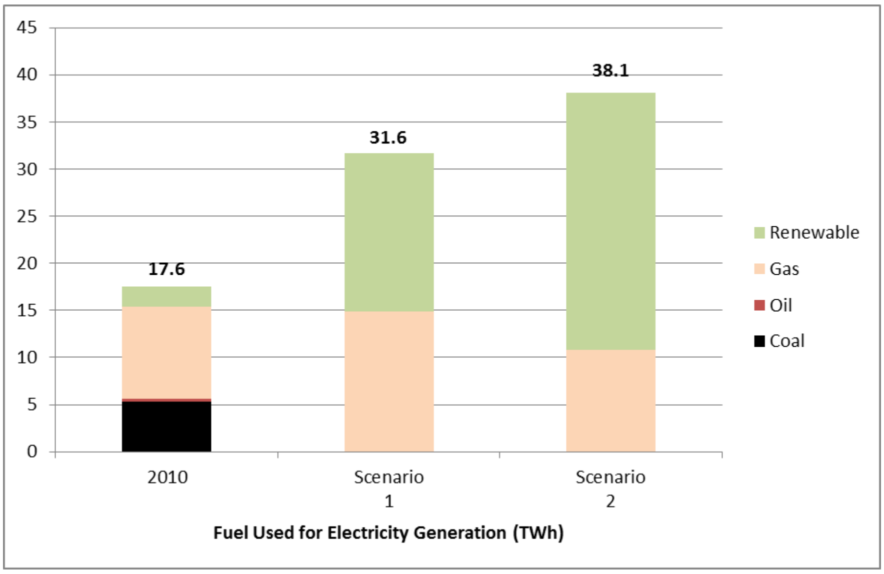
Figure 21 Fuel switching for heating fuels



For electricity generation, the use of imported fuels falls slightly to 97% of 2010 levels in Scenario 1 and falls to 70% of 2010 levels in Scenario 2. This does not appear to be a significant reduction, but this is in the context of significant increases in electricity use e.g. for space heating and transport.

As with 2010, the main fuel import for electricity generation is gas. There is the potential for some gas to be produced in Northern Ireland, if this proves commercial and is consented for development.

Figure 22 Fuel switching for electricity generation



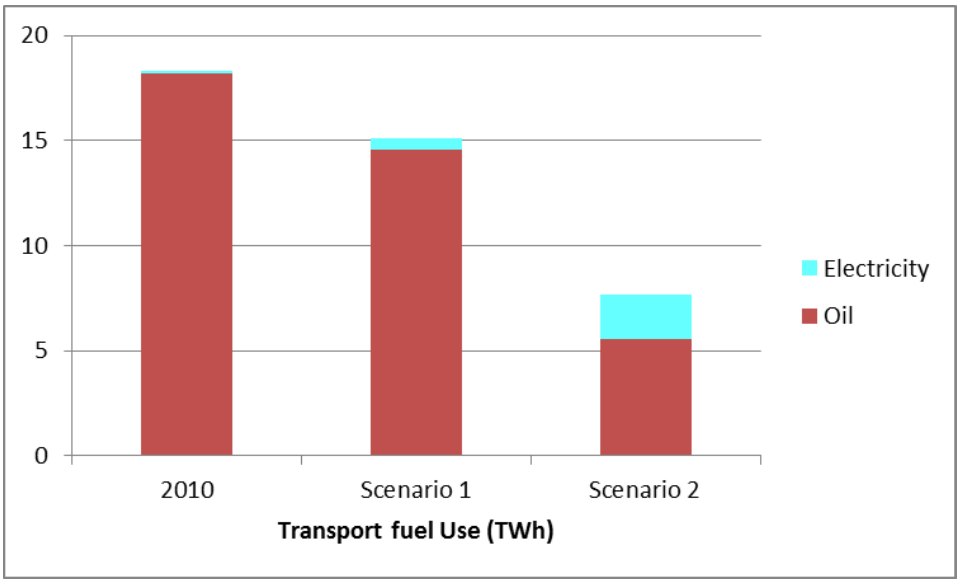
The position on electricity imports reverses to become one of significant electricity exports, particularly under Scenario 2.

Table 23 Electricity imports & exports (TWh pa)

	2010	Scenario 1 2050	Scenario 2 2050
Net Imports	2.1		
Net Exports		2.77	6.18

For transport the use of imported fuels falls to 80% of 2010 levels in Scenario 1 and falls significantly to 30% of 2010 levels in Scenario 2.

Figure 23 Fuel switching for transport



So security of supply is improved in both scenarios through a reduction in use of imported fuels. This is particularly true in Scenario 2 where imported fuel falls significantly in absolute and percentage terms.

Table 24 Summary of fuel use and fuel imports (TWh pa)

	2010	Scenario 1 2050	Scenario 2 2050
Gas	13.4	24.3	15.6
Oil	37.4	19.0	6.5
Coal	7.4	0.0	0.0
Renewable	2.1	20.2	31.2
Total	**60.4**	**63.5**	**53.3**
Imported	**58.2**	**43.3**	**22.1**
Imported (%)	**96%**	**68%**	**41%**

5.4 Impact on GHG emissions

The UK and the EU have targets to reduce GHG emissions by 80% from the 1990 baseline. Northern Ireland has a target to reduce emissions by 25% from 1900 levels by 2025. While there is no specific target or GHG budget for Northern Ireland in the Climate Change Act 2008, it is implicit that Northern Ireland contributes towards the UK effort[13].

This section draws out the impact of the two 2050 scenarios on GHG reduction.

An important point to note is that this study is focused on energy supply and demand and hence GHG emissions associated with energy. There are important non-energy sources of GHG emissions that are not included in this study, these include:

- emissions from agricultural livestock, principally ruminants including cattle;
- emissions from changes in land use and forestry;
- emissions from industrial processes, e.g. cement kilns.

[13] Cross – Departmental Working Group on Greenhouse Gas Emissions

Because these non-energy GHG emissions are outwith the scope of this study, the outcomes envisaged in Northern Ireland cannot be compared with the UK's 80% GHG reduction target.

5.4.1 Exports of GHG emissions

As shown earlier in Section 4.3 both scenarios suggest that there will be significant exports of electricity from Northern Ireland. In Scenario 2 the electricity mix is dominated by renewable energy, but also includes gas fired generation. So, electricity use is not zero GHG in 2050 and so the exports of electricity envisaged require an appropriate allowance for export of the associated GHG emissions.

It is assumed that the emissions factor for the average generation mix in 2050 is used to calculate these exported emissions. This is in line with current practice for imports of electricity to the GB market from France.

5.4.2 GHG Reduction Outcomes

The impact on GHG envisaged for the two 2050 scenarios are shown in Table 25 and Table 26 respectively, it is important to note that these are energy related GHG emissions only. The non-energy emissions are not included.

Table 25 Top down estimate of NI Energy Demand & Emissions under 2050 Scenario 1

Northern Ireland 2050 Scenario 1	Electricity TWh	Other Fuels TWh	Total Demand TWh	Total GHG kt CO_{2e}
Agriculture	0.22	1.21	1.42	287
Business (P&C)	1.99	0.75	2.71	536
Business (Industry)	3.08	4.04	6.93	480
Public	1.01	0.64	1.63	300
Residential	5.35	10.27	15.12	2,720
Transport	0.52	14.59	15.11	3,636
Total	**12.18**	**31.51**	**42.93**	**7,960**
	% of 2010 Energy GHG Footprint --->>			**48.8%**
	% of 1990 Energy GHG Footprint --->>			**45.2%**

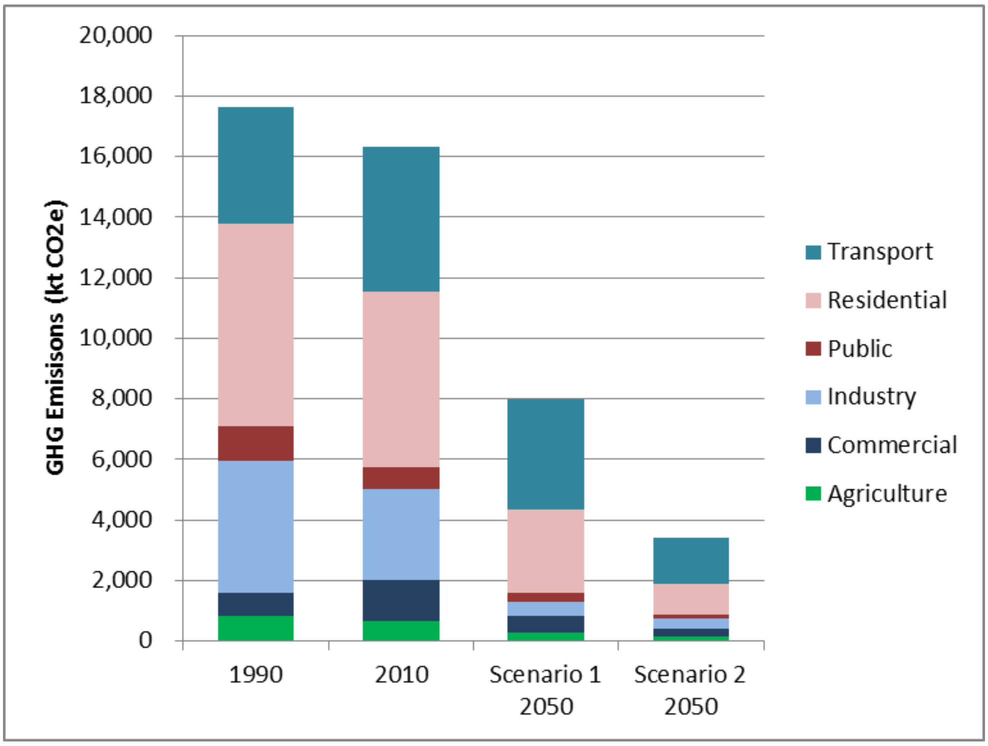
Table 26 Top down estimate of NI Energy Demand & Emissions under Scenario 2

Northern Ireland 2050 Scenario 2	Electricity TWh	Other Fuels TWh	Total Demand TWh	Total GHG kt CO_{2e}
Agriculture	0.24	0.85	1.07	160
Business (P&C)	1.53	0.34	1.80	246
Business (Industry)	3.74	3.18	6.34	334
Public	0.78	0.29	1.02	133
Residential	4.25	4.48	7.91	1,008
Transport	2.14	5.54	7.67	1,544
Total	**12.68**	**14.67**	**25.81**	**3,425**
	% of 2010 Energy GHG Footprint --->>			**21.0%**
	% of 1990 Energy GHG Footprint --->>			**19.4%**

5.4.3 Discussion

While both the 2050 scenarios provide significant GHG reductions, under Scenario 1 emissions are roughly halved, while the more ambitious Scenario 2 offers a route to a reduction of around 80%. So Scenario 2 has the potential to match the EU and UK ambition to reduce emissions to 20% by 2050. Under Scenario 1 the main sources of energy related emissions in 2050 are from transport and the residential sectors.

Figure 24 Outcomes for GHG emissions



The DECC assessment of UK pathways to 2050 includes the non-energy GHG emissions. These include emissions from additional sectors such as agriculture, land use change and industrial processes. Reducing emissions in some of these sectors is hard to achieve without placing very restrictive measures in place that would affect their economic well-being. Hence to meet an overall 80% reduction in energy and non-energy emissions, there is a need to achieve a greater than 80% reduction in the energy related share. This may or may not be required in Northern Ireland, but the importance of the agricultural sector to the Northern Ireland economy may mean that this is the case. Work is on-going in Northern Ireland and in the UK, to better understand and assess the emissions and emission reduction potential in agriculture[14].

[14] Efficient Farming cuts Greenhouse Gases

5.5 Cost of Energy

The cost of energy is a key policy issue because of the impacts on:

- household spending, energy expenditure for households in Northern Ireland is already high, with 42% in fuel poverty;
- business spending, as energy is a cost which can influence the location and continued operation of businesses and hence influences the long term economic prospects for Northern Ireland;
- business competitiveness for international companies

Total energy cost for any household or business is the product of the volume of energy used and the price per unit. So to understand the cost of energy, the volume consumed and the price per unit both need to be considered.

5.5.1 Energy Consumption

The demand sections of this study show that the volume of energy consumption falls. This is particularly true in Scenario 2. The following table shows how energy use per household may change from 2010 to 2050.

Table 27 Energy use per household in MWh pa

	2010	Scenario 1 2050	Scenario 2 2050
Electricity	4.3	5.3	4.3
Fossil Fuel	18.7	8.4	2.8

Electricity use changes due to:

- decreases from using more efficient appliances and lighting;
- increases due to the use of heat pumps and resistive heating as well as increased demand from lifestyle changes

Fossil fuel use changes due to:

- switching from oil to gas as a heating fuel, allowing the use of efficient condensing boilers;
- improved energy standards in new buildings;
- switching to electricity as a fuel for heating;
- switching to renewable energy sources (biomass, solar etc).

So, if fuel prices were to remain the same, household fossil fuel costs would fall very significantly, whereas household electricity costs would remain similar. The next section considers the likely changes in energy prices.

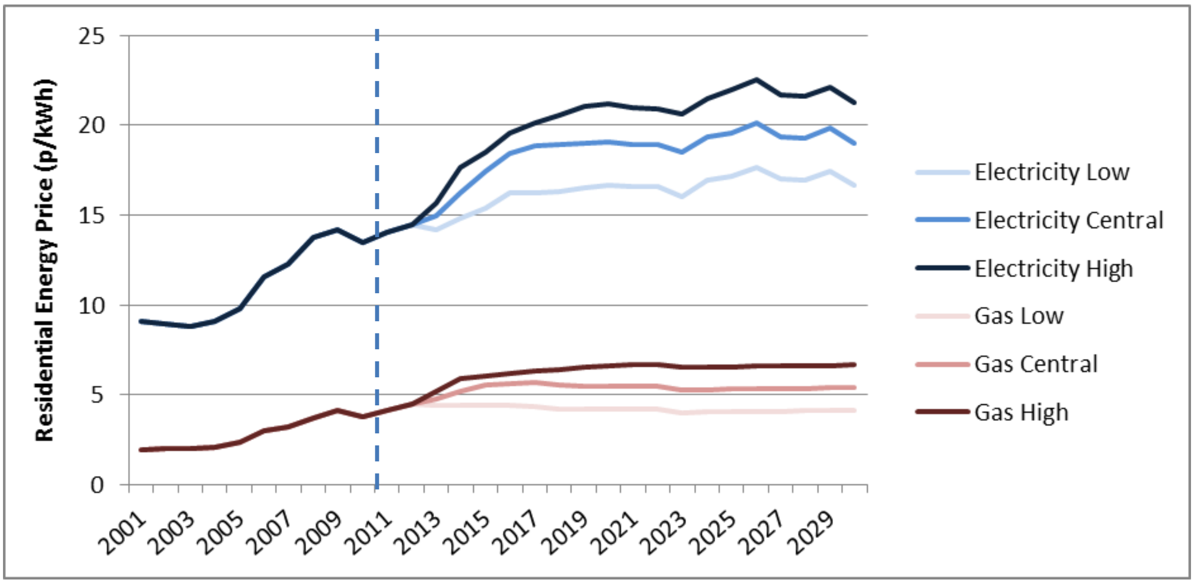
5.5.2 Energy Prices

Assessing the trajectory of energy costs in the medium, far less the long term, is inherently uncertain. World events and energy industry events influence the supply and hence price of energy.

Overall the long term pattern has been for increasing energy costs. Part of DECC's work on projecting energy use includes projections of energy prices for electricity and gas to 2030[15], shown below:

[15] https://www.gov.uk/government/publications/2012-energy-and-emissions-projections

Figure 25 Projected UK residential energy prices[16]



The three gas fuel price scenarios are:

- low global energy demand (low)
- timely investment and moderate demand (central)
- high demand and producers' market power (high)

The trajectory for gas prices shows a rising trend to around 2015, followed by a relatively flat trend to 2030, with a 32% increase under the central scenario. Compared to previous trends this appears to be a long period of gas price stability.

The electricity price scenarios include the impact of the Electricity Market Reform and a contribution from renewable energy of 30% by 2020, and increasing beyond 2020. Prices rise to around 2020, followed by a relatively flat trend to 2030, with a 35% increase under the central scenario.

The follow table shows how the DECC projections for 2030 compare to 2010 levels.

Table 28 Increases in residential energy prices 2010 to 2030

	Electricity	Gas
Low	24%	9%
Central	41%	42%
High	58%	75%

The gas price projections are highly relevant to Northern Ireland as UK gas prices tend to be driven by the same factors, including international trends.

DECC's electricity price projections have more of a GB focus as they include the adoption of CCS and hence continued use of coal for electricity generation. In addition the mix of renewable energy technologies identified in this vision study is specific to the opportunities and resources in Northern Ireland, which are not the same as the GB picture.

One way to consider how electricity prices in Northern Ireland may develop is to consider the likely price for the generation types identified in this study as likely to increase in Northern Ireland. This is done using Levelised Cost of Energy (LCOE) as a measure of the cost of electricity generation and hence the cost to consumers.

[16] Prices are real and are in 2012 terms, DECC do not publish projections for retail prices for heating oil

A number of studies have been undertaken by DECC to assess LCOE for a number of different electricity generating technologies. These generally do not provide figures for 2050, but often provide data for 2020 or 2030.

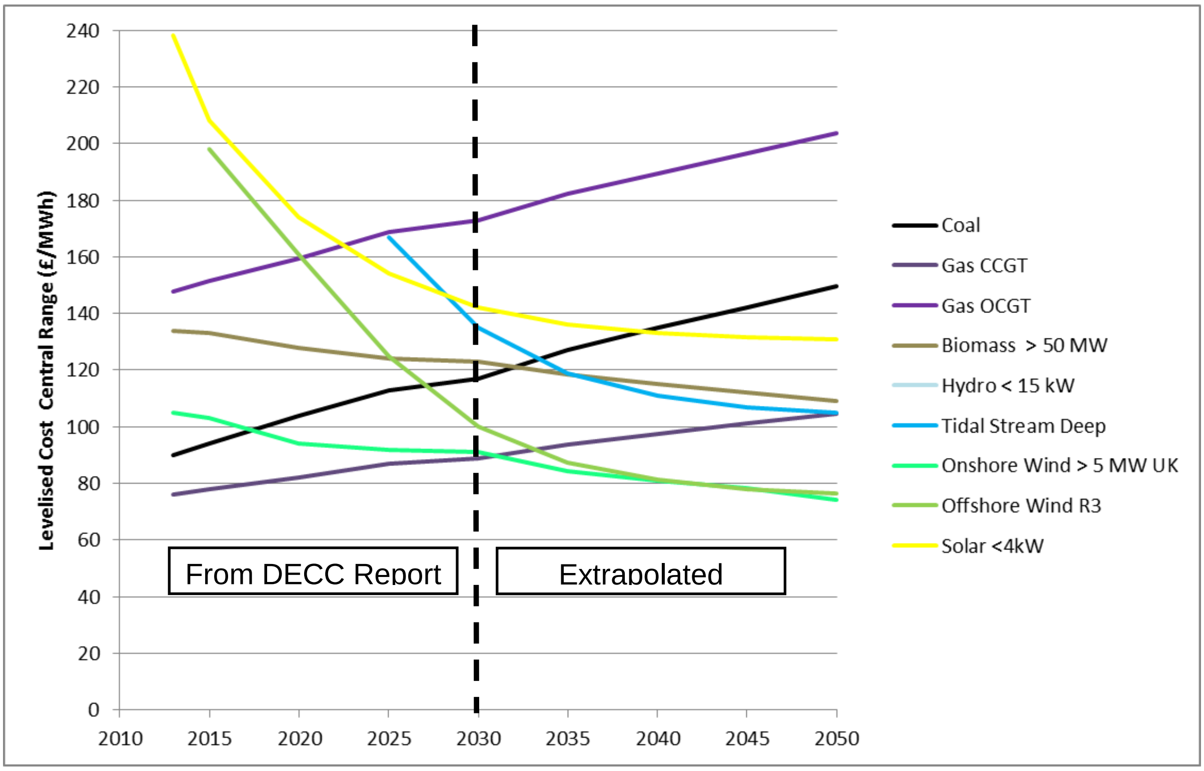
The main data source used was: Electricity Generation Costs, published by DECC in October 2012[17]. This is the most recent in a series of reports produced for DECC providing details of LCOE for a range of technologies. This provides a low, central and high LCOE estimates up to 2030. The central range was used.

The levelised cost assessment includes an element for connection costs. The basis for this is not explained in the DECC report, but this is likely to be costs of grid connection that are specific to the generation project, not the wider reinforcement of the transmission network. Hence there will be additional costs associated with the wider upgrade of the electricity network.

To provide estimates beyond 2030, an extrapolation has been made to provide a source of data for later years. This extrapolation assumes that the trends up to 2030 continue, an assumption that may not hold true.

The DECC 2012 report does not include a levelised cost figure for OCGT power stations. Relatively few of the studies on LCOE include OCGT technology, most focus on CCGT. A US study[18] provides a comparison, the results from this US analysis have been used to scale up the CCGT results from DECC.

Figure 26 Levelised costs for new generation stations



An important point is that the LCOE estimates for a given year are the costs for a new generator built in a specific year. That generator will need to earn the same income over its lifetime of operation. So if a CCGT station is built in 2030, the levelised cost needed to justify that investment is around £90/MWh. This CCGT station needs to earn £90/MWh for all of its operating life.

As a consequence, the renewable energy generation built before 2030 will mostly have been replaced by 2050, with technology that has a lower levelised cost.

[17] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/65713/6883-electricity-generation-costs.pdf
[18] US EIA Levelized Cost of New Generation Resources in the Annual Energy Outlook 2013

Overall the levelised cost data for electricity generation shows:

- an increase in the cost of all the fossil based technologies, with OCGT having the highest cost after 2020. So any OCGT stations built after 2020 will add higher electricity cost;
- a reduction in the cost of all the renewable energy technologies, especially offshore wind, tidal stream and solar PV. After 2035 new onshore and offshore wind is cheaper than CCGT.

This suggests that investment in renewable electricity generation would lead to lower electricity prices than would have been the case had the scenarios focused on investment in fossil electricity generation.

5.5.3 Combined impacts on cost of energy

An assessment of the combined impacts of volume and price on the total cost of energy in 2050 is not possible, as the price required is not available on a long-term basis.

To provide an indication of the possible scale of change in energy costs the following observations are important:

- the scenarios envisage a significant fall in fossil fuel use and a trend to similar levels of electricity use;
- fossil fuel and electricity prices will rise to 2030 according to DECC projections;
- the trend for prices post 2030 is unclear, but it is reasonable to assume a rising trend;
- the combined effect is likely to be a fall in costs for fossil fuel, balanced by an increase in electricity costs;
- the additional costs to upgrade and reinforce the electricity network will further increase the pressure on the costs of electricity.

While this is a guide only, it does show that a trade-off is likely between increasing electricity costs and lower fossil fuel costs. While not modelled, a reasonable assumption would be that the increase in electricity costs is greater than the reduction in fossil fuel reduction, leading to net increases.

5.6 Overall impacts of the 2050 scenarios

The development of Scenario 1 and Scenario 2 were based on information on the potential demand reduction and renewable energy resources in Northern Ireland that would provide security of supply, GHG reduction and lower costs. Emphasising that these are not predictions, but illustrations of two pathways for energy supply and demand in 2050, the key outcomes envisaged for 2050 include:

Table 29 Summary of key outcomes

	Security of Supply	GHG Emissions	Cost of energy (Households)
Scenario 1	Imports fall to 68% of total fuel use	Reduced to 45% of 1990 levels	Fossil fuel costs fall significantly Electricity costs increase very significantly
Scenario 2	Imports fall to 41% of total fuel use	Reduced to 19% of 1990 levels	Fossil fuel costs fall very significantly Electricity costs increase significantly

So the changes envisaged appear to deliver well against the security of supply and GHG reduction objectives. However the position on the cost of energy is less clear, but an increase is likely. There may be further options that could reduce the cost of energy, particularly for electricity.

The trilemma assessments provide a route to identify further changes that offer ways to optimise the scenarios to deliver different outcomes.

The following table shows all of the trilemma scores, with darker shading to highlight the highest scores.

Figure 27 Summary of trilemma assessments

		Security of Supply	Lower Energy Costs	GHG Reduction
Demand Side	Appliances & Lighting	4.5	5	5
	Heating and Cooling	5	1.5	2
	Industry	4	3	2
	Transport	5	5	2.5
Conventional Supply Side	CCGT	1.5	2.5	1.5
	OCGT	3	1	1
	Shale Gas	5	1	2.5
Renewable Energy Supply Side	Onshore wind	1	4	5
	Offshore wind	1	3	5
	Tidal Stream	3	2	5
	Large scale biomass	4	3	2.5
	Anaerobic Digestion	5	2	5
	Solar PV	2	5	5
	Hydro	4	2	5
	Renewable Space Heating	4	4	4
	Solar Thermal	2.5	1.5	5
Infrastructure	Electricity Interconnection	5	1	1
	Electricity Storage	3.5	2	3
	Electricity Networks	4	0	2

So in terms of electricity demand reduction, appliances and lighting is the key sector. However, the standards for these goods are set at the EU level and choices are made by individual householders. So this is an area in which Northern Ireland will have limited direct influence.

In terms of the cost of generating electricity, the trilemma scores indicate that the mix of renewable and conventional generation will have an important influence on the cost of electricity, e.g. choosing onshore wind over some of the more expensive options.

This aspect is illustrated in more detail as the levelised cost of energy (LCOE) shown in Figure 26. The total cost of electricity in Northern Ireland could be reduced, if preference is given to the technologies with lower LCOE in the latter decades before 2050. Up to 2030 onshore wind is the lowest cost option. After 2030 offshore wind reaches a similar level. Solar PV, biomass and tidal stream remain significantly more expensive than these options.

However by 2050 OCGT is significantly more expensive than all the forms of renewables, plus OCGT adds to GHG emissions. So if the security of supply and grid support offered by OCGT can be replaced by other means this would potentially:

- reduce electricity costs to consumers;
- further reduce GHG emissions.

The key role and rationale for OCGT is to provide a controllable and rapid response to the changes in electricity generation from renewables and the changes that occur in electricity demand. Options that might be an alternative to OCGT include:

- large scale roll out of smart metering with load management, to manage the fluctuations in electricity demand;
- large scale roll out of small scale energy storage systems, e.g. smaller systems for household or commercial use to manage demand;
- roll out of medium scale energy storage systems, e.g. systems on renewable energy systems, which store output for sale later, hence managing supply and reducing the impact of renewables on the electricity networks.

At present these systems are at an early stage of development or deployment. Hence the performance and cost of these options are not accurately known and so they are not explicitly included in the DECC assessment. The requirement to find alternative solutions that would avoid the deployment of OCGT will arise in the 2020s, 2030s and 2040s. So these alternatives (and other solutions) may be available by the time investment decisions are needed.

6 Steps towards 2050

To draw out the key stages towards the 2050 vision a back casting workshop was held with DETI and DRD. With the vision for 2050 drawn up, back-casting can help identify the decisions needed on the pathway to reach the vision.

The process has three elements:

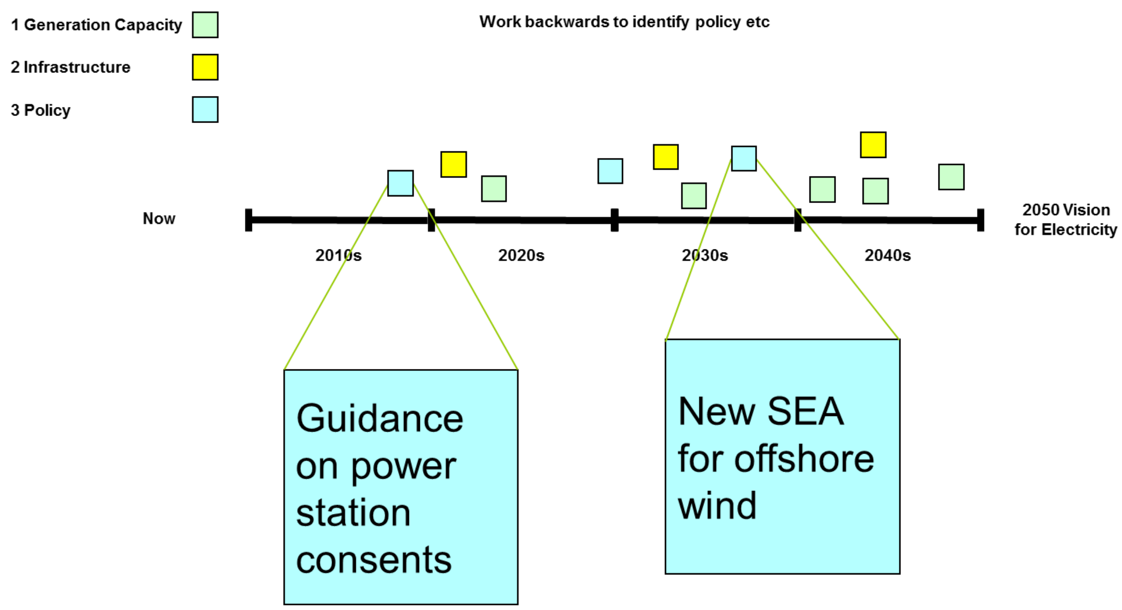
- define the outcomes in 2050, e.g. electricity generation capacity;
- define the infrastructure needed to support this e.g. electricity interconnection and when it is needed;
- taking logical steps work backwards from the 2050 capacity and infrastructure, answering: What decisions are needed? When are they needed? Who makes the decision?

This process provides a high level view of the path to 2050 in terms of:

- the timing of investments in energy supply and energy infrastructure; and
- the timing of policy and decisions for energy in Northern Ireland.

Three separate back casting exercises were conducted, for electricity, heat and transport.

Figure 28 Format for back casting exercises.



The results of the workshops are shown in the following tables:

Table 30: Results of Electricity back-casting

Ref	Investment and Energy Systems (figures are MW for Scenario 2)	2010s	2020s	2030s	2040s
1	New onshore wind farms				
2	Replacement onshore wind farms				
3	New Large Biomass	50	210		
4	New Tidal Stream	200		100	
5	Replacement Tidal Stream				300
6	New Offshore Wind	600		300	
7	Replacement Offshore Wind				600
8	New Open Cycle Gas Turbine		100 100	200	200
9	New CCGT		300 300		
10	New/Replacement Solar PV				

Ref	Infrastructure	2010s	2020s	2030s	2040s
1	Gas pipeline				
2	New Tie-lines to access the SEM				
3	New Interconnector to NW England				
4	Upgrade Moyle interconnector				
5	New ISLES interconnector to Scotland				

Ref	Policy	2010s	2020s	2030s	2040s
1	Consider options for CCGTs on existing sites				
2	Cost Benefit Analysis for CHP/District Heating				
3	Review uncertainties in EMR and EU policy				
4	Strategic policy statement & Mid-term review of SEI				
5	Consider land use policy & energy generation				
6	Consider impact of new EU and UK 2030 GHG and renewables targets				
7	Impact and introduction of capacity mechanism				
8	Revisit 2050 scenarios in light of impact of SEM trading				
9	Assess impact of on gas supplies and gas security of supply				
10	Assess the costs of grid expansion and reinforcement				
11	Revisit SEA in light of actual impacts & new technology				
12	Allocation of EMR contracts (15 year term)				

Table 31: Results of Heat back-casting

Ref	Investment and Energy Systems	2010s	2020s	2030s	2040s
1	Retrofit of low cost heat saving measures (insulation, controls etc.)				
2	Connection to District Heating in Belfast				
3	Retrofit more expensive heat saving measures (Solid Wall Insulation etc.)				
4	Higher energy efficiency in new homes and new non domestic buildings				
5	Further uptake of gas in existing areas (in fill)				
6	New uptake of gas in new areas				
7	Smart systems for electric & fossil fuel heating (storage & load control)				
Ref	**Infrastructure**	**2010s**	**2020s**	**2030s**	**2040s**
1	District Heating network in Belfast, e.g. linked to biomass schemes				
2	Extension of gas network to the West (Strabane, Derrylin & Magherafelt)				
3	Assess biomass security of supply				
4	Fuel Storage & Security of Supply (new Directives?)				
5	Further gas network extension (e.g. to Antrim & Ballycastle)				
Ref	**Policy**	**2010s**	**2020s**	**2030s**	**2040s**
1	Assess biomass security of supply				
2	Review role and policy for smaller District Heating and Geothermal systems				
3	Consider role for gas vs. renewable heat				
4	SMART heating systems in new buildings via standards and regulations				
5	Move from Code 4 to Code 5 energy performance standards				
6	Move to Code 6 (zero carbon) housing energy performance standards				
7	Convergent pricing policy for heating fuels (gas, oil, LPG etc.)				

Because of the long term nature of buildings and their standards for heating performance, many of the decisions and policy are needed in the first two decades.

Table 32: Results of Transport back-casting

Ref	Investment and Energy Systems	2010s	2020s	2030s	2040s
1	Plug In Hybrid Vehicles				
2	Electric Vehicles				
3	Fuel Cell Vehicles				
4	Rail Electrification				
Ref	**Infrastructure**	**2010s**	**2020s**	**2030s**	**2040s**
1	On-going upgrades to Duel Carriageway network, linked to Park n Ride				
2	Electric Vehicle 2013 project 160 charging points				
3	Electric Vehicle Changing Network				
4	Hydrogen Filling Stations				
Ref	**Policy**	**2010s**	**2020s**	**2030s**	**2040s**
1	Planning: Charging points in new homes and other new buildings				
2	Decisions on financial impacts for future roll out of charging infrastructure				
3	Impacts on electricity use of system charges				
4	Assess impacts on tax systems, for funding road infrastructure				

This highlights the point made previously that many of the key decisions in terms of low carbon vehicles are taken post 2040, but many of the infrastructure and policy decisions are required pre 2030.

7 Conclusions

This study has developed and assessed the possible outcomes for two energy scenarios for Northern Ireland in 2050:

- **Scenario 1**: This considers a continuation of trends from 2020 in the move toward increased security of supply and decarbonisation;
- **Scenario 2**: This considers a more aggressive change towards higher security of supply and greater decarbonisation, with higher levels of energy efficiency and greater moves to renewable energy.

These were developed:

- using DECC's pathways analysis for 2050;
- adapting this UK analysis to the situation and opportunities in Northern Ireland;
- with stakeholder workshops at three stages to refine the scenarios and to bring greater understanding of the barriers and opportunities in Northern Ireland.

Following this a numerical estimate was made to assess the overall position on energy supply and demand and the impact on GHG emissions.

The outcomes are a vision of what might happen by 2050, they are neither a prediction nor a plan. With any long term view, there is very significant uncertainty in many of the variables.

Amongst the uncertainties are:

- how global energy supply and prices will change, factors that have changed significantly over the previous four decades;
- the Directives introduced by the EC on GHG and energy targets post 2020;
- how global and EC influences will be experienced in the UK and transposed into UK law and devolved to Northern Ireland;
- how all of these influences change the behaviour and decisions of individual consumers in Northern Ireland and hence affect energy demand;
- how all of these influences affect the decisions of investors in energy projects in Northern Ireland and hence affect energy supply.

The scenarios for 2050 envisage a significant change to energy security of supply for Northern Ireland. From a net importer of electricity Northern Ireland would become a significant net exporter. For fossil fuels the reliance on oil for heating would be very significantly reduced, replaced by gas, renewable heat and electricity. For transport, oil will continue to dominate the fuel mix, making transport the main sector that will be exposed to international energy cost fluctuations.

The outcomes envisaged for 2050 suggest that energy related GHG reductions fall by 55% to 80%, through:

- a switch to renewable electricity as the main form of electricity generation;
- a move to renewable heat;
- improved efficiency of buildings, industry processes, light and appliances;
- uptake of electric vehicles, plug in hybrid vehicles and fuel cell vehicles.

These would require a sustained and concerted effort to deliver, and would require all sectors of the economy to act.

The impacts on energy costs are more difficult to envisage in full detail. In terms of energy consumption, fossil fuel use is expected to fall and this would reduce energy costs. Total electricity consumption would increase, as would household electricity consumption.

Medium and long-term energy price projections are difficult to make and none were found for 2050. Price projections for the UK to 2030 show an increasing trend, followed by price stability. Given that decarbonisation will require further investment in low carbon post 2030, electricity prices may rise further, particularly when the costs of wider electricity network upgrades are taken into account.

Hence, it is suggested that the falling cost of fossil fuel consumption may be overcome by higher costs for electricity consumption. If this proves to be the case, then further measures could be required. For example, further measures that reduce the volume of electricity consumed and solutions that reduce the price of electricity generated.

In 2050 the most expensive form of electricity generation is expected to be open cycle gas turbine technology (OCGT). These provide a rapid response of output, able to follow changes in electricity demand and changing output from renewable generation. But the time OCGT becomes expensive (in the 2030s and 2040s) there may be options to use smart grid solutions or energy storage as an alternative to further investment in OCGT-based electricity generation.

Appendix 1: External workshops

There were two main elements of external workshops:

Initial Workshop: A workshop in Belfast on 17th January presented early ideas and views on the development of energy supply and demand in 2050. Feedback was obtained via:

- A show of hands on key questions
- A response form on the main sectors.

Final Workshop: Three separate workshops were held on the initial thinking for the Electricity, Heat and Transport sectors. Held on 25th and 26th February, these included detailed presentations on the early thinking and feedback on any further changes needed.

The following diagram shows where the workshops fitted into the programme:

Figure 29: Main steps and consultations

Figure 30: Photo from one of the final workshop sessions

A wide range of organisations were invited to the workshops. The organisations attending are listed below, their contribution to the project was extremely valuable and the effort made by the attendees was greatly appreciated.

Table 33 List of organisations attending the stakeholder workshops events

Initial stakeholder workshops 17th Jan	25/26th Feb Final stakeholder workshops
Action Renewables	Action Renewables
AES	AES
DARD	Aramark
DETI	B9 Energy Offshore Developments Ltd
DFP NI	Consumer Council for Northern Ireland
DOE NI	DETI
DRD	ESB IE
DSD NI	ESB Wind Development
Electric Ireland	Hayes Fuels
Firmus Energy	Invest NI
Invest NI	Kelly Fuels & Lindsay Coal
Mutual Energy	NIE Future Networks
NIAUR	NIE Transmission Planning
NIHE	NIHE
NIRIG	Power NI
Power NI	QUB
Ricardo-AEA	QUB - Questor
SIB NI	Renewable Energy
SONI	RES UK and Ireland
SSE Renewables	Ricardo AEA
Strategic Investment Board	Ricardo-AEA
Translink	SONI Ltd
	SSE
	SSE Renewables
	Translink
	Utility Regulator

RICARDO-AEA

18 Blythswood Square
Glasgow
G2 4AD

Tel: 0870 190 1900
Fax: 0870 190 6318

www.ricardo-aea.com