DELIVERING THE NEW GENERATION OF ENERGY

ROUTE MAP TO SCOTLAND'S RENEWABLE FUTURE

SCOTTISH renewables

The Forum for Scotland's Renewable Energy Industry

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EXECUTIVE SUMMARY

The UK Government's 2006 Energy Review made it clear that future decisions about how to meet our energy requirements need to take into account four factors: affordability; carbon reductions; energy security; and competitiveness.

It is clear that there are some long term challenges in changing our current energy system to one that can safely balance these priorities.

This report, *Delivering the New Generation of Energy,* describes the route that Scotland's renewable energy sector could take to help deliver these policy goals outlined above, and the scale of the challenge facing us all in Scotland.

The Scottish Executive has estimated that Scotland has sufficient renewable energy resources to provide up to 75% of UK electricity needs[i] and already Scotland's renewable electricity sector is meeting around 16% of Scots' electricity needs. Harnessing more of this resource takes us on a path towards a low carbon Scotland and emerging as a European green energy powerhouse.

Delivering the New Generation of Energy demonstrates that Scotland's renewable sector is already making significant steps towards this goal but that much more needs to be done by 2020.

However, between 2020 and 2050 a step change will be needed in how we use our energy to ensure significant cuts in overall energy demand, matched with successful deployment of renewable technologies.

Delivering the New Generation of Energy sets out what renewables could practically deliver by 2010, 2020 and 2050 towards Scottish energy needs. In making these projections, Scottish Renewables has drawn on existing research, analysis, Government policies and its own research, to highlight what renewables can contribute towards our electricity, heat and transport fuel needs in the future.

However, uncertainty remains. *Delivering the New Generation of Energy* highlights the gaps in policy, strategy and technologies needed to deliver the 2020 targets and in reaching the 2050 destination. It also highlights the risk of policy changes creating market uncertainty and preventing continued successful delivery of renewable energy in Scotland. In short, *Delivering the New Generation of Energy* highlights that the significant gains already seen are merely a taste of the benefits that could be delivered to Scotland for 2010, 2020 and 2050.

REACHING OUR DESTINATION?

At the heart of this vision is the need to reduce demand for energy by 36% on 1998 levels by 2050. However, this report shows, based on 1990 levels, that Scotland's total energy demand is unlikely to start falling until 2026.

This far away from 2050, it is impossible to predict whether we will make the necessary changes to hit our 2050 goals. However, the changes we suggest are entirely feasible and practical, but are contingent on cross-sector action.

What is clear is that unless we make substantial progress by 2020, our chances of delivery are slight. *Delivering the New Generation of Energy* shows that these changes can be delivered.

i Scottish Executive (2001a)

ROUTE MAP TO SCOTLAND'S RENEWABLE FUTURE

Assuming government policy on renewables remains stable an obvious success will be that by 2020 Scotland will be making real progress on renewable electricity by ensuring delivery of existing Scottish Executive targets, while making an important contribution to wider heat and transport fuel needs.

However, the benefits from the progress in renewables and in reducing carbon reductions could be undermined if the demand for energy continues to grow. For example, if the growth in the consumption of electricity outstrips the growth in the production of renewable electricity then shortfalls may be met by carbon emitting fossil fuelled power stations.

Action on energy efficiency and renewables must therefore go hand-in-hand if we are to reach the destination of a low carbon Scotland by 2050. Before then significant progress is needed by 2020.

Also, with much of the ageing electricity distribution and transmission networks nearing the end of their useful lives Scotland, and indeed the rest of the UK, there is an opportunity to consider what kind of grid system will be required to achieve a renewable future for Scotland. Given that networks have a lifespan of around 40 years, the decisions that we make now will determine how we generate much of our electricity in the future. A more centralised system requires large, centralised power stations to deliver secure supplies of electricity. A shift towards decentralised systems requires power generation closer to the point of use and can be equally secure, but with much of the technology not yet commercial, or in the case of storage technologies, still emerging, such a shift may involve greater risk. It is important that when decisions are made that the right balance is found.

If it wants to, Scotland can deliver. *Delivering the New Generation of Energy* highlights success to date, and the challenges ahead. We need to press ahead and if we encounter difficulties redouble our efforts. *Delivering the New Generation of Energy* sets out the Route Map for this journey and the role of renewables in helping us to reach our intended destination of a sustainable and powerful Scotland.

BASECAMP 2006

In 2006 demand for electricity is expected to be around 35 TWh and *Delivering the New Generation of Energy* has found that if all the operating capacity built in this year operated for 12 months it would contribute around 19% of Scotland's electricity needs. Therefore the Scottish Executives 18% renewables target for 2010 is likely to be achieved three-years early.

Demand for heat dominates, and will continue to dominate the energy sector, with more than half of our energy use in this area but improvements in building energy use will see some improvement, but transport use in vehicle kilometres travelled, with current policies, is set to rise steeply.

2006 represents something of a policy cross roads for all renewable energy technologies with both the Scottish Executive and the UK Government considering their next moves on transport, microgeneration, national energy policy, financial support for Scottish marine energy technologies, the planning system, Scottish building standards and heat. In comparison, the electricity sector has a somewhat clearer idea of the renewables road to be travelled, but mooted changes in 2006's Energy Review could have some major ramifications.

ii A terawatt (TW) is a thousand gigawatts (GW). A GW is a thousand megawatts (MW). A MW is a thousand kilowatts (kW). If a thousand GW are used or generated in an hour it would normally be described as a TW hour (TWh).

iii Scottish Executive, Scottish Energy Study (2006)

iv Royal Commission on Environmental Pollution, Energy the Changing Climate (2001)

PROGRESS TO 2010

By 2010 it is anticipated that demand for electricity will have grown to 36.7 terawatt hours[ii]. Our study shows that over 30% of Scotland's electricity could come from renewables by 2010.

It remains unclear how energy demand for heat will respond to increasing action on energy efficiency. However, recent studies show there has been a decrease in heat demand from 1990 to 2002[iii] and that this trend may continue as inefficient boilers are replaced with higher efficiency models, insulation levels continue to be improved and tighter building regulations focused on delivering carbon emissions cuts lead to lower energy demands in new buildings.

By 2010 vehicle kilometres will have increased to around 45,000 million vehicle kilometres, 10% up on 2002 levels but we anticipate that the increased use of biofuels in Scotland will have an impact on carbon emissions from vehicles.

...BY 2020

By 2020, Scotland has the potential to meet over half of its electricity needs from renewable sources.

Our report assumes that growth in energy demand will begin to stabilise by 2020, but not decrease until after this point. Falling use will mean overall demand returns to 1990 levels by 2026. With the growth in renewables in all energy sectors this means that carbon emissions should continue to fall in the second decade of this century .

More of our heat will come from renewable sources and growing amounts of biofuels - building on the Renewable Transport Fuel Obligation - will be in use.

...BY 2050

Based on current scientific understanding of the impacts of climate change, the UK Government has committed to reducing carbon emissions by 60% by 2050[iv]. The contribution of renewables will be important here, but more fundamental changes in our overall energy use will also be needed. The Scottish renewable energy sector needs to build on current success and anticipated future growth while maximising the potential of new technologies and ideas that are being developed now in energy storage, carbon sequestration and more efficient combustion engines.

Perhaps the most notable change by the middle of the century will be the growth of microgeneration technologies to mass market status. This must happen if the Energy Saving Requirement (see Chapter 5: Conclusion) is to be achieved. In addition our transport use must be low carbon and sustainable.

Summary of Delivering a New Generation of Energy: Route Map to Scotland's Renewable Future

	1990	2006/7
KEY POLICY DRIVERS IN 2006 AND TARGET DATES	> No policy drivers for renewables in operation	> Scottish Executive (Scot Exec) renewable electricity targets > Renewables Obligation Scotland (ROS) (6.7% - electricity = 2.36TWh)) > Renewable Transport Fuel Obligation (RTFO) > Scot Exec Climate Change Programme (SECCP)
All Energy Demand (TWh eq)		
Electricity	26.4	35.3
Heat	101.1	93.5
Transport	42.8	49.0
Total	**170.3**	**177.8**
Renewables Contribution[v] (TWh eq)		
Electricity	3.5	6.9
Heat	3.0	3.0
Transport	0	0.01
Total	**6.5**	**9.91**
Total Emissions Energy Sector (MtC)	12.68	12.2
KEY POINTS	> Statistical and targets baseline year > Hydro and a small number of solar panels operating in Scotland > UK energy self sufficient due to oil & gas fields on UK continental shelf > UK makes a dash for gas > Production for Scottish consumption, excludes exports and transmission losses	> 19% contribution from renewable electricity: hydro and wind prominent > Scot Exec target hit in 2007 > Potential for ROS compliance but significant number of ROCs sold in England & Wales > Heat accounts for 58% all energy use in Scotland but no renewable heat strategy in place in Spring 2006 > Microgeneration policy in Scotland not fully developed > Transport sector gearing up for RTFO > UK net importer of gas and oil

Notes:

v Based on projects operating for a full year

vi ROCs are issued as proof by electricity suppliers that they have sourced renewable electricity

Glossary:

MtC: Million tonnes of carbon

RCEP: Royal Commission on Environmental Pollution

ROCs: Renewable Obligation Certificates

TWh eq: Terrawatt hours equivalent

2010	2020	2050
> Scot Exec (18% = 6.6TWh) > ROS (10.4% = 3.8TWh) > RTFO (5% = 1.75 TWh eq) > SECCP 2.8 MtC cut on 1990 levels	> Scot Exec (40% = 15.36TWh) > Scot Exec target requires 6GW installed to generate required electricity for 40% target	> RCEP Scenario 60% cut in carbon emissions on 1990 levels > RCEP energy demand 36% cut on 1990 levels > Two scenarios developed by RCEP place renewables at the centre of low carbon Scotland
36.6	38.4	23.5
92.3	89.7	53.6
51.0	55	34.2
179.9	**183.1**	**111.3**
12.0	21.0	Not defined
4.0	4.5	Not defined
1.8	3.5	Not defined
17.8	**29.0**	**19.1 - 34**
11.9	10	5.07
> 33% contribution from renewable electricity: all technologies make a contribution > Carbon emissions fall by 6% on 1990 baseline > Electricity demand rises 1% year-on-year > Fewer constraints on onshore wind could lead to 2020 Scot Exec target being hit almost ten years early > ROS eligible projects supply 8.26TWh, but significant number of ROCs[vi] sold in England & Wales > Microgeneration grows but still not mass market > RTFO met and makes 6% contribution to emissions cuts > Bioenergy sector takes root in Scotland supplying heat mostly, but strategically important 'firm electricity' and biofuels for transport > Renewable heat strategy in operation since 2008 and supporting initial heat projects	> Potential 54% contribution from renewable electricity > Potential 9GW installed capacity of renewable electricity projects > Carbon emissions fall by 21% on 1990 baseline > Offshore technologies in wind, wave and tidal stream come of age > 10% of heat sourced from renewables and microgeneration > Storage and carbon sequestration technologies - hydrogen, biomass, batteries - see greater use > A number of decentralised energy systems and greater use of microgeneration take pressure off centralised transmission networks > Vehicle kilometres travelled continue to increase but more efficient motors and greater use of biofuels see carbon impact stabilise and fall > RTFO target increased to 10% and met (= 3.55 TWh eq), making a 5% contribution to emissions cuts	> Renewables supply between 17% and 30% of all energy demand > Renewables electricity the principle provider of renewables > The way we use energy fundamentally different to 2006 with microrenewables and micro CHP mass market > Decentralised energy networks increasingly the norm following evolution in past 44 years from centralised networks and generation > Cost effective storage technologies the norm, including biofuels, hydrogen, hydro pumped storage and large-scale batteries > Carbon sequestration widely in use > Sustainable transport technologies and public transport use see emissions fall in this sector

C.1 ENERGY TODAY IN SCOTLAND

KEY POINTS: ENERGY TODAY:

- 19% contribution from renewable electricity: hydro and wind prominent
- Scot Exec target hit in 2007
- Potential for ROS compliance but significant number of certificates sold in England & Wales
- Heat accounts for 58% all energy use in Scotland but no renewable heat strategy in place in Spring 2006
- Microgeneration policy in Scotland at a crossroads
- Transport sector gearing up for RTFO
- UK net importer of gas and oil

2002 

CONVENTIONAL ENERGY:
RENEWABLE ENERGY:

INTRODUCTION

Until recently it has been surprisingly difficult to get a clear picture of total energy generation and use in Scotland. While publications such as the Digest of UK Energy Statistics (DUKES) and the Scottish Executive Environment Statistics provide some useful data, they do not provide sufficient detail to cover all energy issues.

Therefore, the publication of the first two of five volumes of the Scottish Energy Study (SES) earlier this year was timely. The SES gives detailed energy statistics for 2002 revealing demand in all sectors, generation in all sectors and the carbon emissions from each.

The impact of these statistics should not be underestimated. They provide perhaps the most comprehensive analysis of the way Scotland uses and generates energy since 1990.

This report has used these statistics as a baseline to build a picture of the impact of renewable energy technologies on carbon emissions in Scotland in 2010, 2020 and 2050.

METHODOLOGY FOR THIS REPORT

In looking forwards to scope out the contribution of renewables, Scottish Renewables has sought to follow a clear methodology, based on data sourced from publicly available and authoritative sources.

By using these sources Scottish Renewables has created a detailed picture of all energy use and generation in Scotland in 2010 and 2020. We have then calculated the anticipated level of carbon emissions in Scotland and whether, with the current policy framework the success, or otherwise, of meeting government targets.

Scottish Renewables has then supplemented this data with its own research, where our analysis can help fill gaps in available statistics. For example, as part of this work we have carried out research into expected installed capacity of onshore wind as little authoritative data existed elsewhere.

Lastly, assumptions about levels of installed capacity, energy demand, etc. are based on current policy provisions – changes in the future are likely to lead to different results to those highlighted by this report.

A somewhat different approach was taken regarding 2050. We took as a given the need to hit the 60% carbon cuts recommended by the Royal Commission on Environmental Pollution (RCEP) for 2050. By using scenarios developed by RCEP for the UK, this Route Map has identified what Scotland's 'destination' should be in terms of carbon emissions cuts, reductions in energy demand and - using two possible energy scenarios - for heating, electricity and transport.

BASELINE MODEL

A model (see figure 1) was created to support the projection of Scotland's energy mix in future years, incorporating several key parameters, including:

- **Energy Consumed in Scotland (TWh eq) by fuel type**
- **Installed capacity of energy plant**
- **Carbon emissions**

Figure 1 illustrates how the model works in principle.

For this baseline our primary source of data was the Scottish Energy Study (SES), supplemented where necessary by additional data.

A baseline model was first created to model the 'current' position and to cross check data used from different sources. The data for the baseline model was selected as 2002 as per the SES report.

All data used was adjusted to remove the effect of electricity export from Scotland from 2002 figures, and therefore reflects net consumption. For future years a ratio was applied to electricity production to match supply and demand and similarly reflect net consumption in Scotland for the purposes of calculating Scottish carbon emissions. The same ratio is applied to all fuel types[1].

The SES report provides consumption figures split into categories of use[2], namely:

- **Domestic**
- **Industry**
- **Services**
- **Transport**
- **Refinery Losses**

It also provides consumption figures split into main fuel types, namely[3]:

- **Solid**
- **Oil Based**
- **Natural Gas**
- **Electricity**
- **Renewable & Heat Sold**

The above categories were used at all times for consistency and used to cross check data from alternative sources to provide a matched forecast demand consistent with sectoral use trends and fuel type use trends.

The SES report also provides consumption figures split by fuel type for the generation of electricity and for direct use in heat or transport. No figures are included for electricity subsequently used for heating.

To establish the total energy consumed as heat an estimate of electricity used for heating was included based on data from the DTI[4]. Excluding transportation, 'heat' is estimated to represent 80% of overall energy use and electrical use was estimated at 20% aggregated across domestic, service and industrial sectors. Based on this estimate the amount of electricity used in the form of heat was therefore calculated as 24% across all sectors. Figures for the transport sector were taken directly from SES data.

The mix of generation fuel types is based on SES data and the Scottish Renewables installed capacity database. SES data also

1 This approach is used for consistency between fossil fuels and non fossil fuels and results in pro-rating electricity generated by fuel type to match overall domestic demand. Modelled figures will therefore not match maximum generating potential for any given fuel type.

2 Scottish Executive (2006) Scottish Energy Study Vol 1 Table 24: Energy consumption, based on sum of demand sectors in Scotland, 2002

3 ibid

4 DTI Energy (2005) – Its Impact On The Environment And Society; Chapt 3.1

includes generation from small scale hydro schemes and these have been factored into the installed capacity figures.

Plant efficiency and load factors are taken from the SES data for 2002 for existing plant. For future renewable generation plant load factors were applied as follows: hydro 30%; offshore wind 40%; onshore wind 30%; wave and tidal 30%; microgeneration 30% and CHP/ biomass for electricity 80%.

FUTURE SCENARIOS

A key modelling parameter is the assumed energy demand in future years. Recent trends vary by sector; UK domestic energy use increased by 19.5% between 1990 and 2004, industry reduced by 12%, services increased by 8% and transport increased by 18%, resulting in an overall increase of 9.5%[5]. Based on current fuel mix and sectoral use this has resulted in the level of carbon emissions increasing rather than decreasing in recent years.

The model assumes a continuation of recent trends until about 2020; thereafter the model assumes a reduction in overall energy demand through to 2050 broadly consistent with the RCEP study which highlighted that reduction in effective demand of carbon emitting fuel types of about 36% from 1998 levels will be required to meet the 60% carbon reduction target.

2010 Projections: There is a steady increase in overall energy demand of about 0.3% annually to 2010, with electricity and transportation increasing by about 1% and heat reducing by about 0.35% each year.

The generating mix is broadly similar to that currently although increasing renewables and reduced direct use of coal and oil for heat result in a decrease in carbon emissions by 2010, 6.6% lower than 1990 levels.

Installed electricity generation capacity has increased to 12.6GW, 88% of which is required to meet Scottish demand, the balance being available for export depending on prevailing market conditions. Renewable energy is responsible for 33% of total electricity generation and 8% of total energy consumption.

2020 Projections: There is a large increase in onshore wind with smaller but significant increases in other renewable technologies up to 2020 consumption. Consumption from other fuel types remain broadly the same as 2010 levels with the exception of coal with Scottish consumption reducing considerably through the period. The increase in energy demand has stopped at 4% above 2002 levels. Modest levels of microgeneration contribute to stabilising demand for electricity from the grid. There is a net decrease in carbon emissions by 2020, 21.4% lower than 1990 levels. Carbon emissions from transportation continue to rise, amounting to 37% of all carbon emissions, up from 26% in 2002.

Installed electricity generation capacity has increased to 14.3GW, 82% of which is required to meet Scottish demand, the balance being available for export depending on prevailing market conditions. Renewable energy is responsible for 55% of total electricity consumption and 14% of total energy consumption.

2050 Vision: The electricity generating types remain mixed with contributions from fossil fuels (67%, down from 81% in 2002), nuclear (12%, down from 16% in 2002) and renewables (21%, up from 3.4% in 2002). Large reductions have been made in carbon emissions from transportation and heat generation through substitution of fossil fuels.

Energy demand is assumed to reduce as per the RCEP model, 36% below 1998 levels.

5 'DTI (2005) Energy – Its Impact On The Environment and Society, Chapter 3.1

There is a net decrease in carbon emissions by 2050, 52.8% lower than 1990 levels.

Installed electricity generation capacity has reduced to 12.8GW, only 58% of which is required to meet Scottish demand, the balance being available for export depending on prevailing market conditions. Renewable energy is responsible for 63% of total electricity generation and 19% of total energy consumption.

DEMAND FOR ENERGY IN SCOTLAND

The SES gives a snapshot of the way energy is used in 2002, and to what extent, in the transport, heating and electricity sectors. This section now continues by using that study to set a 'basecamp' for the sector's possible onward journey.

Figure 1 shows the proportion of energy that is used in heat, transport and electricity in Scotland. It shows that energy for heat – mostly gas but also from electricity – accounts for 58% of all energy used in Scotland. The next largest user of energy is the transport sector. Fuelled by oil products, it accounts for 27% of the total. Electricity used to power industrial and domestic needs accounts for 15% of the total. However, this grows to 20% when electricity for heat is included.

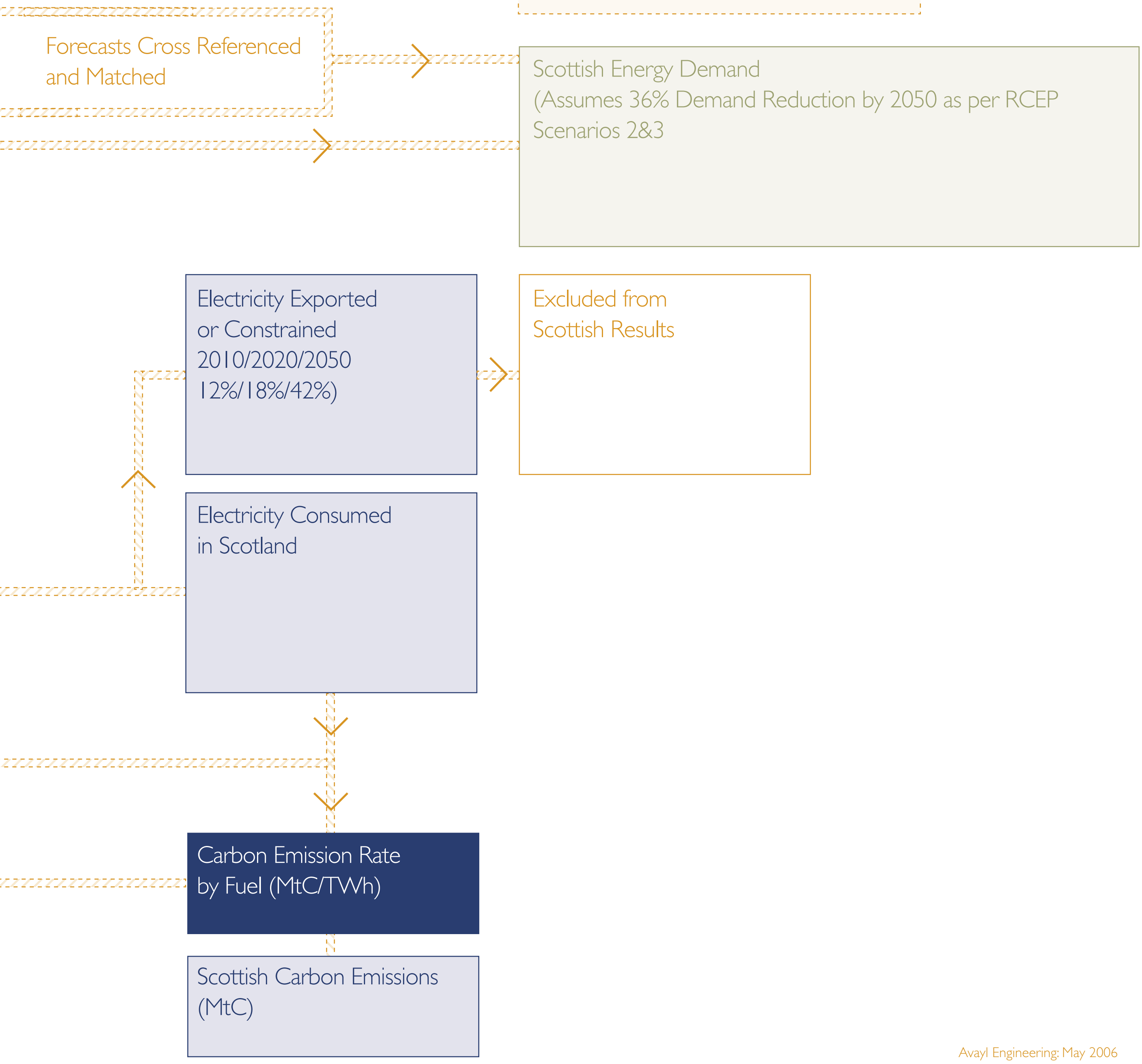
Taken together (see Table 1 on page 15), Scotland demanded the equivalent of 175TWh in 2002 and emitted 12.3 million tonnes of carbon[6], (MtC).

6 Whilst there are several climate change gases, carbon dioxide is the principal greenhouse gas. Reports either refer to CO_2 or carbon and express quantities as megatonnage. A megatonne is a million tonnes. To convert CO_2 into carbon multiply the former by 12 and then divide by 44. A megatonne of carbon is abbreviated as MtC.

(Fig. 1) Schematic of Route Map Methodology

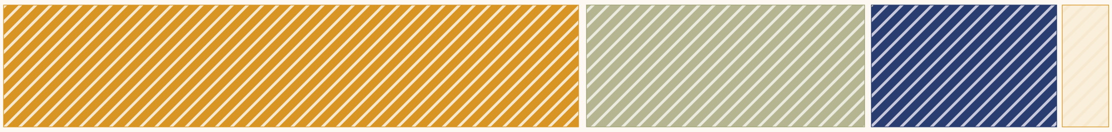
Schematic of Route Map Methodology

A clear methodology was used in the Route Map. It began with the current figures from the SES (2005), and agreed fuel types. These inputs where then fed through cross-reference forecasts, to give future energy use and emissions figures for 2010, 2020 and 2050



Avayl Engineering: May 2006

(Fig. 2a): How Energy Is Used in Scotland (2002)



HEAT: 53%
TRANSPORT 27%
ELECTRICITY: 15%
ELECTRICITY AS HEAT: 5%

Source: Scottish Renewables

In 2002, Scotland consumed the equivalent of 175TWh of delivered energy and in the process emitted 12 million tonnes of carbon (MtC).

Per head of the population, Scotland consumed more energy than the UK population as a whole. The Scottish population makes up 8.5% of the UK total but consumes 9.1% of all energy.

This reflects the greater need for heating north of the border and greater than average oil refining.

Around a quarter of all electricity in Scotland is used for heating, amounting to 5% of total delivered energy.

(Fig. 2b): Consumption of Electricity in Scotland by Technology (2002)

NUCLEAR: 34%
COAL & OIL: 33%
GAS: 20%
RENEWABLES: 13%

Source: Scottish Renewables

There has already been a lot of activity in the electricity generation sector in Scotland in the past few years with the initial focus on reducing emissions from Scotland's two coal fired power stations. In 2002, with around 10% of Scottish electricity coming from hydro another 1.5% from wind, and nearly 1% with biomass and waste, a start has clearly been made.

The Scottish Executive wants to see 40% of electricity sourced from renewables by 2020 and this will involve a great deal more activity from the green energy sector and continued political support north and south of the border.

Table 1: Energy consumption in Scotland by sector and fuel type in 2002 (TWh eq)

	Solid	Oil-based	Natural Gas	Electricity	Renewables & heat sold	Total
Domestic	3.02	5.82	34.48	12.27	0.46	**56.05**
Industry	1.11	5.09	17.65	10.34	1.13	**35.32**
Services	0.04	2.78	11.37	11.28	1.36	**26.83**
Transport		46.77		0.3		**47.07**
Refineries		10.65				**10.65**
Total	**4.17**	**71.11**	**63.50**	**34.19**	**2.95**	**175.92**

Source: Scottish Executive[7]

Table 2: Supply and demand options to replace a large gas-fired power station

		Supply Side		**Demand Side**		
Option		**Investment**		**Investment**	**Retail**	
		CCGT	**Wind**	**Microwind**	**A+ Fridge**	**Low Energy Light Bulbs**
Output	TWh	10	10	10	10	10
Installed Capacity	MW	1,500	3,800	4,500	1.36	26.83
Unit Capacity	MW	1,500	3	0.0015	1.36	26.83
No of Units		**1**	**1,200**	**3,000,000**	**40,000,000**	**400,000,000**

Source: Scottish & Southern Energy

As our discussion of targets below indicates, most activity in reducing carbon emissions is currently focused on electricity. Figure 2b shows the electricity generation mix in Scotland. This shows electricity generated at the point of source. In 2002, nuclear produced 34% of Scotland's generated electricity followed by coal and oil with 33%, gas 20% and renewables 13%.

In advance of the commentary on targets, Table 2 shows policy options available to Government.

In very broad terms this table shows what it would take to replace the electricity produced from a large gas-fired power station, similar to the one operating in Peterhead. It outlines how many large wind turbines, microwind turbines and the level of retail purchases required for A+ rated refrigerators and low energy light bulbs would be needed to replace or avoid the need for 10TWh of electrical generation.

7 Scottish Executive (2006), Scottish Energy Study - Vol 1,.

GOVERNMENT TARGETS

Both the UK Government and Scottish Executive have signed up to relevant international protocols or directives or have set unilateral policy targets for the following: renewable electricity, biofuels in transport, combined heat and power (CHP) systems; and reduction of carbon and greenhouse gas emissions.

The most prominent targets are those that relate to carbon emissions. The Kyoto Protocol commits the UK to cutting greenhouse gas emissions by 12.5% between 2008 and 2012. The UK Government has gone further and targeted 20% cuts by 2010 based on 1990 levels. A recent report published by the UK Government[8] indicates that the former target is likely to be met but that the UK is unlikely to hit the 20% target.

The Scottish Executive recently set targets for the reduction of carbon emissions[9]. It said that Scotland's equitable share of cuts would amount to 1.7MtC in 2010 based on 1990 levels. However, it has targeted even greater reductions with the target set at 2.7MtC by the end of this decade.

The Scottish Executive has also said it would consider establishing a target for renewable heat[10], while two Member's Bills to be presented to the Scottish Parliament in 2006 will seek to set targets for microgeneration.

Longer term, the UK Government is committed to cutting carbon emissions by 60% by 2050 to ensure that the UK is playing a full part in the global effort to stabilise and reduce emissions.

To aid delivery on these commitments and targets, a number of support systems and delivery mechanisms have been established.

For example, the Renewables Obligation (Scotland) (ROS) obliges the suppliers of electricity to source a predefined level of that electricity from renewable electricity generators, excluding old hydro stations. By 2010, electricity suppliers must include 10.4% of ROS eligible renewables in the electricity they supply. In 2006/2007 the obligation is set at 6.7%. The UK Government and Scottish Executive recently confirmed a 2015 target of 15.4%.

If suppliers fail to achieve this target they are subject to penalties which will then be distributed among competitors who have met the target.

In 2003, the Scottish Executive set an aspirational target for 2010 that includes the electricity from larger, older hydropower stations. By 2010, it expects 18% of electricity used in Scotland to be sourced from renewables. This grows to 40% by 2020[11].

The UK Government has introduced the Renewable Transport Fuel Obligation which imposes on fuel suppliers a 5% biofuel obligation to be achieved by 2010, which will have the equivalent carbon emissions effect of taking one million cars off the road.

In addition, the UK Government has established a target for CHP to achieve 10GWe[12] of installed capacity by 2010.

RENEWABLE ENERGY IN 2006

One shortcoming of the SES is that data is only available up to 2002. However, the Scottish Renewables bi-monthly Market and Planning Report[13], which has been published since 2005, provides a very clear idea of the growth in renewable electricity projects, and this has been cross-checked against data from DUKES to ensure accuracy. However, there are no known up-to-date statistics regarding transport and the use of heat in Scotland.

8 'Defra (2006)

9 Scottish Executive (2006) Changing Our Ways: Scotland's Climate Change Programme

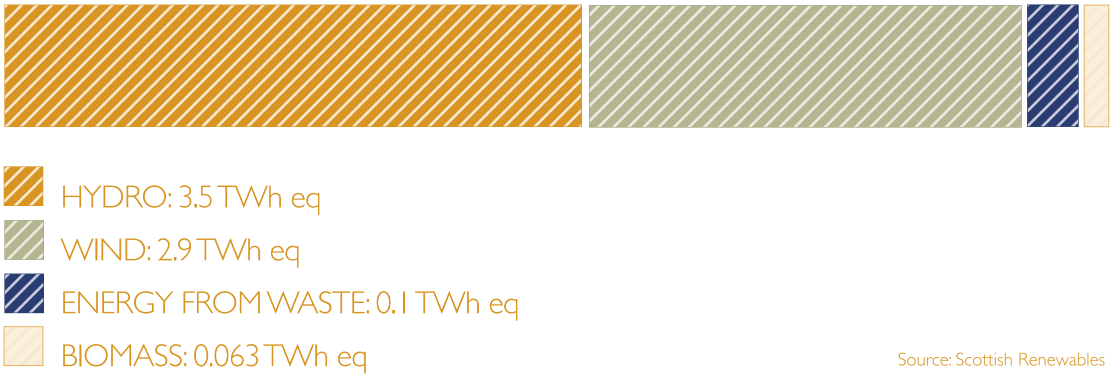
10 Scottish Executive (2006), Renewable heat strategy in pipeline.

11 Forum for Renewable Energy Development in Scotland (2005) Scotland's Renewable Energy Potential. This report recognised that the original target set by the Scottish Executive started as a proportion of generation. FREDS concluded it would be suitable to target electricity use in Scotland given the lack of certainty in knowing what generating stations will be operating in 2020.

12 'The target for CHP generation is generally measured in installed electrical generation capacity of the scheme(s) in megawatts (MWe) or gigawatts (GWe).

13 The reports can be found at: www.scottishrenewables.com/resources.asp.

(Fig. 3): Potential Annual Electricity Generation of Renewable Projects operating in 2006



By April 2006, 2GW of installed capacity of renewable electricity was operating in Scotland. Across 12 months[14] this capacity should generate 6.4TWh, or around 18% of the anticipated Scottish demand for electricity in 2006 of 35.25TWh (see Figure 3).

Furthermore, there is a significant level of development activity in Scotland, and plans for infrastructure investment to facilitate new connections.

The UK Government's CHP target for 2010 was established to encourage the growth of CHP capacity in the UK. Although this technology is making a valuable contribution, rising to 5.6GWe in 2004[15], the industry has faced serious economic setbacks in recent years, largely due to rising gas costs, requiring a range of government interventions[16]. However, Defra estimates that approximately 8GWe of installed industrial and domestic CHP is likely to be operating in the UK by 2010, indicating that current interventions will not be sufficient to meet the target.

These CHP figures summarise the UK market as a whole as there is currently limited up-to-date information available on the contribution of CHP in Scotland.

The targets discussed above are clearly important to the growth of renewables in Scotland. The carbon savings required could be met by transitions in all methods of energy production and evolved end-use, and individual targets and progress are complementary within the overall aims.

The following chapters of this report make projections for renewable electricity and energy generation in Scotland in 2010 and 2020 and outlines two scenarios for a low carbon energy sector for 2050.

Using the methodology outlined above it has been possible - based on possible renewable energy development - to outline productivity and impacts on carbon emissions in 2010 and 2020.

These chapters look at each renewable energy technology (principally in the electricity sector) in turn and identifies possible production levels in each.

The contributions are summarised in Fig. 4.

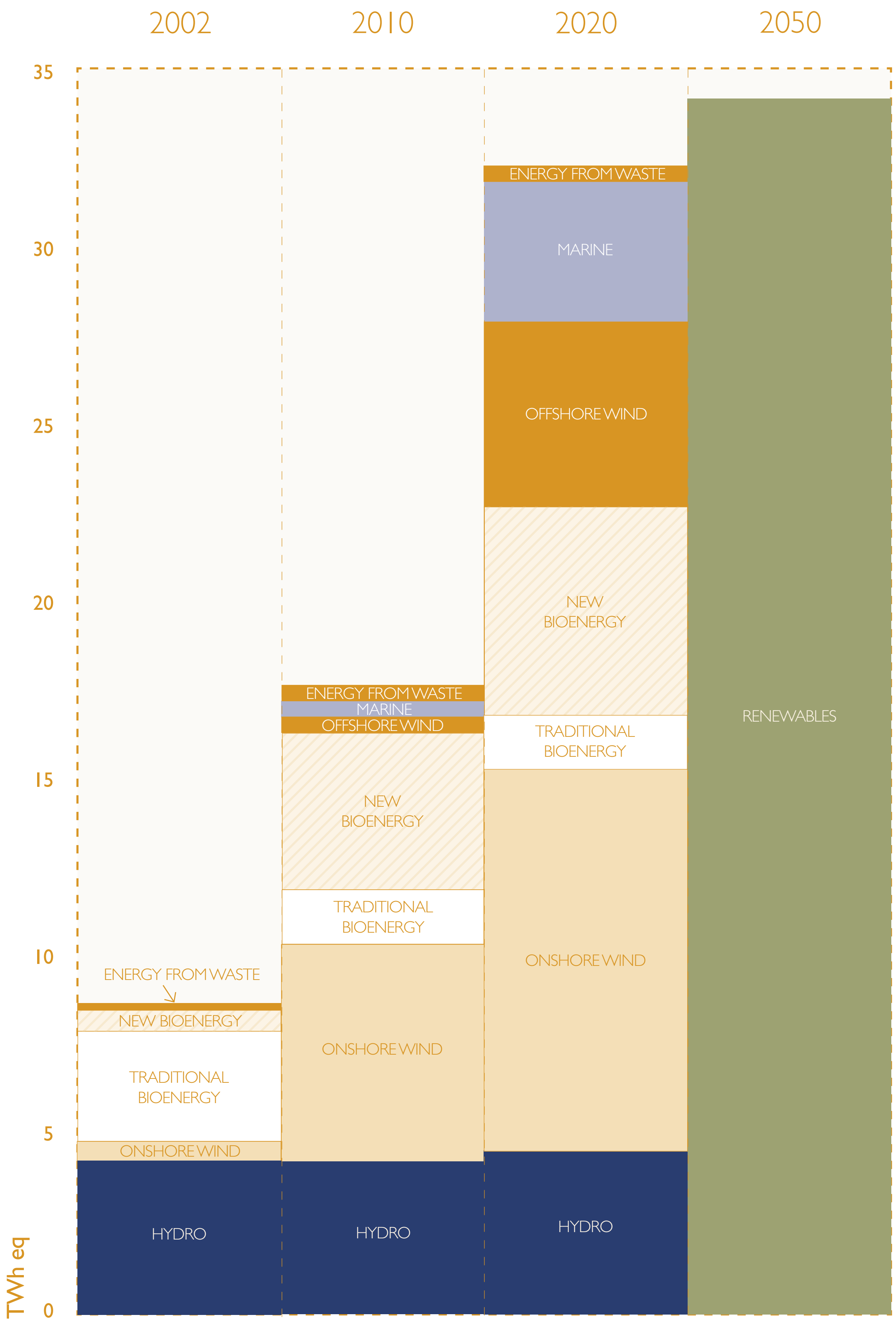
Chapter 2 looks at projections to 2010, and Chapter 3 to 2020. In Chapter 4 we move from earlier projections based on what current development activity to what it would take to capture 60% carbon emissions cuts. This chapter does not consider the contribution of each technology but rather examines what the requirement for renewables is likely to be as well as reductions in the demand for overall energy.

14 Assuming standard industry capacity factor figures and average weather conditions.

15 Department of Trade & Industry (DTI) (2005) Digest of UK Energy Statistics (DUKES)

16 Department for Environment, Food and Rural Affairs (Defra) (2004) The Government's Strategy for Combined Heat and Power to 2010.

(Fig. 3): Renewables All Energy Mix

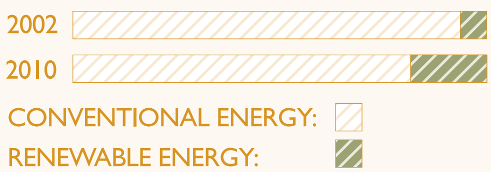


Source: Scottish Renewables

C.2 ENERGY IN 2010

KEY POINTS: 2010 PROJECTIONS

- Potential 33% contribution from renewable electricity: all technologies make a contribution
- Carbon emissions fall by 6% on 1990 baseline, electricity demand rises 1% year-on-year
- Fewer constraints on onshore wind could lead to 2020 Scot Exec target being hit almost ten years early
- ROS eligible projects supply 8.26TWh, but significant number of ROCs sold in England & Wales
- Microgeneration grows but still not mass market
- RTFO met and makes 6% contribution to emissions cuts
- Bioenergy sector takes root in Scotland supplying heat mostly, but strategically important 'firm electricity' and biofuels for transport
- Renewable heat strategy in operation since 2008 and supporting initial heat projects



INTRODUCTION

The 2010 targets, including those for carbon emissions, will provide a benchmark for the deliverability of renewable energy in Scotland and progress towards a low carbon economy.

Our analysis, based on the methodology described in Chapter 1, suggests that due to the significant growth in the use and generation of renewable energy - particularly in the electricity sector - carbon emissions will fall by the end of this decade despite an annual increase in aggregate demand for energy of 0.3%.

DEMAND FOR ENERGY IN SCOTLAND

Total demand for all energy is likely to increase in the foreseeable future[17] given historical trends. This report has modelled an anticipated 0.3% annual increase out to 2010, although it should be noted that demand for heat has fallen in the past but may increase again as the size of the Scottish housing stock increases.

Therefore, by 2010 demand for electricity (excluding heat) is likely to be 27.9TWh, electricity as heat 8.8TWh, direct heat 92.3TWh and transport 51TWh.

Comparing volume one and volume two of the SES shows that there has been a 12% decrease in demand for heat between 1990 and 2002. Stricter building codes, more efficient boilers and other energy efficiency measures should see a continuing decrease in demand for heat per household. In Scotland, the number of households is anticipated to increase, so we have assumed a modest annual decrease 0.35% from 2002 for the period of this study[18].

Transport use measured in vehicle kilometres has shown a steady increase since 1990 and growth currently shows few signs of slowing and will grow by nearly 10% to 45,000 million[19] kilometres by the end of the decade.

17 Scottish Executive (2005) Scotland's Renewable Energy Potential

18 Household projections can be found at: www.scotland.gov.uk/Topics/Statistics/15637/sesoSubSearch/Q/SID/74

19 Scottish Exec (2004)

(Fig. 5): Projected Carbon Emissions in Scotland in 2010

HEAT - DIRECT: 4.9 MtC
TRANSPORT: 3.5 MtC
ELECTRICITY DIRECT: 2.7 MtC
ELECTRICITY HEAT: 0.8 MtC

Source: Scottish Renewables

The SES measures energy used by the transport sector in TWh and we have mapped the sector's growth in this measure.

CARBON EMISSIONS BY 2010

The aggregate growth in the demand for energy is unlikely to lead to a growth in carbon dioxide emissions from the energy sector. The Scottish Executive has targeted 2.7MtC in cuts on 1990 levels. Our research suggests that this may be achievable with a 600,000 tonne reduction (around 5%).

The anticipated reduction in emissions would be largely attributable to the strong performance of renewables and the fall in demand for energy for heat per household.

As noted earlier in this report's model, which continues trends identified in both DUKES and the SES, demand for energy for heat may fall by nearly 3% on 2002 figures. Given the dominance of energy for heat in the energy sector such falls would have a bigger impact and would do much to offset anticipated increase in transport use and electricity.

Figure 5 shows the amount of anticipated MtC emitted by the different sectors in 2010 based on our modelling.

THE 2010 TARGETS FOR ENERGY

Based on projected annual electricity demand of 39.1TWh, the 2010, 18%, Scottish Executive target for renewable generation means that 7TWh of electricity needs to be generated.

In transport the equivalent of 2.5TWh will be required from biofuels based on consumption of an electrical equivalent of 50.8TWh to meet the Renewable Transport Fuel Obligation (RTFO).

GRID INFRASTRUCTURE

Successful development of renewable electricity projects obviously requires a network for connection and distribution of this power. The best sites for renewable generation are in rural areas of Scotland, a significant distance away from large demand centres where business and domestic consumers need the electricity.

However, there are a number of issues relating to the ability of the grid system in Scotland to provide additional capacity and ensure continued growth of renewable electricity.

Most renewable projects connecting in Scotland will be classed as embedded generation, so connect to the distribution system. However, all projects over 5MW in the north of Scotland, and all projects over 30MW in the south of Scotland are classed as large power stations[20], so consideration also has to be given to the ability of the transmission network to accommodate their output.

20 The definitions of "large power stations" is defined within the GB Grid Codes. At present all generators over 5MW in Scottish Hydro Electricity Transmission Limited's (SHETL) are classed as large power stations. It is proposed to adjust this to 10MW. All projects above 30MW in the ScottishPower Transmission Limited's (SPTL) are classed as large power stations.

The main constraint to growth in the sector is lack of capacity to move electricity within the transmission network, though bottlenecks also exist within the distribution system.

The FREDS Future Generation Group[21] concluded that up to 4.8GW of installed capacity, above and beyond the 2.8GW of operating and/or consented generation (as of 2005), could be achieved from transmission upgrades for which Ofgem has already proposed a funding mechanism. However, much of this new infrastructure will be dependent on section 37 (Electricity Act (1989)) consents for line upgrades, and little of this is expected to be consented and constructed by 2010.

The 2010 projections have been done on the basis that the Beauly-Denny upgrade is not ready for use prior to 2010. However, there is sufficient capacity within the existing network to ensure that the 18% target can be exceeded. Analysis of available capacity has been cross-checked with connection dates of the current transmission queue, which highlights that a significant number of projects – primarily in central and South-West Scotland – are being offered connections prior to 2010.

With alternative connection arrangements – for example non-firm connection products provided to bring on projects in advance of new infrastructure such as Beauly-Denny – more capacity from northern Scotland could become available in advance of upgrades being in place.

The FREDS Future Generation Group also assessed the technical challenges associated with connection of an increasing level of variable generation and stated that National Grid believe that, provided network rules are satisfied, there is unlikely to be a technical ceiling due to the variability of wind on the amounts of renewable generation that can be installed in Scotland. Any constraints are therefore likely to be for economic/market reasons rather than technical.

Finally, it is important to recognise that all the connection expected prior to 2010 will have an agreement with National Grid that it can connect without having to wait for provision of upgrades outside of Scotland. While in the longer term, connections might be delayed because of the need for new infrastructure in England, current developments – at least until 2015 – have agreements that do not take this into account.

Returning to the issue of distribution, the initiative of Ofgem to encourage Registered Power Zones (RPZ), to incentivise greater connection is to be welcomed. The 2006 announcement of the RPZ on Orkney is welcome and may be particularly important for development of new marine energy projects between now and 2010, as it increases available capacity by up to 15MW for the islands. It may be the case that further RPZs can be developed to maximise use of other parts of the distribution system within Scotland.

THE ENERGY MIX IN 2010

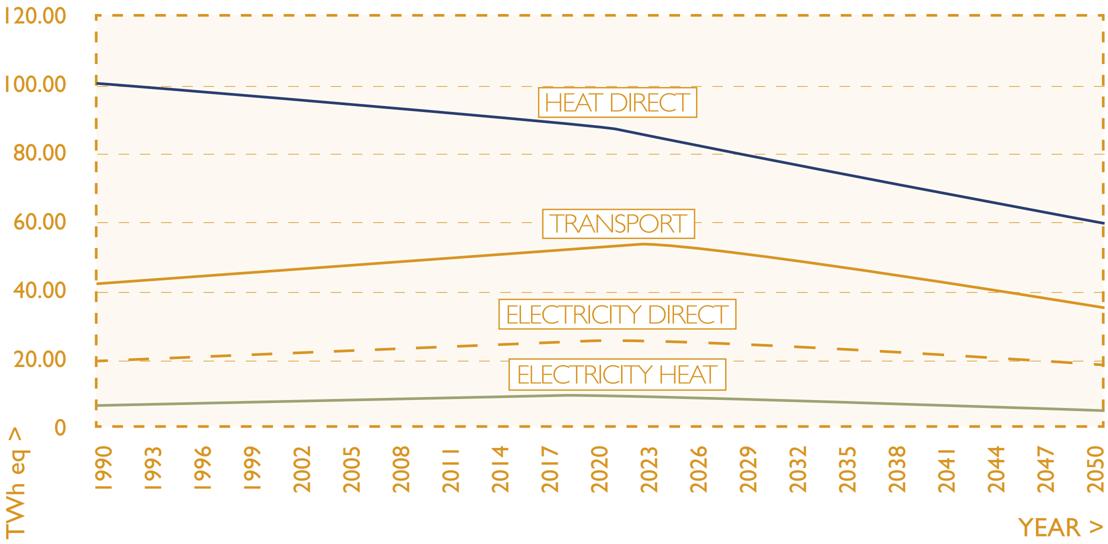
The markets for heat, electricity and transport broadly operate independently of each other though all are likely to be affected by rising price volatility of fossil fuel sources such as oil and gas.

Rising oil prices in recent years have led to the rising cost of gas and has thus made coal used in electricity power stations an increasingly attractive option. It has also strengthened the case for renewables.

So, against the backdrop of the rising cost of a barrel of oil and a growth in energy demand, it is likely that more coal will be used to generate electricity and that renewable projects will make an increasingly important contribution to meeting demand.

21 FREDS, (2005b)

(Fig. 6) Energy Consumption by Sub-Sector in Scotland 1990 to 2050



Source: Scottish Renewables & Avayl Engineering

CONVENTIONAL GENERATION IN 2010

In 2010 both Cockenzie and Longannet coal fired power stations will be operating and together possibly producing more power than at the beginning of the decade, although some of this may be generated for export. The impact of the Low Combustion Plant Directive will mean a reduced output for Cockenzie, though this may be balanced by an increased output from Longannet. There will also be two nuclear power stations – Hunterston B and Torness operating. In addition, the CCGT plant in Peterhead will also be operating.

RENEWABLES IN 2010

Recent growth in generation from renewable electricity projects in Scotland – in onshore wind, hydro, landfill gas and biomass – has demonstrated the sector's ability to develop productive sites. There is no reason to think this will not continue up to 2010 and beyond with major onshore wind and hydro projects coming online. Wave and tidal projects will have progressed from current prototype deployment to small-farm developments.

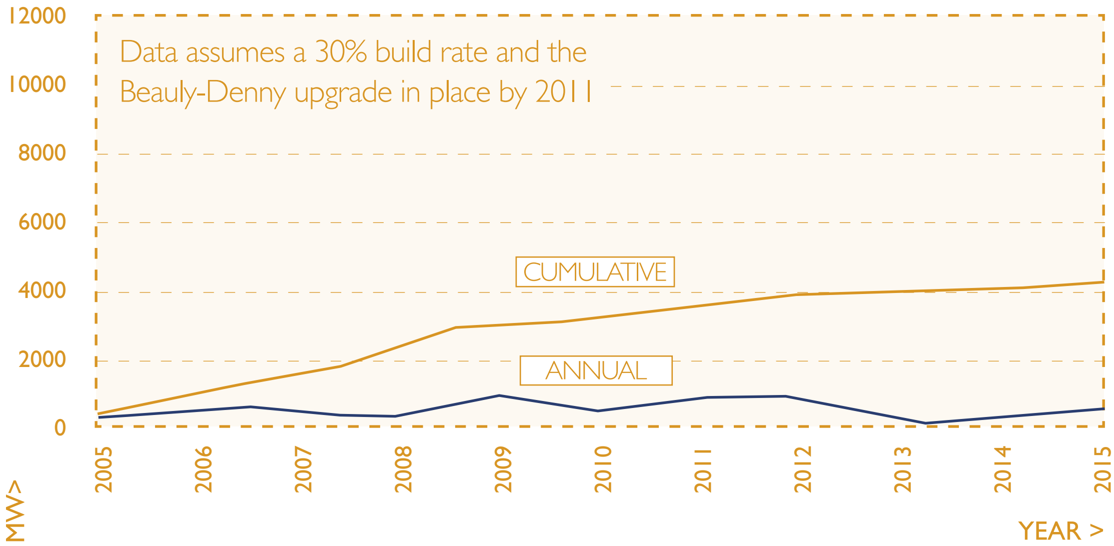
The projections in this report are based on published studies of anticipated build and/or schemes that are in the public domain. This assumes a continuation of current policy, triggering as it does interest in developing renewables projects, rather than a reflection of the available practical resource.

This approach is grounded in reality as it is based on real projects for established technologies and is therefore a snapshot of current market knowledge. The method also introduces for emerging technologies, based on published studies, an idea of potential development activity.

Collectively the renewable electricity sector could produce around 11.98TWh in 2010, almost double that required to meet the 18% target. Whilst some of that will undoubtedly be used for export, it is the equivalent of 33% of anticipated Scottish demand for electricity.

Based on an assumption that this additional renewable generation is mainly replacing coal generation, this 13.71TWh will prevent 3MtC[22] from entering the atmosphere and thus emissions should be considerably

(Fig. 7) Onshore Wind Installed Capacity to 2015



Source: Scottish Renewables

lower than they otherwise might be. Using the DUKES UK generation mix carbon emissions measure, renewable electricity plant would reduce emissions by 1.4MtC[23].

If, as anticipated, the RTFO is met in 2010 and, according to the Scottish Executive[24], 5% of road transport fuel comes from biofuels, this will prevent around 1MtC per annum being emitted. It is anticipated that growing efficiency in motorised transport will be counter-balanced against the growth in the demand for transport. The Scottish Executive has acknowledged in its Climate Change Programme that cutting emissions in the transport sector will be challenging. This implies that the current suite of policies to reduce emissions may not deliver needed cuts. This Scottish Renewables report has therefore projected a small growth in emissions which balances the likely growing efficiency of vehicles with the anticipated growth in vehicle kilometres travelled.

ONSHORE WIND

Scottish Renewables role in representing most of the development activity in the wind sector in Scotland provided it with an opportunity late in 2005 to assess the likely level of development in Scotland for 2010 and 2015.

In a round of interviews with developers, Scottish Renewables detailed the likely commission dates anticipated by the individual project managers (of schemes that were in the public domain). It then applied the constraining factors of planning and infrastructure to arrive at a projection for delivery of onshore wind by 2010 and 2015.

Scottish Renewables was advised by the wind sector in Scotland that Figure 7 is a realistic scenario for delivery of onshore wind. It shows annual installed capacity and the sector's cumulative growth assuming a build rate of 30% and if crucial infrastructural upgrades were completed in 2011.

The 2.7GW of anticipated installed capacity would generate in an average year around 7.4TWh, around 20% of Scotland's demand for electricity.

OFFSHORE WIND

There remains some uncertainty about the potential for offshore wind in Scotland.

22 Based on the BWEA's accepted method of calculating the carbon benefits of renewable electricity schemes. The BWEA methodology can be found at: http://www.bwea.com/edu/calcs.html.

23 DUKES uses a weighted basket of generators to calculate that the average kWh generated would lead to the emission of 432 grammes of CO_2 per kWh. Renewable electricity generation is designed to reduce the amount of power generated from load following plant, especially coal fired power stations and it is power from this flexible plant that is displaced.

24 Scottish Executive, 2006, Scotland's Climate Change Programme

The one large wind farm consented by the Scottish Executive – Robin Rigg in the Solway Firth – will export its power to England – and for the purposes of this report we have excluded it from our calculations.

There is a single large project being planned off Aberdeen and the prototype Beatrice Offshore Wind Farm Demonstrator Project is anticipated to start going through its paces later this year. This outer Moray Firth project will test two 5MW turbines in deep water. Using expertise from the oil and gas sector, this innovative project, if successful, could do much to unlock the potential of offshore wind around Scotland's deep offshore locations.

By 2010 we anticipate that both the Beatrice Demonstrator and Aberdeen projects will be operating with a combined capacity of 110MW generating around 0.4TWh.

There may also be potential for shallow water projects closer to Scotland's coastline. However, so far, the Crown Estate which controls the UK seabed, and the UK Government has yet to reveal any significant interest in this area.

The Scottish Executive *Matching Renewable Electricity Report* (2006) identified 3GW of potential for offshore wind in shallower water. It would be speculation to assume much of this will be developed until project developers show greater interest or when the UK Government launches another licensing round.

MARINE

The FREDS Marine Energy Group (MEG) report[25] projected that 1.3GW of wave and tidal current energy capacity could be installed in Scottish waters by 2020. Using this figure as a guide, and following a survey of marine developers carried out by Scottish Renewables, it is anticipated that around 0.16GW of installed marine energy capacity could be operating by 2010.

This projection assumes favourable market conditions and grid availability, and also suggests that approximately 0.09 GW of this capacity could be delivered by wave energy technologies with 0.07GW delivered by tidal current devices, together generating around 0.4TWh.

HYDRO

The hydro power sector in Scotland is well established and has been operating successfully for more than one hundred years. Its capacity has been the bedrock of the renewables sector in Scotland and has for some time been meeting on average around 9% of Scotland's electricity needs.

It is unlikely that the total installed capacity of hydro will be added to significantly in the coming years. However, there continues to be interest in new development with one large hydro project already under construction and several smaller run-of-river projects in various stages of planning.

In 2006, hydro had 1.33GW of installed capacity and this should grow to 1.45GW by the end of the decade. The SES suggests that there is around 330MW of small hydro capacity.

Combined, this hydro capacity would, in an average year, generate around 4.56TWh; a little over 12% of Scotland's electricity needs.

ENERGY FROM WASTE

Energy from Waste plays a small part in the Scottish electricity mix. By 2010 there could be as much as 100MW of installed capacity generating 0.3TWh.

BIOENERGY

Bioenergy is sustainable yet finite, unlike other renewables, because it is largely dependent on the availability of the biomass resource. Scottish Renewables' projections for future bioenergy development are

25 Forum for Renewable Energy Development in Scotland (2004) Harnessing Scotland's Marine Energy Potential

therefore based on estimated resource figures. Based on figures supplied by both the Forestry Commission[26] and the Sustainable Development Commission Scotland[27] (SDC), the potential annual wood fuel resource available to the bioenergy industry by 2010 would be in the region of 0.8 million oven-dried tonnes (m odt). This figure could rise to almost 1m odt per year if the market grows due to rising demand for wood fuel and untapped resources potentially becoming available.

As stated in the FREDS Biomass Energy Group (BEG) report[28], the larger bioenergy plants (over 10MW installed capacity) are likely to be generating either electricity only or combined heat and power at industrial sites where there is continuous demand for process heating with complimentary demand for electricity.

BIOMASS FOR ELECTRICITY

It is projected that at least 60MWe[29] of installed capacity will exist by 2010 (as shown in Table 3)[30], generating around 0.42TWh of electricity annually[31]. Electricity-only schemes have an average energy conversion efficiency of 25% and such plants can also use the excess, low-grade heat produced for other industrial processes. This can be utilised either by the plant itself, or by nearby businesses, thereby increasing the plant's effective conversion efficiency.

BIOMASS FOR CHP

Combined heat and power generation makes more efficient use of each unit of fuel consumed (around 80% conversion efficiency). One project in Wick, currently in planning, will utilise waste heat from a distillery as well as a wood burning boiler to produce CHP for the distillery itself and district heating to the local community. The project should have an installed capacity of 1-3MW of electricity and 3MW of heat, generating up to 0.03TWh of CHP annually. However, it should be recognised that under current market conditions there are few opportunities for CHP projects in Scotland due to various factors, including the relatively high initial capital costs.

BIOMASS FOR HEAT

According to the SDC, approximately 0.38 odt of wood fuel could produce 1MWh of heat.[32] Therefore, if the total potential wood fuel resource available to the bioenergy sector of 0.95m odt is used for small-scale heat purposes, around 2.5TWh of heat could be generated.

The Scottish Energy Study estimates that Scotland currently consumes around 2.95 TWh of renewable heat and 'heat sold'[33]. The majority of this energy is assumed to be generated from wood-burning fires, boilers and stoves using resources such as discarded wood, ad-hoc tree felling and paper waste, etc.[34] meaning a substantial proportion is estimated to be derived from biomass.

Scottish Renewables would expect this figure, based primarily on older, traditional technology, to fall and be offset by a growth in newer, more efficient biomass boilers.

Assuming that at least 1.48TWh of this is not included in the SDC's resource figure[35], we can project that around 4TWh of heat could be generated from wood fuel by 2010.

A significant proportion of the fuel used for those electricity plants expected to be operating by 2010 will be derived primarily from animal waste and wood fuel from northern England, so they are unlikely to impact substantially on the projected Scottish wood fuel resource. Because of known delays outwith the control of developers (particularly planning and grid connection), it is assumed that no additional large-scale

26 McKay (2003), Woodfuel resource in Britain.

27 Sustainable Development Commission Scotland (2005) Wood fuel for warmth.

28 Forum for Renewable Energy Development in Scotland (2005) Promoting and accelerating the market penetration of biomass technology in Scotland.

29 To distinguish between installed capacity of electricity and heat generating plants, which differ in their conversion efficiencies and capacity factors, the capacity figures are written as MWe (electric) and MWth (thermal).

30 Those considered likely to be operating by 2010 are projects that do not face significant delays due to planning and grid connection queues.

31 Using 80% capacity factor for medium to large-scale plants (Carbon Trust, 2005).

32 Assuming an average seasonal thermal efficiency of 65% (Sustainable Development Commission Scotland, 2005).

33 Heat sold is defined as heat that is produced and sold under the provision of a contract, sourced from CHP plants and community heating schemes (DUKES, 2005).

34 Scottish Executive (2006) Scottish Energy Study – Vol 1

35 It is unclear whether, or how much of, this biomass resource currently used for heating is included in the Forestry Commission's and SDC's wood fuel resource estimations. For this reason we have taken 50% of the 2.95TWh of direct renewable energy consumption as additional to the SDC's projection.

plants generating electricity, CHP or heat will be operating by 2010. For this reason, the majority of the wood fuel resource detailed above, combined with additional biomass resources, is projected to be used in local heat markets. Therefore, to summarise the outlook for 2010, it is suggested that the following bioenergy could be generated:

- Electricity: 60MW installed capacity = 0.42TWh
- CHP: 4-6MW installed capacity = 0.03TWh
- Heat: 4TWh

BIOFUELS FOR TRANSPORT

It is assumed that the Renewable Transport Fuel Obligation (RTFO) target, requiring 5% of all UK fuel sold on UK forecourts to come from a renewable source by 2010, will be met. It should be noted, however, that the RTFO covers road fuels only.[36] It is therefore projected that biofuels will constitute almost 1.75TWh by 2010, making up 3.7% of the total energy consumed for transport in Scotland. This would translate into a carbon emissions saving of 740,000 tonnes[37].

Argent Energy's biodiesel plant near Motherwell currently produces 50 million litres of biodiesel per year, displacing around 200,000 tonnes of CO_2 per annum[38]. This equates to 0.48TWh[39] of energy, but it is distributed around the UK, not just in Scotland. As Scotland consumes 7.4% of UK transport fuel[40], this proportion of Argent's biodiesel would equate to 0.036TWh, meeting 0.1% of Scotland's road transport needs.

The total projected contribution that bioenergy could make to Scotland's energy needs by 2010, compared to the contribution in 2002, is illustrated in Figure 8. By 2010 the bioenergy sector could generate the equivalent of 6.2TWh.

MICROGENERATION, HYDROGEN, STORAGE AND ENERGY SAVING

There are a number of technologies in microgeneration approaching market readiness in 2006 and there is some optimism regarding the increased take-up of devices such as solar thermal, heat pumps, microwind and micro-CHP[41]. However, there remain significant barriers - not least cost - and the Energy Saving Trust (2006) suggests that a mass market will not be established this side of 2010. Hydrogen and storage technologies are still further away and have yet to show the same commercial gains as microgeneration.

(Table 3): Summary of Dedicated Bioenergy Projects in Scotland (April, 2006)

Status	Number of Projects	Electricity Capacity (MWe)	Heat Capacity (MWth)
Operating	1	12.00	0.00
Under Construction	1	44.00	0.00
Resolution to Consent	1	4.20	12.00
In Planning	2	50.00	3.00
Scoping	4	58.50	6.00
Total	**9**	**168.70**	**21.00**

Source: Scottish Renewables

36 Road transport consumes around 35TWh of energy in Scotland each year, equating to over 70% of transport energy demand (Scottish Executive, 2006, Scottish Energy Study – Vol 1).

37 Based on the Scottish Energy Study's (2006) estimation that Scotland consumes 7.4% of the UK's transport fuels, and that the RTFO is expected to cause a UK-wide saving of 1 MtC by 2010 (Scottish Executive, 2006, Changing our Ways: Scotland's Climate Change Programme).

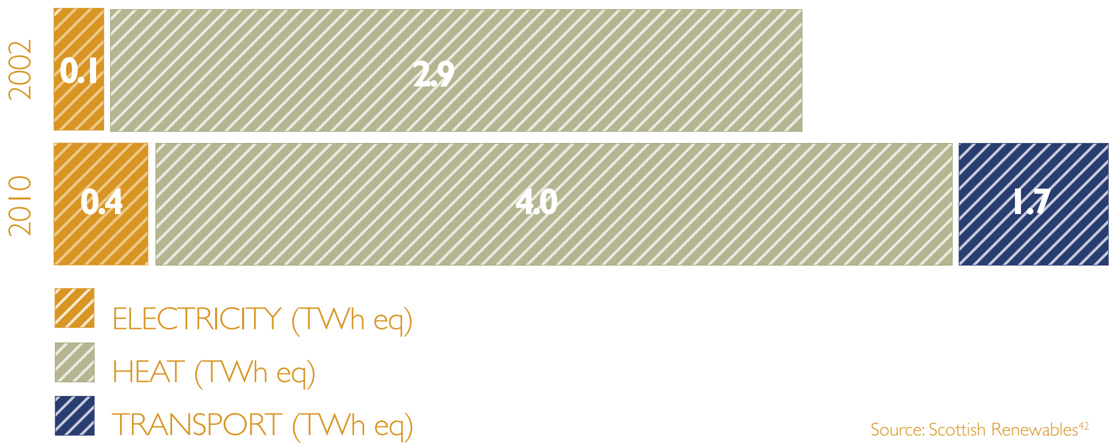
38 Argent Energy (2005)

39 Carbon Trust (2004) and Northwoods (2004) energy conversion tables, stating 34.5 megajoules per litre of biodiesel, and 0.28 kilowatt hours per megajoule.

40 Scottish Executive (2006) Scottish Energy Study – Vol 1.

41 Energy Saving Trust (2006)

(Fig. 8): Current & Projected Bioenergy Generation in Scotland



Source: Scottish Renewables[42]

In understanding the impact of micro-generation we have worked on the assumption that microgeneration is better defined as an energy saving device because it reduces the need for a house or other building to import energy either as electricity, gas, fuel oil, etc.

As described in the section on bioenergy, around 2.5TWh of heat could be generated for domestic-scale use from wood fuel by 2010[43], depending on the efficiencies of the boiler system. It is unclear whether this figure includes the biomass already directly used for energy[44], but if not, we estimate this projection to be in the region of 4TWh. However, this will only occur if the necessary policy interventions are put in place now.

Additional renewable heat sources, such as solar thermal and heat pump technologies, will also contribute in 2010 but there are no published sources explicitly projecting how much they will contribute in Scotland by that year. However, there is clear analysis of longer-term potential at 2020 and beyond.

CONCLUSION

2010 will see some significant achievements for Scotland, but still further work to do in moving towards the overall target of a 60% carbon reduction for 2050. Significant growth in onshore wind and bioenergy, and important initial development of other renewable sources may mean that 2010 electricity targets will be exceeded, perhaps by significant margins.

Establishment of the RTFO is likely to lead to ongoing investment in biofuels production, though it is still too early to see whether incentives and penalties are correctly balanced to drive delivery by the fuel market. It will also be important to ensure regulatory and/or planning barriers do not prevent delivery.

There are signs however that this policy position is changing and that promised Scottish strategies on heat and the stated desire to review overall policy on transport could lead to some effective measures to be in place by the end of this decade but are unlikely to have significant impact until after 2010.

We anticipate that despite growth in aggregate energy demand carbon emissions from the energy sector are likely to fall by 5.2% on 1990 figures, a total reduction of around 600,000 tonnes of carbon.

Reducing our demand for energy should be a priority. Tackling energy demand should not be an after thought as Scotland proceeds on its 'energy journey' but rather it should be central to measures designed to transform Scotland into a low carbon economy.

42 2002 heat and transport figures from Scottish Executive (2006) Scottish Energy Study, 2002 and 2010 electricity figures from Scottish Renewables. 2010 transport figure based on meeting the RTFO target and calculated using the Scottish Executive's 2002 transportdemand figures. 2010 heat figure from the Sustainable Development Commission Scotland (2005) Wood fuel for warmth.

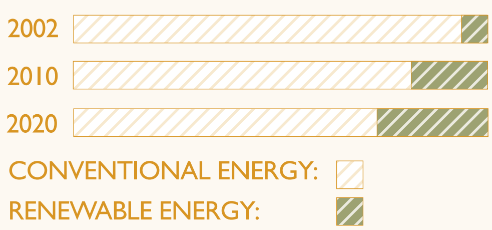
43 Sustainable Development Commission Scotland (2005)

44 Equating to 2.95TWh in 2002 (Scottish Executive, 2006, p41), but reduced to 1.48TWh for this report, as explained in the commentary for bioenergy.

C.3 ENERGY IN 2020

KEY POINTS: 2020 PROJECTIONS

- Potential 54% contribution from renewable electricity
- Potential 9GW installed capacity of renewable electricity projects
- Carbon emissions fall by 21% on 1990 baseline
- Offshore technologies in wind, wave and tidal stream come of age
- 10% of heat sourced from renewables and microgeneration
- Storage and carbon sequestration technologies - hydrogen, biomass, batteries - see greater use
- A number of decentralised energy systems and greater use of microgeneration take pressure off centralised transmission networks
- Vehicle kilometres travelled continue to increase but more efficient motors and greater use of biofuels see carbon impact stabilise and fall
- RTFO target increased to 10% and met (= 3.55 TWh equiv, making a 5% contribution to emissions cuts



INTRODUCTION

If real, significant progress towards a low carbon economy has not been made by 2020 then it is difficult to see how the Scottish Executive and the UK Government will be able to promote a 60% reduction in carbon emissions by 2050.

Against this background this report now turns to 2020 and, based on projections for energy use and generation, assesses progress on our journey to 2050.

The starting point for analysis is projected demand and an assessment of what is required to meet that demand with all the different variables (RTFO, projected renewables development, major plant closure dates, etc) incorporated.

Renewable electricity is likely to continue to make great strides, with the significant contributions from emerging technologies such as wave, tidal stream and biomass.

It is less clear from the current policy framework what the level of demand for heat and transport will be. Building standards that impose strict energy efficiency measures should have an effect and the increased use of microgeneration through a renewable heat and electricity strategy may begin to bite in this period. Transport though - as conceded in the Scottish Executive's Climate Change Programme – may remain a concern.

More efficient vehicles are likely to be operating and there may be an increased use in biofuels on top of the 5% RTFO. The Scottish Executive's Transport Strategy White Paper[45] predicted a 27% increase in vehicle kilometres by 2022, therefore opportunities for reducing emissions may be limited based on current policy

45 Scottish Executive (2004)

DEMAND FOR ENERGY IN SCOTLAND

One of the litmus tests for progress will be the demand for energy. By 2050, based on the scenarios we have outlined in Chapter Four, energy demand needs to be 36% lower than 1990 levels if the 60% cuts in emissions are to be achieved. By 2020 the growth in the demand, we hope, will have stabilised and show signs of falling.

In our report we have assumed that growth will cease in 2020 and overall demand for energy will start to decrease after this point. There is no evidence to conclusively prove that this will be the case, indeed several reports[46] predict energy use will continue to grow, but rather it reflects what needs to be done and recognises the growing interest from Government and the media in energy efficiency. The period 2010 - 2020 is a key transition phase and this report's assumptions also move from what is agreed and understood (that energy demand will rise to 2020) to what is needed (that energy demand must fall by 36% by 2050).

This report has modelled the growth in the demand for all energy in Scotland and by 2020 will, based on current patterns in transport, heating and electricity use, amount to 183.1TWh eq. This is 1.8% higher than 2010, 4% higher than 2002 and 7.1% higher than 1990.

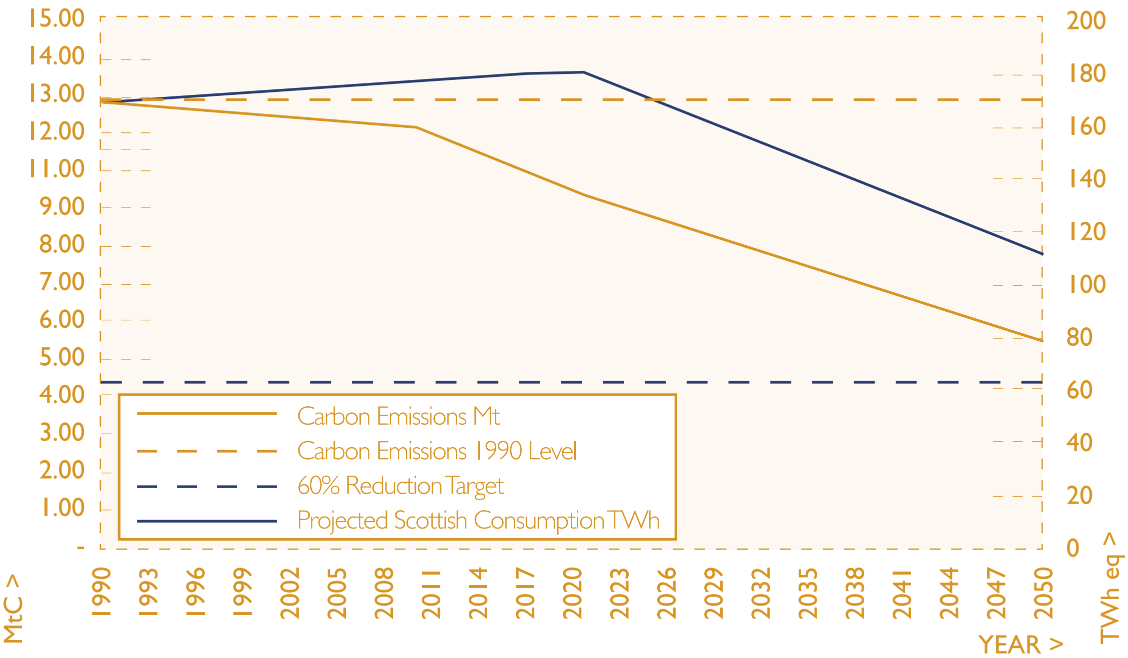
Figure 6 on page 22 shows anticipated demand on each sub sector in 2020. Direct electricity use at 28.8TWh is 3.6% higher than 2010, electricity for heat shows a slightly more modest growth of 3.4% at 9.1TWh, transport grows by 3.3% with the equivalent of 52.7TWh and direct heat, still by far the biggest component, up by 3.7% with the equivalent of 106.3TWh.

CARBON EMISSIONS BY 2020

This report anticipates that Scottish energy sector carbon emissions will fall by 19% between 2010 and 2020 to 9.6MtC.

The expected closure of Cockenzie coal fired power station by 2015 may have a major impact on emissions in Scotland[47] but much

(Fig. 9): Anticipated Carbon Emissions from Scotland's Energy Sector 1990 - 2050

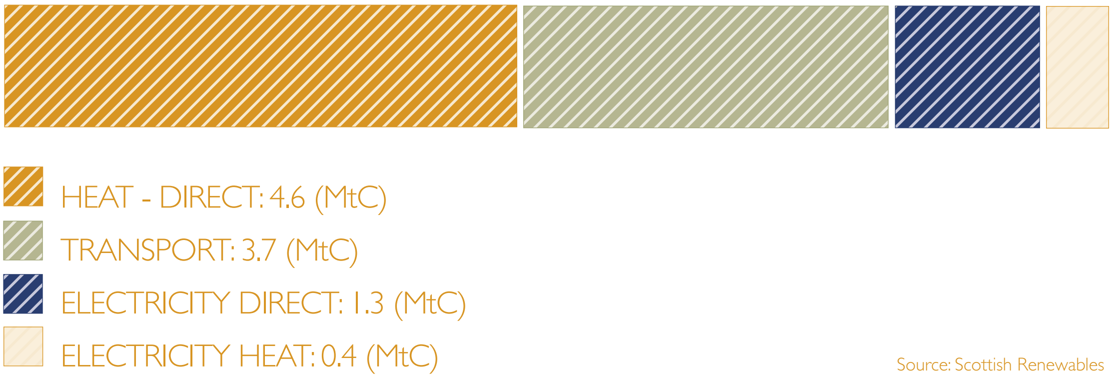


Source: Scottish Renewables

46 University of Edinburgh (2006) and Forum for Renewable Energy Development in Scotland (2005) Future Generation.

47 ScottishPower announced in 2005 that it planned to close its Cockenzie coal fired plant in 2015 and, with investment in desulphurisation equipment, keep its Longannet plant open.

(Fig. 10): Carbon Emissions in Scotland in 2020



Source: Scottish Renewables

depends on the amount of power its sister station, Longannet, exports out of the country.

Cockenzie and Longannet are load following and could be among the balancing plant that will make up any shortfalls in supply from other generating technologies like gas, nuclear and renewables.

Logically then, a significant and steady growth in renewables in Scotland and the UK and limits to what they can emit should lead to steadily reducing levels of generated power from both Cockenzie and Longannet. So, whilst there is a perceived 'cliff edge' in 2015 with the closure of the 1.1GW plant the reality is that it may come to a slow halt. Figure 9, which shows possible carbon emissions in Scotland out to 2050, therefore shows a curve rather than a step change in emissions.

Figure 10 shows emissions from each energy sector. The biggest reductions comes from the electricity sector (direct and heat) with a fall of 35% to 1.7MtC on 2010. Transport, excluding aviation - based on current projections of growth - is likely to emit 4.6MtC; up by 25% on 2010. Heating our buildings in a more efficient way in Scotland is likely to lead to a 15.5% reduction in emissions compared to 2010 to 4.6MtC even though aggregate demand will increase.

THE 2020 TARGETS FOR ENERGY

Currently there are no statutory targets for renewable energy for 2020. In their place the Scottish Executive has an aspiration that renewables provide 40% of electricity demand and the UK Government aspiring to 20%. As yet there are no targets for heat and transport for 2020.

The 40% renewable electricity contribution has been defined as 6GW of installed capacity, which means that green electricity projects need to deliver 15.16TWh. The Scottish Executive *Matching Renewable Electricity* (2006) report and the FREDS 2005 *Future Generation* report note this level of installed capacity is required to meet the targets. However, if the UK Government and the Scottish Executive impose a statutory obligation of 20% (assuming that UK demand will be 400TWh UK renewable electricity schemes will need to deliver 80TWh) Scotland will be in a good position to contribute substantially towards a UK-wide 2020 target.

GRID INFRASTRUCTURE

Whatever the exact level of development, it has to be recognised that much of the Scottish grid network is approaching the end of its design life, so will either need replacing or upgrading between now and 2020. The Energy Networks Association

48 Energy Networks Association (2006) The state of our networks

estimates that 70% of the UK Network assets are now reaching the end of their design life[48], meaning that significant investment will be needed up to and beyond 2020 if we are to have continuing reliability of supply and new connections. This provides an investment challenge but also an opportunity to look for new ways of providing connections and running the network with at least equal quality of supply.

To see continued development of renewable electricity projects between 2010 and 2020, there will be a pressing need for provision of upgraded and new grid capacity.

Ofgem have authorised funding on route development for the Beauly-Denny upgrade, Sloy substation upgrades, South-West Scotland reinforcement and the Scotland interconnector upgrades (and agreed that the Beauly-Denny upgrade should be part of regulated expenditure). While the bulk of this work has yet to receive the necessary section 37 approval, if it proceeds it would release a further 4.8GW of capacity.

However, the FREDS *Future Generation* report noted that additional capacity could also be made available through another series of transmission upgrades. Options here include replacing existing overhead line conductors on existing pylons and increasing operating voltage of some 275kV circuits to 400kV.

In addition, connection standards could be amended to allow greater utilisation of existing or upgraded capacity. This would allow more electricity flow per unit of infrastructure. Options for amending how new generation can connect are now being discussed across industry, meaning there is a possibility that by 2007, new connection and management standards may be in place. If so, this would help support continued connection of renewables post 2010[49,50] and ensure that Scottish Executive targets can be reached and exceeded.

ISLANDS

It is also worth considering the potential for large scale generation for the Western and Northern Isles. Transmission queues mean that no large projects will likely connect until mid-way through the next decade. Even then there are issues about consenting of necessary infrastructure and the current cost of connection for these projects. It is clear that under the current regulatory framework reinforced or new connection of the islands to allow significant development is problematic, although it should be recognised that this is under review and the regulator accepts the need for change.

Options exist either for connecting the islands into the national grid within Scotland or England, but the connections can only be built if a critical mass of installed capacity was approved: this would amount to a little over 2GW of capacity of wind plus the contribution from possible wave, tidal and biomass plants. These projects could produce as much as 5TWh or more and connect either into the northern section of the grid, or possibly into southern Scotland or even England via a sub-sea cable.

There may also be the option for a nascent hydrogen economy to emerge as an alternative to transporting electricity.

To allow assessment of likely project activity, the potential for delivery of the larger onshore island wind farms has been modelled using the same assumptions used for onshore wind proposals on mainland Scotland as outlined in Chapter Two and Figure 7.

49 Ofgem, 2006a, Transmission Price Control Review 2007 – 2012, consultation document

50 Ofgem, 2006b, A framework for considering reforms to how generators gain access to the GB electricity transmission system, a report by the Access Reform Options Development Group

However, if development of marine energy is to be successful, the islands will need new network capacity. At the present time this development is unlikely to happen without larger onshore wind projects on the islands being successful. However, further consideration is needed regarding alternative investment models to support connections to the islands, and further consideration about the use of longer length sub-sea cabling.

Overall experience of the renewables sector to date shows that the current regulatory framework cannot easily respond to provision of new grid capacity, and market signals are particularly weak in peripheral areas such as the Scottish islands.

In part this means that many of the proposals now proposed for the Highlands & Islands are unlikely to connect until sometime between 2010 and 2015. Dealing with this issue has also brought the recognition from industry, grid companies and the regulator that new connection and management controls may be needed. If this initial work is followed through, then the Scottish grid and renewables industry are likely to benefit through better use of available capacity, and provision of new capacity where needed.

Between 2010 and 2020, the UK Government also needs to make major decisions about how it wants to support evolution of the grid, and what signals to send, via regulation and market mechanisms. If we are to have a more decentralised network, the shift will need to begin over this decade, though we may not see major change until after 2020. Providing the correct market signals will ensure that as more embedded generation technologies such as renewables connect onto the network, the network can adapt and respond efficiently, thus ensuring continued reliability of supply to domestic and business consumers.

THE ENERGY MIX IN 2020

The energy mix in 2020 will not be radically different to what it is today. Conventional technologies will continue to operate, but renewables will play a greater strategic role. Perhaps the most fundamental shift will be towards a cleaner energy sector in 2020 and the momentum gained from these changes put us firmly in the path towards a low carbon Scotland with 'greener' cars and renewables being used in ever more efficient heating systems.

CONVENTIONAL GENERATION IN 2020

The policy framework supporting conventional electrical power stations is shifting. In 2010 there will be two nuclear power stations operating in Scotland, one gas fired power station and two coal fired power stations. If no new conventional plant is built and stations close as anticipated, by 2020 Scotland will have only one nuclear power station, one gas fired power station and one coal fired power station delivering around 25TWh, or 66% of Scotland's electricity needs.

However, Hunterston B nuclear power station, which was originally planned to close in 2011, may receive an extension to its licence following an announcement by its operator British Energy in April 2006. If that is the case its 1.1GW of installed capacity could deliver more than 5TWh of electricity.

Our modelling for 2020 assumes that an application for extension has been successful.

The difference between what the conventional power stations deliver and what is needed is increasingly described as the 'energy gap'. Commentators often go on to consider whether this 'gap' can be plugged by renewables and often conclude that renewables could do not do this – often with little evidence.

There is often a failure to recognise that Scotland is part of an integrated British network and market for electricity and that Scotland can both export and import electricity. The overall energy needs of Scotland will have to be satisfied by remaining and new conventional generation, renewable generation, with the potential for imported supplies. It is necessary to do this within carbon targets and clearly renewables deployment in Scotland will have a strategically important role to play. Whether or not renewables can fill the total gap does not negate the significant role they can play.

RENEWABLES IN 2020

A recent Scottish Executive report, commissioned from the University of Edinburgh[51] makes the case that renewable projects in Scotland can on average deliver 40% of Scotland's electricity in a year. Our projections show that with anticipated build; using a broad range of technologies the renewables sector in Scotland can deliver a 54% contribution, or 21TWh of Scotland's electricity in a year. The Scottish Executive Resource Study conducted by Garrad Hassan[52] demonstrates that the resource is available, it is up to government to decide whether it chooses to support this option. The commentary below explains the contribution of each technology.

The net effect of this over a year is to more than plug the perceived 'energy gap' in Scotland. Given the integrated nature of the British electricity system this may not lead to the closure of a significant number of conventional plants in the UK but it is likely to increase the likelihood of a number of closures or the non-replacement of ageing plant.

Therefore, in the round, the Scottish electricity generators have the potential to generate a surplus of Scottish needs and continue the historical practice of exporting power to England, Wales and Northern Ireland. However, there may be occasions when Scotland has to import power – one of the clear benefits of an interconnector network linking north and south.

Regarding heat and transport it is difficult to project the impact of renewable technologies in this area. This report models greater building efficiency and increased transport use with, as noted above, associated impacts on carbon emissions.

If forestry and other resources are available, bioenergy will have a growing prominence in providing carbon neutral heat and biofuels for transport. At present there is little analysis, except the FREDS report[53] on bioenergy, to give strong indications of future activity and impacts.

ONSHORE WIND

Scottish Renewables research of the Scottish wind sector (see previous chapter and Figure 7 on page 23) indicates that there could be as much as 4.2GW of installed capacity of onshore wind power operating in Scotland. This projection is based on projects that have entered the public domain and are currently at various stages of planning, construction or operation.

In addition to this there are a number of projects that have yet to enter the public domain. Scottish Renewables research has found that there is a significant amount of new development activity in onshore wind that has yet to be made public. By applying a 20% build rate to the total installed capacity which may come forward another 680MW could be added to the anticipated 4.2GW of projects that we know about and may get built.

51 Scottish Executive (2006)

52 Scottish Executive (2001)

53 FREDS (2005) Promoting and accelerating the market penetration of biomass technology in Scotland.

Given the significant uncertainty regarding the progress of these projects, including uncertainty regarding available grid capacity and the planning regime governing renewables, this report excludes it from its final figures.

It is possible that in addition to new capacity coming online that there will be some repowering of existing old sites. Given that the incentive to repower is to increase the capacity of schemes it is likely that many projects will scale up. However, it is difficult to ascertain the impact on the overall installed capacity in Scotland and we therefore assume that repowering will have no net affects.

Therefore we project (see Figure 7) that by 2015 4.2GW of wind capacity could be operating and that assuming an average year would produce 11.1TWh of electricity, around 29% of Scotland's electricity needs in 2020.

OFFSHORE WIND

By 2020 Scotland could be enjoying the benefits of an emerging offshore wind sector located in deep water sites. The Beatrice Demonstrator project outlined in the previous chapter may well have shown the viability of such an approach and that by 2020 the first deep water offshore wind farm with 1GW of installed capacity could be operating in the outer Moray Firth.

This may add to the Aberdeen offshore project and combined capacity could be as much as 1.1GW off Scottish coastlines in 2020. This capacity would, in a normal year, produce around 4TWh – around 10% of Scotland's annual electricity needs, if plugged into the Scottish grid network.

MARINE

According to the FREDS MEG report, 1.3GW of total installed wave and tidal stream energy capacity could be operating in Scottish waters by 2020. Using the same proportion for wave energy as projected for 2010, it is assumed that 0.73GW of installed wave energy capacity could be operating by 2020, with 0.57GW of tidal stream capacity installed. Combined they could produce around 3.4TWh.

It should be noted, however, the Carbon Trust[54] has also made projections regarding deployment. It estimates that 3.5GW of installed marine capacity could exist in Europe by 2020, with a substantial proportion deployed in the UK. The report proposes that 3% of UK energy demand[55] could be met by marine energy by 2020. As Scotland consumes around 10% of UK electricity, this would translate to around 1TWh of electricity produced by marine projects by 2020. However, a substantially greater proportion of the capacity is likely to be installed in Scottish waters.

HYDRO

Hydro power will continue to make a strong contribution to Scotland's electricity supply. As we noted above there is limited new potential for hydro in Scotland but resource estimates[56] suggest there is scope to develop a further 500MW of capacity. However, there is nothing to suggest that developers are currently looking to develop anything like this scale and for the purposes of this report we have assumed a conservative additional capacity of 50MW to the 1450MW operating by 2010. More difficult to measure is the level of installations of small scale hydro. Using the SES statistics we assume 300MW, no net change from 2002.

54 Carbon Trust (2006) Future Marine Energy.

55 Equating to almost 10TWh of UK electricity consumption, by 2002 levels (Scottish Executive, 2006).

56 Scottish Executive (2001)

Therefore, Scottish hydro projects operating in 2020 will in a normal year generate 4.69TWh, 12% of Scottish demand for electricity.

BIOENERGY

The SDC[57] report estimates that the potential annual wood fuel resource available to the bioenergy industry by 2020 will be in the region of one million oven-dried tonnes (1m odt). FREDS BEG estimates that approximately 2.7m odt will become available by 2020, equating to 440MWe of installed electrical capacity. However, there is likely to be additional demand from existing industries for this surplus. Taking account of this, the wood fuel resource is estimated to be in the region of 1.7m odt (including a small proportion from northern England).

By taking into account the many other forms of biomass[58] not included in these figures and the potential for increased availability of wood resource and imported biomass resulting from favourable market conditions, the potential for bioenergy generation could be substantially greater, and nearer the quantity estimated by FREDS.

As stated in the FREDS report, the optimum situation for the future biomass industry in Scotland would be the development of a mature market comprising bioenergy schemes at all scales: small-scale heat, medium-sized heat and CHP, and larger scale power plants (including co-firing[59]). The greatest efficiencies come from converting the fuel into heat, so it is projected that the bulk of the market will be made up of heat and CHP. A small number of medium to large-scale electricity-only schemes (utilising low-grade heat where possible) may be established in the short to medium term, serving to accelerate the development of supply chains which would be useful in the development of heat plants.

BIOMASS FOR ELECTRICITY

Using the FREDS model of a mature, diverse market it is projected that at least 100MWe of installed capacity could be developed by 2020, using around 0.6m odt of biomass resource (including projects expected to be operating by 2010). This would generate around 0.74TWh of electricity each year[60]. Energy capture could be significantly greater if the excess, low-grade heat generated is used for industrial heating processes.

BIOMASS FOR CHP

Due to the limited opportunity for CHP plants, it is projected that up to 75MW of total installed capacity, from around five CHP plants, could exist by 2020. This could generate 0.49TWh of CHP, using 0.12m odt of wood fuel[61].

BIOMASS FOR HEAT

By allocating 1m odt of wood fuel for the use of small-scale heat in Scotland, the SDC calculates that this could provide up to 2.7TWh[62] of domestic heating. It is unclear whether this figure includes the biomass already directly used for energy[63], but this would take the projected heat generation figure up to 4.2TWh.

With the above projections for electricity, CHP and domestic-scale heat using the estimated 1.7m odt of available wood fuel, this leaves a substantial proportion of additional biomass resource available for larger-scale heat plants[64]. However, due to the lack of resource figures available, an estimation of energy generation from such sources is not included in this projection.

BIOFUELS FOR TRANSPORT

Assuming that the 2010 RTFO target is reached, it is projected that the RTFO could set a target for 2020 of 10% of transport

57 Sustainable Development Commission Scotland (2005)

58 Additional biomass resources include clean recycled wood, increased planting of energy crops, agricultural/animal waste, sewage sludge, biodegradable municipal solid waste, industrial waste (e.g. from distilleries), etc. Very little information is available on the current and potential extent of these resources.

59 A substantial proportion of biomass used in co-firing is imported from abroad, so is not included in this report.

60 Using a capacity factor of 85% for large plants (Carbon Trust, 2005)

61 At 80% conversion efficiency, and 75% capacity factor (Carbon Trust, 2005)

62 Using a seasonal thermal efficiency of 65% and 0.38odt per 1MWh of heat.

63 Equating to 2.95TWh in 2002 (Scottish Executive, 2006, p41), but reduced to 1.48TWh for this report, as explained in the commentary for 2010.

64 The energy content and thus conversion efficiencies will vary depending on the type of biomass fuel used, however the wood fuel conversion figures act as a reasonable average. Using an estimated figure of 1m odt (wood fuel equivalent) of biomass, at 85% conversion efficiency, around 3.9TWh of heat could be generated annually. Using an average 60% capacity factor for a mixture of medium to large-scale heat plants, the installed capacity would be in the region of 750MWth.

fuels sold to constitute renewable fuel. This would translate into 3.5TWh of annual consumption, equating to 7.5% of total transport energy demand in Scotland, at 2002 demand levels. This would translate into an emissions saving of 1.5MtC.

According to the Department for Transport[65]:

"Today most biofuels come from crops like oilseed rape and wheat, which can be mixed with petrol and diesel and run in ordinary cars. In the future we could see more advanced biofuels made from waste and possibly even renewable hydrogen."

However, the Energy Saving Trust concluded in its road transport report[66] that:

"Hydrogen from renewable electricity sources for a mass market vehicle application is likely to be insufficient for at least 30 years, but significant transitional benefits can be secured from bi-fuelling and from dedicated depot based fleets meeting niche markets, including using hydrogen derived from gas".

In total, combining both generation from bioenergy and consumption, the biomass sector could account for as much as 8.9TWh.

MICROGENERATION, HYDROGEN, STORAGE AND ENERGY SAVING

The Energy Saving Trust has studied the potential of microgeneration and concluded that by 2020 a mass market in microgeneration is unlikely to be established based on current policy[67].

There is little doubt that there is currently increased public interest in microgeneration but high cost and other barriers may limit installed capacity to less than 100MW equivalent by 2020[68], although there is considerable uncertainty as to the rate at which microgeneration markets will develop. As explained earlier, for the purposes of this model, microgeneration will be considered as energy saving devices displacing gas and electricity that would otherwise use transmission networks.

Large centralised generating plant will continue to dominate but there may be an increasing number of district heating networks, and microgeneration market penetration will gradually increase from 2020, with micro-wind, micro-CHP and solar technologies becoming more widespread.

Further development of variable renewable sources in Scotland, combined with the need for increased system balancing and distributed generation may require the development of further pumped storage capacity to provide balancing plant. Market signals would have to change however, if we were to see sufficient economic incentive to invest in new pumped storage, and alternative load management and storage solutions may prove more viable alternatives.

While it is hoped that fuel cells, hydrogen and storage technologies will have advanced by 2020 there are still significant technology developments and cost reductions required for significant take up by 2020. Predicting progress by 2020 is highly uncertain.

As discussed in the bioenergy section, wood fuel could provide around 2.7TWh of domestic heating by 2020[69]. It is unclear whether this figure includes the biomass already directly used for energy[70], but if not, this projection could be significantly higher, and nearer 4.2TWh.

One key conclusion from the EST report is that heat pumps and solar heating could provide up to 10.7TWh eq[71] of heat in the UK by 2020, if the necessary policy interventions

65 Department for Transport (2005)

66 Eyre et al (2002) Fuelling Road Transport, p57.

67 Energy Saving Trust (2005)

68 100MWe would still equate to around 80,000 and 100,000 installations in Scotland.

69 Sustainable Development Commission Scotland (2005)

70 Equating to 2.95TWh in 2002 (Scottish Executive, 2006, p41), but reduced to 1.48TWh for this report, as explained in the commentary for bioenergy.

71 Energy Saving Trust (2005), Potential for microgeneration – study and analysis,

are put in place now. Analysis of these figures in a Scottish context indicated approximately 1% of heat needs (1TWh) could be met by heat pumps and solar thermal panels by 2020.

Therefore, in total, Scottish Renewables estimates that renewable microgeneration could generate as much as 5.2TWh of heat by 2020, equating to 5% of Scotland's heat demand, with the required policy support.

In addition, other microgeneration sources could make a significant contribution to reducing heat demand and CO_2 emissions by 2020. In particular, micro-CHP and fuel cells could generate around 6.9TWh of heat in Scotland by that year[72], equating to 7.3% of Scotland's heat consumption[73]. However, these projections will not occur with the current policy climate.

CONCLUSION

There are only two targets to assess progress against in 2020 and both are aspirations and both relate to electricity. The 20% UK aspiration may not be achieved even though we anticipate that the Scottish contribution of more than 25TWh will account for 31% of the possible RO. Hitting 20% would require a major roll out of offshore wind around British coasts and according to the BWEA[74] this may not happen within the current policy framework.

As Figure 9 shows, Scotland will continue on its path in reducing carbon emissions. As in 2010, much of these reductions will be due to significant increase in supplies of renewable energy in all sectors and anticipated falls in the demand for heat.

The report assumes an extension of the RTFO. It is currently unclear that there is either the resource or the political will to achieve this. Expectations of the latter will no doubt influence the former.

On the other hand, the 40% Scottish Executive aspirations should be met based on the known appetite for project development. However, it must be recognised that achievement could be frustrated if the 2020 aspirational target is not given a statutory basis through the Renewables Obligation or similar mechanism.

There is, in 2006, something of a strategy hiatus regarding heat, transport and microgeneration and, going by current projections for energy demand, inconsistent results in the strategy to promote energy efficiency.

Yet, by 2020 Scotland needs to be well on the way to a low carbon economy, but signs are that current policy is not looking at this issue in sufficient breadth or depth. Successful delivery in changing the electricity generation mix through introduction of renewable electricity demonstrates what is practical and achievable. However, lack of sufficient policy interventions or market mechanisms - to incentivise action in renewable heat, or further action in renewable transport, alongside the necessity of overall energy demand reductions – could mean that Scotland's initial good progress towards carbon reductions is not built upon.

72 Scottish contribution calculated as a percentage of the projected UK micro-CHP and fuel cell contributions reported by the Energy Saving Trust (2005).

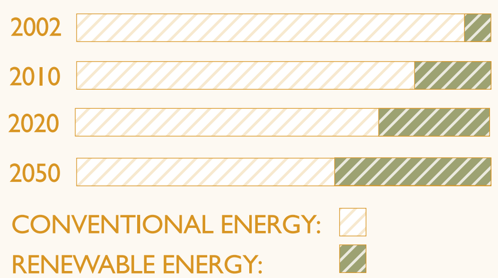
73 Excluding heat from electricity, and based on 2002 demand figures (Scottish Executive, 2006).

74 British Wind Energy Association (2006) Offshore Wind at Crossroads

C.4 ENERGY IN 2050

KEY POINTS: 2050 PROJECTIONS

- Renewables supply between 17% and 30% of all energy demand
- Renewables electricity the principle provider of renewables
- The way we use energy fundamentally different to 2006 with microrenewables and micro CHP mass market
- Decentralised energy networks increasingly the norm following evolution in past 44 years from centralised networks and generation
- Cost effective storage technologies the norm, including biofuels, hydrogen, hydro pumped storage and large-scale batteries
- Carbon sequestration widely in use
- Sustainable transport technologies and public transport use see emissions fall in this sector



INTRODUCTION

It is perhaps worth starting with a defence of what is about to be established. Many a commentator has noted that the only thing certain about future projections is that they will be wrong.

It is therefore important to note that our understanding of energy generation and use in Scotland in 2006 does not properly equip us to make useful projections as far away as 2050. So this report will not try.

Rather this section will work back from what current understanding of climate change impacts and emissions tells us must be achieved by 2050. Using scenarios developed by the Royal Commission on Environmental Pollution (RCEP) in its energy report of 2000[75] this report outlines what needs to be done if Scotland is to reduce its carbon emissions by 60% by 2050.

The UK Government has committed the country to reducing carbon emissions by 60% by 2050 if it is to play its part in stabilising carbon levels in the atmosphere. However, the RCEP notes that it is likely that there will be a need to make even deeper cuts of 80% by the end of the Century.

Previous sections in this report used a simple arithmetical approach that projected expected demand for energy in 2010 and 2020 and the expected generation of plant in both of those decades. Supply and demand in the electricity sector was balanced with shortfalls being taken up by coal fired power stations or imported electricity.

THE RCEP SCENARIOS

RCEP developed four scenarios for the UK energy sector. Scenario One assumed no reduction in overall demand for energy on 1998 levels and that supply met demand with a massive roll out of new nuclear power stations, fossil fuelled plants with carbon sequestration and renewables. Scenario Four involved a 47% cut in demand on 1990 levels with fossil fuels meeting the demand for transport

75 RCEP (2000)

and peak load in the electrical system but renewable electricity meeting the bulk of the demand for electricity.

Scottish Renewables, felt that a 47% cut in demand for all energy (Scenario Four) was difficult to achieve given current growth projections. Similarly, Scottish Renewables felt that Scenario One's option of promoting no cuts in overall energy demand on late 1990s levels but meeting it with a massive roll out of low or no carbon generating technologies was inappropriate.

However, it should be noted that if 36% cuts in aggregate demand do not materialise then there will be a requirement, among other measures, for new plant build that has zero carbon emissions to ensure that both energy demand was met and that the 60% cuts in emissions were achieved.

Scenarios Two and Three covered the middle grounds between Scenarios One and Four and for the purposes of this report have been used as a basis to describe possible options for Scotland's energy users and generators.

Whilst taking the middle ground deliberately demonstrates what is achievable it should be noted that Scenario Four would be achievable if an outstanding effort was made on all fronts.

For both Scenario Two and Three to be viable there is a requirement to cut the overall demand for energy by 36%.This would be 50% lower than demand levels if historical growth trends continued from 1998 to 2050. There is also the acknowledgement in these scenarios that economic growth will continue to be a feature of the UK economy.

The historical trend of decreasing energy intensity is likely to continue and the adoption of Scenarios Two or Three should not hamper economic growth in Scotland.

Both scenarios included reductions of 25% in the demand for transport, electricity and high grade heat (e.g. industrial processes). It also assumed a 50% reduction in low grade heat (e.g. space heating). Both scenarios also assumed that with no technical solutions in removing peaks in demand for electricity gas fired plant would still be available to ensure that demand was met, although it noted that by 2050 more intelligent means to manage and control demand are likely to be available.

These scenarios also assumed that fossil fuels would also be used in CHP plant - especially at the micro level - to power high grade heat processes in industry. Oil would still be the principal way to power transport although there could be hydrogen fuel cells in use.

The RCEP also scope out the beginning of a shift away from centralised power networks: ongoing development of decentralised generation will mean increasingly lower reliance on larger centralised generation stations, and an increasing mix of our energy needs being met from dispersed sources such as renewables.

It is important to note that this will not result in the need for less grid or networks, but different use of our network, and certainly a more efficient use of this network. Primarily, a move to a decentralised network means spreading the sources of generation so that households and businesses contribute to overall energy needs, and that our distribution and transmission systems are more integrated and actively managed as one overall national unit, as well as more regional sub-units.

The development of decentralised networks will require investment in active load management technologies so that greater penetration of renewable sources can be matched with loads able to respond to peaks in generation.

Technologies are now becoming available to allow more active and intelligent network management, but it needs to be recognised that implementation will be by gradual change and adaptation. Given that grid systems have an expected operational life of 40 years, and much of Scotland's infrastructure was built between the 1960s and today, almost all of our infrastructure will need replacement in one form or another by 2050. We foresee that the major shifts in how we use our network coming early on in the period 2020 to 2050. The scale of this investment will be significant, but needs to be seen as part of the necessary investment in a functioning and developing economy. The development and evolution of our energy networks represent only 1% of our overall economy, but without this, much of the remaining 99% could not function effectively. Our research has shown that the generation mix can and will change over time to ensure that carbon emissions are reduced, and to provide future energy supplies, provided that the necessary infrastructure is also in place to facilitate this long term change.

APPLYING THE RCEP SCENARIOS TO SCOTLAND

The difference in the two RCEP scenarios we have chosen to focus on lies in the alternative ways they predict demand for electricity would be met.

This report takes the same proportions used for the UK as whole in the RCEP report and then applies them to Scotland. The intention of this section is not to provide an accurate picture of how energy will be used or generated in Scotland in 2050, but rather to explain some of the strategic options available to us if we are

(Fig. 11): RCEP Scenarios for 2050

The Renewables Scenario in Scotland in 2050

FOSSIL FUELS: 78.4 TWh eq
VARIABLE RENEWABLES: 19 TWh eq
OTHER RENEWABLES: 15 TWh eq

Source: Scottish Renewables

The Baseload Scenario in Scotland in 2050

FOSSIL FUELS: 78.4 TWh
VARIABLE RENEWABLES: 12.6 TWh eq
BASELOAD: 14.6 TWh eq
OTHER RENEWABLES: 6.8 TWh eq

Source: Scottish Renewables

to cut emissions by some 60% by the middle of this century. Applying Scenario Two to Scotland shows that electricity demand would be met by renewables, with a combination of variable and firm power sources, and a proportion of fossil fuels. .

Based on the 1998 aggregate demand for energy and then applying the 36% cut in demand – Scotland would need an overall energy supply of some 112TWh. Fossil fuels would supply 78.4TWh, variable renewables 19TWh and firm renewables 15TWh.

The 34TWh required from renewables would be some 10TWh greater than that which this report projects for 2020 but accounting for 30% of all energy use.

Scenario Three, or the 'baseload scenario', calls for the build of new nuclear power stations, or, if that is considered politically unacceptable, the development of fossil fuelled power stations that sequester all associated carbon emissions.

For Scotland, with the demand for overall energy at 112TWh the renewable contribution of 19.1TWh would be significant. Baseload capacity, using either new nuclear power stations or fossil fuel power stations with sequestration to capture carbon emissions would need to generate 14.6TWh to help balance supply and demand.

Given these numbers what might this mean for Scotland and Scots on the ground?

A VISION FOR SCOTLAND

The way we use transport will have been transformed. There will still be significant private car use and flights taken but engines will be much more efficient than they are now. As well as the increased use of biofuels in engines, hydrogen fuel cells will become established and use of public transport will need to be higher.

Perhaps the most visible and dramatic change will come with microgeneration. The Energy Saving Trust[76] expects buildings to generate (in aggregate) as much as 25% of their electricity needs and 40% of their heating needs 'in-house' by 2050.

By 2050 there will be a significant number of decentralised energy networks generating heat and power close to demand and good progress made in replacing Scotland's existing housing stock with highly efficient homes. Households across Scotland will be powered by a range of microgeneration technologies, including micro-CHP, micro-fuel cells and micro-renewable devices such as solar water heating, heat pumps and micro-wind turbines.

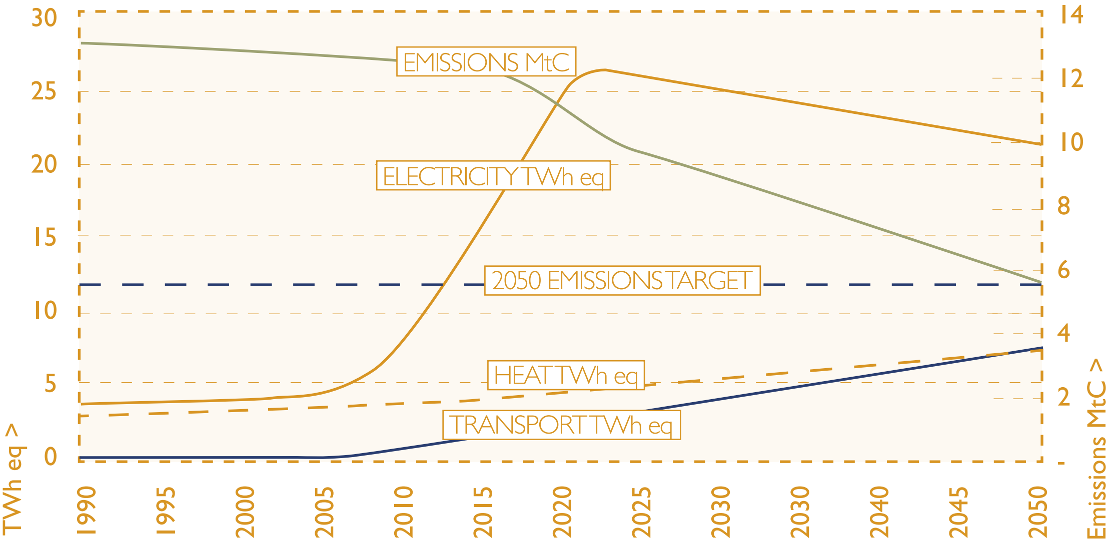
The impact on the heating and electricity networks will be significant with the demand on centralised electricity plant and gas networks significantly reduced.

It is assumed that the development of biofuels and bioenergy is unlikely to go beyond 2020 levels due to competition for forestry and agricultural resources, and a ceiling on the total biomass resource available. However, developments in fuel cell technologies from 2010 to 2050 may mean that biofuels become a feedstock for fuel cell motors, and act as a bridge to longer term development of hydrogen fuel supplies generated from large scale renewable electricity projects. Successful commercialisation of hydrogen and fuel cells may trigger further interest in large scale renewable electricity schemes in Scotland, to power hydrogen production. Given the probable large scale of such production. Scheme development would need to focus on larger scale marine based generation such as wave, tidal and offshore wind.

Decentralised energy networks will become an integrated part of our gas and electricity networks, with many communities generating their own heat for all space heating.

76 Energy Saving Trust, 2006

(Fig. 12): Renewable Energy Consumption in Scotland & Energy Sector Carbon Emissions 1990 to 2050



Source: Scottish Renewables

International experience already shows this is possible and already in Scotland some examples have been working for several years.

There will still be the need for major generating plant for electricity. As noted above, this will involve a significant amount of renewables embracing a broad basket of technologies with significant electricity generation from wave, tidal, wind – on and offshore – hydro and biomass.

There may also be a decision by policy makers to include some fossil fuelled or nuclear baseload plant. Clean coal technology will have been well established by 2050 globally and is likely to play its part in Scotland. The emissions from these plants will be sequestered and stored underground in empty gas and oil reservoirs in the North Sea. Alternatively, a new fleet of nuclear power stations, emitting no carbon at the point of generation but creating radioactive waste, could be commissioned.

There is also great potential in storage facilities. Electricity in Scotland is currently stored in two large hydro pumped storage facilities which are switched on when there is a peak in demand. It is possible that compressed air storage technologies could be used. In addition there is some potential in developing hydrogen storage facilities and there are already prototype facilities in Shetland and Norway up and running successfully. Lastly, there is currently a significant level of research and development spending in new battery technologies and the energy sector could see sizeable units being developed and used alongside variable sources of power.

By 2050 Scotland could be a renewable energy powerhouse exporting green electricity and green technologies all over the world. Already there is discussion and debate about a European supergrid[77] enabling a wind farm on Lewis to theoretically supply power to bakers in Paris, or a hydro station in Norway to power the manufacture of a wave power machine in Methil.

Clearly there are a number of tools that can be used to deliver a low carbon economy. The above includes only two possible outcomes.

77 This idea was described at Scottish Renewables' annual conference in 2006.

C.5 CONCLUSION

The fact that Scotland has an abundance of renewable resources is something that is commonly understood throughout Scotland. Whether or not people are familiar with the mechanical and engineering challenges required, they understand one simple truth: that Scotland has plenty of weather.

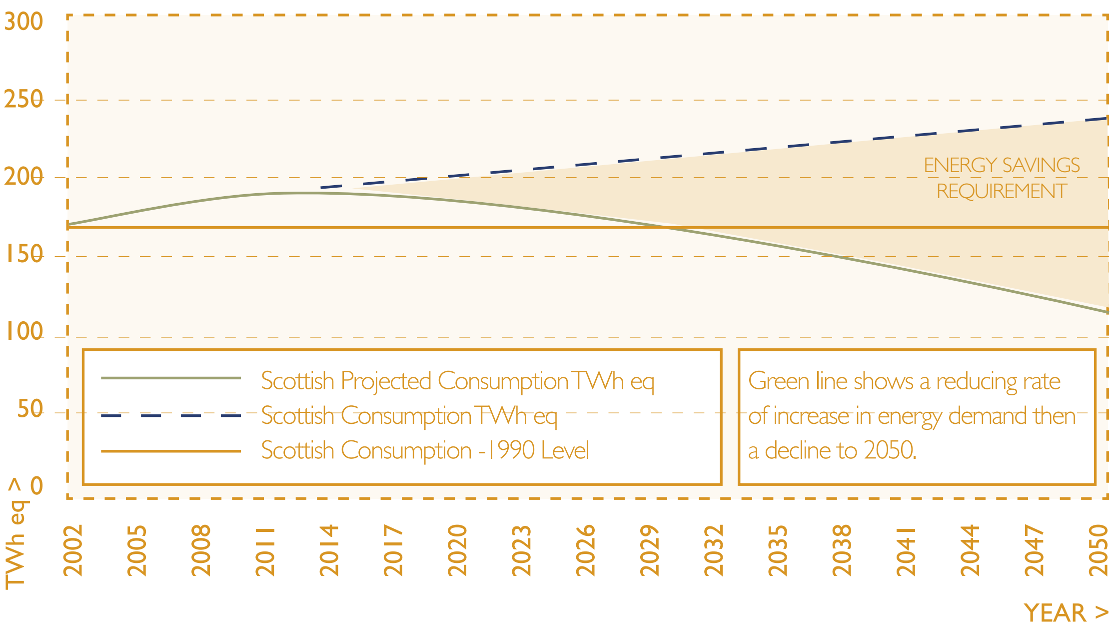
On one level *Delivering the New Generation: A Route Map for Scotland's Renewable Future* merely confirms this fact. It confirms that Scotland's abundant resource means we can deliver on the targets set by the Scottish Executive, while also making a significant contribution to the wider UK renewables targets.

Whether it is using the rain that falls to power our hydro stations, using the wind that blows across our land and seas to power wind or wave turbines, using the power of the sun to grow trees and other crops for energy, or harnessing the power of the tides that courses around our coastline, we have an unrivalled resource and should be doing more to release this potential.

However, more fundamentally, our Route Map proves that the Scottish Executive was right to back renewables, because renewables can be developed quickly to tackle carbon emissions and to help fill a future energy gap. Our analysis shows that the Scottish Executive's 2010 target, that 18% of electricity will come from renewables, should be met three years early in 2007. More revealing is the fact that by the end of 2010, over 30% of Scotland's electricity needs will be met by renewables.

The fact that this could be done using existing policies and with conservative assumptions about planning success rates

(Fig. 13): Energy demand in Scotland to 2050 to meet 112TWh eq Target



and development of new infrastructure demonstrates that Scotland has successfully brought together political will and industrial know-how to develop a new sector and hit a government target in record time. It also means that we no longer need to see existing policy as ambitious and stretching but instead as realistic and based on fact.

Looking further ahead to 2020, our analysis shows that Scotland could surpass the 40% target, and could easily provide over half of its electricity from renewable sources. Importantly we expect to see bioenergy, offshore wind, tidal-stream and wave energy making strong contributions to our future electricity needs.

Longer term projections are obviously hazier, but looking ahead to 2050 we have been able to highlight the role of renewables in meeting the 60% carbon cuts set by the UK Government.

But this will be only for electricity. Heat and transport are larger energy needs, so we must also look to what renewables can contribute here. The establishment of the Renewable Transport Fuel Obligation should see delivery of 5% renewable transport fuel by 2010, and we highlight that 10% of our transport fuels could be coming from renewables by 2020.

Our research also highlights the elephant in the room which is our energy use in heating. Heating needs account for over half of our energy use in Scotland, but little has been done to support the development of renewable heat fuels. However, our assessment of what resource is available highlights the fact that by 2020 over 10% of our heating needs could come from renewable and microgeneration sources.

This set of strong positive projections for renewables is good news for Scotland and the Scottish Executive. Our research demonstrates that renewables can deliver, providing that policy remains stable. Moving forward, all that will be needed is a gradual evolution of support, to bring in new technologies and markets.

And it will be this overall evolution that is important. For 2010 our research shows that hydro and onshore wind will make the largest contributions, but by then we will be seeing the first signs of development in offshore wind, bioenergy and marine. Between 2010 and 2020 we expect these technologies to come to the fore, and make an important contribution to electricity needs, and so push the renewables contribution beyond 50%. Between 2010 and 2020 renewables will also be contributing more to heat and transport needs. Beyond 2020, microgeneration and distributed networks will become the norm, and a hydrogen economy should start to emerge.

If all this happens, Scotland will be on track to make significant carbon cuts and deliver the 60% CO_2 cut needed for 2050, while minimising any future energy gap. Our *Route Map* signals the direction we need to travel in.

Government policy has effectively got the renewables sector on its way: to see us reach our final destination we will need careful evolution of this policy rather than a sudden u-turn, so that the emerging technologies can play their part and so that we can also begin to cut our emissions from heating and transport use. Scotland though can be confident of having the means to reach this low carbon future in a fit and healthy state.

As our *Route Map* highlights, we have the resource, our politicians have the political commitment, and industry has the resourcefulness to deliver. All things considered, our low carbon future is waiting for us. All we need to do is continue one step at a time to reach this desired destination. We hope that this *Route Map* will help to show the path forwards.

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SCOTTISH renewables
The Forum for Scotland's Renewable Energy Industry

About Scottish Renewables

Scottish Renewables is Scotland's leading green energy body with a membership of over 180 organisations involved in making renewables a reality for Scotland.

Scottish Renewables supports the development and provision of a sustainable energy future for Scotland. Sustainable energy comes from sources that are safe, clean and renewable, and which should also be secure, diverse and competitive. Scottish Renewables therefore promotes the effective use of Scotland's abundant biomass, geothermal, hydro, solar, tidal, wave, and wind resources to generate social, economic and environmental benefits for all.

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Scottish Renewables Forum
Central Chambers
93 Hope Street
Glasgow G2 6LD

T: 0141 222 7920
F: 0141 222 7929
E: info@scottishrenewables.com
W: www.scottishrenewables.com

0141 572 0810