SNAPSHOT

- By 2050, the total cost of the UK's energy system is projected to be £294bn a year in today's prices. Whichever path we choose, our energy system is going to be expensive.
- If done in the right way, the cost of cutting carbon emissions by 80% could be as low as £26bn a year by 2050 in today's prices – less than 10% of the total energy system cost.
- Five steps will need to be taken to keep the costs of carbon reductions manageable: improving energy efficiency; replacing ageing nuclear reactors; developing carbon capture and storage (CCS); using sustainable biomass; and reducing the costs of offshore renewables.
- Technology development is absolutely crucial. We simply can't meet our 2050 emissions reduction targets economically using today's technology.
- The Energy Technologies Institute (ETI) – a partnership between global industries and the UK Government – has invested £136m in 35 projects, helping to get new technologies such as CCS off the ground and reduce the cost of offshore wind.

The cheapest ways to cut carbon

Dr. David Clarke, Chief Executive of the Energy Technologies Institute, and Corin Taylor, Senior Economic Adviser at the IoD, **outline how the UK can provide affordable, secure and sustainable energy in the future, reducing emissions in the cheapest way.**

The UK needs a revolution in its energy system. Getting by with today's technology isn't a viable option. While fossil fuels are currently the cheapest solution, on their own they will not be able to provide our future energy needs in a sustainable way.

As a country, it's vital that we think about the longer term, not just how we can scrape by over the next few years. This means designing our 2050 energy system now. It also means understanding the rigid constraints in that design along with the areas where we need flexibility to cope with uncertainty, new demands and global changes in economics, politics and technology.

At a time when consumers are spending £124bn a year on energy, we've got to get it right. If we do, not only will we have a reliable and sustainable energy supply, the UK will also win a big economic prize in terms of greater employment, new export markets and increased inward investment. There are also tremendous reputational gains to be won in positioning the UK as a technological leader and innovator.

FOSSIL FUELS: CHEAP BUT DIRTY

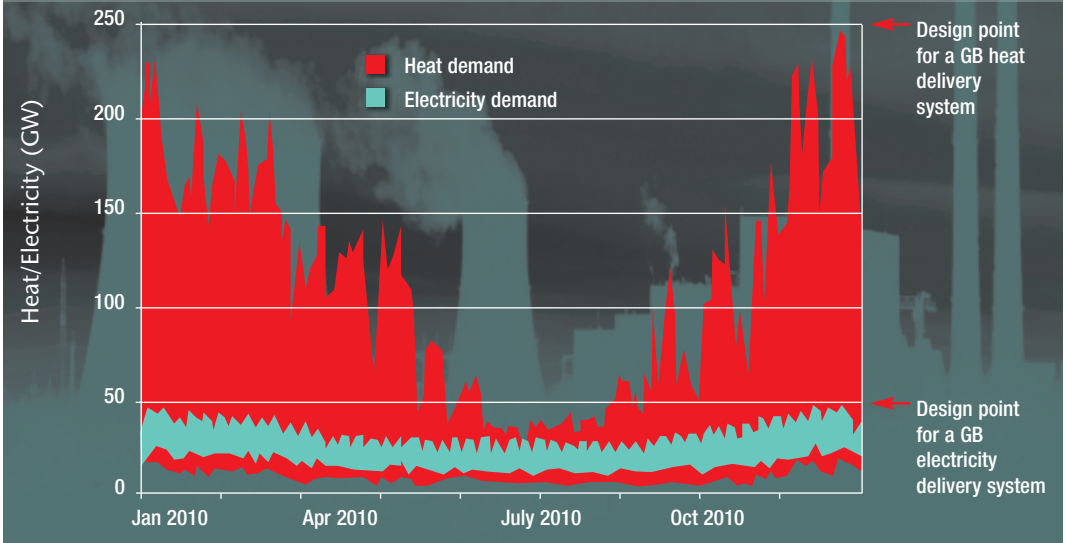
Coal and gas power stations, domestic gas boilers and vehicles that run on petrol and diesel are currently the cheapest solutions to meet our energy needs.

Gas is crucial for meeting the highly variable demand for space heating. The demand for energy at peak times in winter is many times greater than the lowest summer demand, which is a critical challenge for future energy system designs.

As Chart 1 shows, this seasonal heat variability is far, far higher than the intra-day peaks and troughs in electricity demand, although it is far less commented upon.

CHART 1

Seasonal heat demand fluctuations dwarf daily electricity demand movements



GB 2010 heat and electricity hourly demand variability – commercial & domestic buildings. Data source: UKERC (2011)

The UK energy system will grow to rely on significant imports of fossil fuels, raising concerns over security of supply. However, supply is likely to be more diverse in both fuel type and geographical source than at present, potentially making the UK more resilient to supply disruption and global price changes than in recent years.

Our current technologies have all seen improvements in efficiency but further significant improvements can and must be delivered. Low-cost and low-risk technology initiatives such as improving insulation in buildings, replacing old gas boilers, installing waste heat recovery units and continuing to improve the fuel efficiency of vehicles, will all help to reduce our energy consumption significantly, even as the number of cars on the roads increases.

Fuel switching – increasing the use of gas and sustainable biomass in place of coal in energy intensive industries – can also deliver significant reductions in emissions whilst sustaining economic production.

"There are no silver bullets. To meet future energy demands, fundamental shifts in the energy mix will be needed."

There are, however, no silver bullets. Efficiency and fuel-switching are important measures, but will not be sufficient on their own to meet our future energy demands sustainably. More fundamental shifts in the energy mix will be needed.

BOX 1

Modelling energy system costs

Like most businesses, the Energy Technologies Institute (ETI) operates on the principle that we need sound evidence on which to base our decisions – objective facts, backed by expertise, which provide the best guidance there is for developing our future energy base.

To help achieve just that, the ETI has ESME – its internationally peer-reviewed Energy System Modelling Environment. ESME analyses 128 different technologies, assessing the impact they might have on the UK's energy system and finding the lowest-cost route to meeting future energy demands.

As a national energy system design tool, ESME has a unique combination of features:

- It focuses on a whole system analysis – looking at all aspects of the energy system including interactions between power, heat, transport and infrastructure.
- It establishes the lowest-cost solution based on engineering design considerations and using 'back-casting' – that is, it assesses what the UK will need to deliver starting with the 2050 end-date for carbon emissions targets and works back to today.
- It allows for uncertainty in technology performance and global resource prices.
- It includes factors such as peak heat demand and seasonal capacity.
- Finally, it considers the effect of geography on energy supply and use.

There are a number of questions that are crucial to the design of the UK's future energy system, which ESME helps us to answer, such as:

- What might the 'no regret' technologies be – those which could be used in all reasonable future energy scenarios – in order to meet 2050 climate change targets affordably?
- How might accelerating the development of particular technologies impact on the solution?
- What is the total system cost of meeting those energy targets?

ESME helps us understand the effect of different technologies at the energy system, sector and individual technology levels. Technology costs including investment, operating, fuel and resource costs are incorporated into the model. Uncertainty in future demand and supply, technology costs and global resource are also considered.

ESME provides insights on the regional variation in energy system designs. It has the ability to define demands and natural resources at a UK regional level and show the geographical location of possible new energy infrastructure.

Economic growth is also factored in and a particularly important and unique feature of ESME is its detailed representation of peak energy demands and system flexibility requirements.

THE FIVE STEPS TO LOWEST-COST DECARBONISATION

It's crucial to understand that, whichever path we choose, our energy system is going to be expensive. By 2050, the ETI projects that the total cost of the UK's energy system – including capital costs, operating costs and fuel costs for all energy technologies, from power stations to vehicles to infrastructure (e.g. transmission and storage) – will be £294bn a year in today's prices.

The UK can't meet its 2050 emissions reduction targets using today's energy system – the cost would be too high and the technology we currently have in place won't do the job. But if done in the right way,

the cost of cutting carbon emissions by 80% could be as low as £26bn a year in today's prices by 2050 – less than 10% of the total energy system cost and just 0.7% of GDP.

Five steps will need to be taken to keep the cost of carbon reductions manageable:

- **Efficiency** – *demand reduction and smarter use of energy in our businesses and homes.*
- **Nuclear** – *while it is possible to create a future energy system capable of meeting our 2050 emissions reduction targets without nuclear energy, it will come with too high a price tag to be realistic. Supply chain development and early deployment is critical in realising the optimal 2050 UK energy system design.*
- **CCS** – *particularly useful when combined with bioenergy, but it has a long development time and requires an early start.*
- **Bioenergy** – *could provide a significant proportion of the UK's energy needs but requires sustainable supplies whether grown in the UK or imported.*
- **Offshore renewables** – *provide an important hedging option but cost reduction is critical.*

It is not a case of choosing one over another. As Table 1 shows, we will need a combination of them all. For instance:

- *If we don't use biomass, we project that the total system costs would be £44bn a year higher by 2050.*
- *If there are no meaningful technological developments that improve performance and reduce costs, the total energy system cost would be £106bn higher.*
- *Without using one or more of biomass, CCS and nuclear, there is no route to the UK delivering an energy system that meets our climate change targets.*

TABLE 1

Projected energy system costs in 2050

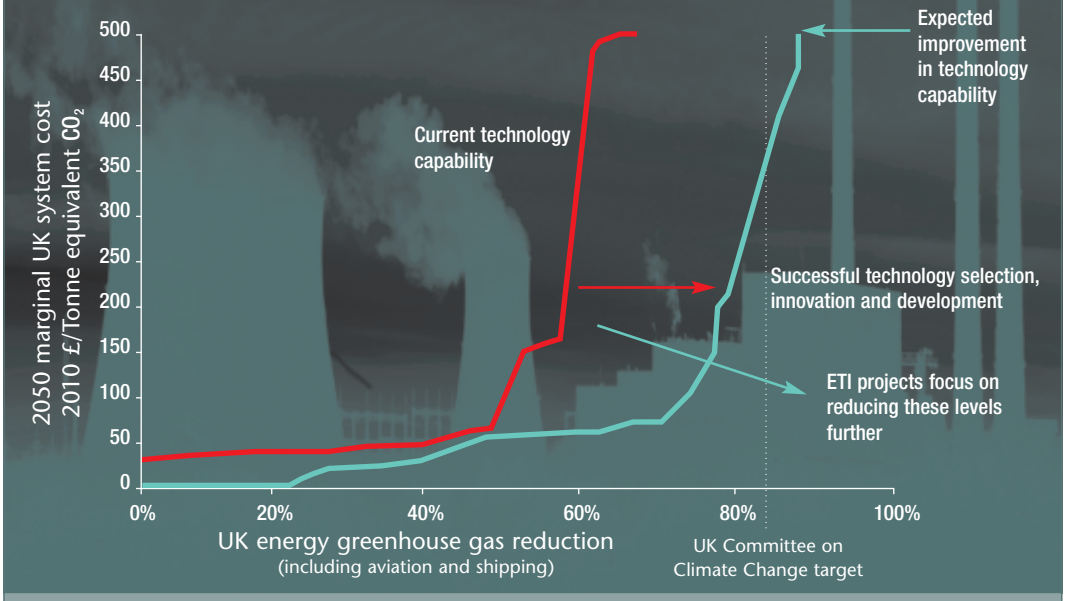
£ billion per annum, 2010 prices

Total system cost	294
Of which CO_2 abatement cost	26
No biomass	+44
No CCS	+42
No nuclear	+4
No technological development	+106

Chart 2 illustrates the importance of improving on the technology we currently have. At today's technological levels, reducing CO_2 emissions by 80% by 2050 would be prohibitively expensive. But these costs become far more manageable with expected improvements in technology. ETI projects are focused on reducing the cost of new technologies still further.

CHART 2

Technology development is needed to keep decarbonisation costs manageable



Source: Energy Technologies Institute.

THE VITAL ROLE OF CCS

While new green technologies will make up an increasing proportion of the UK's energy mix, we will still be burning fossil fuels for decades to come.

CCS technology captures carbon dioxide from fossil fuel power stations. The CO_2 is then transported using pipelines and stored offshore in deep underground structures such as depleted oil and gas reservoirs and saline aquifers. CCS technology will affect the whole range of CO_2 emitting fuels, including coal, gas and biomass.

Power generation accounts for approximately a third of the UK's CO_2 emissions and CCS is a critical development. It means that fossil fuels can continue to be used in power generation whilst dramatically reducing emissions from the power sector by up to 95%.

"While new green technologies will make up an increasing proportion of the UK's energy mix, we will still be burning fossil fuels for decades."

And, by applying CCS to biomass we can effectively remove CO_2 from the atmosphere, creating 'negative emissions'. These can offset our continued use of gas and liquid fuels in specific parts of the domestic heating and transport sectors where their replacement is likely to be particularly difficult and hence very expensive.

Although CCS appears an expensive addition to power generation, it

is one of the most important strategic levers we can use. The opportunity costs associated with delivering a sustainable future energy system with CCS, ranged against the cost of doing so without it, far outweigh the absolute cost of CCS.

ETI modelling shows that the total mean cost of the energy system design including CCS is reduced by £42bn per annum (or around 1.2% of GDP) compared with the cost without this technology. To put it another way, a successful CCS sector could reduce the cost of all forms of energy in 2050 by two pence per kWh.

As well as power generation, CCS can also be converted to hydrogen, offering storage opportunities in the future energy system as well as a potential fuel source for use in vehicles.

There is an urgent need to demonstrate the technologies required for CCS and appraise potential offshore storage sites in order to design the optimal CCS system. The ETI has launched or is commissioning projects concerned with carbon storage, capture for coal and gas plants, pipeline network design, and CCS with biomass to power. Showing that CCS is practical will build public and commercial confidence in the technology.

In the ETI's view, UK policy support for wind energy looks right. But we also need to introduce the right levels and structures of support for the equally rapid introduction of CCS, as well as nuclear.

Time is of the essence. If we delay, the UK will be unable to meet its 2030 and 2050 emissions targets without more aggressively deploying more expensive renewable energy sources. These will still require fossil fuel back-up to deal with intermittent supply shortages.

OFFSHORE RENEWABLES AS A HEDGING OPTION

The UK is blessed with significant natural, renewable resources such as offshore wind and marine, the potential of which far exceed the nation's energy demands. Unfortunately, the technologies needed to exploit these resources require significant development and cost reduction before they can compete with fossil fuel technologies. The problem of supply shortages and power blackouts must also be overcome.

ETI modelling assumes that the first coal and gas plants fitted with CCS will be deployed by 2020, in line with the Government's plans. If we delay by five years, the cost of meeting our emissions targets will rise, with offshore wind becoming more important. This would add approximately 1% to the total energy system costs out to 2050.

Offshore wind provides a vital hedging option in case any of the other technologies, including CCS and bioenergy, which currently look to be more valuable, fail to deliver.

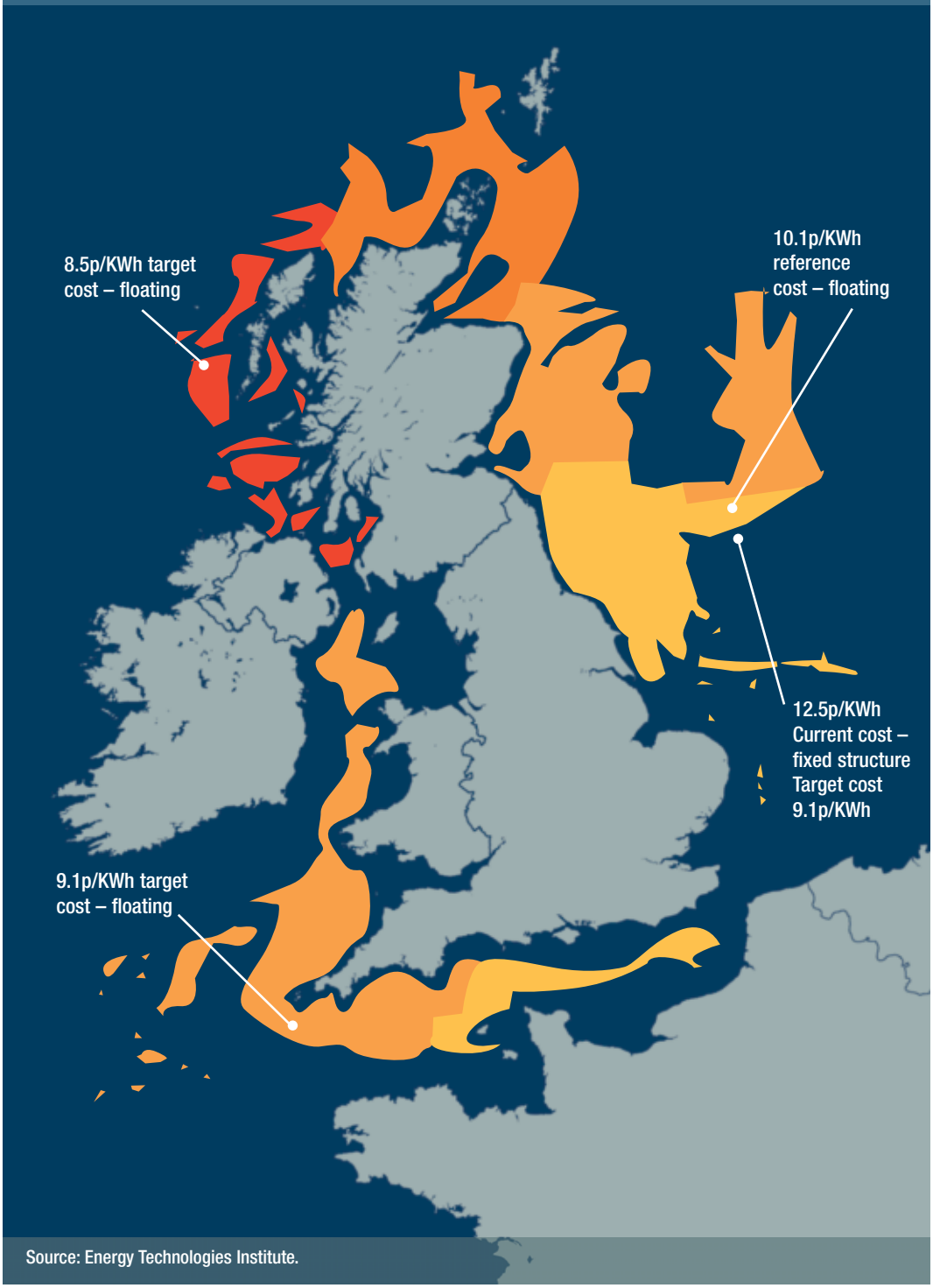
The ETI believes that the costs of offshore wind can be reduced

significantly, which is why it is investing heavily in the demonstration of technologies such as floating offshore wind platforms, very long blades, condition monitoring systems and test rigs that could significantly lower the lifecycle costs and lead to far higher levels of deployment.

CHART 3

UK offshore wind development potential

The UK has high winds in 50-100m water. Average wind speeds over UK waters that are 50-100m deep range from 9m/s (light orange) to 12m/s (bright red).



Source: Energy Technologies Institute.

SMART SYSTEMS AND ENERGY STORAGE

As the energy supplied from renewables increases, the system must be sufficiently flexible to cope with variations in demand (for heat and, potentially, electric vehicles) and supply from sources such as wind and wave power.

That is why the ETI launched a Smart Systems and Heat Programme this year, along with a new project in energy storage. The two will see ETI invest heavily in smart systems that integrate both supply and demand-side factors, allowing us to take a holistic view of how our power and energy systems are likely to develop.

The ETI is also exploring the role that gas, heat, electricity and hydrogen storage may play in balancing supply and demand to avoid excessive investment in peak load plant – which is only used on a few days a year – as well as providing security against disruptions in supply. It is essential that we guard against power black-outs if our economy is to thrive. Introducing a storage mechanism to seasonally store heat from power stations will provide the potential to balance the seasonal mismatch.

THE REGIONAL ANGLE

Not surprisingly, Scotland is likely to supply a very significant proportion of the UK's renewable power by 2050 in the form of onshore and offshore wind, marine energy and biomass. This will have long-term implications for the UK's transmission network, which is capital intensive and has long development lead times. Infrastructure installed in the next five to 10 years is likely still to be in use in 2050, so a credible investment plan needs an understanding of an appropriate energy system design.

CCS can be expected to be mainly located around major industrial areas in the Midlands, North East England, the South East and Scotland, but will require the development of CO_2 networks to gather and transport CO_2 to offshore storage sites.

KEEPING ENERGY COSTS DOWN

To keep future energy system costs down, it is essential that the UK prioritises: nuclear, to provide clean and reliable baseload supply; CCS, which will allow us to continue burning fossil fuels; and sustainable biomass, which combined with CCS will actually take carbon out of the atmosphere. Improving the efficiency of energy use and reducing the cost of offshore renewables are also vital.

"To keep future energy system costs down, it is essential that the UK prioritises nuclear, CCS and sustainable biomass."

The UK faces enormous challenges in providing an affordable, clean and secure supply of energy in the future. Whichever path we choose, our future energy system is likely to be expensive. But if decarbonisation is approached in the right way, the additional costs of an 80% reduction in CO_2 emissions needn't be prohibitive.

BOX 2

What is the ETI and why does it matter to business?

The Energy Technologies Institute is a public-private partnership between global industries and the UK Government that is helping to make a difference for the UK's future energy mix and economy.

Its aim is to accelerate the development, demonstration and eventual commercial deployment of a focused portfolio of affordable energy technologies, which will increase energy efficiency, reduce greenhouse gas emissions and help achieve energy and climate change goals.

Fundamentally, it is seeking to address the energy 'trilemma' – delivering a future energy system that is affordable, sustainable and secure – whilst driving green growth and helping to make the UK a world leader in energy technologies.

Since it was established in 2008 it has invested around £136m in 35 projects covering offshore wind, marine, distributed energy, buildings, energy storage and distribution, carbon capture and storage, transport, bio energy, and smart systems and heat.

It uses the combination of its members' expertise and experience at companies such as BP, Caterpillar, EDF, E.ON, Rolls-Royce and Shell, together with government departments, including the Department for Business, Innovation and Skills and the Department of Energy and Climate Change, to deliver targeted investments in energy technology. Each project, which is delivered through consortia of large companies, SMEs and leading academic institutions, will help make a big difference to realising the UK's target to reduce carbon emissions by 80% by 2050.

The UK's energy environment is a complex set of needs, technologies and choices. Given the challenges, how do we prepare for the future? The development of highly complex energy systems requires a sophisticated approach – the ETI understands the importance of analysing energy holistically, planning ahead and targeting investment in priority technologies.