energy technologies institute

A perspective from the ETI's
Jo Coleman and Andrew Haslett

Strategy
Targets, technologies, infrastructure and investments – preparing the UK for the energy transition

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Preparing the UK for the transition to a low-carbon energy system

The UK was one of the first countries to take the climate challenge seriously and give the transition an institutional framework. This has allowed it to take an integrated approach to the journey to 2050. It starts with preparing for the mass scale deployment of key technologies by the mid 2020's.

Key headlines

- The UK can implement an affordable (approximately 1% of GDP) 35-year transition to a low carbon energy system by developing, commercialising and integrating known – but currently underdeveloped solutions
- There is enormous potential and value in CCS and bioenergy in delivering a low carbon future
- The ability (or failure) to deploy these two technologies will have a huge impact on the cost of achieving the UK climate change targets and the national architecture of low carbon systems and future infrastructure requirements
- To avoid wasting investment, crucial decisions must be made about the design of the future UK energy system, driven by choices on infrastructure
- The next decade is critical in preparing for transition
- Preparation will require major investments in developing and proving key technology options by the mid 2020s
- Preparation creates options, demonstrates leadership and provides scope for economic advantage in a global market place
- Planned UK spend is probably sufficient, if it is targeted to develop genuine deployment readiness of the most strategically valuable options on the pathway to 2050
- Significant policy intervention will be required to support key technologies with characteristics that make a pure market approach difficult (e.g. CCS, bioenergy, nuclear, offshore wind, heat networks)

A transition to a low carbon energy system

Context

The UK's North Sea oilfields began production in the 1970s and in the decades that followed the country grew accustomed to near-self-sufficiency in primary energy. However domestic oil and gas output eventually began to taper, turning the UK into a net importer by 2004. By 2012 the UK was importing almost half its primary energy.[1]

Energy security remains a key priority, yet it is far from clear what threatens this security most: geopolitical risks and dependency on imports, or domestic issues such as ageing infrastructure, lack of investment, rising energy prices and extreme weather events. Either way, the need to simultaneously remake the energy system in response to these risks and to address climate change represents a significant opportunity.

We have been struck by how little it is appreciated that the supply and use of energy need to be understood as a set of complex, interlinked systems underpinned by substantial investments in infrastructure. Many proposed solutions seem to ignore this. That is why the Energy Technologies Institute (ETI) seeks a broader approach. Our detailed understanding of the UK highlights how very different the energy systems of different countries are and how likely they are to diverge further. The discussion in this paper is based on extensive techno-economic analysis by the ETI, the experience gained from over fifty ETI projects, and the expertise of our public and private-sector members. This has enabled us to develop a broad and detailed understanding of how the UK should rise to the challenge of meeting its citizens' needs for energy services while reducing the catastrophic economic and social consequences of uncontrolled climate change.

"Energy security remains a key priority, yet it is far from clear what threatens this security most: geopolitical risks and dependency on imports, or domestic issues such as ageing infrastructure, lack of investment, rising energy prices and extreme weather events."

[1] Digest of UK Energy Statistics (Dukes) 2013

Support for change

There is no time to invent and deploy a set of novel breakthrough technologies and the cost of adaptation will inevitably be higher than the cost of mitigation. The UK can allow itself a 35-year transition to low carbon, by developing, commercialising and integrating known but currently underdeveloped solutions. In the decade ahead the UK's low-carbon energy policy should focus on 'preparedness'. We have to develop options and explore trade-offs, while also testing our technical, operating, business and regulatory models at a sufficient scale to give stakeholders the confidence they need to commit to full-scale implementation.

This comes at a difficult time for change. Although the UK enjoys some of the lowest energy prices in Western Europe[2], the rising cost of gas is the main reason that household energy bills have doubled in the past decade. Over 80% of British homes are heated by natural gas, with a similar volume of gas going towards power generation. The price of energy has become a major political issue. During 2015 Britons are voting in the general election and energy policy is featuring prominently. Concerns over energy prices, combined with patchy customer service and episodes of mis-selling by energy retailers, mean that the trust needed to embark on fundamental changes is currently lacking.

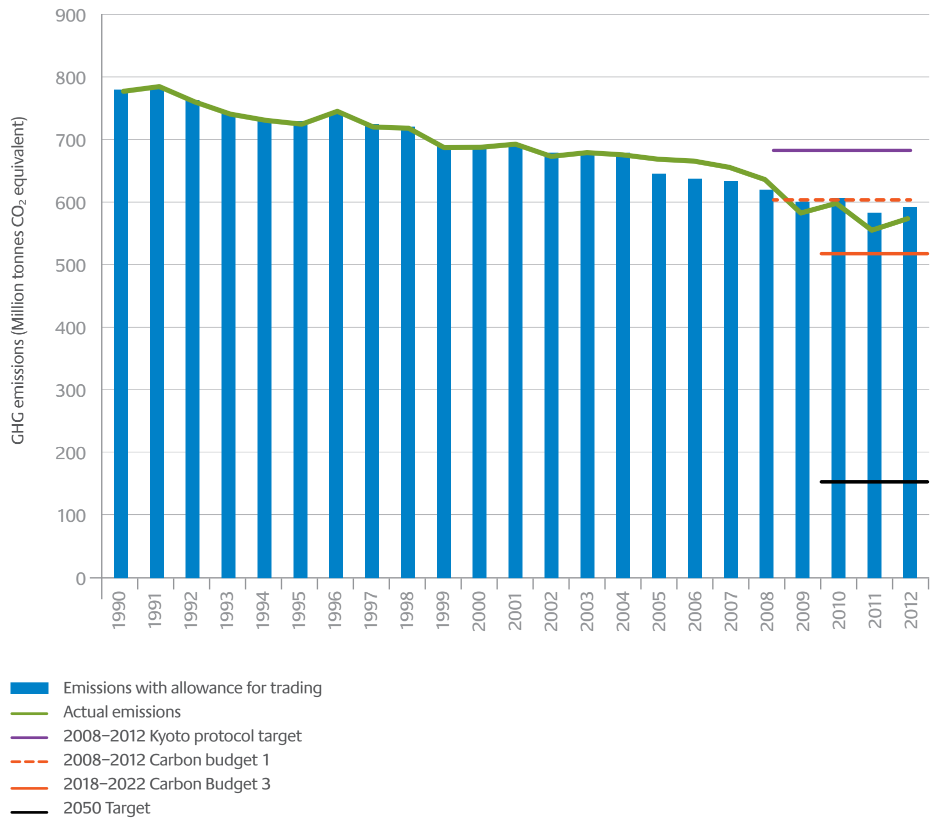
The UK passed the Climate Change Act in 2008, making it the first country to introduce a long-term, legally binding framework to tackle climate change. The Act set the target of reducing greenhouse gas emissions by at least 80% relative to 1990 levels by 2050, and required carbon budgets to be fixed for successive five-year periods[3]. The government announced in 2013 that it had achieved its first carbon budget and was on target to meet the second and third (2013-17, 2018-22).

However a substantial proportion of the reduction in emissions since 2008 is a consequence of the economic downturn. Consumers have faced the triple whammy of stagnating or falling household income, higher energy prices and electricity surcharges to fund the parallel drives for greater efficiency and more renewables.

The burden has fallen disproportionately on poorer households, which are more likely to use electricity for heating. Although the Climate Change Act garners strong support across the political spectrum, the tension between energy security, affordability and climate change is highly politically charged and depending on which Minister or Shadow Minister is speaking, any of these may be the top political priority.

FIGURE 1

UK greenhouse gas emissions; progress towards climate change budgets[4]



[2] Eurostat. http://epp.eurostat.ec.europa.eu/statistics_explained/index.php?title=File:Half-yearly_electricity_and_gas_prices,_second_half_of_year,_2009-2011_(EUR_per_kWh).png&filetimestamp=20130116115243

[3] http://www.theccc.org.uk/tackling-climate-change/the-legal-landscape/

[4] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/295961/20140204_2012_UK_Greenhouse_Gas_Emissions_Final_Figures_-_revised_27_March_2014.pdf

The UK's unique opportunity

Whilst there are many commonalities between the energy systems of different countries, each country will be blessed with its unique opportunities and challenges. These need to take advantage of global technology platforms such as low carbon vehicles, but they also present the distinct possibility that each will find its own unique packages of solutions. The UK starts from a relatively unusual but fortunate position in that regard. Many of its ageing power plants need replacing: rather than having to pay for low carbon capacity to be installed above and beyond existing capacity, the UK needs to pay for new capacity regardless of climate change and therefore the cost of installing low carbon capacity is incremental only. Out of a total capacity of approximately 90GW in 2010, 16GW will be decommissioned by the end of 2015, primarily to comply with the EU's Large Combustion Plants Directive. A further 5GW of gas-fired plant capacity has been closed, mothballed or derated for economic reasons, and most of the UK's remaining nuclear capacity will have to be replaced by 2030.

Although UK power demand has fallen since 2010, the capacity margins have been reduced and various organisations have highlighted the possibility of shortfalls in capacity as early as winter 2015/16. Some of the 21GW of the closed capacity needs to be replaced to maintain capacity margins. Furthermore we need to consider the increase in demand that can be anticipated as emissions reductions targets drive electrification of our home heating and cars on top of the growth in demand that generally accompanies growth in the economy and population. For a modest incremental cost we have the choice to make this new capacity low carbon.

> "The UK needs to pay for new capacity regardless of climate change and therefore the cost of installing low carbon capacity is incremental only"

Offshore Wind

The energy potential of the UK's offshore waters is immense. It has been estimated that offshore wind could generate 400TWh of electricity a year, together with 60TWh of tidal and 50TWh of wave power. This is on top of 70TWh of solar and 50TWh of onshore wind potential. To put that in perspective, the UK currently consumes just under 400TWh of electricity annually.

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The UK's unique opportunity

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Biomass

Biomass, too, has much potential. The UK has a total land area of about 24 million hectares (60 million acres), of which built-up regions account for around 15%, agricultural land for 72% and forests for 13%. 73% of the agricultural land is grassland, on which animal stocking rates have reduced in recent years. If these rates were to return to their 1990 levels, some 2 million hectares could be released for energy cropping with no detrimental impact on food production. Much of the agricultural land was formerly wooded and could, if reforested, yield around 7.5 million oven dry tons (odt) annually. Our existing forests, meanwhile, are not always managed optimally. The UK has the lowest forestry per capita in the EU after the Netherlands, despite a land resource per capita almost twice the Dutch level. The UK's forests are the worst managed of any European Union member state[5]. Even without reforestation, the country could achieve additional production of 4.2 million odt simply by better forestry management.

Carbon Storage

Another opportunity is the offshore capacity for carbon storage. The UK is ideally placed to achieve a significant proportion of its emissions reductions to 2050 and beyond through carbon capture and storage (CCS)[6]. The country has more than enough potential CCS capacity in the shape of saline aquifers and depleted offshore oil and gas reservoirs. ETI has identified 78GTe of unrisked potential storage capacity in UK waters, of which 14GTe has been selected for further evaluation, based on risk and cost factors. This compares very favourably against the 3GTe we estimate the country will need by 2050. There is also potential for providing storage capacity to other Western European countries.

Public Support

The British public has not displayed any significant hostility to storing carbon dioxide offshore and – in stark contrast to attitudes in Germany or Japan – its attitude towards nuclear has not been undermined by the 2011 Fukushima incident. Although nuclear has relatively low public support (34%), this level has remained consistent since 2005. At the same time, the proportion stating that they are fairly or very concerned about nuclear power dropped from 58% in 2005 to 47% in 2013. People living close to existing nuclear plants generally value the jobs they bring and the boost they give to the local economy. Although public support for renewables is greater, backing for wind has declined sharply from 82% in 2005 to 64% in 2013, while backing for solar has fallen from 87% to 77%[7]. The fall-off in public support for renewables possibly reflects an increased awareness of their cost and the impact this is having on energy bills. The findings of this research into public attitudes suggest to us that British people will accept CCS and nuclear as part of a coherent strategy that also involves affordable renewables.

[5] AEBIOM (2013). European bioenergy outlook (Annual Statistical Report on the contribution of biomass to the energy system in the EU27)

[6] D. Gammer (2013). A picture of CO_2 storage in the UK: Learnings from the ETI's UKSAP and derived projects. Available at: http://eti.co.uk/downloads/related_documents/A_Picture_of_Carbon_Dioxide_Storage_in_the_UK(UPDATED).pdf

[7] W. Poortinga, N. Pidgeon, S. Capstick & M. Aoyagi (2013). Public attitudes to nuclear power and climate change in Britain two ears after the Fukushima accident. 19 September 2013: REF UKERC/WP/ES/2013/006. Available at: www.ukerc.ac.uk/support/tiki-download_file.php?fileId=3371

Challenges for the UK

Some of the challenges facing the UK are shared by many countries and will be tackled on a global scale, such as reducing the cost of zero-emission vehicles and increasing their range. Other issues are more specific to the UK, beginning with its housing stock. Around 90% of today's homes will still be around in 2050, and the vast majority are poorly insulated and highly inefficient in terms of energy use. The government is seeking to improve this poor performance by offering households free surveys and financial support for energy-saving improvements. Nevertheless, the deep cuts in emissions that will be needed if the UK is to meet its 2050 targets will be both expensive and disruptive.

Solar power presents a limited opportunity in the UK. In comparison with much of western Europe, the UK has a relatively low solar gain, which diminishes the further north you go. The largest solar gain tends, moreover, to be found in areas with the highest land and amenity values. The seasonal variation in insolation is strong (Figure 2) and utterly out of sync with demand for residential energy (Figure 3), which peaks during the dark hours before dawn and early evening in the winter.

90%

Around 90% of today's homes will still be around in 2050 and the vast majority are poorly insulated and highly inefficient in terms of energy use

FIGURE 2

London Insolation (tracking)

Source: NASA

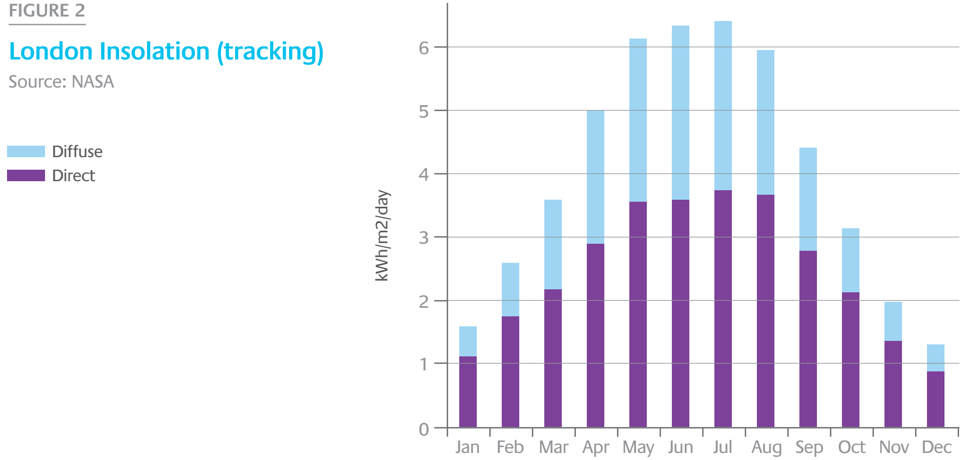
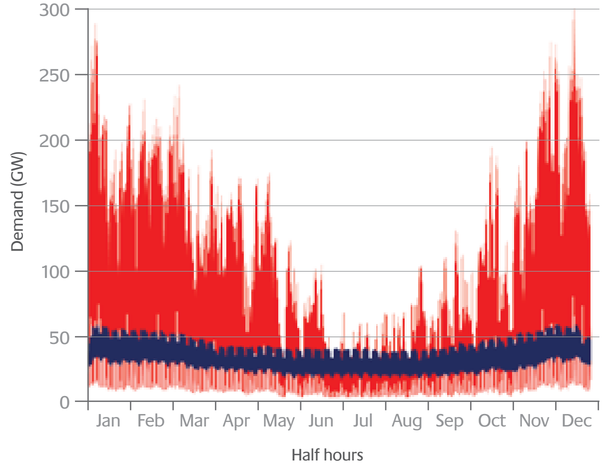


FIGURE 3

Half hourly GB electricity and low grade heat demand variation 2010

Source: Robert Sansom Imperial College



Challenges for the UK

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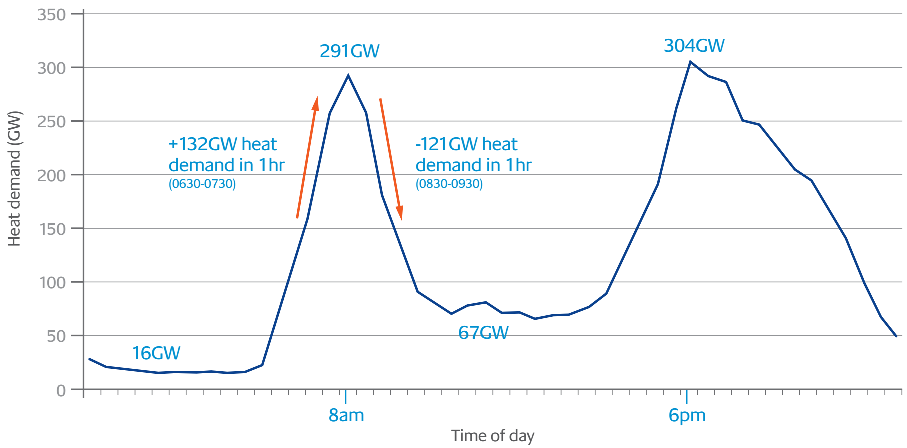
The UK likewise has to contend with a significant peak demand for heat. Heating buildings and water is one of the UK's largest and most difficult energy challenges. It is hardly surprising that demand for heating should be seasonal in a country with a temperate climate. What is less obvious however, is that this demand can vary as sharply as it does in the course of a single day. During a cold winter, demand for heating can increase at a rate of 130GW per hour, from 16GW overnight to a peak of 300GW, before falling away again almost as quickly (Figure Four). The inherent storage capability and low distribution costs of the natural gas grid mean it can readily cope with these variations. They will become a significant challenge, however, as the share of heating delivered by electricity increases. To meet that challenge, we will have to improve heating efficiency, heat storage and demand response, while simultaneously altering usage patterns with the support of more advanced heating controls. Several days of exceptionally cold weather combined with very low wind across Western Europe presents a huge design challenge for a more electrified system.

“Heating buildings and water is one of the UK's largest and most difficult energy challenges”

FIGURE 4

Winter peak heat demand – 18th December 2010



The other specific challenge confronting the UK is the hype surrounding shale gas, which is having such a dramatic impact on energy prices and security in the USA. The UK does indeed boast a significant potential shale gas resource (estimates of between 800 and 1300Tcf[8]). However, no production has occurred yet, and it is too early to say how much, if any, will prove commercially viable. Geology, population density, land-ownership practices, safety and environmental regulations and the relative immaturity of an onshore-drilling supply chain all suggest that shale gas is unlikely to develop to the same extent, or at the same pace, in the UK as it has in the US. However this has not discouraged shale gas advocates from hailing it as a silver bullet for all the UK's energy issues, including climate change. Whilst additional home-grown energy sources are very welcome, the hype surrounding shale gas has fed through into an anti-renewables message heard increasingly loudly in the boardrooms of companies considering investment[9].

[8] British Geological Survey & DECC. https://www.gov.uk/government/publications/bowland-shale-gas-study

[9] Caroline Flint, Labour Shadow Energy Secretary in The House Magazine. 6th March 2014. http://www.politicshome.com/uk/article/94071/flints_steel.html

An affordable UK energy transition

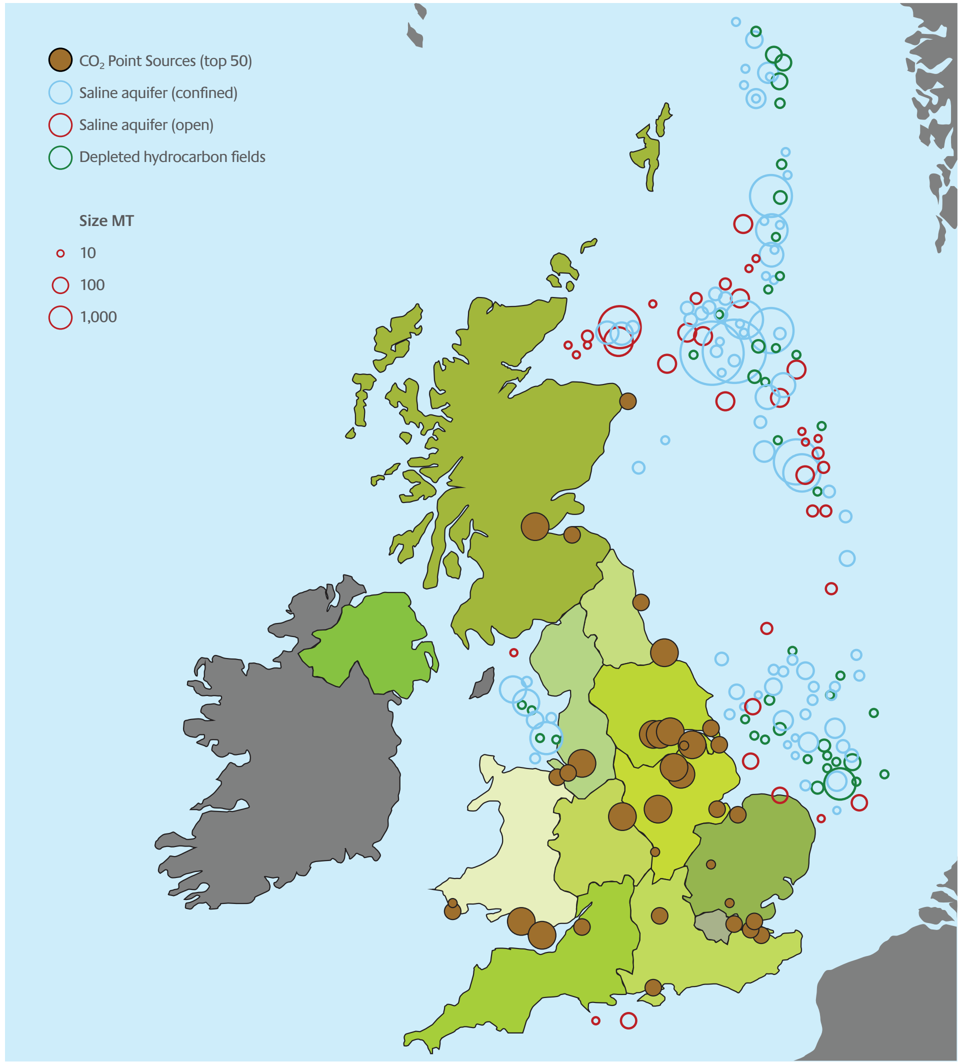
Delivering affordable, secure and reliable energy to end users when they need it is the key objective of any energy system. The wide range of energy sources and uses, and the different technology and network infrastructure options that have to be integrated, make this a complex challenge. The way the various parts of the system interact is critical to delivering effective overall solutions. As the UK moves towards a low-carbon economy, the interdependencies between the heat, power, industry and transport sectors, and the infrastructure that connects them, will become increasingly important. The system-level analysis, modelling and design we do at ETI are crucial to our understanding of these interactions. Energy system designs need to be robust against a range of scenarios that take account of the many uncertainties we face in the future; this means that they may not be the cheapest design in any individual scenario. At the ETI we factor these uncertainties into our modelling and system analysis and then consider the role and value of individual technologies within the energy system. The UK will embark on a wholesale transformation of its energy system from around the mid-2020s. To ensure the country is prepared for that, we need to develop and test a portfolio of proven solutions that will give it the best possible chance of achieving an affordable, secure and sustainable energy system.

Our analysis highlights the enormous potential of CCS and bioenergy across the full range of future scenarios. Missing out on one of these technologies would at least double the cost of delivering the climate change targets from around 1% of GDP to 2%, or put another way, the value of CCS or bioenergy in the energy system is well in excess of £200bn (NPV to 2050). If neither were to be developed, it is difficult to see how the UK would be able to meet those targets at all. People are often surprised to hear this, partly because they tend to focus on a single sector, such as electricity; and partly also because they concentrate on unit cost – comparing technologies on a £/MWh basis, which fails to capture the value of a particular technology, the timing of its production or its role across multiple sectors. CCS must be central to any national strategy to meet carbon targets cost-effectively, as it enables flexible, low-carbon electricity generation, supports renewables and cuts emissions from industrial processes.

“The UK will embark on a wholesale transformation of its energy system from around the mid-2020s”

FIGURE 5

Potential Carbon Capture and Storage Sites



An affordable UK energy transition

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Crucially, CCS can also deliver ‘negative emissions’ when used with biomass, by capturing and storing the carbon that plants and trees take from the atmosphere. This delivers a net reduction in atmospheric carbon dioxide, offsetting emissions from activities such as transport, which are particularly expensive to decarbonise. CCS can also produce flexible, low-carbon fuels needed to meet peak demands and balance intermittent supply sources, such as hydrogen or synthetic natural gas through the gasification of coal or biomass.

CCS has experienced a number of false starts and frustrations in the UK. Two development projects are currently under way, but we need to ensure that these are not just one-offs. They need to form the backbone of a future network capable of transporting and storing carbon dioxide from power generation and industrial sources. Additional storage locations must be appraised over the next decade, to persuade businesses that sufficient storage will be available to support investment in new capture facilities.

Different energy system designs require very different infrastructures, but the role of CCS cuts across all of them. Without it, renewables – predominantly offshore wind – would have to contribute a much greater share: upwards of 90GW potentially, resulting in prolonged periods of oversupply. This would require the UK in turn to install additional dispatchable capacity to meet demand when the wind drops. Enhanced storage and demand response could help, but the country would most likely still need a significant amount of reliable, flexible generating capacity in the form of hydrogen or gas turbines. No CCS would mean no hydrogen generated from fossil fuels or biomass, so we would have to turn to electrolysis during periods of wind oversupply instead. Bioenergy would not be in a position to generate negative emissions either, and so the optimal role for biomass would switch to the production of biofuels for transport.

These two worlds – one with CCS, the other without – entail fundamentally different infrastructures across the entire energy system. It would be a mistake to build both sets of infrastructure: this would result at best in under utilisation, and at worst in the sidelining of huge investments as the optimal solution emerged. If the UK is to prepare effectively and avoid wasting investment, it must take crucial decisions about the design of its future energy system. The country will have to reorganise its energy distribution infrastructure, build major new networks and adapt its buildings and vehicles. An example of this is the replacement of heating systems in our homes; not deciding for an area whether the distribution system investment will be in district heating, major electricity distribution upgrades, bio-gas or hydrogen distribution will leave building owners unable to make appropriate choices every fifteen to twenty years, when they need to replace their heating system. The scale of these efforts will be such that key decisions need to be made by the mid 2020s if these options are to have sufficient time for mass rollout to be completed between the mid 2020’s and 2050.

This timing is critical to the UK’s transition to low-carbon energy. The work required to develop the options and demonstrate them at scale so that the country can make informed, evidence-based choices is likely to take the best part of a decade. Our conclusion is that there is still just enough time, but that every year spent deploying options which ultimately may not be required will cost a considerable amount of money. Moreover, further delaying full-on implementation beyond this point will push back the end-point almost year for year.

> “If the UK is to prepare effectively and avoid wasting investment, it must take crucial decisions about the design of its future energy system”

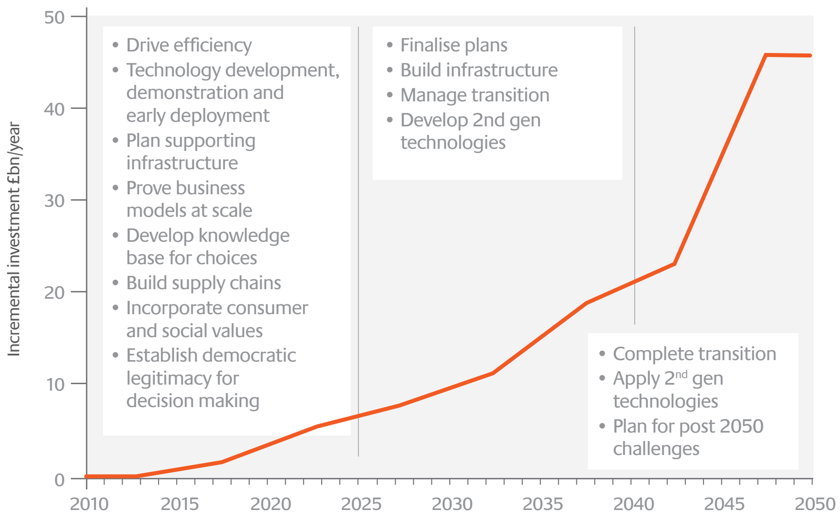
Preparedness

Whether we work backwards from 2050 or forwards from 2015, the next decade will be critical in preparing for the transition. Consequently, the metric of success for many technologies in the run-up to the mid 2020s will be preparedness rather than mass-scale deployment. The country has to develop options and explore trade-offs, proving the technical, operating, business and regulatory models at sufficient scale to give stakeholders the confidence they need to commit themselves to action.

Preparedness also means building enough UK capacity to provide a launch pad for implementation. Preparedness is not a no-cost ambition, but it invests resources where they will have the best economic leverage in the long-term. The scale on which the proving investments will take place is consistent with early deployment and will certainly signal political intent.

FIGURE 6

Preparing the UK for transition



The priority throughout all this will be to develop and test the technologies that are likely to offer the key choices on the path to 2050. In the case of CCS, this would go beyond White Rose and Peterhead; the appraisal of a further seven storage locations and the development of 3GW power generation with carbon capture, possibly with an additional hub feeding into the East Irish Sea, will ensure that there is sufficient evidence of available storage capacity, confidence in the capture technologies and that the benefits of co-ordination can overcome counterparty risks. For nuclear, preparedness means at least two operational plants by 2025 and more under construction, demonstrating the capability and capacity of UK nuclear operators, regulators, investors and supply chain to support the planning, construction, operation and regulation of a diverse nuclear fleet. The situation for bioenergy is more complex: here we have to test the credibility of negative emissions, which will require us in turn to assess the sustainability issues and the availability of land in the UK and internationally. We need a clear picture of the most appropriate pathways for bioenergy use and the right combinations of feedstock, pre-processing and conversion technologies. In addition to these science and engineering questions, the UK has to develop market, regulatory and policy mechanisms (spanning farming and energy) that will support development without compromising food production, and to address issues of public acceptance.

The focus for other renewables over the next decade should be on driving down costs rather than on the speed of rollout, although a certain amount of deployment will be needed to achieve this. For offshore wind, lower costs will require larger turbines with longer blades in deeper waters than we see today, which should be the focus of future licensing rounds. The emerging results of ETI development work suggest that Offshore Wind has the potential to compete head on with other low carbon energy sources, provided that the right technology strategy is followed. The combination of CCS with Offshore Wind and Nuclear would make the UK a successful executor of affordable, secure low carbon electricity by the 2030's.

Preparedness

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From one perspective, the cost of preparedness will only be a fraction of the hundreds of billions of pounds that will have to be invested in buildings, vehicles, pipes and wires, power stations, refineries and industrial plant in the next 35 years. All the same, the billions the UK will have to find over the next decade to support CCS projects, nuclear plants, offshore wind, hard-to-treat building retrofits, vehicle-charging infrastructure, hydrogen vehicle infrastructure, district heating schemes and so on remain very large investments. It is vital that they are designed in such a way as to deliver the evidence, confidence, learning and capacity needed to scale up successfully.

The only areas in which the focus should be on immediate, large-scale deployment are replacement nuclear, efficiency measures and generating energy from waste. The net cost of many efficiency measures is modest or even negative in the case of new assets, whereas considerable time is needed to retrofit existing assets skillfully and cost-effectively – not least because of limited access windows or slow asset turnover (i.e. vehicles). This makes efficiency an urgent development priority. Waste offers another immediate opportunity, driven by the Landfill Directive. Waste gasification allows heat or electricity to be generated locally and syngas to be injected into the gas grid, with the prospect of cheaper flue-gas clean-up, reduced emissions and higher efficiency compared to incineration plants.

UK government spending on these types of activity is scheduled to rise from £3.3bn in 2014-15 to £7.6bn in 2020-21, which is considerably lower than the €23bn Germany had earmarked for power subsidies in 2014[10]. The planned UK spend is probably sufficient, so long as it is targeted at technologies that are likely to be key choices in 2025 for the transition, and designed to create the evidence, confidence, learning and capacity to fulfil the aforementioned scale-up requirements. Preparedness requires a relatively low-cost investment, which will help us achieve our climate change targets while itself reducing emissions. It lays the foundations for managing large scale deployment post-2020 and will successfully position the British economy within the broader global political and economic landscape.

[10] D. Buchan (2014). The Oxford Institute for Energy Studies, 27 February. https://connect.innovateuk.org documents/3132264/11521341/Recasting%20EU%27s%20

Building investor confidence

Our analysis highlights that CCS is critical to achieving the UK's climate change targets affordably. Planning regional networks and getting a clear picture of transport and storage costs will be vital in terms of fostering investor confidence. The detailed analysis we have carried out at ETI[6] shows that if we plan and co-ordinate development properly, we can limit the infrastructure required in the years to 2050 to six shoreline hubs feeding fewer than 20 storage facilities. The net present cost would be under £5bn. Transmission-scale systems like this can be developed at national level, while choices and plans for distribution systems have to be developed locally and regionally. Plans to decarbonise buildings must also be informed by major national and local choices of this kind, but can only be made with sufficient knowledge of the details of each building and of consumer requirements.

It has long been recognised that the UK economy suffers from low investment in physical infrastructure compared to OECD benchmarks. Many local authorities see energy infrastructure as a critical factor in maintaining their attractiveness as places to live, work and do business. Furthermore, investing in infrastructure is an attractive way of strengthening the economy in the present climate. A cost-effective and resilient energy infrastructure is an important foundation for a successful mixed economy, and appropriate public-sector investment will provide the confidence for greater levels of private investment.

When it comes to major infrastructure sub-systems there are several critical issues, beginning with that of sequencing. Infrastructure investments in areas such as CCS, heating distribution and vehicle fuel supplies need to be made early enough to build investor and consumer confidence and usually the most collectively economic solution is to oversize them against initial requirements. Even in CCS, with a limited number of actors, this presents some challenges. For cars and heating, uncertainty in the rate of consumer take-up is exacerbated by the 15 year lifetime of the incumbent technologies and presents a major challenge for private infrastructure investors, in addition to the greater complexity of the sub-system.

> “A cost-effective and resilient energy infrastructure is an important foundation for a successful mixed economy”

Building investor confidence

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Existing infrastructures require support until it is realistic to buy-out the remaining users in some way (as we have seen for terrestrial TV and in an earlier age the regional rail networks). Since these remaining users will be disproportionately economically and socially vulnerable, this requires a clear up-front strategy which also avoids other users positioning themselves to be bought-out.

Practicality is a second critical issue affecting major infrastructure sub-systems. All sorts of technical and regulatory details can derail a proposed solution unless they are addressed by means of full systems development and validation. It is important to check the practical details thoroughly, so legitimate concerns can be responded to, while also rebutting challenges by parties with an agenda of their own. Verifying final practicality requires large scale systems demonstration, but issues that can be addressed through smaller scale testing and modelling should be closed out before that point.

The next issue is that of consumer and social acceptance. People have to want and accept what is being proposed. There is a substantial risk that solutions that are unfamiliar to consumers, potentially more expensive and possibly underdesigned will significantly delay market uptake. Consumer and social acceptance has significant implications for transition planning[11].

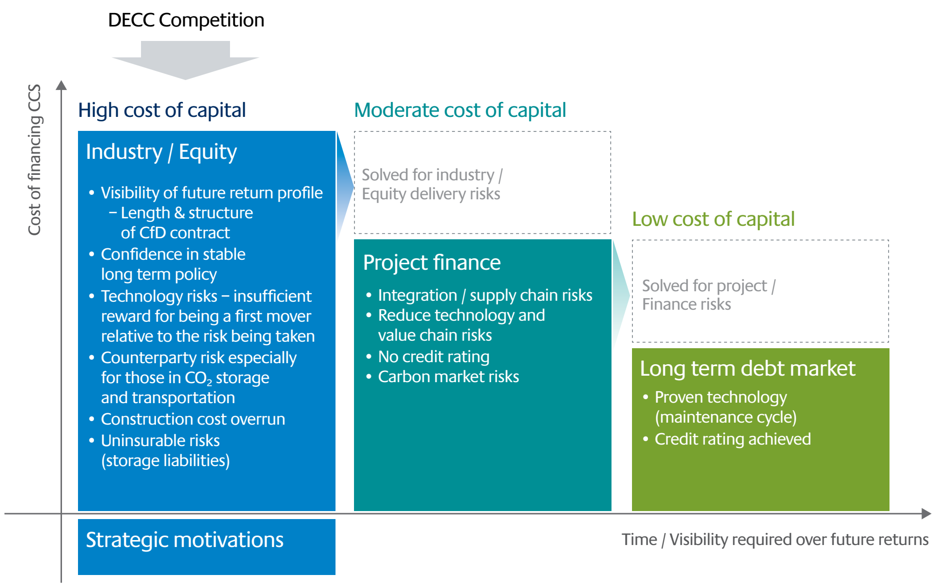
The issue of investability is likewise critical. The investments needed to deliver the UK's future energy system will be a combination of public and private, collective and individual. The technical, market and policy risks associated with these investments need to be addressed as the UK prepares for transition. In addition to public policy issues there are also training, design tools and design standards, whether regulated (e.g. gas fitters) or not. Industry investment in the required tools, standards and training is as important as investment in assets. Like physical infrastructure, investment in capacity is required in advance of need and is difficult for private investors to undertake without support. Without investment in capacity, consumers in particular are likely to have poor experiences that will create a barrier to progress.

Financing CCS

Although CCS preparedness is back on track with the White Rose and Peterhead projects, market mechanisms for supporting further initiatives are untested and are not found beyond the power sector. The work we have done at ETI with the Ecofin Foundation and the financial community offers a generic model for the funding of large-scale technology development[12]. Policy (market) risk was highlighted here as critical. Electricity Market Reform has been introduced, including Contracts for Difference for low-carbon power generation, but the details are still emerging.

FIGURE 7

A Financial Vision for CCS



[11] K.A. Parkhill, C. Demski, C. Butler, A. Spence & N. Pidgeon (2013). Transforming the UK energy system: Public values, attitudes and acceptability. Synthesis report, UKERC, London

[12] Carbon capture and storage – Mobilising private sector finance for CCS in the UK, November 2012, http://eti.co.uk/downloads/literature/Ecofin_CCS_Report.pdf

Financing CCS
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Further indications of how this approach will work in practice, together with the overall funding available for CCS, will be needed in order to give lenders confidence. A clearer understanding is also required of the risks in terms of the regulatory and long-term operating requirements of carbon storage – in particular, the basis on which potential leakage liabilities would be shared between government and storage developers.

Appropriate business structures must also be developed to reduce counterparty risk and to share the rewards fairly between the different actors across the value chain (power, capture, transport and storage operators), each of which has a different risk appetite and expectation of reward. This applies to the initial value chain but also to developments tying into the infrastructure after the initial development phase. Lastly, no policy is in place to encourage investment in CCS beyond the power sector, even though most of the value of CCS ultimately lies in industrial deployment, negative emissions, synthetic natural gas, and hydrogen generation. Unless support mechanisms are created in these areas, the full value of CCS will remain elusive, along with the UK's ability to meet its targets cost-effectively.

“No policy is in place to encourage investment in CCS beyond the power sector”

Business development, governance and leadership

Although current market structures are unlikely to deliver the changes needed, it is not clear how best to facilitate the process of change. Small adjustments can be encouraged by financial incentives, but this model breaks down when large-scale changes are desired, such as retrofitting heating systems in 20 million homes. There would appear to be two main options, both of which ultimately rely on a long-term expectation of consistent carbon prices. The first is a free-market approach, underpinned by a carbon price rising to around £150 per tonne by 2030 and then £350 per tonne by 2050. The challenge posed by this approach is twofold: how to create the expectation of a consistent carbon price in a free market? And how to ensure that investments happen in time to meet the targets?

The European Union's commitment to creating a common energy market does not allow for national carbon pricing, yet EU-wide pricing looks set to remain ineffective for the foreseeable future. The challenge of investment timing is highlighted by zero-emission vehicles. These are expected to require a carbon price of over £250 per tonne, and so would not be deployed at scale until after 2040, leaving insufficient time for roll-out given the rate of vehicle turnover. The alternative is more government-led support, including penalties and incentives tailored to each sector until a carbon market is firmly established. The national plans this would take boil down to 'picking winners' – something the government prefers to leave to the market. This approach would also require the free market's efficient allocation of resources, innovation and deep technical skills to be combined with the government's democratic legitimacy, social acceptance and protection of consumers. In which case, the outcome risks encapsulating the worst of both these worlds.

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Whichever of these approaches is adopted, European and global support for climate change will be crucial, as the UK cannot go it alone and risk becoming uncompetitive. There are many scenarios about how and when global concern for the climate will finally elicit a commitment to act. Some believe that a global agreement is the key, while others pin their hopes on national and bilateral agreements. These, they argue, will crystallise into action by blocs of key nations, which will then force others to act through trade agreements and border pricing of embedded carbon. It is also possible that – as island nations begin to disappear and other countries suffer extreme weather events that are clearly linked to climate change – the threat of international lawsuits will result in accelerated action.

Insurance companies and banks are starting to think about these possibilities. Others are simply crossing their fingers and hoping that the 259 scientists from 39 countries who agreed the IPCC's Fifth Assessment Report[13] got it wrong. Some place their faith in our creative ability to develop as yet unidentified solutions and to adapt. Our view at ETI is that action will accelerate as extreme climate events become more commonplace and the first successful lawsuits are brought for damages. Societies that have prepared pathways for integrated, whole-system solutions, structured around component sub-systems that have already been demonstrated at scale, will enjoy an advantage. Those that have not will suffer from unfavourable terms of trade and lawsuits against their major companies.

Wherever you stand on the issue of climate change, preparedness in the course of the next decade represents a relatively low-cost pathway. It creates options for the UK, while also showcasing solutions that will support decarbonisation of much larger nations with more significant emissions than the UK's.

The UK needs to continue on the path marked out by the Climate Change Act and Carbon Budgets, to show leadership and to create scope for prompt action and economic advantage in what will ultimately be a global marketplace for low-carbon technologies and supply-chain capacity.

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[13] Climate Change 2013. The Physical Science Basis. Working Group 1. http://www.ipcc.ch/pdf/unfccc/cop19/cop19_pres_plattner.pdf

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