CASE STUDY: A LONG TERM VIEW OF THE UNITED KINGDOM'S NATURAL GAS REQUIREMENTS WITH SPECIAL EMPHASIS ON THE OPPORTUNITIES FOR US LNG SUPPLIES

by

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1. Background

Energy and Climate Change have been hot topics in the United Kingdom for over ten years – and not just amongst politicians – but also with the population at large, the big retail energy suppliers and the differing agendas of many lobbying groups.

Looking back to after WWII it appears that the broad topic of energy has been treated as a political football by UK governments yet in the 21st century there appears to be a strong political consensus that the UK should be in the forefront of energy and climate change policy-setting that could lead the world into a post-fossil fuel era by 2050. Having said that, the precise route is very much subject to debate and revision by governments with the result that many uncertainties exist as to how and if the long term targets will be achieved by the set date. Nuclear energy – once seen as a major component of the UK’s long-term energy supply – has been pushed and pulled by politicians and the public such that today a nuclear energy renaissance appears to be almost underway but is far from certain as to how much impact nuclear will eventually have on the UK’s long term energy supply.

Coal and gas have been important components of Britain’s energy heritage. However, it was the Clean Air Act of 1956 which curtailed the use of coal for domestic purposes allowing gas in the form of cleaner burning “town gas” (manufactured gas) to replace it. Gas fires, space heaters and then gas boilers came into the majority of homes and in 1977 the ten year conversion of the gas system was completed to cater for the new source of supply: North Sea gas.

Indigenous coal and North Sea oil and gas are now in terminal decline and the current excitement about the potential for onshore shale gas has yet to be demonstrated. Today natural gas accounts for 40% of the UK’s primary energy supply; 92% of homes in Britain have a piped gas supply and 83% use it for heating; other common uses being for cooking and hot water supply. Electricity is a poor second choice for heating in only 9% of all British homes.

Since 1998 Britain has been connected to continental Europe (Belgium) by the ‘Interconnector’ gas pipeline and in 2006 the ‘BBL’ pipeline started operating between Britain and the Netherlands. A new generation LNG receiving terminal opened in 2005 in the river Thames Estuary to the east of London and then two further terminals opened in 2009 in west Wales. Future gas supply - via imports - is assured but the price will be that prevailing in the international market.

Gas has been and currently is an important part of the UK’s energy supply and in the words of the present Secretary of State for Energy and Climate Change, Ed Davey (September 9, 2013), “gas will continue to play a role right through to 2050”.

2. UK Political Background with Respect to Energy

a. Up to 1979 (pre-Margaret Thatcher)

Whilst coal had been the mainstay of British energy supply since the late Middle Ages the two World Wars necessitated the government to take control of this fundamental resource which led the post-WWII Labour (Socialist) Government (1945-51) to nationalise the industry and form the National Coal Board (NCB) in 1946.

From 1951 Conservative Governments were in control till 1964 during which there was not much change in the primary energy supply sector - except that Calder Hall (north west of the UK), the first nuclear power station in the world, started operating in 1956.

Meanwhile, British Petroleum had been exploring for hydrocarbons onshore in the UK following occasional discoveries in Germany and Holland. The southern North Sea appeared to have the geological potential for hydrocarbons. It was during the Labour Government of Harold Wilson (1964-1970) that natural gas was discovered in the UK sector of the North Sea by BP in September 1965 and other discoveries followed. However, the sole buyer, British Gas, offered low prices and gas export was not permitted so exploration efforts declined and initial enthusiasm faltered.

The following Conservative Government of Edward Heath (1970-1974) took place against the backdrop of the 1973 Yom Kippur War with the resultant Arab oil embargo producing an oil price shock and high inflation in Great Britain. Government’s reaction was to limit public sector wage rises and encourage private sector restraint but trades unions’ response was to ‘work to rule’. This was particularly effective in the case of the coal miners (the powerful National Union of Mineworkers - NUM) who controlled the supply of coal to the power stations and who had allowed coal stocks to dwindle. Coal prices on the international market had risen in response to high oil prices. Electricity shortages ensued and Heath implemented the ‘three day week’ (January – March 1974) where commercial users of electricity were limited to three specified consecutive days’ consumption each week and prohibited from working longer hours on those days. Services deemed essential (e.g. hospitals, supermarkets and newspaper printing) were exempt.

Public unpopularity with these measures resulted in Heath calling a snap General Election to confront the unions on the basis of ‘who runs Britain’. He lost the election and in March 1974 Harold Wilson returned as Prime Minister settling the dispute with the miners and negotiating a new social contract with the unions. Wilson chose to resign in 1976 (on reaching age 60) and was followed by James Callaghan (Labour) until 1979.

b. From 1979 (the Margaret Thatcher Era)

From 1979 till 1990 Margaret Thatcher (Conservative) served as Prime Minister and is noted for privatising many of the industries that had been nationalised under previous Labour governments, decreasing the power of trades unions and dealing with the miners’ strike of 1984-85. This strike came about because Thatcher wanted the coal mining industry to improve its profitability and this meant pit closures and job losses. However, the government’s action was well planned with secret stockpiling of coal and conversion of some power stations to burn oil. A national coalminers strike was called in March 1984 which lasted a year after which the NUM voted to return to work. This result significantly weakened the British trades union movement.

Thatcher’s process of privatisation of nationalised industries and market liberalisation was associated with marked improvements in performance, however, some of the privatised industries including gas, water, and electricity, were natural monopolies for which privatisation involved little increase in
competition. Therefore, regulation was significantly expanded to compensate for the loss of direct
government control with the formation of regulatory bodies like Ofgas (Office of Gas Supply) – now
Ofgem (Office of Gas and Electricity Markets).

Natural gas producers, now with some 20 years of experience from the UK sector of the North Sea,
moved into power generation using gas turbines: the "Dash for Gas" was experienced whereby a
massive expansion in gas-fired power generation took place competing with coal and nuclear power.

For other reasons, by 1990 Margaret Thatcher had become extremely unpopular with the public and
her own party and after a challenge to her leadership she resigned and was replaced by her
Chancellor John Major who continued as Prime Minister until 1997 when the General Election placed
Tony Blair in power (‘new’ Labour).

c. From 1997, Climate Change on the Agenda

The UK became one of the early signatories of the Kyoto Protocol under the Labour Government of
Tony Blair (1997-2007) which, surprisingly, had no Secretary of State for Energy, the position having
been abolished in 1992 by John Major following the privatisation of the energy industries. Many of the
energy related government functions had been abandoned with the remainder being absorbed into
other bodies or departments; the core activities relating to UK energy policy had been absorbed into
the Department of Trade and Industry (DTI).

With the 1997 adoption by the Parties to the UNFCCC of the Kyoto Protocol the UK signed-up in 1998
and ratified the commitment in 2002. A landmark energy policy was laid out by the Blair government in
the 2003 Energy White Paper “Our Energy Future – creating a low carbon economy”. This formal
energy policy was the first one for 20 years and has largely remained the same in principle up to
today’s Conservative / Liberal Democrat Coalition government.


A new long term direction for energy policy was advocated to tackle climate change; the UK was
committed to a 60% reduction in CO\textsubscript{2} emissions by 2050 (relative to 1990) with an interim target of
20% reduction by 2010. The four pillars on which the policy was built consisted of the environment,
energy reliability, affordable energy and competitive markets.

In late 2005 a full scale Energy Review was undertaken with hundreds of organisations and individuals
contributing. Amongst other things it looked at cutting carbon emissions and the issue of energy
security of supply now that UK North Sea oil and gas production had peaked in 1999/2000. The report
was published in 2006.


Saving primary energy, using less energy and using cleaner energy were identified as measures for
reducing carbon emissions. Promoting renewables and encouraging timely private sector investments
in infrastructure and generating capacity were seen as important to meet security of supply
challenges. New nuclear power stations were neither encouraged nor discouraged but it was up to the
market, not government, to propose such projects for which the government would ease some of the
planning constraints.
Under pressure from cross-party politicians and environmental groups this Bill was presented to parliament by the Secretary of State for Environment, Food and Rural Affairs. This put a framework in place to achieve a mandatory 80% reduction in carbon emissions by 2050 versus the earlier 60% target – all relative to 1990 levels. The intermediate target, previously a 20% cut by 2010 was proposed at between a 26% to 32% cut by 2020 (revised to 34% in April 2009).

The Bill passed into law in November 2008: “The Climate Change Act” placing the UK as the first country in the world to set legally binding long range emissions reductions targets on itself. A system of 5-year Carbon Budgets was initiated – to date making commitments through 2027 - and a Committee on Climate Change was established to manage the budgets and to advise the Secretary of State.


This White Paper from the DTI documented the government’s strategy for (i) cutting carbon emissions and (ii) ensuring clean and affordable energy as the North Sea oil and gas declined and the UK had to increasingly rely on imports. The four policy goals (pillars) of the 2003 Energy White Paper were restated and practical measures to achieve the strategy were enumerated:

- Businesses: cap and trade scheme, energy performance certificates, smart metering
- Homes: new homes to be zero-carbon, energy efficiency improvements including light bulbs, appliances and electronics, upgrading of electricity meters to real-time displays
- Transport: a low carbon innovation strategy, including aviation in the EU Emissions Trading Scheme
- Energy Supply: biomass, distributed electricity generation and CHP, reconfirming the renewables obligation, carbon capture and storage competition, option for private sector to invest in new nuclear, biofuels for transport, enhanced recovery of North Sea oil and gas resources, planning permission processes to facilitate infrastructure and power plants.

Tony Blair resigned as leader of the Labour Party in June 2007 and his successor Gordon Brown (Prime Minister 2007-2010) established the new position of Secretary of State for Energy and Climate Change (the Department is known as DECC) - October 2008 - with Ed Miliband the first holder of the newly defined post. This position combined for the first time the energy and environment portfolios of a UK government minister.

Energy activities continued apace: the “Energy Bill 2007-2008” (January 2008) leading to the “Energy Act 2008” (November) which implemented the legislative aspects of the 2007 White Paper (“Meeting the Energy Challenge”) and also made provisions relating to gas importation and storage, electricity generated from renewable sources, electricity transmission, etc.

Simultaneously “A White Paper on Nuclear Power – January 2008” set out the government’s preliminary view on this topic: “The Government is not itself proposing to build nuclear power stations. We have, however, reached the conclusion that private sector energy companies should have the option of investing in new nuclear power stations, subject to six conditions…”

In March 2009, Ed Miliband was trapped into declaring to the House of Commons a change to the government’s policy on coal-fired power stations, saying that any potential new coal-fired power stations would be unable to receive government consent unless they could demonstrate that they would be able to effectively capture and bury 25% of the emissions they produce immediately, with a
view to seeing that rise to 100% of emissions by 2025. This set the agenda for “clean coal” Carbon Capture and Storage (CCS) technology in that sector.

“UK Low Carbon Transition Plan” (July 2009)

This detailed the actions to be taken to achieve the 2020 emissions target (34% reduction relative to 1990 levels). Actions included upgrading of energy efficiency in homes, 40% of electricity generation from low carbon sources (renewables, nuclear, clean coal), lower levels of gas imports than would otherwise have been needed, 40% reduction in new car emissions compared with 2009 levels.

“Energy Act 2010” (April 2010)

This Act largely concerned itself with provisions for the demonstration, assessment and use of Carbon Capture and Storage technology related to electricity generation and broader provisions concerning the functions of the Gas and Electricity Markets Authority.

In the May 2010 General Election Labour lost and the Conservative Prime Minister David Cameron (in Coalition with the Liberal Democrats led by Nick Clegg, Deputy Prime Minister) took over government. The position of Secretary of State for Energy and Climate Change was assigned to the Liberal Democrats with Chris Huhne as the first holder, succeeded by Ed Davey as the incumbent. Since September 2010 Ed Milliband has been the Leader of the Labour Party in Opposition.

“Planning our electric future: a White Paper for secure, affordable and low-carbon electricity” (July 2011)

This White Paper was premised on noting that since the electricity market was privatised in the 1980s it had worked satisfactorily but that it could not meet the challenges of the future with around a quarter of existing capacity – mainly coal and nuclear power stations – due to close in the next decade. “Keeping the lights on” would mean raising a record amount of investment but the current market arrangements cannot deliver investment at the scale and the pace needed.

Traditional fossil fuels leave the UK open to volatile prices and deepen the dependence on imported energy and emit too much carbon. Consequently a huge investment in renewables; a new generation of nuclear stations; and, in time, gas and coal plant that can capture harmful emissions, will diversify supply and wean the UK away from imported fossil fuels.

The White Paper therefore set out the Government’s commitment to transform the UK’s electricity system to ensure that the future electricity supply would be secure, low-carbon and affordable.

These ambitious statements laid down the basis for Electricity Market Reform (EMR) which defines the current state of play of the UK energy market.

“Energy Bill 2012-2013” (November 2012)

This Bill aimed to maintain a stable electricity supply as coal-fired power stations faced retirement. This included facilitating the building of a new set of nuclear power stations and the establishment of a new Office for Nuclear Regulation.

The Bill proposed a delay in setting targets for decarbonisation of the electricity supply – imposed under the Climate Change Act 2008 - until 2016. Businesses and analysts have criticised the uncertainty this causes for investors.
An “Energy Bill Summary Impact Assessment” (February 2013) provided analysis of the concepts in the Bill ahead of the approval of the “Energy Act 2013”.

“Energy Act 2013” (December 2013)

This Act set into law the Electricity Market Reforms that had been contemplated in the recent White Paper and the Energy Bill. Fundamental to the Act is the setting of decarbonisation target ranges for electricity supply: the earliest year for setting a target range is 2030 – which is not to be done until 2016.

d. Conclusions

Despite changes of government, structure of ministries and of Secretaries of State there continues to be wide all-party support for the UK to be in the vanguard of tackling climate change – indeed, the UK has demonstrated a passion in setting itself challenging targets related to emissions – targets which have been the subject of UK legislation in three significant Energy Acts (2008, 2010, 2013) and a Climate Change Act (2008) – all originating from the landmark Energy White Paper of 2003.

The approach to Energy (and now to Climate Change) has been fairly consistent under Labour and Conservative Governments. However, the difficulty of the hands-off approach that governments have to take in an open market environment nowadays has meant that frequent shifts have taken place in the use of different economic and policy tools to encourage or discourage certain patterns of energy supply and usage. This is still being tweaked and it is not 100% clear if today’s declared objectives for Electricity Market Reform (EMR) - whereby the UK’s future electricity supply is stated to become secure, low-carbon and affordable – will finally be achieved nor the 80% reduction of GHG emissions by 2050.

The role that fossil fuels – refined products as transportation fuels and natural gas in electricity generation and domestic heating use – is uncertain for some years to come.

3. The Situation in the European Union

Whilst the EU as an entity supports the UNFCCC / Kyoto Protocol agendas on Climate Change its Energy policy is mainly concerned with the pan-European open market; gas liberalisation, security of supply and infrastructure connections across borders.

Fundamentally, the ambition in the EU is to transform Europe into a highly energy-efficient, low carbon economy. With the coming into force of the Kyoto Protocol in 2005, the EU announced in March 2007 its “20-20-20" targets…to be achieved by 2020:

• 20% reduction in EU greenhouse gas emissions from 1990 levels (this would increase to 30% if other countries undertake to increase their commitments)
• Raising the share of EU energy consumption produced from renewable resources to 20%
• 20% improvement in the EU's energy efficiency.

Targets are set to reduce GHGs by 2050; 80% - 95% GHG reductions relative to 1990 levels.

It can be seen that the UK approach is consistent with these EU ambitions and in several areas is in advance of them.
4. UK Supply and Demand History

Snapshots of UK energy DEMAND over time by main sector: (“Other” includes Services Sectors such as commercial, social activities, tourism, consultancy, etc.)

Snapshots of UK energy PRIMARY SUPPLY over time by fuel type:

Note that the above are merely snapshots of 6 years chosen to illustrate how the components of Energy Demand and Supply have evolved historically.

Observations: trends of UK energy demand and primary supply over the last 40 years can be traced as follows –
In summary over 40 years:
- Industrial energy demand declined due to shifts from heavy industry and manufacturing plus progressive energy efficiencies in processes
- transport demand increased in all types
- domestic and other energy demand constant
- coal in primary energy supply declined continuously
- natural gas increased
- overall role of petroleum (products) declined
- primary electricity (nuclear, wind, hydro, biofuel) supply slowly increasing.

It is worth noting that Margaret Thatcher’s attack on the coal mining industry and on liberalisation of previously nationalised industries occurred before the Kyoto Protocol came into existence – yet some of the implications of that, surprisingly, seem to have been anticipated but not to the extent of defined emissions reductions as such. We might not be where we are today if the early steps to reduce coal burning and to open up energy markets had not taken place in the 1980s.

The Tony Blair 2003 initiative to address the prospect of a low-carbon future was a milestone in setting the subsequent agenda that would determine how energy would be supplied and utilised in the long term future of the UK. This is now over 10 years and after several White Papers, Energy Bills, Acts of

<table>
<thead>
<tr>
<th>Period</th>
<th>Trends</th>
<th>Status of natural gas</th>
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<tbody>
<tr>
<td>1970s and early 1980s</td>
<td>Coal dominated power generation and was significant in industry and domestic heating sectors. Some oil and nuclear used in power generation. Petroleum in addition to transport use significant in industry (gas oil / fuel oil) but quickly declining.</td>
<td>Significant in industry and homes (trend increasing, progressively having the edge over domestic coal use); gas not relevant in power generation</td>
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<td>Late 1980s into early 1990s</td>
<td>Power generation still coal dominated but small oil burning being displaced progressively by nuclear. Gas starts to contribute to power generation. Transport sector demand increasing.</td>
<td>Domestic use of natural gas continues to grow but industrial uses shrinking (as is the total industry demand for energy)</td>
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<td>Through 1990s</td>
<td>Coal for power generation declining significantly through period to become an equal ⅓ of input alongside nuclear and gas. Coal displaced in home use. Energy demand in transport sector growing.</td>
<td>Domestic use of gas taken over any coal use. National gas demand rising due to power generation requirements.</td>
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<tr>
<td>Early 2000s</td>
<td>Gas demand grows noticeably – for power generation and in domestic use. Coal on the decline for power and now trivial in industry and home use. Power generation about equally split between coal, gas and nuclear.</td>
<td>Gas claiming a solid place in power generation and showing as the preferred fuel in homes</td>
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<tr>
<td>Later 2000s into 2010s</td>
<td>Coal use holding steady in power generation but otherwise not used in industry or homes; natural gas use falling back; nuclear component steady. Renewables starting to come in. Trends of lowering energy demand in industry and homes. Electricity showing inroads into industry and domestic usage.</td>
<td>Gas a solid ⅓rd in power generation and dominant in home use. Recessionary and energy savings reduced overall energy demand at national lever in this period.</td>
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Parliament and Climate Change initiatives we are largely following the same approach mapped out then.

History has shown successes clearly in the areas of reducing power generation from coal but, what could have been a replacement, such as a progressive advancement of nuclear energy, has faltered as public opinion and private investment has baulked at the opportunity this offered. Meanwhile gas, which has not had the same amount of political attention of coal or nuclear but has been largely in the realm of the private sector, has established itself in the power generation sector and is firmly rooted in domestic utilisation for home heating, hot water supply and cooking. Government concern about the decline in North Sea production since it peaked in 2000 and hence the need to rely on imported (oil and) gas was clear to foresee but the interesting parallel development is that a gas pipeline connecting the UK to the continent came into operation in 1998 (the “Interconnector” between the UK and Belgium) and then in 2006 the “BBL” gas pipeline connected the UK with the Netherlands. Also, today we have four LNG receiving terminals, the first one of the new era starting up in 2005. These linkages with the external gas supply market have come into existence with private investment and little public awareness.

Government’s push for renewable sources of energy has focussed on wind power – both onshore and offshore, putting the UK at the forefront of deployment and today the world leader in offshore wind generation. Solar and marine (tidal) systems are very poor alternatives and biofuels of any sort are negligible at this point in time. However, these technologies and the use at scale may bring them forward to compete with wind. Biomass in its various guises has yet to make real inroads into the UK energy supply.

The government’s ambition for the new energy landscape to be secure, low carbon and affordable scores high on secure to date (however, the next few years are questionable), low carbon – heading in the right direction mainly as coal-fired generation is closing down), affordable is a big question as energy retailers are under pressure right now to cut costs of electricity and gas sold to end customers. The term “fuel poverty” is now widely used for those who cannot afford to heat their home at reasonable cost.

In the free market environment the government has a limited tool kit at its disposal: incentives, hidden subsidies, taxes, levies, penalties and targets can work but they must not contradict EU regulations, must allow a level playing field and above all must be consistent to foster a stable investment climate. It has been the uncertainty arising from shifting and redefined or tweaked energy policy that has hindered new nuclear and advancement in renewables and may interfere with the pace of new infrastructure (electricity transmission systems) investments. Even today there is uncertainty about how much fossil fuel and low-carbon power generation will be allowed in the mix to the extent that defining the overall 2030 statutory decarbonisation target range for electricity will not be set until 2016. Investors in new fossil fuel generation will tend to defer their investment decisions unless CCS – at present in the experimental and pilot stages – makes a breakthrough so that they can be classified as low-carbon.

In summary, the evolution of the energy sector of the last 40 years has been partially consistent with government policy as it has evolved but to what extent this has been purely a coincidence is difficult to tell. The case of UK nuclear energy is a good example where early potential dating back to 1956 has not been pursued adequately by government because of adverse public opinion and lobbyists. Today the government are pushing new nuclear projects forwards.

One thing is clear for the future: the UK government will have to act decisively and in a timely manner if they are to achieve the 80% self-mandated emissions reduction by 2050 as laid down in the 2008 Climate Change Act. This is well supported by the IPCC report (April 13, 2014) stating that “in order to
have a good chance of limiting global temperature rises to below 2 degrees, greenhouse gas emissions need to be cut by 40 to 70 percent compared to 2010 levels by 2050…”

5. Demand Side Looking Forwards

a. General discussion

The size of the UK electricity and gas markets at 2050 is not clear given the vague statements from government about “the demand for electricity is expected to double from its current level by 2050 particularly with the expected electrification of heating and transport.” Then again, scenarios of actions to tackle climate change, assumptions on policy and effectiveness, have generated mixed results which can show future energy dominated by nuclear or wind or fossil fuel CCS or biomass!

There is a strong inference in the Electricity Market Reform (EMR) embodied in the Energy Act 2013 that home heating – today dominated by natural gas in the UK – is set to be replaced by electricity. The underlying concern is that domestic gas boilers are not abated (i.e. the CO$_2$ emissions are released to the atmosphere) and that older or inadequately serviced boilers are not as energy efficient nor as safe as they should be.

This basic issue of fossil fuel in extensive use for distributed (home) heating (gas is also used for cooking and hot water supply in many homes, but represents a smaller demand) is certainly an obstacle to achieving the 80% emissions reduction targeted for 2050. The total conversion of domestic heating, cooking and hot water systems from gas fired boilers with the twin circulating water pipes, radiators, pumps, valves and controls to electric cables, heating panels, underfloor heating, heat pumps, electric cookers and immersion heaters is not going to be popular with the public. Moreover, the conversion of older housing stock is sure to show up the need in some cases for a complete, expensive overhaul of electric wiring systems to meet today’s different and higher standards.

The contemplated electrification of transport (which includes public transport) for private cars and vans will depend on a breakthrough in cost effective, compact battery technology or hydrogen fuel cells for personal vehicles – these taking over from hybrid engines that have entered the market. Today the take-up of all electric-type vehicles is low even though they do exist and are generally favourably regarded by their owners. The fear by new owners of a flat battery has not been properly allayed. Costs of battery cars have to come down too. Meanwhile, vehicle engine manufacturers seem to have recently achieved fuel performance improvements and construction enhancements that have made new petrol and diesel cars much more economical on fuel consumption that ever before. Having said that, biofuels that can be substituted in internal combustion engines can have a valid place in vehicles in 2050 to the extent that biofuels can be demonstrated to be truly carbon neutral on a life cycle basis.

The contemplation of an “electric future” – and this is a hot topic in UK energy discussions – has many uncertainties as to the realities of scope, timing, technology and cost. From an energy economists point of view the fact that electricity is overwhelmingly a secondary energy source (excepting renewables such as wind, solar, marine/tidal) it therefore has to be produced from a primary source; a fossil fuel which must be abated with CCS in order to meet the emissions targets. Now, the big inefficiency in all this “electric future” is the energy lost when converting from a primary fuel – of the order of 40% to 60% is lost today. Thus to produce 1 kW of electricity it is such that around 1.7kW (with gas CCGT) to 2.5 kW (with coal fluidised bed technologies) primary fuel is needed as input in current plants. If CCS is applied to power generation from fossil fuels – retrofitted or in new builds – there is additional energy lost from the CCS process itself.
b. Defining the 2050 demand

The challenge in this is to be able to relate the primary and secondary energy sources that will be in the mix at 2050 to the CO\textsubscript{2} emissions associated with them at that time. It is imperative for the UK government’s 80% ambition to be met to be able to model different mixes of energy that could supply the different demand sectors at that time and to predict the aggregated emissions.

Excellent work on such modelling has been done by the UK Energy Resource Centre (based in London) who have worked with the UK Department of Energy and Climate Change and the Committee on Climate Change on energy scenarios for 2050. The highly credible work “The UK Energy System in 2050: Comparing low-carbon, resilient scenarios” (pub. February 2013) will be utilised here for the energy demand in 2050 that satisfies the 80% emissions reduction relative to a 1990 base line.

The output from UKERC’s “UK MARKAL” linear optimisation energy system model (originally developed by the International Energy Agency – IEA) shows below the total final energy demand (scenario 50 CEA) by sector in 2050. This chart contains as well the same data as in the Demand pie charts shown earlier in this paper.

Note, the x axis (years) is not linear and the y axis is expressed in Million Tons of Oil Equivalent – consistent with the pie charts.

![Chart showing energy demand by sector in 2050](image)

The messages for 2050 are that (i) significant reductions in total final energy demand are evident, and (ii) the main reductions come from the Domestic and Transport sectors.

What is not immediately evident is that the power sector is the key to achieving the emissions reductions with CCS being deployed from 2020 on existing fossil fuel plants. Electricity generation (output) rises by ca. 60% in 2050 from today’s (2012) level to satisfy the needs of electric vehicles and domestic heating. The generation mixture contains a high percentage of nuclear (range 37% to 45%) with fossil fuel CCS plus wind (range together 42% to 48%). Other renewables (range 7% to 21%) cover the remainder of electricity needs.

In 2050 gas still has a minor role in direct use in the domestic and service sectors for heating – contributing to residual emissions - and has only a standby capacity role (Gas CCS) supporting base load electricity demand.
6. The Place for Gas in the Energy Supply 2050

As noted above the direct use of unabated gas is predicted to be limited to a minor heating role in some domestic and service sectors, it being recognised that it does produce CO₂ emissions which will contribute to the residual 20% amount accepted by the UK and will be within EU and international emissions commitments.

Gas CCS can clearly have a role in electricity generation but unless indigenous gas – for example additional offshore reserves from the North Sea or West of Shetlands, or from new onshore unconventional sources (shale, CBM) – are available, imported gas (by pipeline or LNG) still has the challenge to overcome of the security of supply concern. This is an argument that can be levied at coal as well since the UK is progressively importing more and more coal as indigenous coal mines close due to high costs of production, HSE issues and geological considerations (coal production in the UK was at an all-time low in 2012 at 17 million tonnes, compared with the peak in 1952 of 228 million tonnes).

Another challenge for gas is that coal on the international market is usually cheaper than international gas prices and would be preferred on that basis alone (allowing for the difference in thermal efficiencies of gas and coal in conversion to electricity).

In the nearer term to 2025 gas can increase its penetration into power generation by 20% more than its position today. This is mainly because 6 coal fired power stations plus 3 oil fired ones and 4 nuclear stations (having reached the end of their operational lives) will be coming offline before 2016 and progressively thereafter without new nuclear coming online (the first of the UK’s new nuclear stations is predicted at 2024 if it takes FID this year).

Gas use (input) to power generation in 2012 was 18.4 MTOE and this could easily grow to about 22.5 MTOE by 2025. New nuclear coming in strongly from 2025 to 2040 could displace gas use, however, the electrification of heating and vehicles (the time line is difficult to predict but is unlikely to be significant before 2030) will add to electricity demand such that one scenario that meets the 80% emissions mandate at 2050 shows gas CCS input to power generation could be over 40 MTOE. This is a major increase in gas demand, almost entirely for power generation – other direct uses becoming negligible - and it would sit alongside nuclear generation and a combination of renewables, wind or biomass (the dominant one depending on the scenario) as the other third of 2050 electricity supply. However, should gas prices rise and if coal CCS has been invested in and stations are operational 15+ years from now, then the use of gas will be lower.

Then again, a lot of uncertainty surrounds the quantification of gas generation as a back-up to base load nuclear and intermittent wind, solar, marine power. Gas CCS CCGT stations standing by to switch in to meet peak demand are an important part of the security of supply aspect of EMR and this is to be achieved by paying a capacity charge to generators who build and have capacity on standby to come in quickly. The capacity market concept proposed by the government provides through an auction system steady payments to be made to the winner for capacity in return for a commitment to deliver energy when required some 4 years ahead and when called upon, or face penalties for the value of the lost load. This is where Gas CCGT can really come into its own and meet the need that no other fuel (except possibly storage hydro) could offer.

Looking at the magnitude of UK gas demand for power generation historically and with a low carbon future projected.

(Note that the years on the x axis are not linear and that the y axis is MTOE):
The chart represents gas CCS used exclusively for power generation. Today and for 10 to 15 years until the “electric future” is realised, with home heating moving from gas to electricity, the domestic gas demand, plus industry use, is an extra 47.6 MTOE. This will decline to the extent that the electrification of heating systems comes true and unabated gas in other uses is forced away.

A scenario for the total UK gas demand (power generation plus domestic heating) could look like the following -

7. Gas Supply Routes

The UK has been over 50% dependent on imported gas since 2011 as UK North Sea supplies have declined. Gas from the Norwegian sector comes to the UK by pipeline and also from Europe via the Interconnector from Belgium (capacity 25.5 BCM/yr; 23 MTOE/yr) and the BBL line from the Netherlands (capacity 19.2 BCM/yr; 17.3 MTOE/yr).

The three main LNG receiving terminals in the UK have gas send out capacities of

- Isle of Grain LNG (River Thames estuary) 20 BCM/yr; 18 MTOE/yr (to be increased to 28 BCM/yr; 25.2 MTOE/yr)
- South Hook (west Wales) 21 BCM/yr; 19 MTOE/yr
- Dragon LNG (west Wales) 7.6 BCM/yr: 6.8 MTOE/yr.
The above is to be viewed against the 2012 UK gas demand of 73.8 MTOE total for gas to power generation, domestic use and industry.

8. LNG Imports to the UK

As the decline of indigenous gas supplies from the North Sea was anticipated LNG receiving facilities were constructed to meet the needs of imports. The two pipelines between the UK and the continent are used mainly for handling peak demand of gas in the UK winter months and for commercial gas trading activity. LNG is expected to be the main source of imported gas to the UK for the future (unless a shale gas revolution were to happen).

The two LNG terminals in west Wales are not open access and were built for their owners who have exclusive capacity rights. The Isle of Grain terminal on the River Thames east of London is not a dedicated terminal but is open for capacity bidding and is undergoing a potential expansion at this time; offers for use of future importation capacity are being solicited at this time.

In the north east of England the Teesside GasPort has facilities owned by Excelerate Energy for use by their Floating Storage and Regasification Units (FSRUs) which meet seasonal UK gas demand when there is a commercial opportunity to do so. The north west of England has an offshore LNG loading facility connected to the onshore gas grid at Port Meridian. A moored storage and regasification vessel accepts ship-to-ship LNG transfers at this deepwater location and pipes the gas to shore. This facility has open access.

9. Conclusions for US LNG Suppliers Looking to the UK Market

The UK gas market can be considered as a highly risky place for new entrants. All the signs are that government policy is geared towards a low carbon, all electric future and nuclear plus renewables will be the big energy sources. However, the public are not so convinced about either nuclear or renewables (particularly onshore wind farms) and are not going to be inclined to discard their gas boilers at home for complete new electric heating, cooking and hot water systems.

Separately, new LNG to the UK has a problem of access – unless a supplier wishes to apply to construct a new receiving terminal – which is not out of the question since it and the supplier would enhance security of supply which is a UK government objective. However, the economics of this are questionable given what appears to be an oversupply position of LNG in about 10 years time. The exception to this could be for a fast mover to acquire import rights at the Isle of Grain LNG terminal for a suitable period and be in a position to have a supply cost structure that would make economic sense against the market uncertainties. The north west England Port Meridian facility offers access to third party LNG carriers with deepwater ship-to-ship transfer, storage and regasification of LNG.

Finally, a couple of alternatives exist in continental North West Europe (NWE): a large open access LNG receiving terminal at Zeebrugge in Belgium operated by Fluxys and which is a part of the Belgium gas network and actually a hub for the whole of North West Europe with access down to Italy for example and the ability to handle gas from Russia. The terminal is also linked to the Interconnector pipeline to the UK and gives an access thereby to the UK market. In the Netherlands at Rotterdam the GATE LNG receiving terminal is open for business to receive, store and regasify LNG for sale to NWE markets and potentially via the BBL pipeline to the UK.

For a US LNG supplier looking to export to the European market these opportunities might be worth investigating – more so that the UK itself.