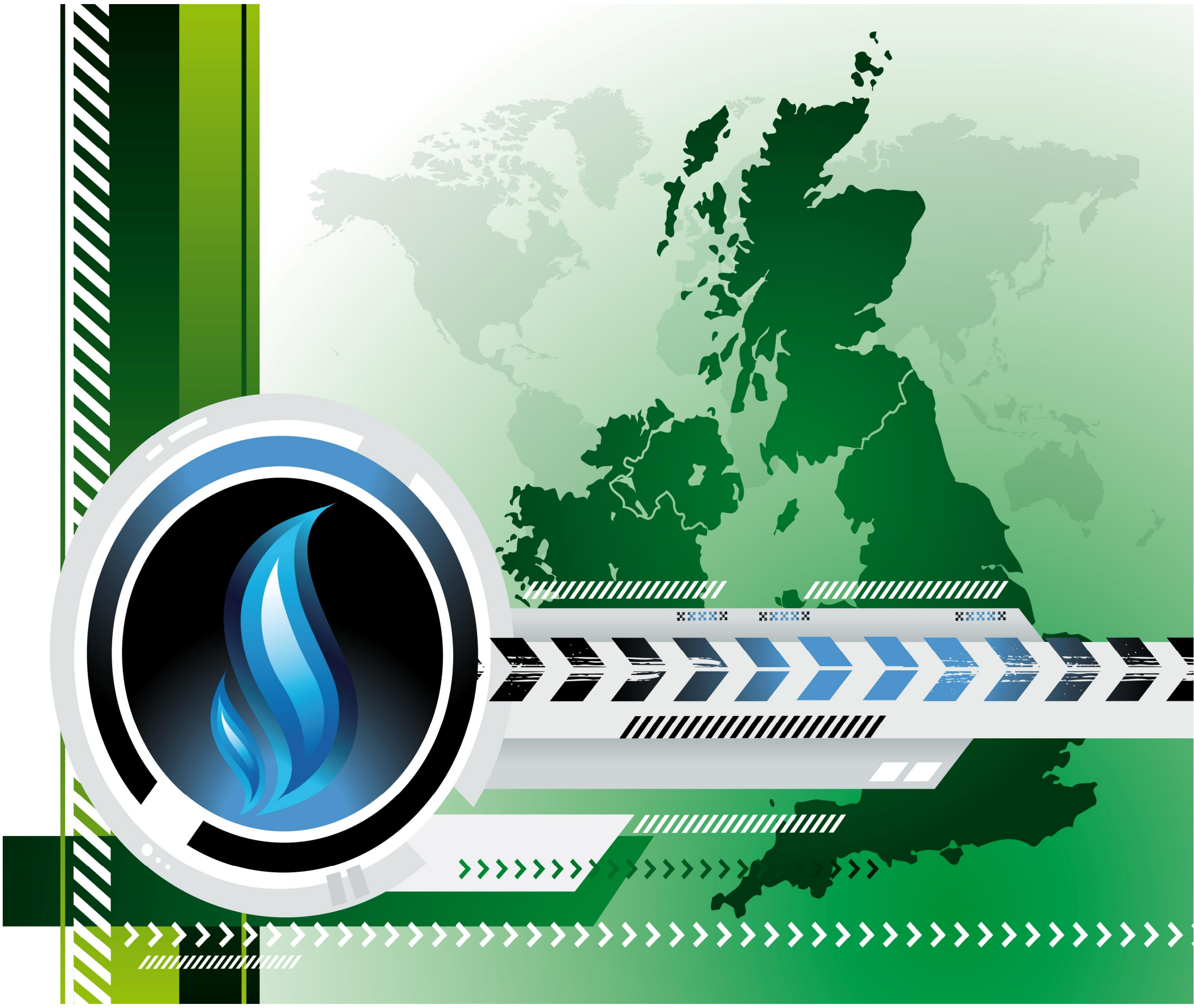
GAS: AT THE CENTRE OF A LOW CARBON FUTURE

A review for Oil & Gas UK

September 2010



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Pöyry Energy Consulting is Europe's leading energy consultancy providing strategic, commercial, regulatory and policy advice to Europe's energy markets. The team of 250 energy specialists, located across 15 European offices in 12 countries, offers unparalleled expertise in the rapidly changing energy sector.

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EXECUTIVE SUMMARY

The challenge

Energy policy has to balance security of supply, affordability and the challenge of climate change. The EU and the UK rightly remain committed to significant reductions in carbon emissions, as the plethora of policy targets in this area indicate. More specifically the UK is committed through the Climate Change Act to deliver an 80% reduction in greenhouse gases between 1990 and 2050, to meet its share of the EU's 20–20–20 programme, and in particular meet the UK's 15% renewable energy target by 2020.

Even with these strong commitments, there is ongoing discussion at an EU level over the desirability of a move to 30% reduction in CO_2 emissions by 2020.

In order to meet the various targets one thing is certain – if Britain is to establish a secure, affordable, sustainable and low-carbon future it will require a fundamental change in the way in which we produce and use energy, and it is the electricity supply sector that is expected to make the lion's share of the emission reductions.

The challenge for government is to find a way to deliver this long-term shift in a way that minimises risks to security of supply and affordability. Delivering a low carbon world at a price that significantly increases the numbers of people in fuel poverty or at higher relative prices to other countries will adversely affect our wider industrial competitiveness.

The Pathways

Any vision of a low carbon future relies heavily on three characteristics: deployment, innovation and changes in consumer behaviour.

Most carbon-compliant energy pathways and scenarios being advanced, whether by government in its 2050 Pathways Analysis or the Committee on Climate Change in its annual reports, combine electrification of heat and transport with rapid decarbonisation of the power sector (driven by major growth in renewable generation) and significant improvements in energy efficiency. Such a vision relies heavily on:

- extraordinary rates of deployment – for example high build rates for renewables of up to 3GW per annum over a sustained period (only 1 GW was built in 2009), requiring facilitatory expansion of and connections to networks and very large capital expenditure;
- highly successful technical innovation – emergence of smart grid systems, electric vehicles at scale and rapid commercialisation of CCS; and
- dramatic changes in consumer behaviour – a willingness to adopt new technologies such as electric vehicles, solar panels, heat pumps, and use energy in a more responsive and energy efficient manner.

The risks with electrification

Although all energy pathways rely to a greater or lesser extent on successful deployment, innovation and behavioural change, there are significant risks along the current consensus of an 'electricity focused' pathway. These include:

Supply Chain – with large scale renewable build, new nuclear power stations and a major expansion in electric grid infrastructure (both offshore, mains transmission and within homes) required, there is an enormous challenge in putting together the resources, capabilities and skills required.

Funding – the sums involved are stretching (in the order of £200bn by 2020 and 400bn by 2050) and there are questions over the ability of the market players to raise the necessary debt or equity funding.

Innovation – many of the potential new technologies remain at an early stage of development. For example, CCS is not proven on the scale required and the smart grid concept has not been tested. Expanding electricity to a peak demand in the region of 110GW (compared with 60GW today) to replace much of the current heating supply (e.g. gas in 80% of homes) and for use in transport will require rapid and sustained progress in all forms of the 'electric' future.

Security of Supply – based upon various substantive analysis we have undertaken we believe there is a greater risk of the 'lights going out' through insufficient power generation and increased peak forecasts than any concerns over security and price from rising fuel imports. Renewable generation is mostly intermittent in nature so will require sufficient flexible generation capacity to balance the system. Flexibility from nuclear stations is not proven and CCS costs may limit its contribution. Without an electricity market that correctly values flexibility, there remains a risk that it will not be delivered.

Affordability – many of the pathways rely heavily on improved energy efficiency so that consumers can pay a higher unit rate for energy in order to fund all this major investment referred to above. Unless changes in consumer behaviour deliver their side of the equation we will see a substantial rise in the numbers of consumers in fuel poverty.

Gas is a lower risk alternative

Gas has been the foundation for a large part of the UK's success in meeting Kyoto carbon reduction targets enabling the economy to both increase energy consumption (and hence maintain economic growth) while delivering carbon reductions. It has also contributed to improved competitiveness, greater security of supply and better air quality.

However, there have been concerns raised about the risk of gas interruptions and/or increased prices as the UK moves into an environment where it will need to import more and more gas. Recent studies by Pöyry, and supported by DECC, concluded that there are no major security of gas supply concerns as Britain increases its gas imports, so such concerns are misplaced. We also survived the coldest winter in over 30 years in 2009/10 with plenty of gas available and no impact on the wholesale price.

Yet gas hardly features in policymakers' outlook. The reason for this is not clear. As the CCC acknowledge 'switching from coal to gas generation can also achieve a significant one off reduction in emissions'. CCGTs are cheaper to build and emit 45% less CO_2 than unabated coal power stations. Such a move would provide the flexible generation required to balance the deployment of intermittent renewables in the interim and then, through adoption of gas CCS, could also be an integral part of the long-term low-carbon generation future.

This alternative plan would give time to establish supply chains for renewable technologies and develop and commercialise other technologies, such as CCS, district heating, micro-generation and large-scale biomethane. This approach may not only relieve the time pressure to develop new technologies; by delaying the need for early investment, it can also reduce funding issues in the short-term.

These options mean there is **no need to reinvent the wheel**. Continued use of gas allows technologies to develop, it can make much better use of heat recovery from electricity generation and could result in a lower cost solution, as much of the existing infrastructure is already in place.

Conclusions

Policymakers efforts to move the country to a low carbon future have resulted in a confusion of targets. Whilst the need to set targets as part of the move towards a low carbon world is recognised, there appear to be too many and not all are complementary. The resulting confusion is not sending the correct investment signals to the market, as evident in continuing delays in new investments.

Current policies and pathways to the future see a solution involving a major electrification programme. However our review has identified that this route carries enormous risks and failure of any stage should not be discounted by policy makers. There is much uncertainty on when the different elements of the solution can contribute to reducing carbon intensity. Early targets do not mean they will be achieved and panic-style measures to deliver are to be avoided , as these will likely increase the costs and may not have the desired effect.

Our view is that a deliberate policy to reduce gas' share of the energy mix represents a flawed pathway for society to progress towards decarbonisation. Policymakers should present an unbiased set of technologies to market investors including gas CCS, CHP, district heating and biomethane. By doing so, markets will be able to choose the mix of technologies and energy sources that best ameliorate the risks and uncertainties of meeting the long term carbon targets in the most secure and affordable way for consumers.

Recommendations

Government policy needs to focus more strongly on achieving carbon reductions by 2050. In order to reach the longer term target the government should properly consider all the weaknesses in its plans, and incorporate appropriate fallbacks and contingencies to reduce the obvious risks.

Foreclosing certain technologies or fuel sources that may be able to support a low-carbon transition does not make sense. We need to keep our options open and this includes gas. Government should review its current policy framework to ensure gas-based investments can be appropriately rewarded for their contribution to meeting policy targets. Whether a far more realistic alternative would see more gas used not only in the transition but also in the endgame is for markets to decide.

We believe the priority attached to the 2020 renewable energy target should be reviewed and a more realistic timescale set. Not only is the target likely to be missed, it also appears to be a distraction to achieving the longer-term carbon targets and may result in increased costs and/or security of supply concerns.

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1. INTRODUCTION

Admirably, despite current economic conditions, both the EU and the UK remain committed to significant reductions in carbon emissions and the power generation sector is expected to make the lion's share of such a reduction. Targets have been set relating to the amount of renewable energy there should be in the energy, and by implication, electricity mix and there are various EU directives aimed at reducing the environmental impact of electricity generation.

Despite the many targets, the road to achieving them is far from clear. Many advocate that renewable generation, together with improvements in energy efficiency, can deliver the targets without the need for any expenditure on nuclear or fossil fuel power stations. Indeed, such expenditure is often claimed to be at the expense of a renewable alternative. For example, in its letter to the Department for Energy and Climate Change (DECC) on 9 September[1], the Committee on Climate Change (CCC) stated that 'the national policy statements provide an opportunity to address the risk that continuing investment in unabated gas generation will displace investment in renewable and other forms of low-carbon generation'.

Some argue that without ambitious targets the tendency will be to say change is too difficult and expensive and result in insufficient action. Others hold very different views on practical ways forward and of the risks involved. This was again reflected on by the CCC 9 September letter to DECC when the Chief Executive David Kennedy said 'Ensuring that more of the energy we use is from renewable sources is vital for meeting carbon budgets. The current target is desirable, but there are significant risks around achieving it. We do not see any merit in raising this target further. Instead, government should focus its efforts on meeting the current target, in particular by providing the right incentives to encourage investment in renewable energy projects in the UK'.

The UK is on target to achieve its Kyoto commitments mainly because of the major expansion of gas-fired power generation in the 1990s. Its widespread use of gas in heating homes and businesses also gives it a lower carbon footprint than many other countries. However, many policy makers and lobbyists seem to envisage no future for gas in the low carbon world of 2050.

Oil & Gas UK is the leading representative body for the UK offshore oil and gas industry. It has commissioned Pöyry to consider the challenges that the energy industry faces in moving to a low carbon world and to evaluate what, if any, role natural gas might play in the transition.

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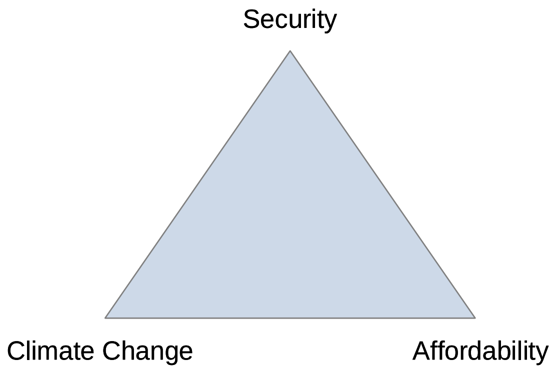
1 http://downloads.theccc.org.uk.s3.amazonaws.com/Renewables letter Sept2010/ LetterDavidKennedy_ChrisHuhneMP_090910.pdf

1.1 Energy policy objectives

When considering the challenges into the future it is worth remembering that government has set out three key objectives for energy policy to measure their success: energy security, affordability and reduced carbon emissions.

As we go through this review we will be considering the potential options being proposed and how they perform in meeting these objectives.

Figure 1 –Energy policy objectives



1.2 The scale of the low-carbon challenge

If the UK is to have a secure, sustainable, low-carbon future it will require a fundamental change in the way in which we produce and use energy. This is especially true when we consider what needs to be done in order to achieve the 2020 and 2050 carbon and renewable targets. As Figure 2 overleaf shows, over the next 40 years we will need to reduce the emissions of CO_2 by nearly 4 times that achieved in the last 20 years.

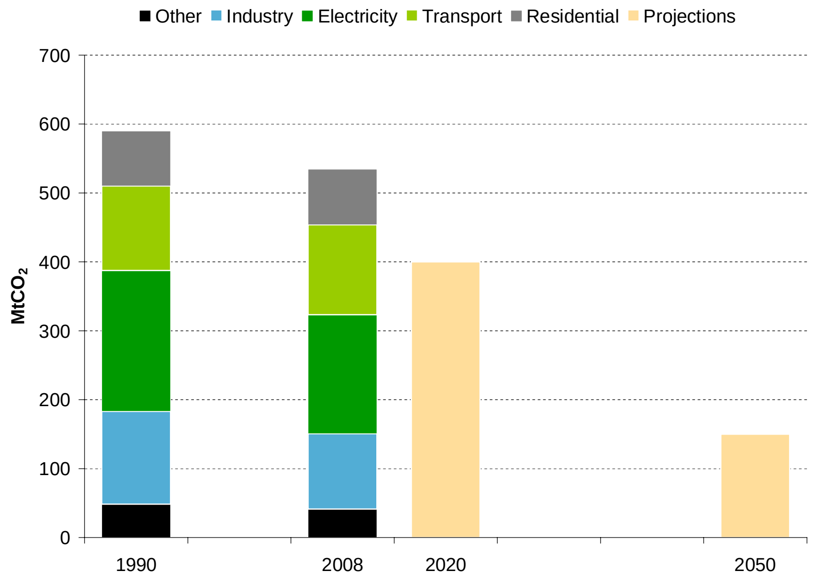
Successes to date have been in:

- electricity, which reduced annual emissions between 1990 and 2008 by 40MtCO_2 (16%) while electricity demand grew by 65TWh (or over 23%). This was achieved mainly by replacing coal-fired power stations with gas–fired combined cycle gas turbines (CCGTs) – in energy terms around 40% of electricity is now generated from gas; and
- industry, with annual emissions reduced by over 30MtCO_2 (19%), reflecting both improvements in process efficiency and the contraction of the manufacturing sector.

However, other sectors have actually increased, e.g. transport, despite the move to more efficient vehicles. Any improvements from energy efficiency of residential heating and lighting have been negated by increased use of more gadgets and white goods.

The transformation has to take place in a market that is still recovering from the financial crisis and credit crunch and where pressure on the two other objectives of energy policy – security and affordability – is rising. It is idealistic to want a low-carbon, low-risk, low-cost energy system, but there are inevitable trade-offs in the choices that must be made; governments and market participants will have to choose.

Figure 2 – The scale of the challenge



Source: DECC, Committee on Climate Change

In a spate of recent publications, various public bodies have published their views on the way in which the longer term targets can be achieved, and it is worth noting their arguments.

As a prime example, on 27 July 2010 the DECC published its 2050 Pathways Analysis. It detailed a number of potential routes (or pathways) for meeting a target of an 80% reduction in carbon emissions since 1990.

The publication had similarities to many other publications in that all pathways rely and depend on either commercialisation of unproven technology or unprecedented deployment of existing ones – or both.

While it examined the pathways' robustness to failure of individual technologies in delivering each pathway, it does not address ways to reduce the risk, despite recognising the scale of the challenge.

DECC also stressed the importance of both the other two main objectives, affordability and security of supply, as being critical parts of any truly viable carbon reduction plan. These are far from easy to incorporate in the pathways:

- **Affordability** – recent government efforts to improve energy affordability by the use of social tariffs and a range of other measures have not had the desired effect. Those in fuel poverty have doubled from 2.5 to 5 million, despite incentives to improve home insulation. There remains a major concern that the extra costs required to deliver the renewable energy expansion will further exacerbate the problem.
- **Security of supply** – a number of industry commentators and policymakers have expressed concern around the security of the UK's energy supplies, and have suggested that the lights will go out, possibly as early as in the latter half of this decade. They believe that, unless significant focus is given to provision of new generation, the UK could face a serious energy shortage with all the associated consequences.

However, the Pathways Analysis does not quantify these points or specify whether these are transitory or not.

The challenge for government is to find a way to deliver this long-term shift in a manner that minimises risks to security of supply and affordability. Delivering a low carbon world in a way that significantly increases the numbers of people in fuel poverty, or at higher relative prices to other countries (reducing Britain's wider industrial competitiveness), will not be acceptable.

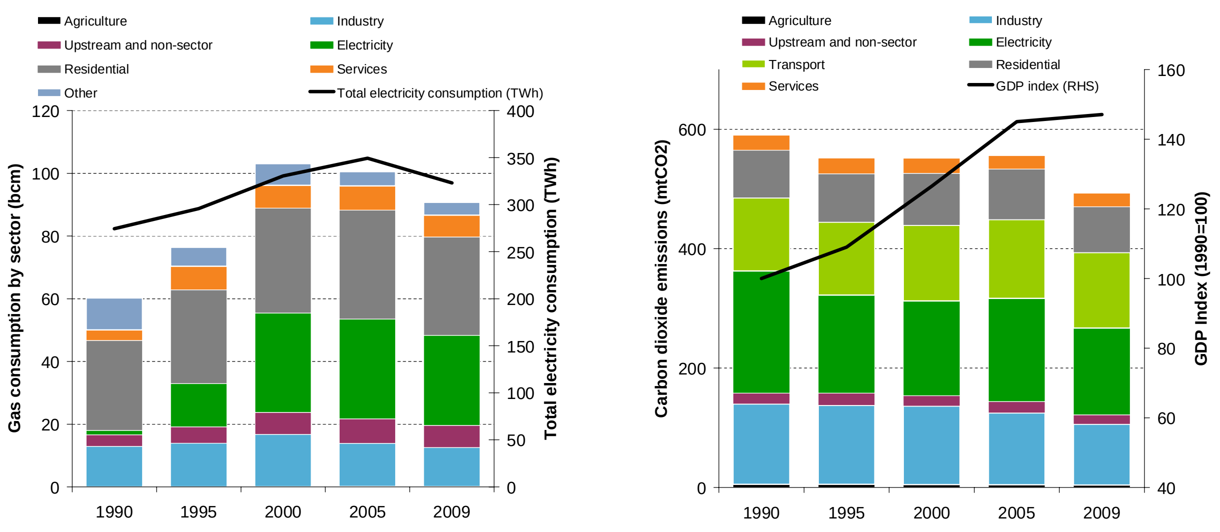
1.3 Gas has delivered the carbon savings to date

Gas has been the foundation for a large part of Britain's success in meeting immediate carbon reduction targets (Kyoto commitments) enabling the economy to simultaneously increase energy consumption (and hence economic growth) while delivering carbon reductions.

Since 1990 it has underpinned cost-effective carbon reductions (alongside continued economic growth) and is now a major part of the country's energy mix. It has also helped to improve security of supply, diversify the generation mix, reduce energy costs for householders and industry and improve air quality and the local environment.

Figure 3 shows the historical growth in gas consumption, as well as electricity, linked to GDP (and the impact of the recent recession) whilst CO_2 emissions have been reducing over the last 20 years. Gas is the fuel of choice for heating, with over 80% of homes supplied and its use in power generation has played a key role in also reducing SO_X, NO_X, heavy metals and dust emissions – Britain no longer has the 'dirty man of Europe' tag from the acid rain concerns of the 1970/80s.

Figure 3 – GB gas consumption and CO_2 emissions



Source: IEA for gas and electricity consumption, DECC for CO_2 emissions and GDP index.

However, looking forward there is a highly confused picture as to what, if any, role gas will play.

Current policy focus appears to be very much elsewhere for several reasons: gas being a fossil-fuel, concerns on increased import dependence and the risk of higher future prices.

Though there are many alternatives that are consistent with a low-carbon future that embrace gas, policy focus appears to be moving away from it as a cornerstone of the energy mix. Many pathways see gas as a fuel of the past, maintaining its relative position only if targets are missed – for example the 'dash for gas' scenario in Ofgem's Project Discovery[2] results in CO_2 emissions being only 12% below 1990's by 2020, compared with a target of 34% and in the Reference scenario in DECC's 2050 Pathways analysis[3] emissions by 2050 are at 80% of 1990's, four times higher than required.

With several energy user sectors heavily dependent on gas the question is whether this is inevitable (i.e. we have reached saturation point), or misses the potential benefits from exploiting our gas infrastructure to securely deliver carbon savings and underpin the next stage of energy system transformation in the UK?

2 Project Discovery – options for delivering secure and sustainable energy supplies, Ofgem, 3 February 2010.

3 www.decc.gov.uk/assets/decc/What we do/A low carbon UK/2050/216-2050-pathways-analysis-report.pdf

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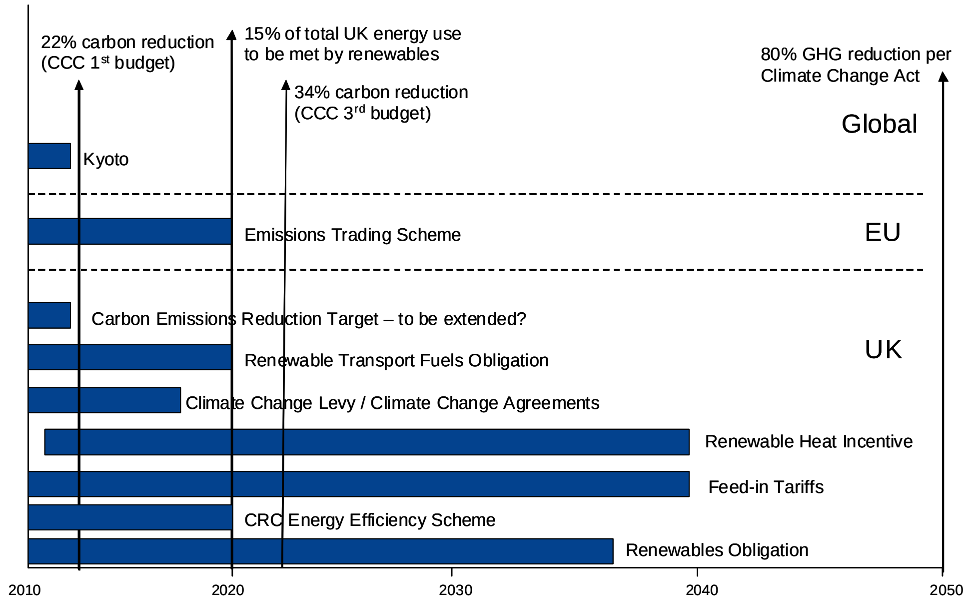
2. A WORLD OF TARGETS

2.1 What are we trying to achieve?

A prominent feature of climate change policy has been the plethora of targets relating to greenhouse gas (GHG) and/or carbon reduction and renewable deployment – see Figure 4. These relate to agreements internationally (Kyoto), at a European level (2020 targets) and nationally (the Climate Change Act). Most of these targets are short-term in nature, focussing on the period up to 2020, and the policies that are supposed to deliver them have similar bias to short-term action.

In general they are based on achieving a particular result rather than delivering an end vision. Delivering a certain amount of renewable generation does not mean that the equivalent amount of CO_2 is removed from electricity generation. As we will see later the intermittent nature of wind may well see a need for more flexible generation, which in the medium term will be fossil-fuel based, and this will operate at lower efficiency than currently.

Figure 4 – Overview of UK GHG measures



Thus, when we compare the targets we observe that carbon and renewables objectives are not necessarily always complementary or they require extra actions to ensure compatibility. For example, and as recognised by the CCC, heat pumps and electric vehicles only materially reduce carbon if the electricity grid is decarbonised concurrently and significantly.

Now policy makers still seem to be keen to set even more ambitious short-term goals. Recently the EU mooted the idea of raising the bar to increase the target greenhouse gas reductions to 30% from 20%. Few of the EU targets extend beyond 2020, yet the longer term ambition clearly remains to reduce carbon emissions to limit global warming to the 2°C.target.

While most of the policies are focused on delivering in the short to medium-term, investment decisions are long-lived. Decisions made now risk locking in future trajectories and locking-out potentially cost effective options for meeting the 2050 targets.

So there appear to be too many policy instruments acting on the short term, and too much uncertainty about policy in the longer term. While there are plans to alter many parts of the energy chain there is scant detail. For example, should the electricity market have a carbon price floor? or will the renewable heat incentive survive the expected government spending cuts in order to repair the UK's deficit? It is not obvious that either of these will reinforce delivery of other policy priorities, such as fuel poverty reduction targets. Furthermore there is an implicit assumption that higher unit energy cost is tolerable because better energy efficiency will keep the overall burden within acceptable limits.

2.2 Are the targets making a difference?

Perhaps the most definitive view of progress against the UK's carbon reduction targets is that reported by the CCC itself. The 2010 report contained mixed views. On the one hand:

- Emissions during 2009 fell by 8.6%, primarily as a result of the recession (which made measuring any benefit from the energy efficiency programmes very hard);
  - Non-traded sector emissions fell by 5.7%, more than the 1.3% annual average reductions required to meet the budget;
  - Traded sector emissions fell by 12.5%, more than the 2.5% annual average reductions required to meet the budget; and
  - Selected sectors showed substantial reductions: power (-13.1%), industry (-18.2%), and residential (-5.0%).

On the other hand the report also highlighted several serious concerns about the capability to deliver the longer term ambitions. A step change in implementing measures is still required, particularly for the non-traded sector, in order to meet the budget through to 2022.

Many areas were identified where significant improvements in progress are required:

- **Wind capacity** – only 1GW added in 2009, against 3GW annual average required by third budget period.
- **Onshore transmission grid** – some slippage on agreement of onshore grid investments.
- **Carbon Capture & Storage** – more clarity needed on financing for retrofit and operation of unabated plant into 2020s.
- **Nuclear** – progress required on enabling actions by Ministers and Parliament.
- **Non-residential buildings** – more effective compliance mechanism required for Energy Performance Certificate, need to refurbish existing housing stock to zero-carbon.
- **Renewable heat** – significant increase in uptake required, need to ensure non-financial barriers are addressed.
- **Electric cars** – need deployment targets for 2020, greater price support may be required to support early market.

Overall, the 'success' of 2009 was considered to be something of an anomaly due to the effects of the recession, and the CCC is voicing growing concerns about the delivery of many components of the low carbon goal.

3. THE ROAD TO DECARBONISATION

There is a multiplicity of paths that Britain's energy system could follow to meet its carbon targets, and the role of gas will differ depending on the technologies and sectors targeted. Yet, a very common theme in most published pathways, especially those produced by DECC and the CCC, is the rapid expansion of electricity's share in the energy mix. Equally, few consider the practicalities of navigating the pathways.

A selection of different papers is reviewed below.

3.1 CCC's 2050 roadmap

The CCC provides advice to the UK Government on climate change issues, and in particular on long term emissions targets and carbon budgets. In December 2008, the CCC published its first report 'Building a low-carbon economy'[4], which recommended a 2050 target of 80% reduction in greenhouse gas emissions between 1990 and 2050. The report focussed on two main sections; setting the 2050 target, and determining the first three carbon budget periods up to 2022.

Setting the 2050 target

The CCC summary findings and recommendations relating to the 2050 target were based on consideration of appropriate global and UK targets to reduce the risk of dangerous climate change and analysis of the technological feasibility of radical emissions cuts and the possible costs of achieving them. Based on these objectives the CCC concluded that:

- The UK should aim to reduce Kyoto greenhouse gas emissions by at least 80% between 1990 and 2050 (77% below 2005 levels).
- The 80% target should apply to the sum of all sectors of the UK economy, including international aviation and shipping. To the extent that international aviation and shipping emissions are not reduced by 80%, more effort would have to be made in other sectors.
- The costs to the UK from this reduction in emissions can be made affordable – the CCC estimate between 1-2% of GDP in 2050 – with appropriate policies and given early action to put the UK on an appropriate path.

Determining the budgets

The second part of this study determined the first three carbon budgets covering the period 2008-22. In doing this the CCC had to take into account the following:

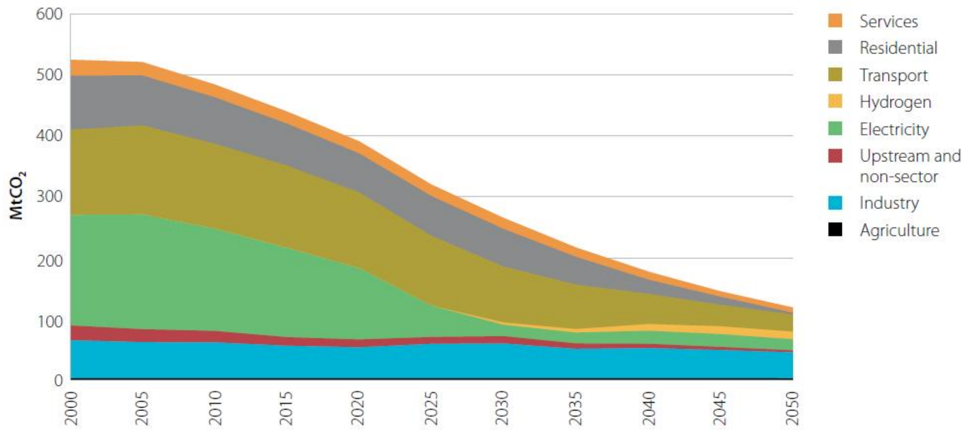
- The implications of the 2050 target for the appropriate trajectory over the next fifteen years, and appropriate contributions by the UK to required global emissions reductions in 2020.
- The implications of EU targets for emissions reductions to which the UK is already committed.
- A bottom up sector by sector analysis of feasible emissions reductions, likely costs, and the policies required to ensure that they are achieved.

[4] www.theccc.org.uk/pdf/TSO-ClimateChange.pdf

- The Intended budgets require an emissions reduction of 42% in 2020 relative to 1990 (31% relative to 2005). The Interim budget requires a 34% emissions reduction in 2020 relative to 1990 (21% relative to 2005).

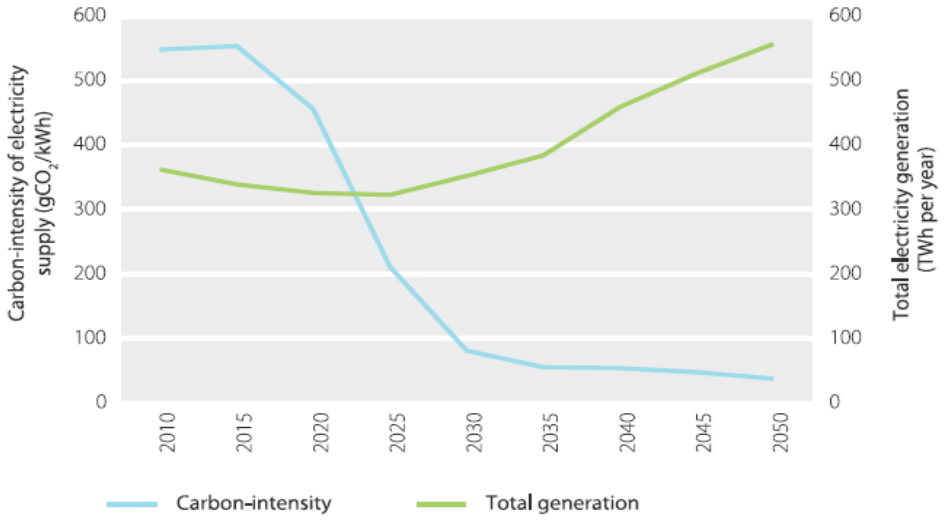
The impact of these changes are illustrated in Figure 5 and Figure 6, which shows the repaid reductions in carbon intensity and CO_2 emissions whilst also requiring a rapid growth in electricity generation.

Figure 5 – UK sectoral CO_2 emissions on an illustrative 80% reduction path to 2050



Source: 'Building a low carbon economy – the UK's innovation challenge', July 2010, Committee on Climate Change

Figure 6 – UK sectoral CO_2 emissions on an illustrative 80% reduction path to 2050



Source: 'Building a low carbon economy – the UK's innovation challenge', July 2010, Committee on Climate Change

In conclusion the CCC stated that the proposed budgets can be reached through energy efficiency improvement in buildings and industry and fuel efficiency improvement in road vehicles, combined with a significant shift towards renewable and nuclear power generation and renewable heat. However to deliver the emissions reductions, strengthening of existing policies and development of new policies – at the EU, UK and national levels – will be required.

3.2 DECC's Low Carbon Transition Plan

In mid-2009 DECC published the Low Carbon Transition Plan[5], setting out detailed targets for meeting the UK's 2020 targets. This proposed a reference path on how to move to a low carbon world in the long-term and identified that it required concerted and new policy action in all areas which would add significantly to costs in some sectors such as power and heavy industry, as shown in Table 1.

Table 1 – Lifetime net costs of proposed measures

Sector	Lifetime net cost in today's terms (£bn)
Power and heavy industry	48.7 to 53.0
Transport	6.4
Workplaces and jobs	-2.9
Homes and communities	-26.9 to -27.9
Farming, land and waste	0.1
Total	25.4 to 28.7

Source: DECC Low Carbon Transition Plan

The principal policies that DECC proposed to adopt in order to achieve the targets were:

- energy efficiency policies – e.g. building regulations, the Carbon Emissions Reduction Target for households, the Carbon Reduction Commitment Energy Efficiency Scheme, and smart metering roll-out;
- renewables support mechanisms; and
- policies which put in place a carbon price – e.g. EU Emissions Trading Scheme, Climate Change Levy and Climate Change Agreements.

In addition, some of more detailed policies were proposed to address some barriers to progress in certain areas, for example:

- Introduction of streamlined procedures for planning and regulatory approvals for new power stations.
- Introduction of a support mechanism for up to four carbon capture and storage (CCS) demonstration projects.
- Development of a future smart electricity grid to facilitate the connection of renewable electricity sources.
- Introducing a 'pay as you save' approach for financing energy saving approaches, thereby reducing the up-front payment requirements.
- Rolling out smart meters in every home by 2020.

5 www.decc.gov.uk/assets/decc/white papers/uk low carbon transition plan wp09/1_20090724153238_e_@@_lowcarbontransitionplan.pdf

- Investing in the research and development of low carbon technologies including offshore wind, marine energy and smart girds.
- Demonstrating new electric and low carbon cars, and providing financial support to new ultra-low carbon cars and to electric vehicle charging infrastructure.
- Support for anaerobic digestion, to turn waste and manure into renewable energy.

In terms of shedding light on how to move from policies to concrete actions to deliver a low carbon world the plan gave little detail, but it does illustrate well a paradox for government: it cannot publicly discuss a plan which implicitly shows any target failing to be delivered. In other words government plans are structurally limited in dealing with contingencies.

3.3 DECC Pathways Analysis

In July this year DECC published its Annual Energy Statement and the accompanying 2050 Pathways Analysis. The Pathways Analysis used a scenario approach to describe six potential pathways to meet the 80% emissions reduction target, and one reference case, which is a scenario in which minimal effort is made to decarbonise and new technologies fail to materialise. The pathways can be summarised as follows:

- Alpha – reflects an equal effort across all sectors, while the other five pathways each investigate the impact of missing a key technology, as follows;
- Beta – failure to deploy CCS;
- Gamma – no new nuclear plant;
- Delta – no new renewable generation;
- Epsilon – only small quantities of bioenergy available; and,
- Zeta – minimal behavioural change, so energy demand continues to rise.

The model used projects the progress across ten low carbon energy supply sectors, including the key sectors of nuclear; fossil fuels with CCS; and onshore and offshore wind.

However, the model only supports annual energy balancing so has no ability to deal with meeting rising electricity peaks or the impacts of wind intermittency on balancing the electricity grid – see Section 4.4 for further insight. It also had no gas CCS believing the technology was more expensive than coal CCS.

The pathway analysis then goes on to identify the key challenges faced when following each of these pathways. The challenge of balancing the electricity grid is significant in all the pathways (except in Delta where no new renewables are built) and other messages include: the need for ambitious per capita energy reduction and substantial electrification of heating, transport and industry.

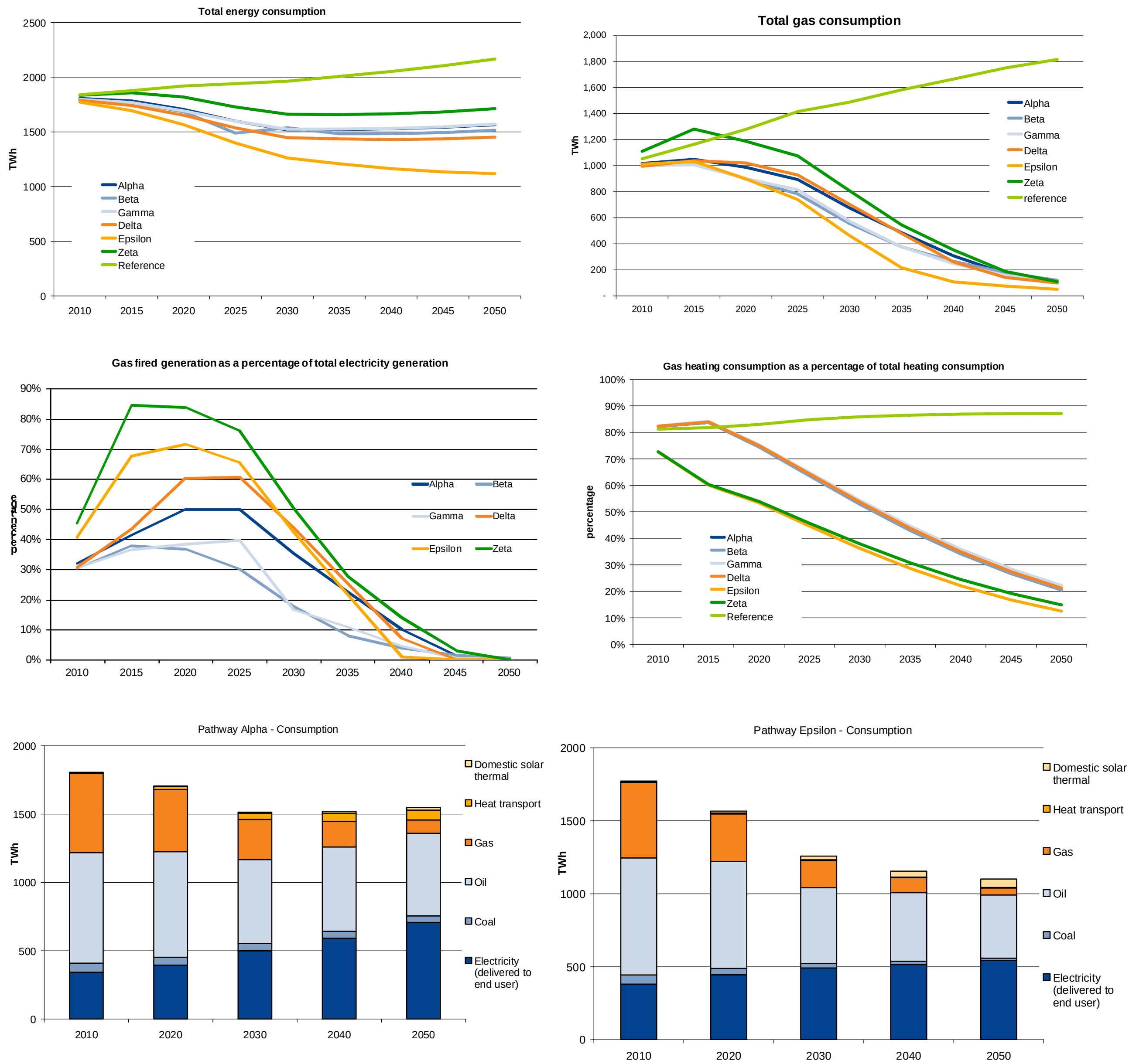
Unabated fossil fuel generation ceases completely between 2040 and 2050 in all of the pathways. CCS generation makes a significant contribution by 2030, in all but the Beta pathway, from which it is excluded. There is some discussion in the analysis about the application of CCS to coal versus gas generation.

According to DECC, if gas is to play a significant role in the UK energy market by 2050 it will be contingent on the development of gas-based CCS. It is the Pathway's view that gas-fired CCS deployment will also be heavily dependent on the success and desire for coal CCS.

Figure 7 illustrates some interesting results from the DECC model. All the pathways see a reduction in total energy consumption by 2050 but the total gas consumption as part of this will have decreased in the order of 80%. So there is no gas fired generation in the mix and very little in the heat sector, with a rapid decline from around 400TWh now to around 50TWh (a four fold decrease).

In the central Alpha Pathway the share of gas in the energy mix reduces from the current 33% to 6%. Rather surprisingly the other two fossil fuels hardly change, with oil only reducing from 45% to 39% and coal virtually constant, despite their higher carbon content. The other pathways, (typified by Epsilon in Figure 7), also envisage a major expansion in electricity delivered to consumers up from 19% to 45%. In order to achieve the 80% carbon target nearly all of this must be low carbon.

Figure 7 – DECC Pathway Analysis



Source: DECC

3.3.1 Energy use in industry

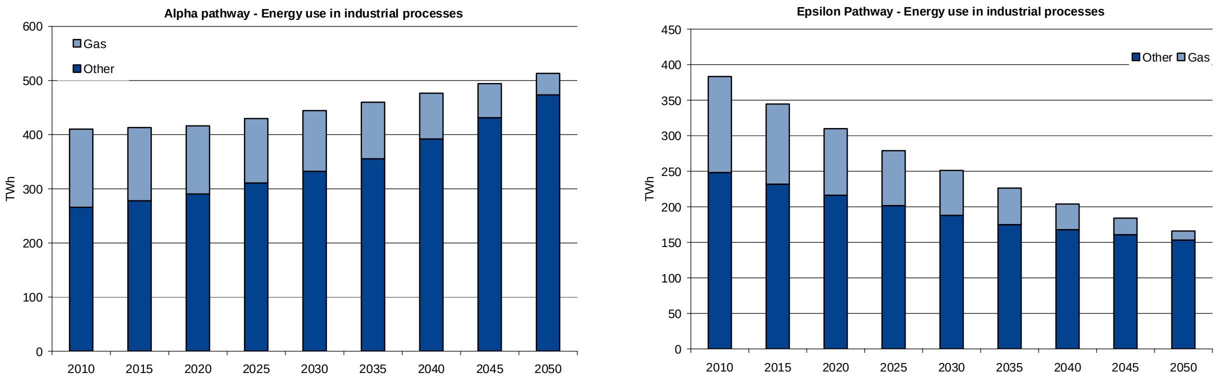
There are some concerns amongst major energy intensive industries that they will be asked to pay too much or be set targets that cannot be achieved without moving production to another country with less stringent targets and a lower value of carbon. Such an impact on industrial competitiveness would potentially hinder the GDP growth estimates that underline the DECC Pathways assumptions.

All but one of the DECC 2050 pathways, illustrated with Alpha on the left side of Figure 8, show an increase in industrial energy usage and linked to GDP growth. They also repeat the same move away from gas as an energy source to other sources, reflecting the 80% plus electrification supply. However, it is not clear to us whether industry can make such a transition, especially those who need gas as a feedstock or for very high furnace temperatures, and so such an outturn remains in doubt.

The exception is the Epsilon pathway, right side of Figure 8, which shows a 50% reduction in energy usage but still with similar reductions in the gas usage to the other pathways. Whether such a reduction can be achieved solely through process performance and energy efficiency improvements is not made clear.

The Epsilon pathway assumes that the UK can only access half the projected market share of global bioenergy source by 2050. So according to the 2050 Pathways Calculator, it is not possible to meet our targets and energy needs with this limited bioenergy. The energy gap is met by significantly increasing solar thermal energy provision compared to Pathway Alpha, such that all suitable buildings get approximately 30% of their hot water from solar thermal installations. In order to balance the total energy needed, extremely high levels of electrification of heating and transport are assumed: all car and van travel is powered by electricity by 2050; and all heating may need to be provided through electric heating technologies. The demand side changes are similar to Pathway Alpha in domestic and commercial appliances; and domestic and commercial heating, hot water and cooling.

Figure 8 – DECC 2050 pathways industrial energy usage

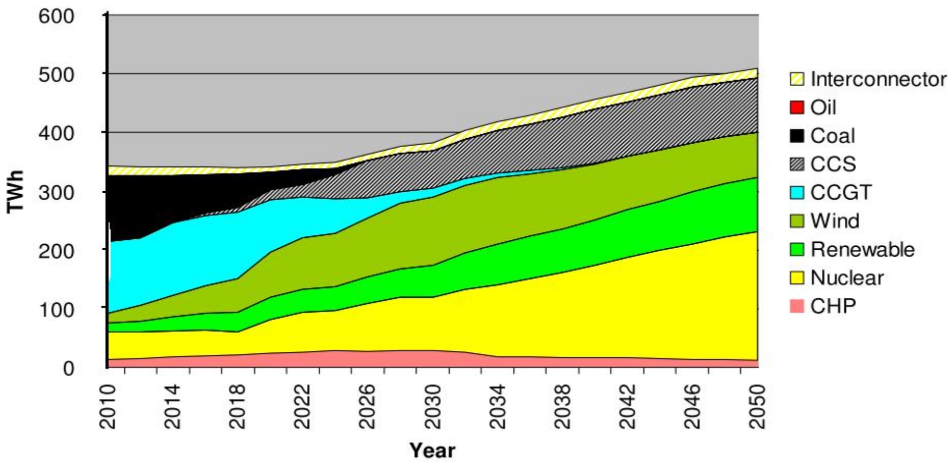


Source: DECC

3.4 National Grid's Transporting Britain's Energy

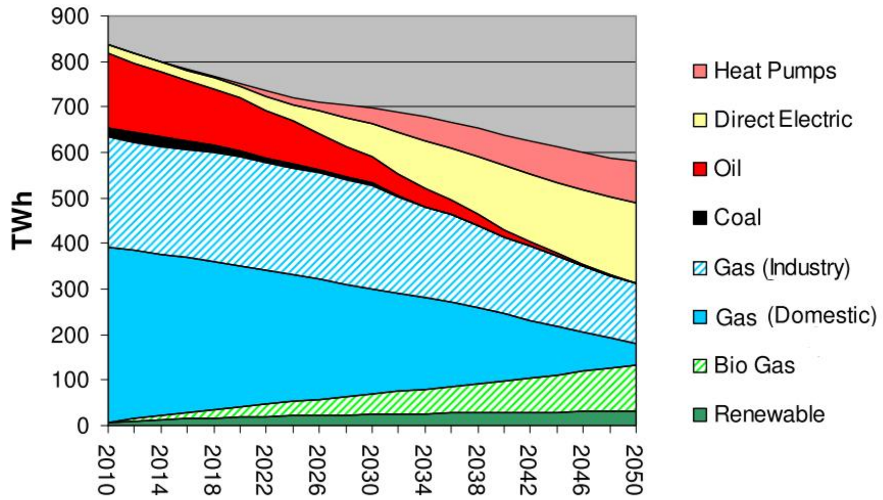
At its annual Transporting Britain's Energy conference National Grid delivered its projections for the future just ahead of publication by DECC of its 2050 Pathways Analysis. While containing little detail on how the low carbon transition is to be made Figure 9 and Figure 10 below both show the company's projections of generation mix and heat requirement respectively. These reinforce the government scenarios, implying considerable dependence on electrification of the heat sector, including heat pumps, as well as significant deployment of nuclear and renewable generation to lower the grid carbon intensity.

Figure 9 – National Grid: Electricity generation mix 2010-2050



Source: TBE 2010 – Development of Energy Scenarios, National Grid, July 2010

Figure 10 – National Grid: Annual supply of heat 2010-2050



Source: TBE 2010 – Development of Energy Scenarios, National Grid, July 2010

3.5 Ofgem's Project Discovery

Project Discovery was launched by Ofgem in March 2009. In October 2009 it set out its views on the risks and challenges facing the gas and electricity industries in GB over the next 10–15 years through its energy scenarios document. Four possible scenarios had been developed, the main results of which are summarised in Figure 11.

Figure 11 – Ofgem's Project Discovery scenarios results

	Green Transition	Green Stimulus
Key supply risk:	Generation intermittency	Generation intermittency
CO2 impact:	Down 33% by 2020	Down 43% by 2020
Impact on bills:	Up by 23% by 2020	Up 14% by 2020
Invt required:	£200bn	£190bn
	Dash for Energy	**Slow Growth**
Key supply risk:	Gas import dependency	Deferred investment
CO2 impact:	Down 12% by 2020	Down 18% by 2020
Impact on bills:	Up 60% by 2016	Up 22% by 2020
Invt required:	£110bn	£95bn

Source: Ofgem

Ofgem also undertook an extensive public consultation as part of Project Discovery. Whilst respondents were generally supportive of the need for such future modelling of potential paths to meeting carbon reduction targets, there was extensive criticism of the interventionist nature of some of Ofgem's proposals and of the apparent way that Ofgem's modelling did not appear to reflect how markets react to increasing demand needs. In particular, in the Dash for Energy scenario, it was pointed out that the approach to the modelling of UK gas storage was unrealistic, and that this gave rise to potentially misleading concerns around the UK's security of gas supply. Interestingly, the scenarios illustrate the extent to which the higher investment requirement is driven by the renewables target.

3.6 Summary

All of these pathways illustrate a high degree of commonality in the nature of the low-carbon future. Electrification is at the heart of each transformation pathway underpinned by rapid decarbonisation of the power sector. The sensitivities between scenarios are centred more on the precise mix of generation that will emerge and the reduction in energy demand that will have been achieved. In all scenarios, there is a declining role for gas. While this may be understandable in the long-run without development of appropriate abatement technology, the risks of delivering such a fundamental change in the energy mix are far from clear in the discussion.

4. THE CHALLENGE OF ELECTRICIFCATION

As we saw in Section 3 the majority of published views of the pathway to the low carbon future involve a massive expansion in the use of electricity for both heat and transport. We now examine the challenge in delivering this.

Each of the components of all future pathways involve, to a greater or lesser extent, risks around three key characteristics namely deployment, innovation and changes to consumer behaviour. There are significant challenges and risks associated with each which could mean any pathway either ends up not achieving the carbon reductions or does it in a way that has unacceptable impacts on other energy policy objectives.

This section examines in more detail each aspect of deployment, innovation and behaviour.

4.1 Deployment risks

Deployment risks embrace three main concerns: access to capital (do we have the funds?), supply chain constraints (do we have the resources?) and coordinated delivery (can we deliver network and production assets concurrently? will planning help or hinder?).

4.1.1 Access to capital

The amount of investment required is very large. Many observers have estimated the costs of the transition:

- The Climate Change Act Impact Assessment estimated the total costs of meeting the 2050 targets as being between £324–404bn.
- In early 2009, Ernst & Young reported a requirement of £234bn of investment would be required through to 2025.
- Later in 2009, as part of its Project Discovery, Ofgem estimated that £200bn of investment would be needed to meet the 2020 targets, around double that in its non-compliant scenarios.

Whatever the figure, the fact remains the UK requires a major influx of investment capital in the near future. This is made more challenging in the current economic climate where many commentators and studies have identified a lack of liquidity in the financial markets is affecting the availability of debt and equity.

Although much of the new developments will be commissioned by the large European utilities they do not have limitless capacity to invest. For example, whilst EDF Energy was required to sell various assets as part of its acquisition of British Energy this was also required in order to keep its debt ratio within acceptable bounds.

The lack of funds adds greatly to the time taken to obtain finance for a project. Typically at the moment many independent developers are struggling to access any finance and large scale projects, such as the London Array windfarm, have needed funding from the EIB in order for other banks to join the loan syndicates.

New nuclear is another example where financing affects potential deployment. This was recently highlighted by RWE in the July 2010 report commissioned from KPMG[6]. This explored whether it was possible to secure the finance needed for the nuclear generation required in the UK in an efficient and timely manner. It identified that in order to meet carbon budget targets of less than 100g CO_2/kWh a radical shift in the nature of future investments into power generation is required. The previous Government's draft National Policy Statement states that, even after a large increase in renewable generation, there will be a need for a further 25GW of low carbon generation. They expected that a significant proportion will be filled by nuclear power.

The report stated that nuclear generation favourably compares to other power generation sources. New nuclear power generation has a life cycle cost of £60/MWh-£80/MWh, whereas the cost of offshore wind is estimated at £150/MWh-£200/MWh. Investors' estimates of the installation costs of new nuclear capacity range from £2/MW up to £4/MW. The report believes the most likely sources of financing are project finance, export credit agencies (e.g. the European Investment Bank), external financing, notably by French banks.

However, the report says that investments in new nuclear generation have four main disadvantages:

- long-term commitments of large capital (up to seven years of construction, payback periods of 30 years or more);
- uncertainty of costs, market structure or policy interventions in long time periods;
- high risks of construction cost overruns and time delays; and
- returns are sensitive to the capital costs, cost outcomes and future prices over a long period of time.

In order for new nuclear to progress the report identified that a sufficiently developed commercial framework is required by 2011 to support major investment decisions, otherwise there may be delays to investment decisions. Any delay is likely to weaken the procurement position, as the wave of nuclear investment around the world gathers pace. It also runs the risk of weakening the government's position in interaction with potential investors. As a result, well managed, measured but effective progress towards a new commercial framework is required.

4.1.2 Supply chain constraints

With a rapid expansion required in deployment of renewable generation, building of new nuclear power stations and the development of CCS, together with the on-going investment expected in the existing oil and gas sector there remains a risk that there is insufficient supply chain capability to construct all projects that have completed the development phase.

CCS is one obvious example. In its 2009 report to the CCC on the milestones for the deployment of CCS in the UK[7], Pöyry focused on the practical issues and highlighted amongst others that lack of supply chain capacity may restrict the ability to develop and construct the expected number of CCS projects in the timescales anticipated, particularly

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6 Securing Investment in Nuclear in the Context of Low-Carbon Generation, KPMG, July 2010.

7 www.ilexenergy.com/pages/Documents/Reports/Carbon/504_CCC_CCS Final Report_v3_0.pdf

if initial developments are delayed. DECC in their report on CCS clusters[8] also highlighted supply chain constraints, in particular:

- Potential bottlenecks when it comes to high value manufacturers (for full scale absorber tower).
- CO_2 storage – with substantial upfront costs, uncertain market demand and a very small number of very powerful customers. The transport and storage markets are unlikely to be established in advance of the commissioning of the government-backed demonstrations and are likely to be determined by the needs of those demonstrators in the first instance.
- The UK has a weak position in compressor technology.

Similar concerns relating to other technologies were also raised by many other industry studies and commentators: Pöyry in its July 2009 report to the CCC on the timeline for wind generation[9]; SKM reported in 2008 'Quantification of Constraints on the Growth of UK Renewable Generating Capacity'[10] and BVG Associates reported in 2009 on how to improve delivery of UK offshore wind[11].

These studies identified a range of constraints associated with wind farm deployments, namely:

- availability of wind turbines (with some parts such as gearboxes and bearings part of a global market);
- cabling;
- substations;
- constraints in transmission access;
- availability of offshore installation vessels; and
- skilled engineering resources; physical access to onshore sites.

Due to the long lead times to deliver additional supply chain capacity, the key to attracting investment in the supply chain is transmitting clear market signals that additional supply chain capacity is required for offshore wind. However, moves to alleviate the supply side constraints will not be easy as the rest of the world is also looking to expand its windfarm capacity, including across the EU, USA, India and China. So developing the supply chain will be expensive and may require the UK to develop its own capability rather than rely on importing the required capability. In any event, the competition for limited resources is likely to push up prices.

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8 www.decc.gov.uk/assets/decc/What we do/UK energy supply/Energy mix/Carbon capture and storage/1_20100317095408_e_@@_ccsbusiness clusters.pdf

9 www.ilexenergy.com/pages/Documents/Reports/Carbon/503_WindTimelines&Progress Indicators_v7_0.pdf

10 webarchive.nationalarchives.gov.uk/+/http://www.berr.gov.uk/files/file46779.pdf

11 webarchive.nationalarchives.gov.uk/+/http://www.berr.gov.uk/files/file49871.pdf

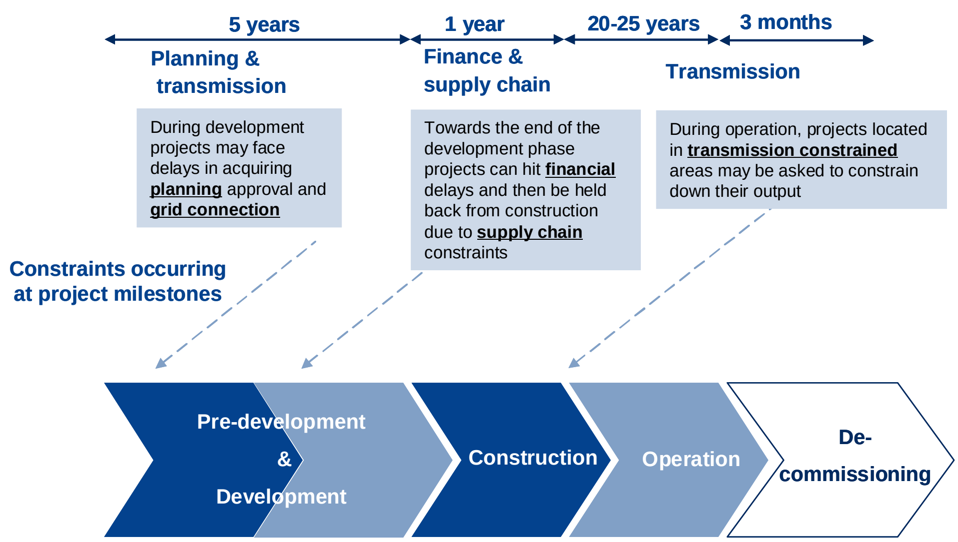
4.1.3 Coordinated delivery

Deployment at the requisite rate will need delivery of parallel large scale engineering projects that will require significant coordination in order to deliver on time and to budget. Many obstacles will to have to be overcome throughout the project development cycle ranging from planning applications, environmental assessments and inter-linked investments.

4.1.3.1 Project cycle risk

For example, in our July 2009 report to the CCC on the timeline for wind generation it was noted that in parallel to the wind generation programme there is an estimated £14bn of transmission investment required by 2020 to enable 26–34GW of new wind capacity to be connected. Failure to deliver this, especially if delays comparable with those that have been experienced with the reinforcement of the Beauly-Denny transmission line occur, could mean we have the wind power but cannot deliver it to homes and businesses. Figure 12 illustrates an example of an onshore wind project cycle and where major constraints may occur.

Figure 12 – Example of an onshore wind project cycle and the stages of when the major constraints occur



NB: Timings are for an above 50MW windfarm located in England under 2009 planning statutory guideline timescales

4.1.3.2 Concurrent infrastructure risks

The need for additional network investment is widely accepted. Several studies have sought to assess the potential scale of investment required for both offshore and onshore transmission network reinforcement. Estimates of the cost of an adequate system are in the region of £15bn. Though this is only around 10% of the total investment requirement, it is a vital component of the new energy system.

ENSG Report

Following the publication of the UK Renewable Energy Strategy in June 2008, the Electricity Networks Strategy Group (ENSG)[12] asked transmission licensees to complete a study to:

- develop electricity generation and demand scenarios consistent with the EU target for 15% of the UK's energy to be produced from renewable sources by 2020; and
- identify and evaluate a range of potential electricity transmission network solutions that would be required to accommodate these scenarios.

The study was published in March 2009[13]. The total cost of the onshore reinforcements proposed by the ENSG is £4.7bn. This will result in an onshore network that can accommodate 34GW of onshore and offshore wind generation, plus a further 11GW of nuclear generation. The study outlines the cost of transmission reinforcement required to accommodate 34GW of wind capacity (on a £ per kW of installed capacity basis) of £145/kW on average[14]. The study concludes that the onshore transmission reinforcements can be delivered to the required timescales, on the assumption that they are taken forward in a timely manner and that the planning consent process facilitates network development.

Crown Estate Report

While the ENSG report focuses on onshore transmission reinforcement required to accommodate anticipated generation connections, a report commissioned by the Crown Estate[15] focuses, in the main, on the offshore transmission investment required to deliver up to 25GW of Round 3 offshore wind generation projects. The total cost of the transmission investment projected in the report is £10.4bn. This equates to a cost per kW of installed capacity of over £400/kW on average across the projects. Approximately £500m of the overall investment cost relates to onshore network reinforcement, covered by the ENSG report. If this is stripped out, to avoid double counting, the specific offshore transmission investment costs relating to Round 3 are £9.8bn and the cost per kW of installed Round 3 capacity falls to approximately £380/kW.

Clearly the risks arising from deployment are not only numerous, they are also well documented and shared by the wider community. We now move on to the risks from depending on innovation.

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12 The ENSG is a cross industry group jointly chaired by the Department of Energy and Climate Change and Ofgem.

13 'Our Transmission Network: a vision for 2020', ENSG, March 2009.

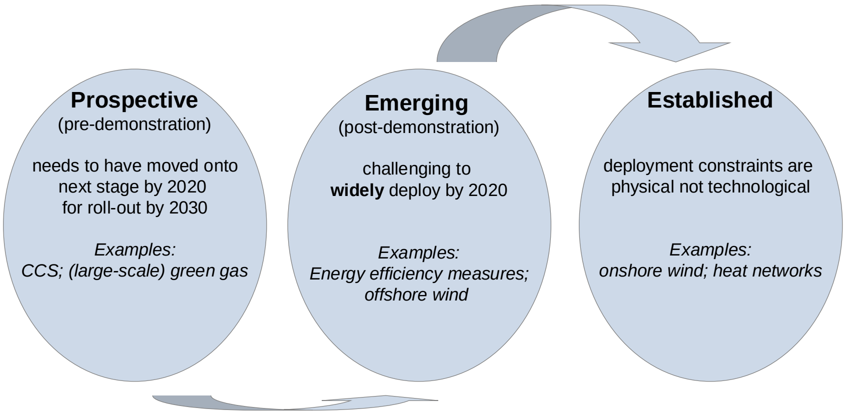
14 This drops to £129/kW if the additional nuclear capacity that is able to connect as a result of the onshore reinforcements is also included.

15 'Round 3 Offshore Wind Farm Connection Study', The Crown Estate, December 2008.

4.2 Innovation

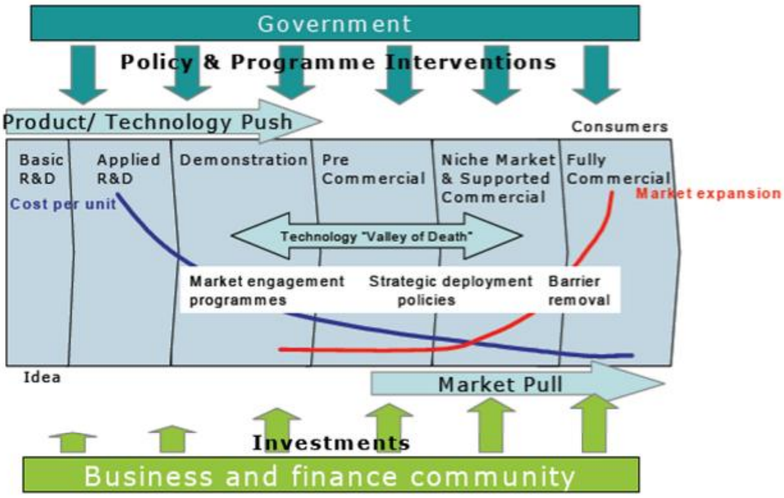
To play a significant role in energy systems by 2030, young technologies now in the first stage need to reach maturity by 2030 to provide deployment time to achieve the 2050 target. Figure 13 shows that many of the low carbon technologies require considerable development.

Figure 13 – Technology cycle of low carbon technologies



Furthermore the challenges involved in taking new technologies from the laboratory to full commercial status are well understood. Pertinently, the Carbon Trust re-iterated the 'valley of death' problem to full commercial operation, see Figure 14, and this review highlights the crucial successful delivery of technical development.

Figure 14 – The valley of death



Source: The Carbon Trust

There also may be other technologies that have not yet reached the radar of policy maker's decision making, or within the timescale of 2050 could become important.

To highlight the challenge we discuss CCS and electric vehicles, where technical innovation is vital to their use, and there are already strong incentives and much hope.

4.2.1 Carbon Capture and Storage (CCS)

The fact remains that today, in 2010, there is no full scale fully integrated carbon capture and storage power generation project operating anywhere in the world. One of the most eminent researchers in the field, Professor Jon Gibbins, has outlined the way in which such projects may ultimately reach commercial roll out (shown in Figure 15 below), and highlighted the need for *two* cycles of full scale demonstration before widespread roll out can be contemplated.

Figure 15 – Development of CCS from demonstration to commercial deployment

Source: Gibbins and Chalmers[16]

Despite many of the elements of an integrated system existing individually, there remain tremendous technical challenges in increasing scale by factors of 50x as well as operating them together, and while the likely costs and performances are encouraging compared to many renewables, they remain forecasts.

The government's CCS demonstration programme originally targeted a start date of 2014, but this appears increasingly tough, and the flagship US 'Futuregen' project was dramatically reshaped by the Obama administration, setting it back further.

So far most of CCS developments have focused on coal-fired projects, but recently various industry commentators (e.g. the CCC) have suggested that gas-fired CCS should be considered in a low carbon future. Mott MacDonald in its June 2010 update on electricity generation costs update[17] for DECC showed a range of levelised costs depending on when different projects start and under different development and financing cost assumptions, which are shown in Table 2 overleaf.

16 Gibbins. J. and Chalmers, H. (2008). 'Preparing for global rollout: a 'developed country first' demonstration programme for rapid CCS deployment'. Energy Policy, Volume 36, pp 501-507.

17 www.decc.gov.uk/assets/decc/Statistics/Projections/71-uk-electricity-generation-costs-update-.pdf

The report notes that determining the costs of generation is not an easy matter, especially for less proven technologies, and its cost exclude any externalities (such as wider electricity system impacts). Under a range of different assumptions relating to project start dates, projected EPC costs, and first of a kind (FOAK) and nth of a kind (NOAK) it shows gas CCS has a lower cost than coal CCS and offshore wind but is slightly more expensive than nuclear. So while gas-fired CCS power stations require many of the technical innovations of coal-fired ones, economically they may be far more suited to the markets of the future

Table 2 – Levelised costs of main generation technologies (£/MWh)

Total levelised cost (£/MWh)	CCGT	CCS CCGT	CCS Coal	CCS Coal IGCC	Offshore Wind (Round 3)	Nuclear (PWR)
Case 1	80.3	112.5	142.1	147.6	190.5	99.0
Case 2	79.7	111.4	136.2	143.0	177.4	97.1
Case 3	86.7	113.5	134.4	141.7	174.6	94.6
Case 4	96.5	115.8	136.8	142.4	172.9	93.4
Case 5	113.2	123.8	118.2	113.3	127.9	68.9
Case 6	50.5	67.7	93.3	90.00	127.9	66.8

Case definition	
Case 1	10% discount rate, 2009 project start at 2009 EPC prices, mixed FOAK/NOAK
Case 2	10% discount rate, 2009 project start at projected EPC prices, mixed FOAK/NOAK
Case 3	10% discount rate, 2013 project start at projected EPC prices, mixed FOAK/NOAK
Case 4	10% discount rate, 2017 project start at projected EPC prices, mixed FOAK/NOAK
Case 5	10% discount rate, 2017 project start at projected EPC prices, all FOAK, high fuel price and DECC carbon price
Case 6	10% discount rate, 2017 project start at projected EPC prices, all FOAK, low fuel price and fit £20t/CO2 carbon price

Source: Mott MacDonald for DECC

4.2.2 Electric Vehicles

The challenge of innovation is not just linked to energy but will also apply to transport. In its 'Building a low-carbon economy' report the CCC identified that "electric vehicles combined with decarbonisation of electricity generation could lead to a dramatic reduction in emissions from cars and light vans". Significant improvements in battery technology and further innovation are required before this technology could be applied to the more challenging HGV segment.

In the UK the total transport sector is targeted to deliver 19% reductions between 2008 and 2020, and the EU has introduced the stringent regulations that new cars will have to emit less than 120g/km by 2015 and less than 95g/km by 2020. A powerful penalty structure is also part of the new regulation, whereby, for the first g/km over 120g/km, there would be a €5 penalty per car sold, for the second g/km, a €15 penalty, the third a €25 penalty and €95 per g/km above this.

This incentive mechanism is designed to help stimulate growth in electric car use with the objective of meeting the EU target. The 2020 target assumes that around half of all new vehicles sold will have an electric component (10% electric, 10% range extender and 25% hybrid). Under a business as usual scenario with low oil prices this drops to 17% of cars sold (2% electric, 5% range extender and 10% hybrid). However, it should be noted that no major uptake can begin before 2014, as there are simply not the models available to generate mass demand.

Other key factors affecting the growth are:

- Battery costs – currently the 5 year total cost of ownership of electric cars exceeds equivalent conventional engine cars, and battery prices need to fall by about 30% to redress this. Batteries are likely to be at mass produced costs by 2015, and certainly by 2020.
- Oil price – if the price of oil doubles (from around $70-80/bbl currently), then electric cars will have the same 5 year cost as conventional vehicles.
- Consumer perception – a large shift in thinking will be required away from long range capability and quick refuelling times in order for electric cars to blossom, which is why hybrids are likely to be the market leaders in the medium term due to their practicality. It is impossible to predict when there will be a shift in conventional thinking, but this is likely to be a pivotal point in the growth of the electric market.

Mass adoption of electric vehicles will also require the local distribution networks to operate very differently and as mentioned before for electricity supplies to have much lower carbon content.

In conclusion, simple examination of two cornerstone technologies shows the barriers are very high, and the convenient assumptions that the necessary innovation will simply happen hides very real risks.

4.3 Consumer behaviour

While the challenges of deployment and innovation are largely under the control of the energy industry, the move to low carbon world also requires dramatic **change in behaviours**. Yet there is scant evidence to show that this can be achieved in an enduring fashion.

4.3.1 Energy efficiency

Consumers are being expected to be more efficient in their use of energy and not just replace savings made by keeping their homes warmer or have ever more gadgets and appliances.

There were some brief signs of lower car use when pump prices reacted to the crude oil price hikes in 2008, and signs of residential energy consumption reducing when energy prices reached unprecedented heights.

The Committee on Climate Change have similar concerns over whether the consumers will deliver their part. Table 3 overleaf shows the sheer scale of the challenge by comparing the numbers taking up energy efficiency in its various guises. The gap is worryingly high even for such well known applications: future energy efficiency initiatives will need households to adopt far more novel appliances. The risk is obvious.

Table 3 – Implementation of domestic energy efficiency measures in 2009, and rate required for second and third budget periods

	Outturn 2009	Budget 2 average (2013-17)	Budget 3 average (2018-22)
Loft insulation (CERT professional)	0.80m	2.08m*	-
Loft insulation (DIY & other schemes)	0.62m		
Cavity wall insulation	0.59m	1.41m*	-
Solid wall insulation	0.02m	0.15m	0.22m
Efficient boilers	1.15m	0.87m	0.66m
A++ rated cold appliances	~0.5pp	2.9pp	5.4pp
A+ rated wet appliances	~2.0pp	4.7pp	3.7pp

pp – percentage points; * maximum uptake achieved by 2015
Source: 'Second progress report', Committee on Climate Change, 30 June 2010

4.3.2 Heat pumps

Mass deployment of heat pumps is central to the electrification of the supply of heat. In July DECC published scenarios for renewable heat supply to 2020[18]. Around 2,500 air source heat pumps are currently installed and sales are close to 3,000 units pa. For ground source heat pumps the respective figures are 8,000 installed and 4,000 pa sales.

Yet in its central scenario there are 300,000 air source and 330,000 ground source heat pumps by 2020.

For these, still relatively low, figures to be reached, annual sales over the next ten years will need to be ten times current rates. This is not just a challenging sales target – it demands a massive expansion in the supply chain to manufacture, install and maintain the systems. How credible is such a sales plan in the face of a doubting public? Already there is information to doubt their value.

The Energy Saving Trust (EST) has just reviewed heat pumps, both monitoring the technical performance as well collecting the consumers' experiences[19].

While the trial demonstrated that the potential carbon savings from the technology are actually very good in the UK, the only properties that were likely to benefit most from the technology were homes that were not connected to the national gas network, and currently heated by oil or electricity.

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18 www.decc.gov.uk/assets/decc/What we do/UK energy supply/Energy mix/Renewable energy/policy/renewableheat/1_20090724115050_e_@@_renewableheatscenarios.pdf

19 www.energysavingtrust.org.uk/Generate-your-own-energy/Heat-pump-field-trial/Getting-warmer-a-field-trial-of-heat-pumps-PDF

One of the major concerns with large-scale deployment of these technologies is incentivising consumers to switch to the technology. Domestic consumers in particular display a high degree of inertia in their decisions, as experience in retail competition has found. DECC's own analysis as part of the renewable energy strategy and renewable heat incentive identifies additional 'hassle factors' associated with renewable heat technology take-up. These 'hassle factors' add to risks of delivering high growth targets for new heat technologies. Enviros in its September 2008 report to DECC on barrier to renewable heat[20] highlighted in particular:

- Time cost for search and options appraisal (all technologies) – assumes that finding out about renewable technologies takes longer than their conventional equivalent. Time will depend on whether any awareness campaigns are in place.
- Time cost for installation – assumes that extra time to install alternative technology over and above conventional technologies.
- Time cost for operation – this includes delivery of fuel.

These two examples of energy efficiency and heat pumps show how changing customer behaviour will be a significant barrier to the low carbon transition. Just because a technology exists does not mean it will be embraced by the consumers. But without these changes, the other measures in government's plans, mainly in the energy sector, will have to shoulder a much larger share of the burden, thus adding to the risks of delivering the intended outcomes.

4.4 Can this be done and keep the lights on?

Whilst policy should look to longer-term goals it is also important that the "lights stay on". An electricity system needs to balance the various components of supply and demand throughout the transition and in the low carbon world of the future. Hitherto, it appears that there has been a tacit assumption that wind generation will fit simply into the electricity system. While that is true for the amount currently in operation, recent work by Pöyry, supported by many UK industry stakeholders, clearly shows that at the levels of wind expected by the government by 2030, its intermittency will dominate the character of the market[21].

The work suggests many questions of investment risks, market structures and operating regimes – but it also suggested that many of the economic drivers that favour gas-fired power stations will be accentuated in this world. Such an important linkage is currently missing from the government pathways.

Figure 16 overleaf shows an example of the scale of the intermittent generation swing that might be expected (over 40GW) in the middle chart, the likely prices in the market resulting from this at the top chart and the impact on the running regimes of the other different types of generating plant in the bottom chart. If there are no flexible gas plants to balance the intermittency then which technology, either generation or demand side, will step-up? At this point in time it is far from clear.

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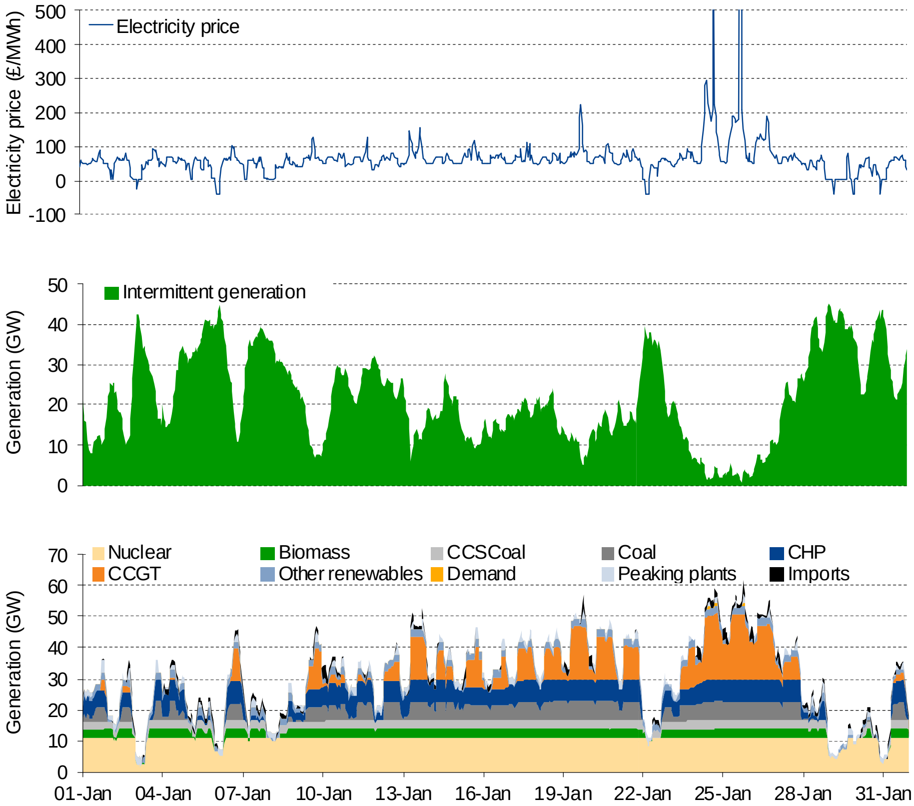
20 www.decc.gov.uk/assets/decc/consultations/renewable energy strategy consultation/related documents/1_20090501125239_e_@@_3part2finalreportv10.pdf

21 www.ilexenergy.com/pages/documents/reports/renewables/Intermittency Public Report 2_0.pdf

Figure 16 – Model of UK power system in 2030 with large wind output



Hourly generation for intermittency (wind, wave and tidal) and conventional plant. Assumes weather patterns of January 2000. Nuclear turns down to minimum-stable generation as a result of subsidies paid to wind generators.

Another conclusion from the study was that any generation built before 2016, conceivably to cover closure of existing coal-fired power stations under emissions regulations, would only operate in a 'stable' market price regime for relatively few years. Thereafter, revenues will be volatile and uncertain to the point where plant may only operate for a few hours one year, and then some hundreds of hours the next. So generating companies may not be willing to invest and should they delay new plants this will increase the chance of the lights going out towards the end of this decade (with many coal plants due to close).

The study was also able to directly compare the capacity payment system in the Irish market with the energy-only British electricity market. While the Irish market is able to continually incentivise new peaking plant with increasing wind penetration, the study highlighted the real challenge in delivering very low load factor plant in the British market. This will stretch the current market design to its utmost and most likely require some significant structural reform. The risk of intervention in a market with very high prices for short periods is significant, and has been seen repeatedly in other markets. Equally, a market with 'spiky' and volatile prices is one where the risk of operation is greatly increased and it is unlikely to send clear economic signals to new investors.

4.5 Can we afford it?

In July DECC also published a supporting report on the 2020 price impacts[22] as part of the 2050 pathways analysis. This considered the impact on domestic and non-domestic electricity and gas bills in light of the likely changes in energy policy to facilitate the low-carbon transition to 2020.

4.5.1 Domestic Sector

Policies to increase renewable energy deployment will add to energy prices and bills. Aside from the increase in deployment, this will be one of the major impacts of the policies set out in the Strategy. The impact on consumer prices and bills will depend on the subsidy costs of the financial instruments – the renewable obligation (RO), renewable heat incentive (RHI), feed-in tariffs (FITs) and the renewable transport fuel obligation (RTFO) – designed to incentivise deployment, and on the extent these costs are passed through to final consumers. The estimated impact on prices and bills will also depend on how the costs of other components of energy prices change, particularly underlying fossil fuel prices.

Table 4 below summarises the percentage increase in unit price of gas and electricity, assuming fossil fuel prices consistent with oil at $80bbl and a gas price of 69 pence per therm in 2020. In this case the average increase in the unit price of gas is estimated to be around 18 percent by 2020, while the average increase in the unit price of electricity is estimated to 33 percent.

Table 4 – Percentage increase in domestic unit price of gas and electricity

	Percentage increase in unit price of gas	Percentage increase in unit price of electricity
2010	4%	14%
2015	10%	26%
2020	18%	33%

Source: DECC

Although Table 4 shows a substantial increase in the unit prices of electricity and gas, the actual impact of an average bill is much smaller due to strong assumptions on energy efficiency improvements. Table 5 overleaf estimates that by 2020 the increase in an average domestic customer bill will be limited to around 1 percent. If the energy efficiency improvements are not forthcoming it will result in higher bills that predicted and result in more people being classed as being in fuel poverty.

22 www.decc.gov.uk/assets/decc/What we do/UK energy supply/236-impacts-energy-climate-change-policies.pdf

Table 5 – Estimated impact on domestic energy bill (real 2009)

2009 prices	2010	2015	2020
Estimated average energy bill without policies	£1,060	£1,149	£1,226
Estimates average energy bill with policies	£1,103	£1,150	£1,239
Impact of policies on the energy bill	£42 (4%)	£1 (0%)	£13 (1%)

Source: DECC

4.5.2 Non-domestic sector

Table 6 below shows the average increase in the unit prices for non-domestics – around 24 percent for gas and 43 percent for electricity. However unlike the domestic sector these increases in the unit price of gas and electricity result in a substantial increase in the average non-domestic bill. Table 7 shows that by 2020 the average non-domestic bill will increase by 26 percent. As previously discussed in Section 3.3.1 such an increase will put pressure on the ability of industry to remain competitive with other countries and may lead to more industrial closures.

Table 6 – Percentage increase in non-domestic unit price of gas and electricity

	Percentage increase in unit price of gas	Percentage increase in unit price of electricity
2010	6%	20%
2015	10%	28%
2020	24%	43%

Source: DECC

Table 7 – Estimated impact on non-domestic energy bill (real 2009 £ms)

2009 prices	2010	2015	2020
Estimated average energy bill without policies	£1.217m	£1.327m	£1.410m
Estimates average energy bill with policies	£1.392m	£1.477m	£1.778m
Impact of policies on the energy bill	£175 (14%)	£150 (11%)	£368 (26%)

Source: DECC

4.6 Pathway balancing

From the above it is clear and needs to be stressed that most pathways will have a degree of commonality – there is no silver bullet solution to the decarbonisation question. Where paths will differ is in the extent to which they rely on deployment or innovation of the various technologies or behavioural changes of customers.

The previous sections all provide evidence to strongly indicate a multitude of risks in each area associated with an electric-based solution; it:

- depends on unprecedented build rates for wind;
- requires the commercialisation of CCS in short-order;
- necessitates a rapid realisation of a smart grid to provide flexibility to deal with intermittency and security issues;
- has substantial retrofitting of heat pumps to domestic heating;
- close to a 50% expansion of the electricity grid (largely offshore);
- major energy efficiency improvements to mitigate domestic consumer price effects; and
- requires rapid resolution of all the associated issues with electric vehicles.

It is clear that without changing consumer behaviour the challenge will become even more difficult. The approach also requires a large amount of early/upfront investment to get initial carbon reductions from, say, heat pumps and renewable generation.

Finally, each pathway needs to 'work' at any point in time and constraining the solutions available by seemingly 'picking winners' in order to achieve short-term goals is likely to increase the risks and be counter-productive.

Table 8 summarises the range of new technologies currently envisaged and whether they have risks associated with deployment, innovation and/or consumer behaviour.

Table 8 – Pathway characterisitcs summary

Technology	Deployment	Innovation	Consumer behaviour
Nuclear plant	✓	✗	✗
Wind farms	✓	✗	✗
Electric vehicles	✓	✓	✓
Heat pumps	✓	✗	✓
CCS	✓	✓	✗
Smart meters	✓	✗	✓
Biomass plant	✓	✓	✗
Smart grids	✓	✓	✓
District heating	✓	✗	✓
Building efficiency measures	✓	✗	✗

Note: offshore wind farms may require further innovation to meet deeper water challenges for some Round 3 sites.

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5. CAN GAS HELP LOWER THE RISK?

It is no secret that there will be risks however we look to achieve our low-carbon future, but the question is, are we considering all options to help minimise the risk? Though all energy pathways rely to a greater or lesser extent on delivering deployment, innovation and behavioural change, it is far from certain to us that reducing gas's share of the energy mix represents the best way for society to progress towards decarbonisation.

As we have seen, many of the talked about pathways ignore some of the gas-based options that could contribute to the solutions. While gas has many attractive qualities as part of the transition, such as relatively low cost availability and established infrastructure, it would appear to have been considered by government as that part of the current energy mix to be removed at the earliest opportunity.

During this Section we will discuss in more detail why gas may have been ignored and highlight some of the potential benefits it can offer to policymakers and markets looking to find a lower risk solution.

5.1 Why is the playing field biased against gas?

During this review we have identified various reasons that seem to result in gas not being considered as part of the long-term solution to a low carbon world.

5.1.1 No gas CCS

The DECC pathways model does not incorporate gas CCS, with government policy focussing support on coal-based CCS instead. So by definition, there is almost no gas in the power sector post-2040 and zero from 2050.

However, a gas-based power sector has its benefits. In the short- to medium-term it offers the flexibility to integrate intermittent generation more quickly, lowering the risk of interruptions or price spikes associated with wind. In addition, it provides some breathing space to develop viable CCS technology, reducing the risk of undershooting carbon targets or having worse security if CCS technology cannot deliver in the right timeframes and scale to abate coal-fired generation, which is assumed to be deployed at scale in the DECC Pathways analysis by 2025. CCS on gas is less capital intensive than CCS on coal so it could economically provide an important back-up to intermittent renewable generation in the long-term.

Further, while there is recognition that some industry will remain reliant on gas the lack of a viable industrial CCS option will restrict growth in these sectors.

The lack of gas CCS and recent evidence that it could be cheaper than coal CCS was reflected in the CCC's innovation report[23]. They stated that 'our analysis suggests that gas CCS is likely to be competitive with coal CCS even in a central gas price scenario, and more so in a low gas price scenario (e.g. if significant quantities of unconventional gas comes to market) and when operating flexibly. However, there are currently no plans to demonstrate gas CCS in the UK. There is an opportunity to demonstrate gas CCS as at least one of four CCS projects to which the government is committed. In doing this, the

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23 Building a low-carbon economy – the UK's innovation challenge; supporting analysis and review of evidence, CCC, 19 July 2010.

UK could become a leader in gas CCS, and develop a potentially valuable option for decarbonisation of the power sector both in the UK and in other countries'.

We would support the move to incorporate gas-based CCS as part of a wider programme of technology development in line with the recent CCC suggestion of needing to have a gas-CCS demo.

5.1.2 Modelling limitations

In February 2010 the CHPA published a study undertaken by University of Surrey and Imperial College, London, looking at heat delivery scenarios to 2050 in the UK[24]. The study highlighted some issues associated with the 'MARKAL' modelling tool that has been used in the DECC and CCC work. In particular it noted that MARKAL does not handle changes to wider energy system transformations well, such as a hydrogen economy, increased utilisation of combined head and power (CHP) or district heating. The study states that these "imply linkages between different energy sub-systems and which may involve smaller scale, decentralised resource conversion, and thus need characterisation of local conditions".

In addition, as previously noted, the model only supports annual energy balancing so has no ability to deal with peak capacity provision to meet rising electricity peaks or the impacts of wind intermittency on balancing the electricity grid.

5.2 The value of gas as a fuel of the future

5.2.1 Quick wins

In its recent heat pump field trial report, the Energy Savings Trust estimated that it would be possible to install around 10 million microgeneration units by 2030, saving in the region of 10m tonnes of CO_2 per annum. In comparison, replacing the existing stock of gas boilers with more efficient condensing boilers (a process that would occur naturally over the next 15 years) can, in itself, save in the region of 6.3 $MtCO_2$ and places no additional pressure on the supply chain.

Another quick win could come from switching from unabated coal to gas-fired generation. The DECC 2050 'Alpha' pathway shows 121TWh and 112$MtCO_2$ of unabated coal generation in 2010 and 45TWh and 42$MtCO_2$ in 2020, with a cumulative amount in this period of 914TWh and 844$MtCO_2$[25].

Switching to gas would give an emissions reduction of 66$MtCO_2$ in 2010, 25$MtCO_2$ in 2020 and a cumulative saving in this period of 501$MtCO_2$. Further, during the period 2020 to 2050 another 260TWh and 241$MtCO_2$ is generated from unabated coal plant, which if switched to CCGTs would save an additional 143$MtCO_2$.

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24 www.chpa.co.uk/media/e9a9f61d/Building_a_roadmap_for_heat_Full.pdf

25 DECC 2050 Pathways forecast generation and CO_2 emissions at 5 year intervals between 2010 and 2050. The cumulative figures assume a linear trend between these.

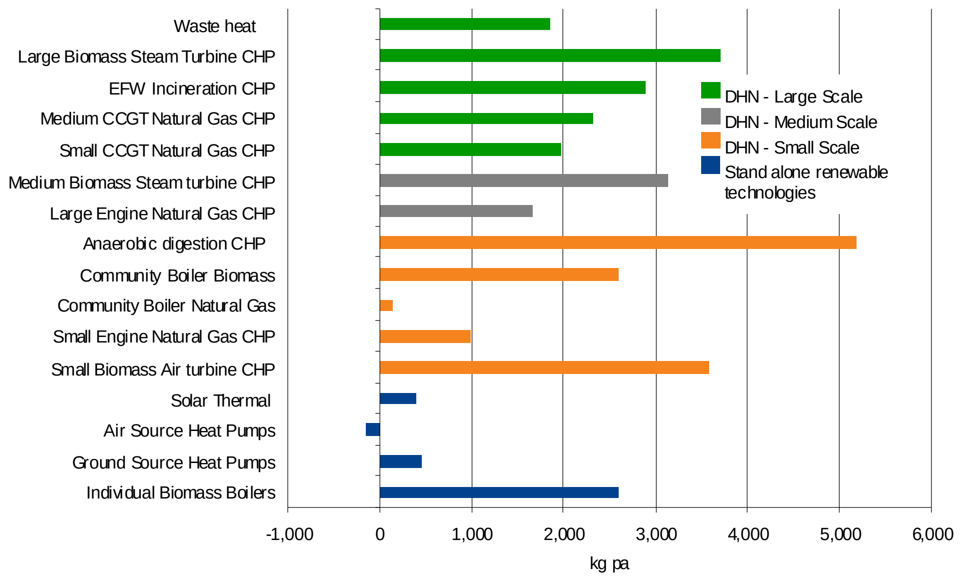
5.2.2 District heating networks

We have already seen that the focus is on achieving the renewable energy target rather than the carbon targets. This is particularly the case when looking at the heat market. In our April 2009 report to DECC on the potential and costs of district heating networks[26] the potential conflict between the two targets was starkly illustrated.

Our analysis considered the relative benefits of delivering heat through district heating schemes (via various fossil-fuel and renewable sources) and stand alone renewable technologies instead of conventional (oil, gas or electric) heating. Without some additional support widespread expansion of district heating is not likely, but this is the same for renewable heat technologies that are due to receive support through the renewable heat incentive.

The main benefit of moving to district heating or renewable technologies is expected to be the carbon savings they can deliver. Figure 17 shows that district heating can offer higher potential annual savings than stand-alone renewable technologies – and even when using fossil-based fuels. More importantly, the cost of delivering these savings through a district heating solution can also be lower, as illustrated in Figure 18 overleaf.

Figure 17 – Carbon savings compared to the composite benchmark dwelling



Of course, these relative benefits are dependent on the assumed efficiency and costs of the various technologies. Recognising this, the analysis considered how the technology choice altered under different assumptions. The main drivers of the attractiveness of heat pumps as a carbon reduction technology are their efficiency, the electricity cost and the carbon content of the electricity used. Figure 19 reproduces a phase diagram boundary between heat pumps and waste heat district heating schemes. Even under favourable conditions, electricity for heat pumps requires significant decarbonisation without any increase in the unit cost to be a lower cost carbon abatement option.

[26] www.ilexenergy.com/pages/documents/reports/electricity/A_report_providing_a_technical_analysis_and_costing_of_DH_networks.pdf

Figure 18 – Implied carbon abatement cost (£/tCO_2)

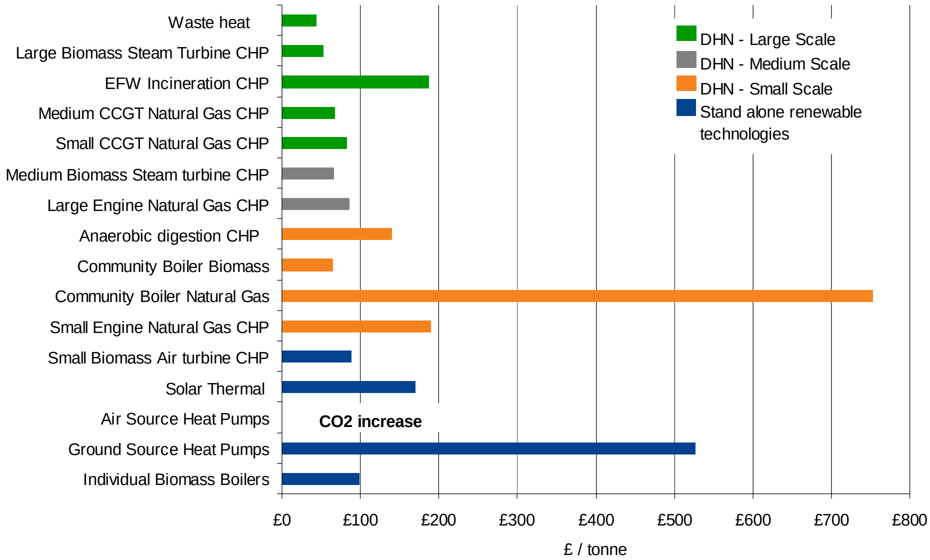
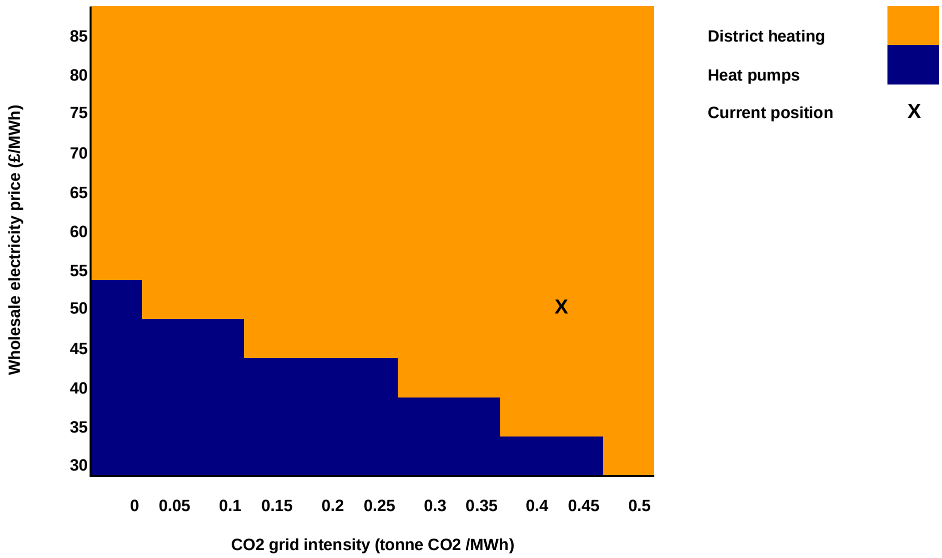


Figure 19 – Phase diagram of the attractiveness of heat pumps and district heating schemes



Notes: Assumes 8% discount rate for heat pumps (10% for district heating). COP of 3.2 and 2.5 for ground and air-source heat pumps respectively.

Source: Pöyry Energy Consulting and Faber Maunsell

5.2.3 CHP heat

The CHPA study naturally looked at the value of CHP, and found that it provides a solution that 'allows more efficient use of primary resources by reducing thermal losses'. The study noted that the consensus view of an "all-electric future is low carbon but associated with continued reliance on fossil fuels and large losses of energy at the power generation stage. This future also creates challenges related to the management of power flows, demand peaks associated with electric heat and end-user adoption of insulation, heat pumps and other measures". It identified an 'integrated scenario' that resulted in:

- By providing 4.2 MTOE heat and 4 MTOE electricity from gas-fired CCS-CHP plant, and 3.7 MTOE heat and 0.5 MTOE electricity from biomass fired CHP plant, demand for electricity is reduced by 13% and demand for primary energy is reduced by 5%.
- Use of networked heat has the potential to reduce peak power demand and offer a degree of energy storage in the form of heat. This may provide system management benefits such as providing a buffer to diurnal electricity demand peaks and mitigating the effects of intermittency.
- Reducing electricity demand has the potential to reduce the ambitious build rates implied by the 'all-electric' scenarios of DECC/CCC.
- Heat networks also obviate the need for installation of heat pumps, reducing the disruption associated with the installation of large surface area heating systems, such as under floor heating, and may offer one route to decarbonisation for some of the hardest to insulate buildings.

The study noted that the 2003 Energy White Paper showed a significant expansion of CHP by 2030 to provide a low carbon interim solution before diminishing as other low carbon options become available, in this case CCS. Adoption of CHP has the benefit in the near-term of being a cost effective means of reducing CO_2 from heat delivery and helping to limit the cumulative emissions over the period to 2050 and would also facilitate development of low carbon supplied CHP and district heating in the longer-term future.

5.2.4 Biomethane

The gas network is an existing asset so there is less of a coordination problem to overcome on network development than there is for accessing offshore wind (through new offshore grids) or dealing with the impact of large-scale CCS deployment (CO_2 transport grids). Over time, the distribution system can be converted to deliver green gas to continue to lower the carbon intensity of the fuel. If we switch away from gas quickly, there is a risk this infrastructure will not be maintained.

National Grid identified this potential for renewable gas[27] in a paper published in January 2009. It said that given the right government incentives biomethane could not only provide a significant contribution to the UK's renewable energy and carbon reduction targets but provide in the longer-term provide up to 50% of residential gas demand. By using bio-degradable waste, biomethane represents a readily implementable solution for delivering renewable heat to homes in the UK as well as a solution for waste management as UK landfill capacity declines.

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27 www.nationalgrid.com/NR/rdonlyres/9122AEBA-5E50-43CA-81E5-8FD98C2CA4EC/32182/renewablegasWPfinal2.pdf

The report went on to state that the unit cost of biomethane would be of a similar level to the cost of other sources of renewable energy, which are currently supported with subsidies. There are no insurmountable technical or safety barriers to delivering this solution – indeed the technology is already being deployed in many other countries. However, for the potential to be realised urgent changes would be need to government policy and regulation, with focus on this technology being recognised fully under the renewable heat incentive in order to have a level playing field with the less thermal efficient use in generating electricity as allowed for under the renewables obligation mechanism.

5.2.5 CNG and biogas for HGVs

Ricardo in its 'review of low carbon technologies for heavy goods vehicles[28] for the Department for Transport identified that HGVs and vans represent 24% and 12% of total domestic GHGs. The review stated that the fuel technologies with the greatest lifetime CO_2 benefits maybe biogas, biofuels and hydrogen and the powertrain technologies that offer the greatest CO_2 tailpipe reductions are electric drives, fuel cells and full hybrids, although the benefits are application specific and depend on the assumed energy mix of power generation. For example, all electric drives are only suitable for vans and not HGVs.

Because some of the technologies can deliver benefits in only limited circumstances the review went on to identify seven technologies that have the potential to deliver consistent CO_2 benefits when applied to a particular vehicle type and are not significantly affected by variables such as vehicle load and driving style. These technologies included compressed natural gas ('NCG') which can give a 10-15% reduction if using a dedicated CNG engine. It is also possible to use renewable biogas to give full well to wheel benefit, especially as waste gas has a greater GHG harm potential than CO_2.

In some countries, especially the United States, they are expanding their CNG infrastructure to allow greater use in this sector and new biomethane trucks are being marketed. Such an expansion of CNG capability would provide direct benefit on CO_2 reductions now and through biomethane a long-term solution to the difficult HGV sector.

5.3 Other countries' experience

5.3.1 Pöyry's 'Visionet' analysis of The Netherlands and Germany

The UK is not alone in facing the challenge of decarbonisation. Many other countries are grappling with the same issues. The Netherlands has a similar position to the UK in that it has had a large indigenous supply of gas and it is used widely in both industry and home. Like the UK, it has committed to dramatic reductions in carbon and some have questioned the continued use of gas in its energy mix.

In 2009, Pöyry completed an independent study[29] into feasible environmentally sustainable energy systems in the Netherlands and Germany to 2030. Many of the findings are directly applicable to other countries given the supra-national nature of the targets.

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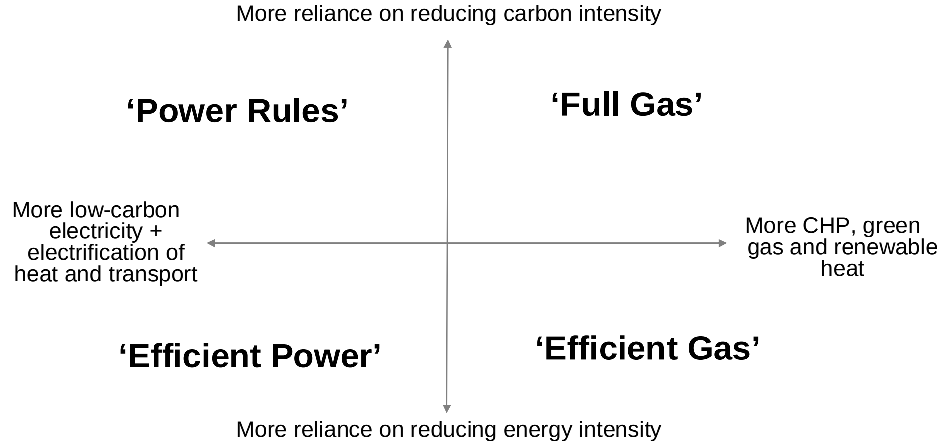
[28] www.dft.gov.uk/pgr/freight/lowcarbontechnologies/lowcarbon.pdf

[29] Realising the low carbon energy future – the role of gas, Gasunie, 24 February 2010.

Figure 20 characterises the four scenarios in terms of the balance between changes in two key dimensions - the extent to which the scenario is relatively more reliant on reductions in energy intensity than in carbon intensity, and the relative importance of the power and gas sectors in driving the fall in carbon intensity.

Figure 20 – 'Visionet': characterisation of each scenario



Apart from confirming the DECC views about how stretching the targets were, the 'Visionet' study also concluded that there were potentially different ways of moving towards the low carbon targets, especially by the degree to which energy efficiency and the electrification of heat and transport were factored in.

In considering the pathways to the low carbon future in the Netherlands and Germany, the analysis included a qualitative risk assessment of the different pathways, summarised in Figure 21 below.

Figure 21 – 'Visionet': qualitative risk assessment of delivery risks

	Efficient Gas	Efficient Power	Full Gas	Power Rules
Physical investments	✗ Limited compared to other scenarios	✗ ✗ Offshore grid requirements by 2020	✗ ✗ Deployment of heat networks	✗ ✗ ✗ Highest offshore grid requirements by 2020
Technology roll-out	✗ ✗ Renewable heat	✗ Limited compared to other scenarios	✗ ✗ ✗ Renewable heat and green gas	✗ ✗ ✗ CCS
Behavioural change by 2030	✗ ✗ ✗ Energy demand 20-30% below BAU	✗ ✗ ✗ Energy demand 20-30% below BAU	✗ ✗ Energy efficiency improvements lower but still stretching	✗ ✗ Energy efficiency improvements lower but still stretching

The risk assessment concluded that, while there were still major risks to delivery, the relative risks were lower for the scenarios that had a higher proportion of gas-based technologies e.g. increased CHP, green gas (biogas), and renewable heat. Such thinking had not featured in the Dutch policy documents before but is beginning to be recognised as the debate continues.

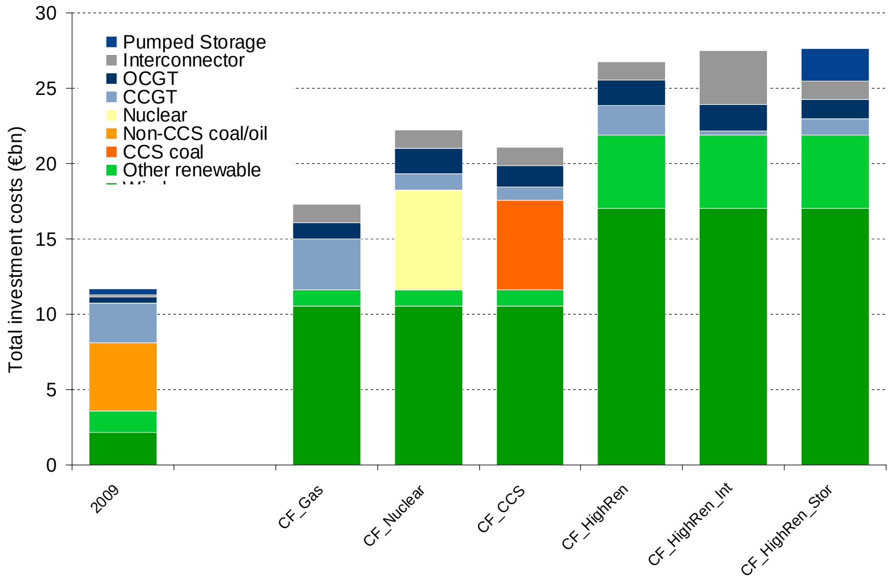
5.3.2 Low Carbon Generation Options for the All-Island Market

Earlier this year Eirgrid, the electricity transmission operator in Ireland, published work by Pöyry that examined potential scenarios of the generation mix that would deliver a carbon intensity of 100g/kWh by 2035[30]. This figure and date were chosen as a sensible point on the way to complete decarbonisation by mid-century.

The aim of the report was to compare and contrast portfolios centering on different generating technologies, including renewables, CCGT, nuclear and CCS; metrics included market prices, end consumer prices, investment costs etc. Figure 22 below provides a flavour of the detailed analysis in the report.

Particularly of note for this report was the way in which gas-fired generation featured significantly in all six scenarios – clear economic recognition of the importance of having gas in the mix. It was noted that the 'gas' portfolio would only be a stepping point on the road to decarbonisation, but it did have significant cost advantages.

Figure 22 – Eirgrid report: portfolios' total capital investment



30 www.ilexenergy.com/pages/Documents/Reports/Electricity/085_Low Carbon Generation Options for the All Island Market 4_0.pdf

5.4 Will there be enough gas for the UK to rely on?

If gas is to be part of the transition and potentially the long-term solution then it is important that concerns over whether there will be enough, affordable gas must be addressed. It is no good identifying the attractions of using gas if these are outweighed by concerns that gas cannot be considered a secure source of energy for the future. Indeed, the need for further gas storage facilities in the UK is constantly being advocated by some.

The concern stems from the UK becoming a net importer of gas in recent years, following decades of virtual self-sufficiency. Even today gas sources are far more diverse as LNG flows and longer haul pipelines supply gas to the UK. Inevitably the new pattern of gas supply raises a range of supply security-related questions:

- Will the LNG actually flow to the UK, given the nature of the global LNG market?
- Can Russian gas supplies be relied upon, following the recent disruptions by transit countries like Ukraine and Belarus?
- Will new pipelines across Europe actually be built?
- What might be the impact of so-called unconventional gas (e.g. shale gas), and over what timeframe? and,
- Does the UK need more gas storage, perhaps even strategic storage, in order to help insulate it from its import dependence?

5.4.1 Winter 2009-10

Many of these questions have been asked for some time, so it is worth mentioning that, in the past winter, gas security of supply proved resilient to a combination of highly challenging conditions:

- it was the most severe winter for 31 years;
- a record peak demand was reached on 8th January of 465mcm/d;
- the week of 4 January 2010 had seven of the sixteen coldest days in the past fourteen years; and
- coincidentally technical problems with Norwegian fields significantly reduced output from Norway.

The effect on the market might have been expected to be dramatic, but despite these extreme events on the demand-supply balance, prices were hardly affected and were even relatively low compared to recent winters.

After passing such a test, one might conclude that the situation today seems highly secure, so the question remains what is the outlook?

DECC in its April 2010 gas security of supply policy statement[31] concluded that the diversity of supplies available to the UK and the competitive market had delivered sufficient so that risks to gas security are very low up to 2020 and beyond. This was

[31] www.decc.gov.uk/assets/decc/What we do/UK energy supply/Energy markets/gas_markets/1_20100512151109_e_@@_gassecuritysupply.pdf

supported by three studies carried out by Pöyry for DECC which were published this summer[32].

5.4.2 DECC security of gas supply studies

The first study was carried out in 2009-10 to examine the impact on the Britain's security of gas supply to a range of supply shocks including the contribution from demand side response and storage.

These were followed by two more studies to look at these wider factors:

- firstly the global gas market (focusing on LNG and unconventional gas); and
- secondly the European gas market (including Russia).

By combining the analyses in all three reports we were able to take a view on the robustness of gas supply not only to events in the UK, but also the evolution of gas supply far across the globe.

This work broadly concluded that the UK's gas supply security is robust to a range of underlying demand scenarios, including in the event of low probability, high impact events causing disruption to gas supplies. Specific events modelled included:

- prolonged outages to key pipeline routes (from Norway and Russia); and,
- long disruptions to major LNG sources and LNG regasification capacity (Qatar and Milford Haven).

Outages were modelled under severe weather and using a very high UK demand profile (up to around 120bcm per annum), corresponding to National Grid's top of the range of its central demand projections. While the events did cause increased UK gas prices, only in the coincident occurrence of the most extreme circumstances was there any gas interruption.

Drawing on the DECC studies, the following sections provide more detail on some of the particular concerns about future gas security of supply.

LNG availability to the UK

Global trade in LNG has grown significantly in the last decade, doubling to around 250bcm in 2009. Projecting forward to 2025 on the basis of terminals under construction or being planned, liquefaction capacity could grow to 350–600 bcm pa.

However, sufficient liquefaction capacity is not the full picture: the DECC work, specifically examined the LNG volumes that would be available for delivery to the UK should the price signals be right (so it excludes the Pacific Basin). The analysis categorises the volumes as divertible (i.e. contracts allow the destination to be readily changed), portfolio (i.e. non destination-specific) and uncontracted.

For comparison with the supply volumes, Figure 23 overleaf shows a UK demand profile and the projected GB regasification capacity. It shows how the potentially tradable volumes far exceed total projected UK demand over the period, and projected GB regasifcation capacity by an even greater margin.

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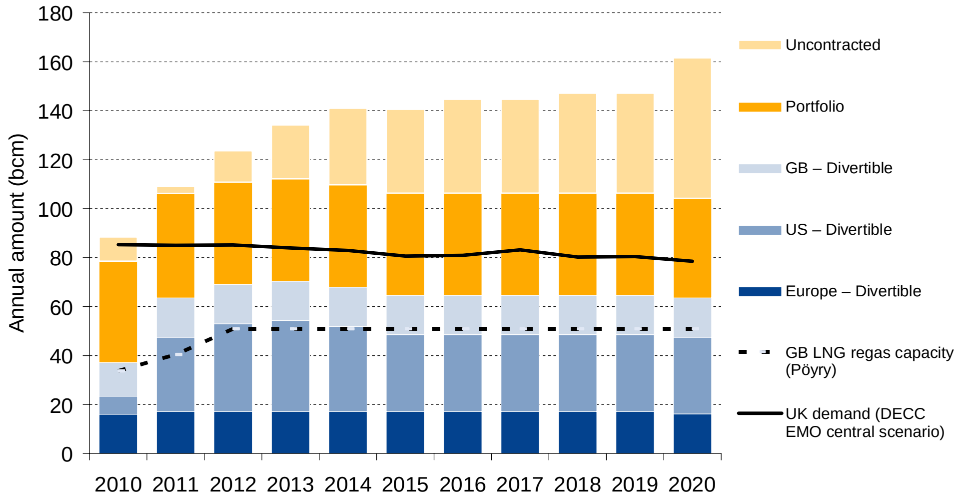
32 www.decc.gov.uk/en/content/cms/what_we_do/uk_supply/markets/gas_markets/gas_markets.aspx

Figure 23 – LNG volumes potentially accessible to GB from capacity in operation and under construction in February 2010 by region



Analyses like these draw a clear conclusion that there are plentiful volumes of LNG through to 2020, and that they would be delivered to the UK should the prices signals be right.

Russian supplies

Russian gas supplies have historically proved reliable, but subject to occasional difficulties in the pipelines through which they are delivered.

Expected commissioning in 2012 of the Nord Stream pipeline, bringing up to 55 bcm pa of Russian gas directly to Western Europe and avoiding potential disruptions from transit counties is likely to improve not only the UK's security of supply position but also that in the rest of North-West Europe.

Unconventional gas

As has been much publicised recently, the US has seen a dramatic expansion in its unconventional gas[33] production, which has increased four-fold in the last decade to around 300bcm per annum, representing around 50% of the US's indigenous production.

While the US may seem remote, the DECC studies analysed the potential impact of unconventional gas on the UK's security of supply. Furthermore there is significant potential elsewhere including China, India, Australia and Europe.

In practice, the models suggested that increased unconventional gas production in the US would make more LNG available to the UK. We believe that European unconventional gas, most obviously from Poland, is unlikely to be developed before 2020.

Overall, the prospect of growing development of unconventional gas sources, wherever they are located, will improve security of supply in the UK.

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33 includes shale gas, coalbed methane, tight gas and gas hydrates.

Demand Side Response

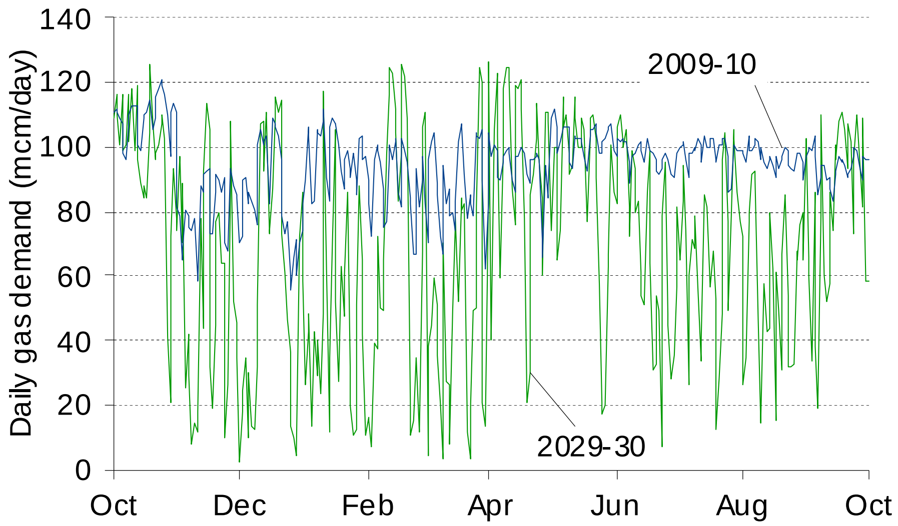
In the UK management of high peak demands or unexpected problems in gas supplies has always historically included the use of 'interruption'. This is exactly the same way as electricity systems throughout the world, where industrial consumers have long held contracts with the system operator to reduce load. In fact such a process is ideally suited to deal with low probability but important situations, and end consumers normally benefit economically from taking their gas supply on an 'interruptible' basis. Nevertheless, the use of demand side in maintaining gas security of supply is a key measure of how 'tight' the system is.

The DECC studies examined sensitivity to extreme demand and severe weather (1 in 50 winter and 1 in 20 peak demand) and found that demand side response (DSR) should only be needed when there was also an extreme supply disruption. Even then most of the requirement could be met CCGT distillate backup and only very occasionally by invoking interruptible contracts at appropriate industrial and commercial (I&C) sites.

5.5 Can gas work with wind intermittency?

As previous identified a major risk with the electrification pathways is how to balance the system when there is a large amount of intermittent wind generation connected to the grid. Following on from our seminal 2009 study into the effects of integrating large volumes of wind to the UK system, Pöyry published results in June 2010 of a follow-up study[34] to understand what happens to the gas market when large amounts of wind are deployed on the electricity system – for example how the market reacts to the intermittent requirements for gas-fired generation. Figure 24 reproduces one of the diagrams from that report, showing the dramatic changes in the pattern of gas demand that might happen.

Figure 24 –Evolution of the power sector gas demand in GB markets



Gas demand with the weather of gas year 2007-08, in a scenario with high build of renewables and CCGTs

34 www.ilexenergy.com/pages/Documents/Reports/Gas/264_GasIntermittency_Public Summary_v1_0.pdf

Despite such changes in swing required the study concluded that the gas market was able to deliver in an intermittent world with only relatively minor perturbations – although the work did highlight potential need for more storage facilities that could respond in much shorter timescales, so-called 'fast storage'. This additional storage capacity is, however, relatively small and not needed until the end of the decade.

Thus, whilst large scales wind intermittency will present significant challenges to the electricity market, the gas market is well placed to contribute to providing the flexibility required and at the least cost.

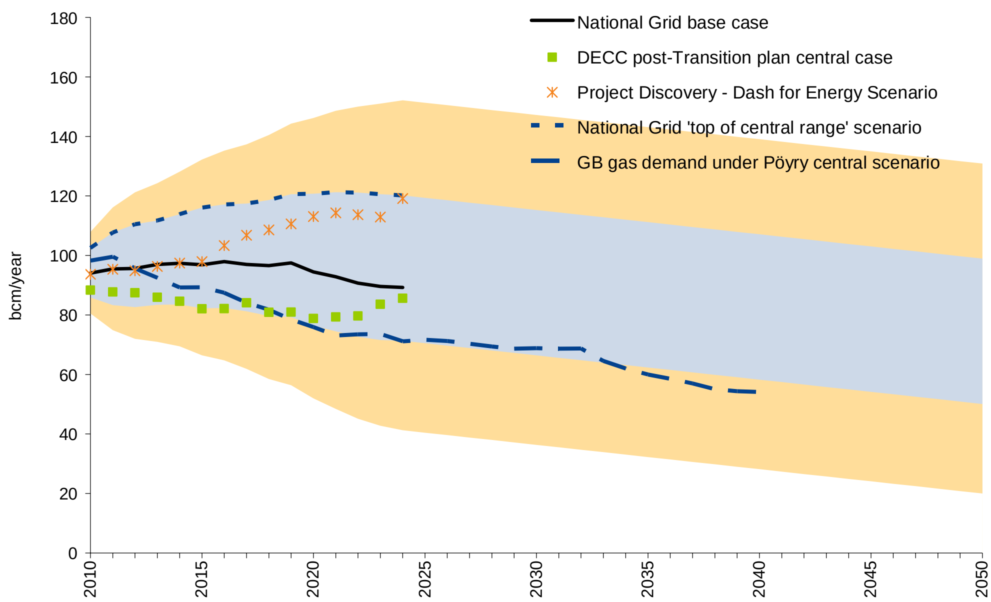
5.6 What will be gas usage in the future?

As purpose of this review is to examine the role of gas in the low carbon transition and future world, it is pertinent to bring all of the above together and examine the various projections for gas use at this point in the review.

Apart from the Pöyry Visionet work, most of the published transition plans only show the role of gas through their demand projections, and by inference split by end use (i.e. electricity generation, heat), as shown in Figure 25 below.

The figure also includes the central and outer ranges, published by National Grid in their 2009 Ten Year Statement[35], which extend to 2024. The ranges have been projected to 2050 assuming the bottom of the outer range should reach zero by 2050.

Figure 25 – Demand projections



Source: DECC, National Grid, Ofgem and Pöyry

35 www.nationalgrid.com/uk/Gas/TYS/current/TYS2009.htm

The wide range of view stands out – different bodies have different views on the meeting of targets as well as the combination of changes through which they are met:

- The DECC and National Grid Base Case projections assume broad compliance with the UK's carbon reduction targets.
- The Ofgem 'Dash for Energy' and National Grid 'top of central range' demand profiles are also considered to be feasible outcomes in the event that policies to achieve carbon reduction are much less effective.
- The latest Pöyry projections, which assume meeting the 2020 renewable targets by 2030, show that UK gas demand in 2040 still represents around 55% of demand in 2010.

So we can summarise that there is still much uncertainty on what role gas can play. We have seen that a gas-based solution adds more flexibility to the power generation mix, requires less infrastructure expansion as we can rely on the existing network, improves conversion efficiencies using mature technologies (CHP, CCGTs and condensing boilers) and delays the need for major investment.

This set of characteristics appears to offer potentially valuable options to the market when making investment decisions for a sustainable low-carbon future. If we fail to keep our options open, then we may exacerbate the dangers on the journey to the low-carbon future.

6. IMPLICATIONS FOR POLICY

6.1 Conclusions

Energy policy has to balance the need for secure energy supplies, affordability and delivering a low carbon world. In order to achieve this government must consider what is feasible – we are making investments for our long-term future, so they need to be value for money.

In order to move to a low carbon future we have been given a world with many targets. Whilst the need to set targets as part of the move towards a low carbon world is recognised, there appear to be too many, not all are complementary, and the resulting confusion is not sending the correct investment signals to the market.

Current policies and pathways to the future see a solution involving a major electrification programme. In particular, this vision of the future relies heavily on:

- extraordinary rates of deployment – e.g. high build rates for renewables of around 3GW per annum over a sustained period, requiring facilitatory expansion of networks and large capital expenditure;
- highly successful technology innovation – emergence of smart grid systems, electric vehicles at scale and rapid commercialisation of CCS; and
- dramatic changes in consumer behaviour – quick adoption of new technologies e.g. electric vehicles, solar panels, heat pumps, and more responsiveness to price signals e.g. for household investment in energy efficiency.

Though all energy pathways rely to a greater or lesser extent on delivering deployment, innovation and behavioural change there are significant risks along the current consensus of an ‘electricity focused’ pathway.

Risks with electrification pathway

Supply Chain – with large scale renewable build, new nuclear power stations and a major expansion in electric grid infrastructure (both offshore, main transmission and within households) required there is an enormous challenge in putting together the resources, capabilities and skills required.

Funding – The sums involved are enormous (in the range of £200–400bn) and there are questions over the ability of the market players to raise the necessary debt or equity funding.

Innovation – similarly many of the potential solutions are at the early stage of development. CCS, smart grids, heat pumps, etc. are not proven on the scale required. Expanding electricity demand, including its peak to c.110GW (compared to 60GW today) to replace much of the current heating supply and for use in transport will require rapid and sustained progress on all forms of the ‘electric’ future.

Security of Supply – we believe there is a greater risk of the ‘lights going out’ through insufficient power generation and increased peak forecasts than any concerns over security and price from rising gas imports. Renewable generation is mostly intermittent in nature so will require sufficient flexible generation capacity to balance the system. Flexibility from nuclear stations is not proven and CCS costs may limit its contribution.

Without an electricity market that correctly values flexibility there remains a risk that its provision is not delivered.

Affordability – many of the pathways rely heavily on improved energy efficiency so that consumers can pay a higher energy unit rate in order to fund all this major investment. Unless changes in consumer behaviour deliver their side of the equation we will see a substantial rise in consumers in fuel poverty.

So this route has enormous risks and failure of any stage should not be discounted by policy makers. There is much uncertainty on when the different elements of the solution can contribute to reducing carbon intensity. Early targets do not mean they will be achieved and panic-style measures to deliver will likely increase the costs and are unlikely to have the desired effect.

Gas is the lower risk alternative

Gas has been the foundation for a large part of the UK's success in meeting Kyoto carbon reduction targets enabling the economy to simultaneously increase energy consumption (and hence economic growth) while delivering carbon reductions. It has also contributed to improved competitiveness, greater security of supply and better air quality. Recent studies by Pöyry, and supported by DECC, concluded that there are no major security of gas supply concerns as we move to a supply picture with increased imports.

Yet gas features very little in policymakers' outlook. The reason for this is not clear. As the CCC acknowledge 'switching from coal to gas generation can also achieve a significant one off reduction in emissions'. Such a move would provide lower carbon flexible generation required to balance intermittent renewables in the interim and then through adoption of CCS gas can be an integral part of the low-carbon generation future.

Such an alternative plan would also give time for other new technologies, such as large-scale biomethane, to develop or other technologies to develop on a commercial scale, such as district heating, CHP and micro-generation. These alternatives mean there is **no need to reinvent the wheel**. They would make much better use of heat recovery from electricity generation and could result in a lower cost solution, as much of the existing infrastructure is already in place.

Thus there is significant scope for gas to support a successful low-carbon transition for the following reasons:

a) It can produce significant carbon savings in short-term – improved conversion efficiency (CHP, CCGTs, condensing boilers, etc) as well as further fuel switching.

b) It will facilitate the smooth roll-out of intermittent renewables – gas represents the only real option to provide the flexibility that will be required for firm back up if we have penetration of intermittent generation in the region of 25 – 30%.

c) It offers the government greater optionality for future technology adoption, through reducing the need to lock-in on any one technology at this early stage.

d) In the industrial sector, there is often no alternative to gas for heat or as chemical feedstock and failure to recognise this dependence will limit our economic growth;

e) It reduces risk of not meeting government targets because we will be relying more on mature technologies and existing infrastructure and so provide greater certainty in achieving carbon savings.

f) Gas security risk is low in at least the medium-term. Pöyry's DECC studies showed gas supplies are still abundant, even if coming from more distant sources, and it is no more likely to be high cost to consumers, with less investment required early.

It is our view that reducing gas' share of the energy mix represents a flawed pathway for society to progress towards decarbonisation. Options such as gas CCS, CHP, district heating, biomethane, should be given equal opportunities to participate in the pathways in order to ameliorate the risks and uncertainties and so deliver our carbon targets in the most secure and affordable way for consumers.

6.2 Recommendations

Based upon these conclusions this review believes that policy makers should consider adopting the following recommendations:

- Government policy needs to focus more strongly on achieving carbon reductions by 2050. In order to reach the longer term target the government should properly consider all the weaknesses in its plans, and incorporate appropriate fallbacks and contingencies to reduce the obvious risks.
- Foreclosing certain technologies or fuel sources that may be able to support a low-carbon transition does not make sense. We need to keep our options open and this includes gas. Government should review its current policy framework to ensure gas-based investments can be appropriately rewarded for their contribution to meeting policy targets. Whether a far more realistic alternative plan would see more gas used not only in the transition but also in the endgame is for markets to decide.
- We believe the priority attached to the 2020 renewable energy target should be reviewed and a more realistic timescale set. Not only is the target likely to be missed, it also appears to be a distraction to achieving the longer-term carbon targets and is almost certainly going to result in increased costs and/or security of supply concerns.

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