WWF

REPORT

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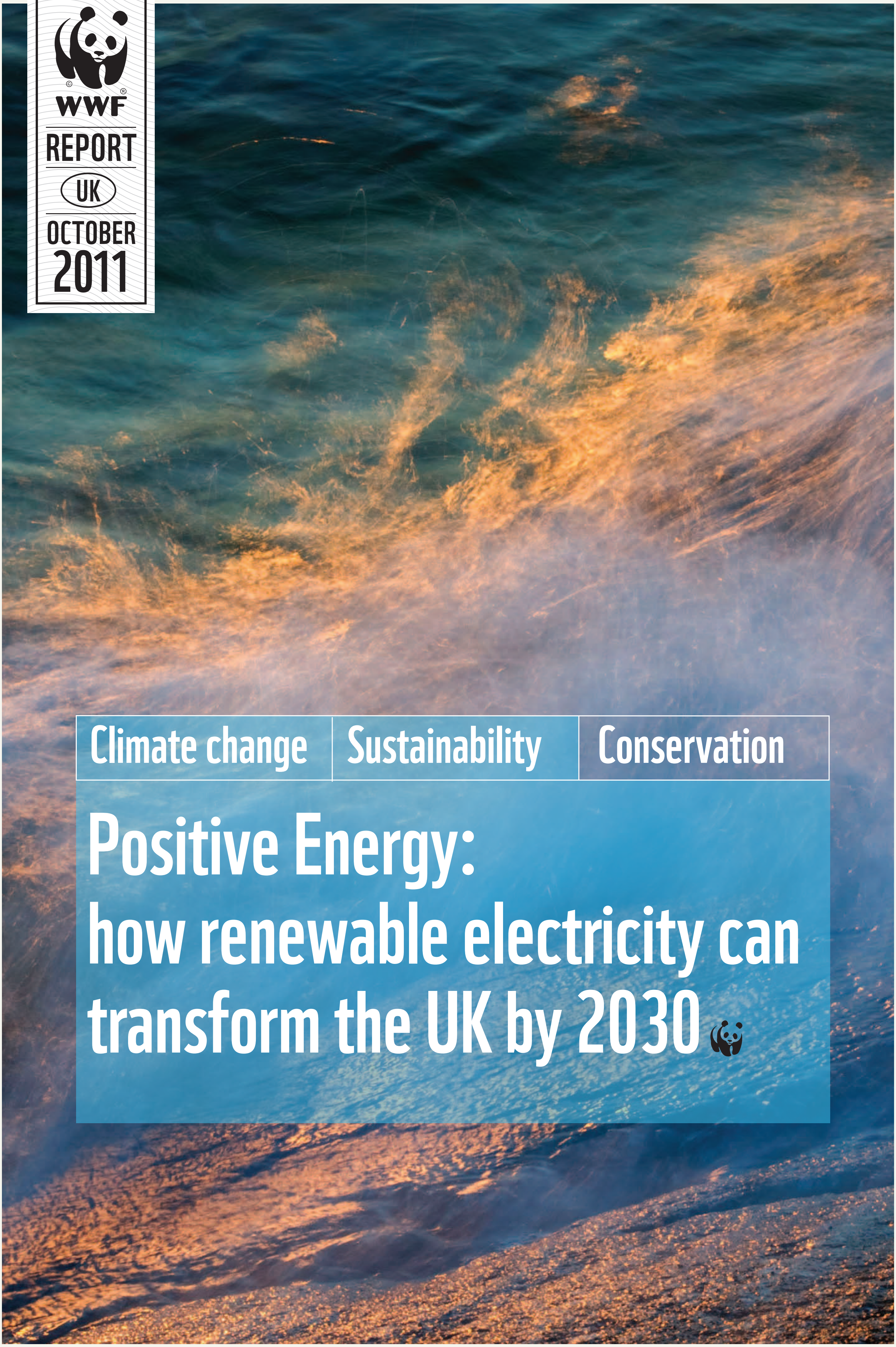

Climate change | Sustainability | Conservation

Positive Energy: how renewable electricity can transform the UK by 2030

ABOUT WWF-UK

WWF is at the heart of global efforts to address the world's most important environmental challenges. We work with communities, businesses and governments in over 100 countries to help people and nature thrive. Together, we're safeguarding the natural world, tackling climate change and enabling people to use only their fair share of natural resources.

The way energy is produced and used has a massive impact on the world. Energy for heating, electricity, transport and industry accounts for around two-thirds of global greenhouse gas emissions. As well as driving climate change, fossil fuels can damage ecosystems, cause air pollution and have serious health impacts. We're working to change that by engaging with governments, businesses and consumers to create a sustainable, renewable energy system.

Acknowledgements

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EXECUTIVE SUMMARY

UK energy policy is at a crossroads. The government's current work to reform the electricity market will determine the shape of the UK's power sector for decades to come.

The UK has an opportunity to become a world leader in clean, renewable energy. But choices made in the coming months and years could lead to continued dominance of high carbon fossil fuel power generation. Or to greater dependence on risky nuclear power.

UK POWER GENERATION MUST BE ESSENTIALLY CARBON-FREE BY 2030

This report shows that renewable sources can meet 60% or more of the UK's electricity demand by 2030. By using this amount of renewable energy, we can decarbonise the power sector without resorting to new nuclear power. We will also be able to maintain system security – that is, provide enough electricity at all times to make sure there's never a risk of the 'lights going out'.

Around a quarter of the UK's ageing power generation capacity is due to close over the coming decade. To ensure system security, we need significant investment in new electricity generation capacity and to reduce demand for electricity. The government must also rise to the challenge of climate change, making sure the power sector plays its full part in meeting the requirements of the Climate Change Act. The Committee on Climate Change (CCC) has made it clear that UK power generation must be essentially carbon-free by 2030. The government needs solid, ambitious commitments and targets to drive investment in sustainable low carbon power generation and avoid locking the UK into a new generation of high emission unabated fossil fuel plants.

WWF believes that the UK must decarbonise its power sector in an environmentally sustainable way. For this reason we would prefer to avoid new nuclear due to the unacceptable risk of a catastrophic accident and the legacy of dangerous radioactive waste for which there's no effective long-term storage solution.

In this context, this report aims to answer the key question:

Can the UK achieve a secure, sustainable and decarbonised power sector by 2030 by shifting away from polluting fossil fuels and nuclear power to an energy efficient system built around clean and inexhaustible renewable energy?

To ensure system security – so there's no risk of the 'lights going out' – the UK needs to invest significantly in new electricity generation capacity, and reduce demand for electricity. WWF believes the UK can and must decarbonise its power sector by 2030, and that renewable sources can meet 60% or more of the UK's electricity demand by this date.

The scenarios

We commissioned GL Garrad Hassan (GL GH) to investigate this question by developing six scenarios for where the UK's electricity will come from in 2030. The scenarios all achieve the near decarbonisation of the power sector by 2030 without new nuclear power. The generation mix differs according to the level of electricity demand and the use of different methods for ensuring system security as shown in the table opposite.

In all cases, the scenarios make full provision for ambitious increases in electric vehicles (EVs) and electric heating. Energy efficiency and behavioural change lead to the reductions in demand in the ambitious demand scenarios.

THE SCENARIOS ALL ACHIEVE THE NEAR DECARBONISATION OF THE POWER SECTOR BY 2030 WITHOUT NEW NUCLEAR POWER

The volume of renewable capacity installed by 2020 in all scenarios is similar to that set out in the government's *Renewable Energy Roadmap* in July 2011[1]. However, critically, the scenarios envisage installation continuing at a similar rate during the 2020s. This will avoid the risk of 'boom and bust' in the UK renewables sector – lots of work being done to install renewable capacity up until 2020 and then work falling off a cliff after that – and mean renewables provide at least 60% of the UK's electricity by 2030.

The amount of renewable capacity the UK can and should build is determined by economic constraints – not available resources or how fast infrastructure can be built. GL GH assumes that it is economic to supply around 60% of demand from renewables. Going beyond 60% depends on whether there's a market in other countries for the excess electricity the UK would generate at times of high renewable energy production. Therefore, given uncertainty over future markets, in the core scenarios (A and B) GL GH has not assumed a European market for UK renewable power despite the construction of high levels of interconnection under the B scenarios. By contrast, in the stretch scenarios (C), we assume that interconnection creates a European market for the UK's excess power, and that it becomes economic to build much more renewable capacity in the UK.

	A 'CORE' SCENARIO SYSTEM SECURITY MAINTAINED PRIMARILY WITH GAS	B 'CORE' SCENARIO SYSTEM SECURITY MAINTAINED WITH HIGH LEVELS OF INTERCONNECTION TO EUROPE	C 'STRETCH' SCENARIO WITH HIGH RENEWABLES AND HIGH INTERCONNECTION
1 'CENTRAL' SCENARIO FOR ELECTRICITY DEMAND	**A1** **61% of annual electricity demand met with renewables** **Capacity mix:** - 73GW renewables capacity - 56GW gas capacity (18GW requires carbon capture and storage (CCS)) - 3GW interconnection capacity (already existing) Average utilisation rate for gas capacity: 33%	**B1** **61% of annual electricity demand met with renewables** **Capacity mix:** - 73GW renewables capacity - 24GW gas capacity (17GW requires CCS) - 35GW interconnection capacity Average utilisation rate for gas capacity: 78%	**C1** **88% of annual electricity demand met with renewables** **Capacity mix:** - 105GW renewables capacity - 20GW gas capacity (no CCS required) - 35GW interconnection capacity Average utilisation rate for gas capacity: 30%
2 'AMBITIOUS' SCENARIO FOR ELECTRICITY DEMAND	**A2** **62% of annual electricity demand met with renewables** **Capacity mix:** - 59GW renewables capacity - 44GW gas capacity (14GW requires CCS) - 3GW interconnection capacity (already existing) - Average utilisation rate for gas capacity: 33%	**B2** **62% of annual electricity demand met with renewables** **Capacity mix:** - 59GW renewables capacity - 20GW gas capacity (13GW requires CCS) - 27GW interconnection capacity - Average utilisation rate for gas capacity: 73%	**C2** **87% of annual electricity demand met with renewables** **Capacity mix:** - 83GW renewables capacity - 16GW gas capacity (no CCS required) - 27GW interconnection capacity - Average utilisation rate for gas capacity: 31%

Key findings

1 By 2030, it is perfectly feasible for renewables to meet at least 60% of the UK's electricity demand

The core scenarios (A and B) show that it is perfectly feasible to develop a stable and secure electricity system where renewables deliver at least 60% of the UK's electricity demand by 2030. This is substantially higher than the 40% share suggested by the CCC in the illustrative scenario published in its May 2011 *Renewable Energy Review*[2]. Gas, including the use of carbon capture and storage (CCS), and greater interconnection provide the rest of the UK's electricity under these scenarios.

60% MINIMUM RECOMMENDED RENEWABLES TARGET FOR 2030

The two 'stretch' scenarios (C) show the potential for significantly higher levels of renewables by 2030 – nearly 90%. This would depend on increased interconnection capacity and integration with European power markets so the UK could export surplus green power. Under these scenarios, we would meet the decarbonisation objective set out by the CCC without the need for CCS technology.

WWF recommends that a target should be set for renewables to supply at least 60% of UK electricity demand by 2030. Together with appropriate long-term policies and investment, this will give the renewable energy supply chain the certainty it needs to invest in the UK. Scotland is already taking bold steps to exceed this level of ambition with its objective of meeting 100% of electricity demand with renewable energy by 2020.

2 Reducing demand for electricity substantially reduces the cost of decarbonisation

The more electricity we consume, the more we have to generate. Put simply, if UK demand for electricity increases, we will need to build more power generation capacity and transmission infrastructure – which will cost billions of pounds.

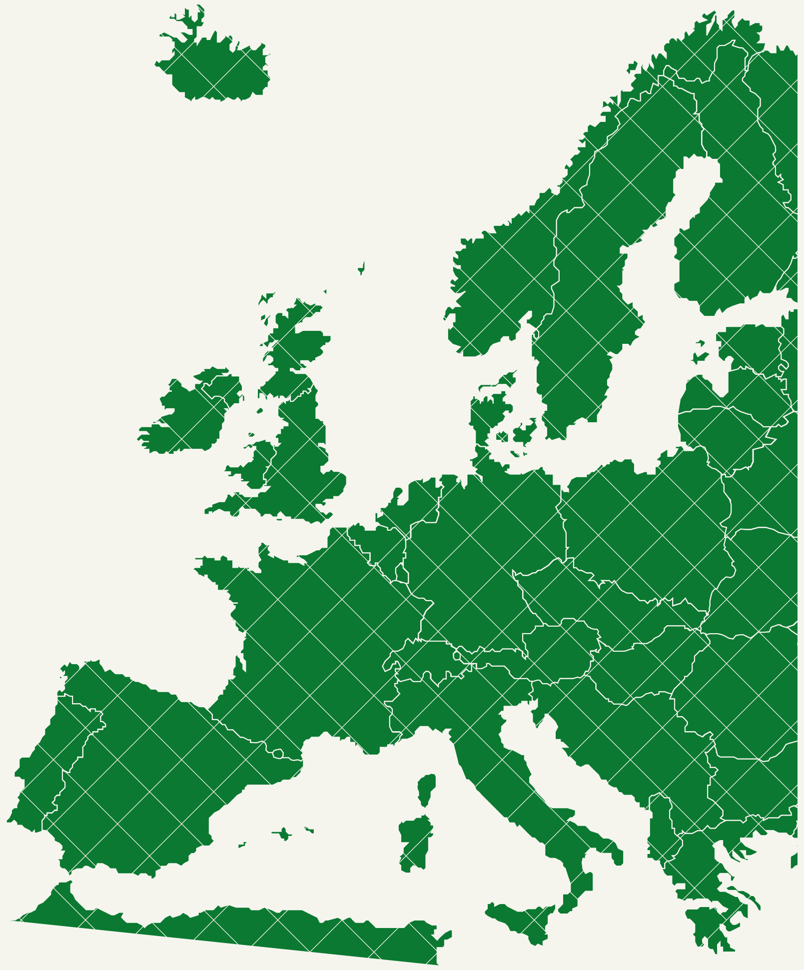
Our ambitious scenarios show that reducing energy demand cuts the capital costs of building new generation capacity by around £40bn by 2030. Reductions in demand could be achieved through a range of measures, including offering financial support and incentives to allow demand reduction projects to compete in the market with low-carbon generation.

3 Increased interconnection has significant benefits

Improving connections between our electricity grid and those in other countries will allow the UK to import power when our demand is high and export power when our output from renewables exceeds demand. High levels of interconnection would give us access to a diverse mix of renewable resources, including northern European wind, Icelandic geothermal, southern European solar and Scandinavian hydroelectric and pumped storage. This would improve energy security while reducing our reliance on thermal plant and therefore imported fossil fuels for back up.

Our report shows that high levels of interconnection to European grids means there is potential to reduce the amount of gas generation capacity (and overall generation capacity) we need to build domestically. This backs up the findings of previous reports, such as the European Climate Foundation's *Roadmap 2050*[3] which shows that increased interconnection between European states would reduce the overall amount of generation capacity that needs to be built across the continent.

HIGH LEVELS OF INTERCONNECTION TO EUROPEAN GRIDS MEANS THERE IS SIGNIFICANT POTENTIAL TO REDUCE THE AMOUNT OF GAS GENERATION CAPACITY



In the stretch scenarios, which assume that there are market arrangements in place at European level to make it economic to export power, high levels of interconnection could enable the UK to build additional renewable energy capacity in excess of domestic requirements and become a net exporter of renewable energy. At the same time, this would further reduce the amount of gas generation capacity being built (and the volume of gas being burned) in the UK. That's why we favour the high interconnection scenarios (B and C). Although B has a similar level of renewables to A, it opens the door to higher use of renewables if market conditions allow.

4 Reliance on gas for system security risks lock-in to high carbon infrastructure

Gas and interconnection with Europe are the two ways set out in the scenarios to supplement renewable energy, making sure there is always enough power available to meet demand.

In the A scenarios, gas generation capacity mainly ensures system security. Much of this operates relatively infrequently at times when demand is high.

However, under the B scenarios, with higher levels of interconnection, a much lower level of gas capacity is required (maximum 24GW – the same as today's level). Under these scenarios, gas plants can also run at higher load factors (capacity), making them much more economic.

WWF believes there is an inherent risk in building too much new gas plant. Once this plant is built, it is in companies' economic interest to run it as often as possible despite climate reasons meaning it should only be used infrequently for back up. We are keen to minimise the amount of gas needed by using more interconnection and more efficiently sharing resources at European level.

5 Higher interconnection means less or no reliance on CCS

The A and B scenarios need a significant level of CCS fitted to gas generation plant to meet decarbonisation targets. Given that CCS has not yet been deployed commercially, this report explores further alternatives for decarbonising the power sector.

The higher levels of interconnection in the B scenarios open up the possibility of increasing the level of renewables on the system (i.e. moving towards the C 'stretch' scenarios), thus leaving open the door for decarbonising the UK power sector by using more renewables if CCS turns out not to be viable.

The contrast between our scenarios shows that the UK's reliance on imported gas and associated generation, storage and transport infrastructure can be minimised through ambitious demand reduction measures and large-scale roll-out of interconnection infrastructure.

6 The renewables industry needs certainty to invest

HAVING A HIGHER LEVEL OF AMBITION FOR RENEWABLES HAS MANY BENEFITS FOR THE UK

The government needs to make a greater long-term commitment to renewables. Current assumptions in the government's Electricity Market Reform consultation indicate that while a 29% renewables share will be achieved by 2020, continued deployment will virtually flatline after that, with only 35% renewables by 2030. This boom and bust approach is bad for business and is likely to undermine UK efforts to become an industrial leader in renewables. Setting out long-term ambition on renewables at 60% or more by 2030 would provide the level of certainty needed to attract large-scale investment in the UK renewables supply chain. We also need stable market arrangements which provide long-term revenue certainty to reduce risk and mobilise capital investment in renewables.

Having a higher level of ambition for renewables has many benefits for the UK. It can help reduce the cost of renewable energy in the long term by accelerating the development of a UK supply chain (no longer dependent on imports of components) as well as economies of scale and technology improvements. Examples from other countries and industry projections show that renewable energy could create many jobs in the UK. Around 367,000 people are already employed in the German renewable energy industry. Harnessing UK renewables potential will also help to reduce the volatility of UK consumer bills. UK electricity prices won't depend so much on fossil fuel price fluctuations, which have been the main cause of the 63% increase in UK domestic electricity prices between 2004 and 2009.

Conclusion

This report makes it clear that decarbonising the UK power sector by 2030 in an environmentally sustainable way that avoids reliance on risky nuclear technology and high levels of unabated gas is achievable without compromising the security of the UK's electricity system.

Developing a low carbon and sustainable power sector in the UK is first and foremost a question of political will. It will require long-term policy and financial support for renewable technologies, ambitious measures to reduce energy demand and improve the flexibility of demand patterns and a greater focus on improving interconnection and integration with European electricity markets. The next Energy Bill will be a unique opportunity for the UK to unleash the tremendous potential of its renewable energy resources – and make the transition to a truly energy efficient economy.

10 POLICY RECOMMENDATIONS FOR THE UK POWER SECTOR

This report shows that it is perfectly achievable to develop a power sector that is decarbonised, environmentally sustainable, affordable and beneficial to the UK by 2030.

To sustainably and affordably decarbonise our power sector we must prioritise renewable energy growth, reducing energy demand and increasing interconnection with the rest of Europe. Making this transition needs bold policies:

- **The government should set a target for renewables to provide at least 60% of the UK's electricity demand by 2030:** A target will provide a signal to investors that the UK intends to continue to invest in renewables post-2020. A high level of ambition will make renewable energy manufacturers confident that the UK intends to exploit its vast renewable resources and is 'open for business'. The 60% target is well within what GL GH believes to be technically achievable by 2030. In fact, it is substantially lower than the levels recommended by industry in other reports[4].

- **The UK must adopt ambitious absolute targets for reducing electricity demand:** The government must recognise the economic and environmental benefits of reducing demand for electricity long-term. Reductions can be achieved through energy efficiency measures and behavioural change in all sectors of the economy. Benefits include reducing the generation and transmission infrastructure needed to maintain system security and lower costs for consumers. Policies should promote real competition between companies which help industry and consumers cut energy use and those seeking to build new generation capacity. Introducing long-term contracts to reduce demand could be one way of generating substantial energy efficiency gains in various sectors of the economy.

- **The government should make the take up of energy efficiency measures happen:** There are many financial and technical barriers which stop the domestic and commercial take up of energy efficiency measures. Removing these will require a range of measures, such as providing low interest rates to consumers insulating their homes under the upcoming Green Deal and other financial incentives. In particular, the government should invest an amount equivalent to a substantial share of the revenues raised by the Carbon Floor Price (and possible future related windfall taxes) into energy efficiency support measures.

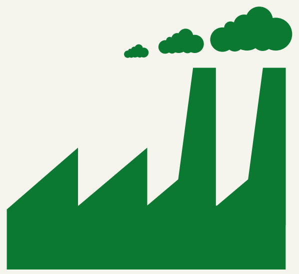
- **The reformed electricity market must include well designed, long-term financial support mechanisms for renewable technologies:** Appropriate support for renewables is needed to attract investors to the UK and drive costs down. The government reforms must deliver mechanisms that are designed to last for the long term, are as simple as possible and are specifically adapted to the needs of renewable technologies.

- **The Green Investment Bank (GIB) must be able to borrow now:** The government must make sure GIB funds are prioritised for energy efficiency and sustainable and emerging renewable technologies, such as offshore wind, wave and tidal generation. Given the urgency to improve the renewables and energy efficiency industries' access to capital, the GIB should be given the power to borrow before 2015 to maximise its efficiency.

- **The government should ensure that the reformed planning system allows for the exploitation of renewable energy resources in the most sustainable way:** WWF strongly supports planning policies favouring the building of renewable energy infrastructure, but we recognise that there is significant scope for community engagement and good practice in developing renewable energy projects. We want to see local authorities encouraged to look at the potential for renewable energy developments in their local development plans. The government should ensure that the reformed planning system supports the continued expansion of renewables, particularly onshore wind, which is the lowest cost low carbon technology, at appropriate locations.

- **The UK should review regulation governing interconnection to maximise future expansion and reap the benefits of better integration with European grids:** Increased interconnection between the UK and other European grids can reduce the amount of conventional back up generation needed. This means less risk of lock-in to long-lasting high carbon infrastructure. Interconnection can also help reduce the cost of developing a renewably powered electricity system for the UK and the EU. It could open up export opportunities for the UK's renewables industry too. However, a significant increase in interconnection capacity will require a move away from the current 'merchant' revenue model (where interconnection operators take all the commercial risks) towards a more regulated model under which interconnector operators would receive more revenue certainty when building new interconnection capacity.

- **The government should play a leading role in European supergrid negotiations and in developing regional interconnection initiatives such as the North Seas Countries Offshore Grid Initiative:** In addition to generating potential revenues for the UK, taking a leading role in developing transparent European market rules that allow the UK to export surplus renewable electricity to Europe would help significantly increase the amount of renewable energy capacity built in the UK. It would also reduce the amount of fossil fuel generation capacity and the volume of gas burned in the UK.



THE UK IS IN DANGER OF BEING LOCKED-IN TO AN OVERRELIANCE ON GAS

- **Clear safeguards, such as a strong Emissions Performance Standard, are needed to prevent a dangerous new dash for gas:** With 24GW of gas power generation currently operational and another 24GW of gas at different stages of the planning system, the UK is in danger of being locked-in to an overreliance on gas. While it is cleaner than coal and can be a useful transitional fuel towards an electricity system powered by renewables, gas is still a fossil fuel. Continued heavy reliance on unabated gas is incompatible with the UK meeting its climate change targets. The government must introduce a strong Emissions Performance Standard. This should be set at a more challenging level than current government proposals, with a view to delivering the decarbonisation targets recommended by the Committee on Climate Change by 2030.

- **The government must develop a strategy and programme of support to bring forward the CCS demonstration programme, in a way which is consistent with nearly decarbonising the UK power sector by 2030:** In all but the most ambitious renewable energy stretch scenarios, where there is very limited fossil fuel generation on the system (which WWF favours), a significant proportion of UK fossil fuel generation would need to be fitted with CCS by 2030. So it is important that the UK CCS demonstration programme, which should include piloting CCS on gas plant, is brought forward quickly and cost efficiently to ensure CCS technology (in particular for retrofit purposes) is available to drive down emissions from the power sector.

INTRODUCTION

WWF believes that renewable energy could meet almost 100% of the world's energy needs by 2050. In February 2011, we published our international *Energy Report*[5], a detailed analytical study by leading energy consultancy Ecofys, demonstrating that it is technically possible to achieve this.

The report also found that reduced fuel costs and improved energy efficiency could save the world economy up to €4 trillion per year by 2050 (roughly 2% of world gross domestic product (GDP) by that date). This does not include the added benefits of avoiding the worst impacts of unmitigated climate change, avoiding long-term radioactive waste management costs and reducing health costs as a result of less atmospheric pollution.

The UK adopted the Climate Change Act in 2008, which commits the country to reducing its greenhouse gas emissions by at least 80% by 2050 compared to 1990 levels. To achieve this, the CCC has made recommendations for each sector of the UK economy. Producing electricity currently accounts for approximately 32% of total UK CO_2 emissions[6]. Low carbon alternatives, especially renewable energy, can significantly cut emissions in this sector. In light of this, the CCC recently recommended that the 'carbon intensity' of the UK's power sector (i.e. the amount of CO_2 emitted per kWh of electricity produced) be reduced to one tenth of its current level by 2030[7], to 50g of CO_2 per kWh of electricity generated.

The UK is also subject to the European Union's Renewable Energy Directive, which set a legally binding target for the UK to meet 15% of its overall energy needs by 2020 with renewable energy. That means the UK needs to generate approximately 30% of its electricity from renewables by 2020. This is because it is easier to generate electricity from renewables as opposed to using renewables for heat or transport. Currently, renewables generate approximately 7% of the UK's electricity.

We are entering a period of huge change for the power sector. The transport and heating sectors are expected to be partly electrified, so will consume increasing amounts of electricity. Provided that UK power supply is progressively decarbonised, this will help significantly reduce their carbon emissions. At the same time, a considerable amount of the UK's ageing electricity generation infrastructure is due to close over the next decade. Decisions made now will play a significant part in determining how successful the UK is in meeting its decarbonisation target in an environmentally sustainable way.

Environmental sustainability

We strongly support the CCC's recommendations for decarbonising electricity generation. However, we believe that decarbonising the power sector should be done in the most environmentally and socially sustainable way possible. Electricity generation has a myriad of impacts on the environment. Whether these are linked to climate change, degradation caused by extracting fossil fuels from unconventional sources[9], or biodiversity loss caused by large hydroelectric schemes, these risks must be fully taken into account by energy policy makers.

We believe that relying on nuclear power should be avoided. It poses unacceptably high environmental risks. These include long-lasting and highly toxic radioactive waste for which there is no satisfactory long-term storage solution[10] and the potential catastrophic consequences of a nuclear accident. Nuclear power leaves future generations with the burden of managing radioactive waste without benefiting from the electricity originally produced. Nuclear isn't necessarily the cheapest option either. Significant delays and cost overruns have blighted nuclear projects in Finland. The Olkiluoto EPR project is running three years behind schedule and 55% over budget. In France, another EPR project at Flamanville is expected two years late with costs almost double the £3.3bn originally forecast[11].

Making energy efficiency and renewable energy the twin priorities of UK energy policy is the best way of minimising environmental impacts from electricity generation.

Cutting demand for energy by increasing energy efficiency and reducing consumption will reduce carbon emissions and other negative environmental impacts. Energy efficiency also lowers bills for consumers and reduces the amount of infrastructure to carry power that we need to build.

CURRENTLY, RENEWABLES GENERATE APPROXIMATELY 7% OF THE UK'S ELECTRICITY.

THE RENEWABLE ENERGY REVIEW

In May 2011, the Committee on Climate Change (CCC) launched a Renewable Energy Review, where it looked at the scope to increase ambition for renewable energy[8]. Its final report recommended that, by 2030, electricity should come from approximately 40% renewables, 40% nuclear, 15% CCS and up to 10% unabated gas. This mix was based on the assumption that nuclear is the most cost effective low carbon technology. However, the CCC suggested that up to 65% renewable electricity by 2030 is technically feasible.

The GL GH analysis supports the conclusion that 65% renewables by 2030 is possible. In fact, the GL GH stretch (C) scenarios show that, in the right economic conditions, even higher levels of renewables (almost 90%) are possible by 2030. WWF is concerned about the CCC's support for nuclear on both sustainability and cost grounds. There have been significant delays and massive cost overruns on the two new EPR reactors currently being built in Europe. **It is by no means certain that nuclear will be cheaper than renewables, particularly as renewable technologies move towards maturity and become less expensive.** Further concerns on the cost of nuclear are set out in chapter two of this report.

The environmental case for renewables

The environmental risks of renewable technologies are significantly fewer and less long-lasting than those of nuclear and conventional thermal generation. But we still need to carefully consider and take action to mitigate them. For example, WWF objected to the Severn Barrage scheme to harness renewable energy from the River Severn because it could pose a risk to important plant and wildlife habitats. However, we strongly support efforts to research alternative projects in the Severn that could strike a better balance between generating renewable energy and protecting biodiversity.

When carefully located, renewable energy technologies are a sustainable source of energy[12]. Renewable energy doesn't leave future generations with a legacy of environmental degradation (whether linked to the impacts of climate change or fossil fuel extraction) or produce radioactive waste that can remain toxic for over 100,000 years. There are many renewable technologies at various stages of development or commercialisation. If they're well supported financially and politically, we expect their costs to fall substantially as technological improvements and economies of scale are realised and domestic supply chains are developed. Prioritising renewable energy could also boost UK economic growth, given the size of the UK's renewable energy sources and its world leading research, development and industrial capabilities.

RENEWABLE ENERGY DOESN'T LEAVE FUTURE GENERATIONS WITH A LEGACY OF ENVIRONMENTAL DEGRADATION

We commissioned GL Garrad Hassan (GL GH) to examine how the UK could meet the CCC's decarbonisation target without relying on risky new nuclear generation and other unsustainable forms of energy. The report looks in particular at how the UK can maintain sustainable growth in renewables capacity beyond 2020. The analysis underlying the government's original Electricity Market Reform proposals assumes the UK will use 29% renewables in 2020, but this will rise to just 35% by 2030. This boom and bust approach to renewables deployment post-2020 is bad for business and likely to undermine development of a UK renewables manufacturing sector.

METHODOLOGY

This report begins by examining two 2030 electricity demand scenarios (a central scenario and an ambitious scenario). It also assesses how much the UK's demand for electricity could be made flexible, with consumers and industry receiving incentives to use electricity at some times but not at others, to draw a conclusion on the level of demand which would need to be met by 2030.

The report then looks at how much renewable energy will be available and how much of it we'll be able to harness by 2030 with the necessary technology being installed at ambitious but feasible rates. It then compares the reliability of renewable generation with that of conventional generation, drawing conclusions on the criteria that would need to be met to ensure security of supply with a high level of renewables.

For each demand scenario, GL GH investigates two alternative generation mixes comprised mainly of renewables, unabated gas, and gas with CCS and interconnection capacity. Both generation scenarios ensure that even in the event of a long spell of anticyclonic conditions – meaning little contribution from wind, solar or wave generation – supply would be secure. In reality, these conditions occur infrequently and the amount of electricity produced from renewable energy sources would normally be significantly higher than the 'worst case' situations considered in the scenarios. The report therefore presents four core scenarios as well as two additional stretch scenarios. Security of supply comes from 'back up' capacity from interconnection and conventional gas generation.

Finally, the report draws conclusions for each of the scenarios, highlights the share of renewables within each scenario and the implications of using gas to supplement renewables. It also identifies how much CCS equipment on gas plant would be needed to ensure that the power sector complied with the CCC's recommended carbon intensity threshold of 50gCO_2/kWh for 2030[13].

CHAPTER 1: HOW THE SCENARIOS WERE DEVELOPED

The scenarios were developed by first assessing how much electricity we will need in 2030 and then modelling a generation mix to ensure security of supply.

Demand reduction

GL GH used two alternative scenarios for electricity demand in 2030. One, the central scenario, is in line with the CCC's medium abatement scenario[14]. The other, the ambitious scenario, is based on scenarios published by the UK Energy Research Centre (UKERC)[15].

GL GH's central scenario assumes limited behaviour change and significant growth in the use of electric vehicles (EVs) and electric heating (for example, by heat pumps) by 2030. It also assumes some increased effort to be energy efficient, which will offset part of the additional demand for electricity that electric vehicles and heating will create.

Current UK electricity demand is around 340TWh per year[16]. In the central scenario, annual electricity demand in 2030 is forecast to be 425TWh. This scenario envisages EVs using a total of 30TWh and heating using 51TWh per year by 2030. WWF's recent report *Electric Avenues*[17] demonstrates that 30TWh per year could power some 26 million EVs in 2030 – equivalent to 74% of all cars on the road.

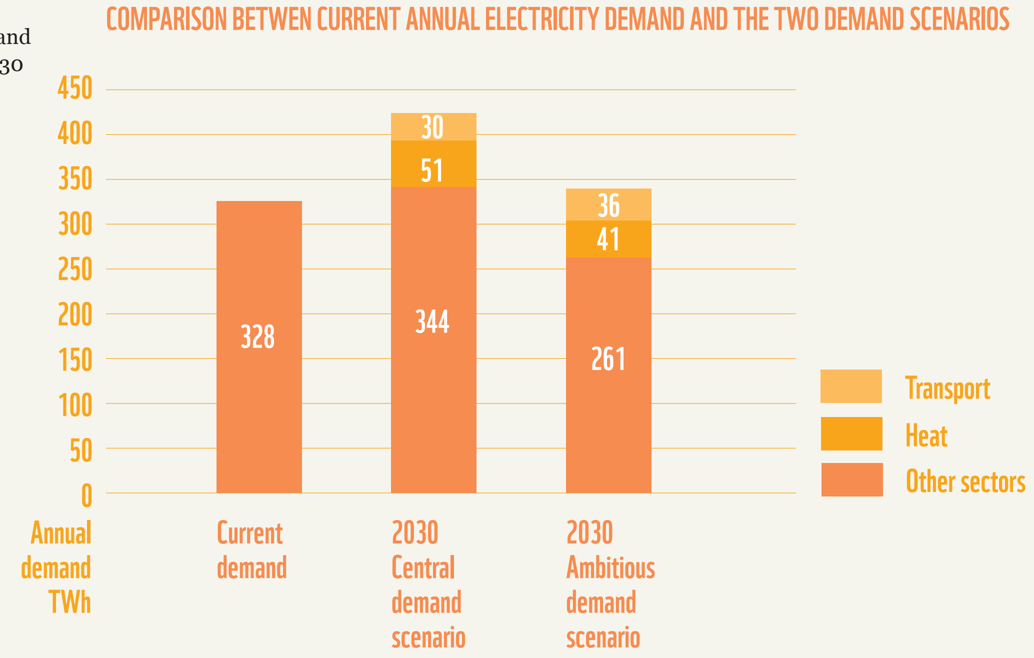
WE ASSUMED HIGH GROWTH IN ELECTRIC VEHICLES AND ELECTRIC HEATING

The ambitious scenario assumes a gradual shift towards lower carbon lifestyles, resulting in a significant reduction in energy demand. For example, excess heating will become unacceptable and energy efficiency a priority. Reducing demand for energy may also be driven by facilitating competition in the market between those companies able to deliver long-term energy demand reductions and those able to build additional electricity generation capacity, as opposed to the current market arrangements which only reward those companies able to build generation capacity. The UKERC scenario stretches to 2050, but GL GH have only used energy demand reductions assumed to have happened by 2030.

Making the ambitious scenario a reality would mean that the amount of electricity consumed in the UK in 2030 would be almost the same as the amount used today – 338TWh. Increases in electricity consumption resulting from a significant shift to electric vehicles and electric heating are offset by significant savings, mainly due to energy efficiency and behaviour change. This scenario assumes electric heating will need 10TWh less electricity than in the central scenario thanks to more ambitious action on the energy efficiency of buildings. The ambitious scenario assumes demand for electricity for transport is higher at 36TWh, due to more EVs.

It is feasible that both scenarios overestimate how much heat will be electrified by 2030. This depends to some extent on government policies on renewable heat and energy efficiency. However, it is also acknowledged that transition to heat pumps, for example, is expensive and disruptive. The CCC may have anticipated a stronger move towards electric heating than will happen in practice. Likewise, the take up of EVs may be lower than forecast. If this is the case, the impacts would be lower overall electricity demand, less flexibility in demand and higher emissions economy-wide. The UK would be at greater risk of missing its climate change targets.

Figure 1: Central and ambitious electricity demand scenarios in 2030



Meeting peak demand

The UK power system must have enough capacity to meet demand when it is highest. 'Peak demand' is likely to happen during particularly cold spells in the winter. Everyday demand for electricity fluctuates over a 24-hour period, with peaks during the early morning and evening.

In 2009/10, UK demand for electricity peaked at 59GW. Peak demand could be higher in 2030 due in part to increased demand for electricity for heat and transport. To reduce this peak demand and limit the generation capacity needed, consumers could be given incentives to spread their demand over the course of the day. For example, EV owners would be more likely to charge their vehicles overnight if it was cheaper.

This mechanism, called 'demand side response', could be based on ex-ante prices (prices agreed in advance) which are derived from daily patterns of demand and don't change day-to-day. However, in an electricity mix with high levels of renewables, active rather than fixed price signals, which respond to real time changes in supply and demand, are more appropriate. Active tariffs would vary depending on output from renewables and demand at any given time. A 2010 report by Pöyry Energy Consultants showed that active tariffs are far more efficient than ex-ante tariffs at shifting demand in response to variations in renewable energy supply[18].

To make sure that demand for heat can be met, the government must drive forward policies to ensure that buildings become significantly more efficient and hot water storage is incentivised. Assuming sufficient incentives to reduce and spread demand, peak demand in 2030 would be 70GW in the central scenario and 56GW in the ambitious scenario.

Security of supply

The UK's electricity system must always be able to meet peak demand. This is a key issue to take into account when looking at how big a contribution renewables can make to our future energy needs.

If, for example, peak demand in 2030 is 70GW, the UK must have significantly more generating capacity than this available to cover periods when some generators are not available (because of issues like maintenance cycles, lack of transmission capacity and weather conditions). Instead of more capacity in the UK, another solution could be significant interconnection to a secure European grid.

This report addresses the challenge of putting a large volume of renewables on the grid while maintaining security of supply.

GL GH's report concluded that "in all respects bar two, intermittent renewable generation is (or can be made to be) no different in its effects on system security than conventional generation". The two principle differences, which are fully addressed later in the report, are:

- Variations in total output on timescales of half an hour and longer, which can be forecasted adequately a few hours ahead, but which the system operator cannot effectively influence, i.e. system operators can predict but can't control changes in the electricity produced by wind farms

- In a system with high use of on and offshore wind, the production of electricity is primarily set by the availability of wind, not by contracts or market prices.

There will inevitably be some periods when there's very little wind or other renewable resources can't meet demand. To meet demand at these times, we will need demand side response (giving electricity users incentives to shift their consumption to times of low demand or surplus supply), energy storage, backup plant or interconnection.

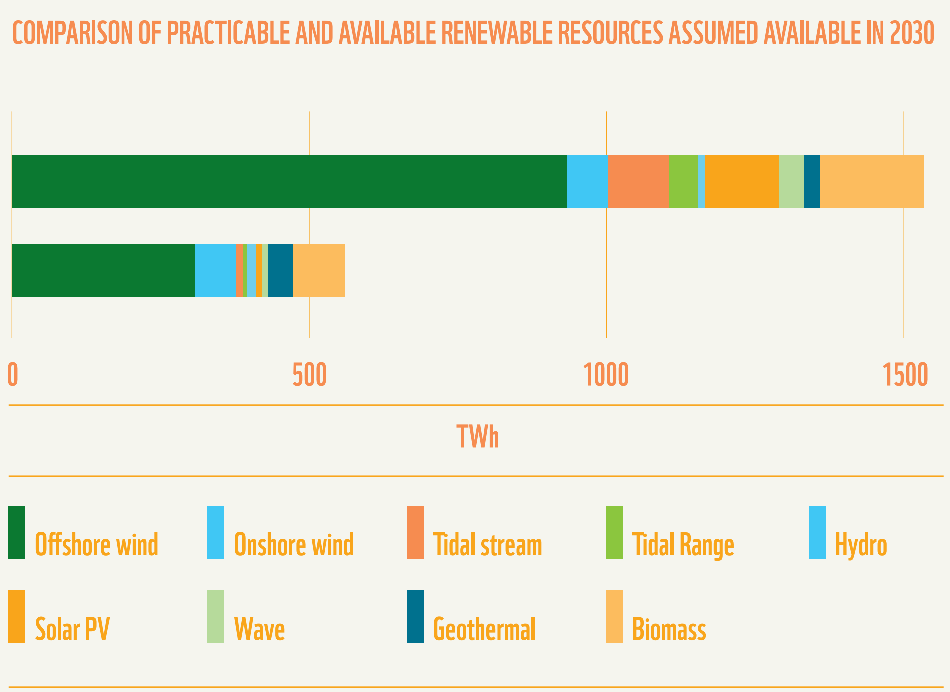
To ensure they addressed all concerns around security of supply, GL GH's scenarios consider a 'worst case' situation, where an extended winter cold spell coupled with anticyclonic conditions covering the whole of the British Isles results in very limited power from wind, solar, wave and run of river hydro. In practice, these conditions occur very infrequently.

As previously highlighted, demand side response will play an important role in providing flexibility in overall electricity consumption. However, the report makes it clear that "very little demand can be deferred by more than a day and certainly not for a period of a week or more". Therefore, it was assumed as part of this worst case situation that no contribution from demand side response would be feasible over such a long period of time.

Resources and generation mix

Having established demand scenarios, GL GH assessed the UK's 'practicable' renewables resource – the maximum amount of renewable resources available to the country, drawing on estimates from the Department of Energy and Climate Change (DECC) and the CCC. They then took into account anticipated technical developments, public acceptance, and build rates to come up with estimates for the 'available' renewable resource in 2030.

Figure 2: Annual renewable electricity resources assumed available in the UK in 2030 (TWh)[19, 20].



In all of GL GH's scenarios, the renewable energy generation needed to meet demand (maximum 425 TWh in 2030 under the central demand scenario) is significantly less than both the practicable and the available resource estimates shown in figure two.

GL GH assumes that it will not be economic to build renewable energy capacity to meet more than the UK's peak demand plus that of our existing interconnector capacity with other countries. This is based on the premise that building excess renewable capacity would mean that at times of high electricity production from renewable energy sources ('peak output') or low demand, there would be no market for the surplus electricity. In reality, it is unlikely that all renewable generators will reach their maximum production levels simultaneously, given that wind speeds vary around the country. Future developments in the EU electricity market may give the UK an opportunity to profitably export surplus renewable electricity, enabling an even higher deployment of renewables in the UK. This is assumed to be the case in the stretch scenario, the implications of which are discussed in chapter three.

Biomass and sustainability

When used for power generation, biomass is dispatchable – it can be used as and when it's needed. That makes it an attractive source of renewable electricity. Greenhouse gas emissions vary depending on the source of fuel, conversion technologies and how efficiently it's used.

There are concerns about the impact of biomass on water resources, biodiversity and food security, particularly in developing countries. These need to be addressed. Robust legislation is needed to set sustainability criteria for forest management and limit the expansion of fast growing plantations.

Under the UK's 2011 Amendment order to the Renewables Obligation, biomass used for power generation must reduce greenhouse gas emissions by 60% compared to the EU average. From 2013, biomass must meet mandatory sustainability standards. Using materials from land with high biodiversity value or which holds a lot of carbon will be restricted. This will cover primary forest, peatland and wetlands.

WWF's assessments show that the world has a finite supply of genuinely sustainable bio-energy resource from both residues and agricultural crops. In the future, these should be prioritised for sectors where other types of renewable energy are unsuitable[21] such as aviation, shipping and high grade heat for industry. In its recent Renewable Energy Review[22], the CCC took a cautious approach on the use of biomass, highlighting that it could be used more efficiently in the heating sector and should be used in a way that avoids locking a large part of the resource into power generation in the long term.

The UK is expected to import significant quantities of biomass. This must be certified under credible schemes such as the Forestry Stewardship Council. To prevent biomass actually causing more carbon emissions, we must develop and adhere to strong sustainability criteria which also take into account impacts such as greenhouse gas emissions arising from indirect land use change. There are also concerns that biomass is currently rated as zero carbon under the EU emissions trading scheme, which could create perverse incentives to use poor quality biomass. Moreover, current international accounting rules for land use, land use change and forestry (LULUCF) mean that emissions from production of biomass may not be accounted for properly or at all. A robust system which ensures that the true emissions of bioenergy are fully accounted for will be required to ensure that genuine emission savings are realised.

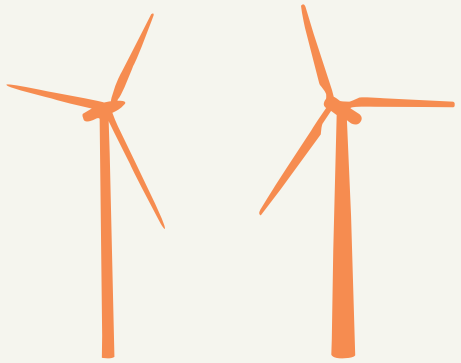
As GL GH's report highlights, biomass could, in principle, provide as much energy as onshore wind. However, because of the concerns described above, GL GH assumes a lower level of biomass deployment for power generation in its scenarios. The government's Renewables Roadmap envisages using 6GW of biomass for electricity generation by 2020. In contrast, GL GH's main scenarios assume up to 3GW by the same date[23]. WWF very strongly prefers biomass for power generation to be combined heat and power plant. In any event, we would oppose any project that doesn't meet stringent energy efficiency and sustainability criteria.

In their 2050 pathways analysis[24], the DECC grades different ways of deploying renewables from one to four based on how much effort they need. For example, level two is 'ambitious but reasonable' and three is 'very ambitious'. Deployment of renewables under the core GL GH scenarios is at or below level two for on and offshore wind and is below level three for all other renewable technologies.

It's valuable to deploy a mix of renewable technologies makes the system more secure. For example, tidal stream generation is predictable, reaches peak at different times depending on where in the UK it is, and has little environmental impact where appropriately located. On the other hand, geothermal can generate on demand.

It is important to stress that other mixes of renewable energy technologies could become possible. This depends on how quickly technology develops and how costs of different technologies change. If emerging technologies don't develop at the expected speed, the shortfall could be solved by using more onshore and offshore wind. There are credible arguments that the DECC and CCC scenarios substantially underestimate the potential for large-scale and cost effective deployment of photovoltaic (PV) solar power. A recent analysis by Ernst & Young indicates that large-scale solar PV could compete with other technologies cost-wise without government support within a decade. If this turns out to be the case, it would likely bring forward significantly more PV than is envisaged in the GL GH scenarios[25].

A MIX OF RENEWABLE TECHNOLOGIES MAKES THE SYSTEM MORE SECURE



CHAPTER 2
THE SCENARIOS

GL GH modelled four core scenarios and two stretch scenarios. Security of supply is maintained in all scenarios which differ in their levels of demand, interconnection with European grids and generation mix.

For each level of demand, GL GH sets out two scenarios for where the UK's energy will come from in 2030. For each demand scenario, GL GH undertook modelling to assess what mix of generation capacity would be required in the worst case scenario: where weather conditions across the country mean little power from supply led renewable generation (like wind power). From this, they were able to assess how much back up generation would be needed to maintain system security.

GL GH examined two options to provide back up in the worst case scenario. At one end of the spectrum, back up comes almost exclusively from gas and there is no increase in interconnection. We reach decarbonisation targets with an ambitious roll out of CCS on a significant proportion of the UK's gas capacity. CCS plant run at 80% of their load factor (capacity) and non CCS plant run at considerably lower load factors.

At the other end of the spectrum, we rapidly increase interconnection by 2030. This reduces the amount of gas generation capacity needed to secure the UK system. In addition and depending on future European electricity systems and markets, it may also become economically attractive to build more renewable energy capacity than the UK needs and export surplus renewable electricity to European markets. As shown in the stretch scenario (see pages 32-33), this could significantly increase the share of renewables in the UK power sector. GL GH points out that the market for UK renewables in Europe "could be considerable, but will depend on competing low carbon generation in other markets" as well as future European market structures.

	LOW INTERCONNECTION (A)	HIGH INTERCONNECTION (B)
Central demand (1)	A1	B1
Ambitious demand reduction (2)	A2	B2

In practice, the generation mixes should be understood to be two ends of a spectrum. The A scenarios assume no further expansion of interconnection from today's 3GW. The other 'high interconnection' B scenarios envisage up to 32GW of new interconnection capacity. Actual interconnection and generation backup capacities are more likely to fall between the two ends of the spectrum.

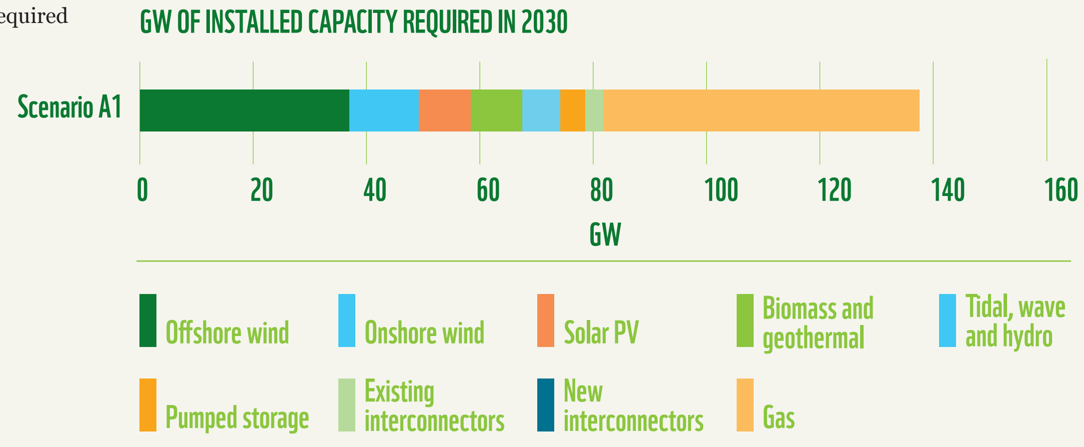
The GL GH scenarios consider the environmental impacts of renewable energy. It is assumed that all new river hydro must accommodate fish spawning and migration. Similarly, marine renewable projects must be considered on a case by case basis to avoid adverse effects on biodiversity.

GL GH also modelled additional stretch scenarios (C1 and C2) which assume higher levels of renewables deployment requiring increased interconnection with Europe and an export market for UK renewable electricity.

GL GH modelled six scenarios to assess how different mixes of energy generation capacity could reach decarbonisation targets and meet the UK's energy needs in 2030. The scenarios also consider the environmental impacts of renewable energy – to avoid adverse effects on biodiversity.

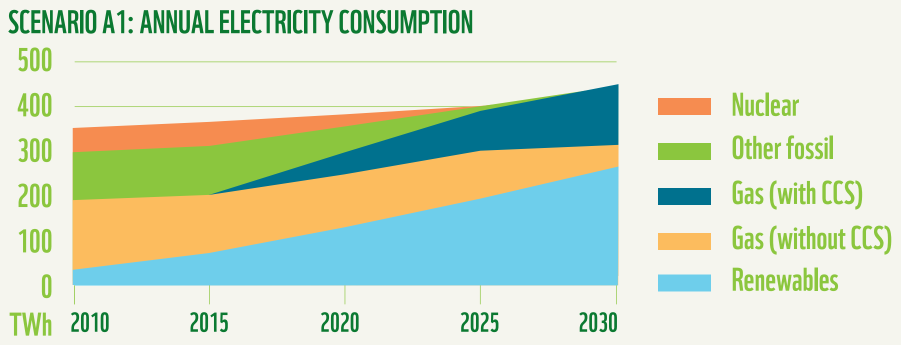
Scenario A1: Central demand scenario with no additional interconnection

Figure 3: GW of installed capacity required for scenario A1



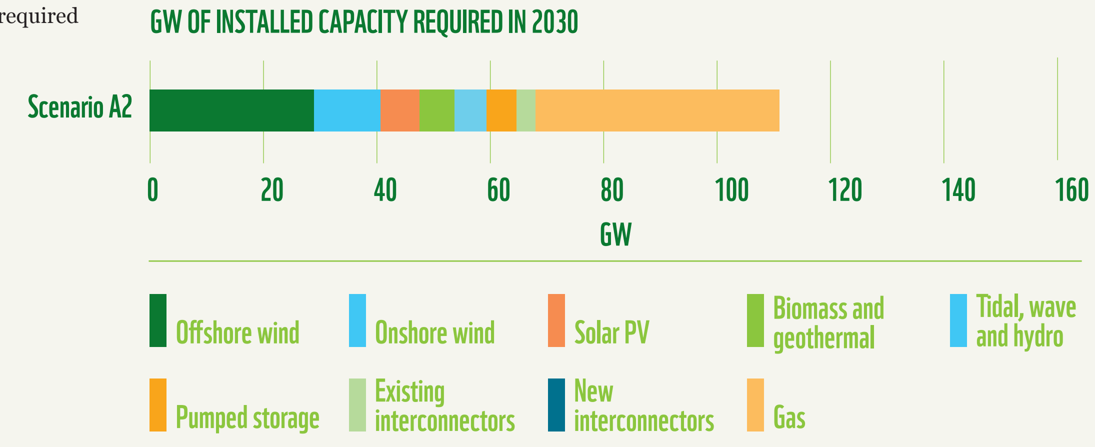
This scenario assumes that the UK is almost entirely self sufficient in electricity supply in 2030 and hasn't expanded its interconnection capacity beyond current levels. Total annual demand has increased to 425TWh/a by 2030, with peak demand at 70GW. Under this scenario, renewables meet 61% or 261TWh of the UK's annual electricity demand. A combination of gas fired plants with and without CCS make up the majority of the remaining capacity. 56GW of gas generation capacity is needed providing 164TWh/a of electricity. A significant proportion of the conventional generation capacity included in this scenario is used relatively infrequently to meet demand at times of low renewable electricity production.

Figure 4: Pathway to 2030, scenario A1



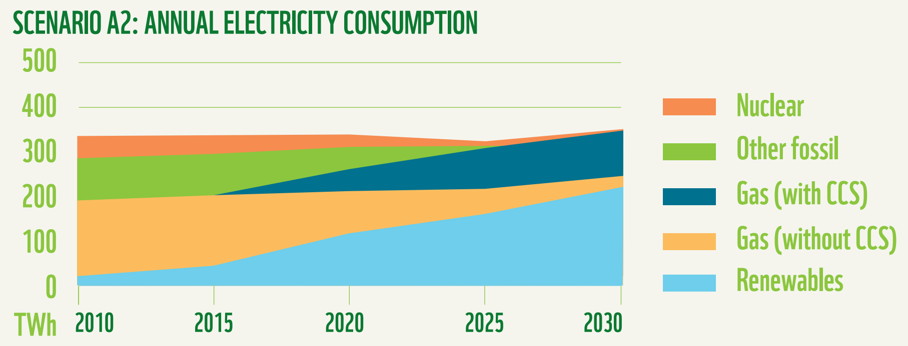
Scenario A2: Ambitious demand scenario with no additional interconnection

Figure 5: GW of installed capacity required for scenario A2



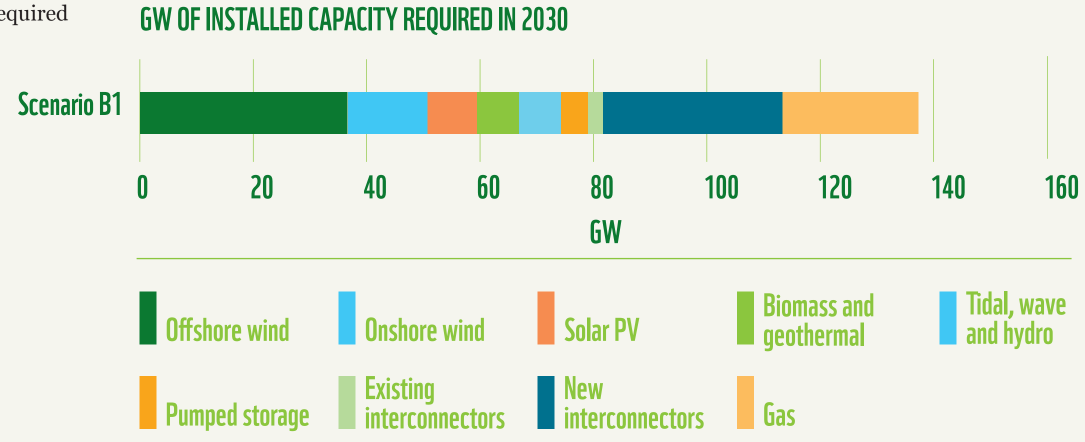
This scenario, like scenario A1, assumes no expansion of interconnection capacity and relies on domestic gas generation capacity for system security. However, total demand is significantly lower than under scenario A1 at 338TWh/a of electricity, with peak demand at 56GW. Under this scenario, renewables meet 62%, or 210TWh/a, of demand. As in scenario A1, a combination of gas fired plants with and without CCS primarily meet remaining electricity demand. 44GW of gas generation capacity is required, providing 128TWh/a of electricity.

Figure 6: Pathway to 2030, scenario A2



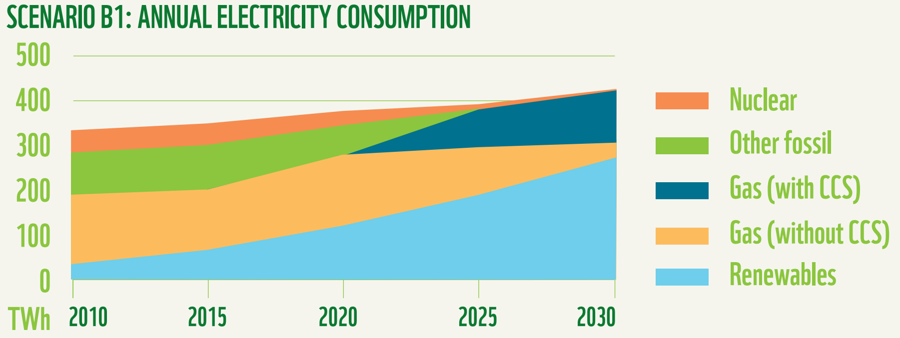
Scenario B1: Central demand scenario with high interconnection

Figure 7: GW of installed capacity required for scenario B1



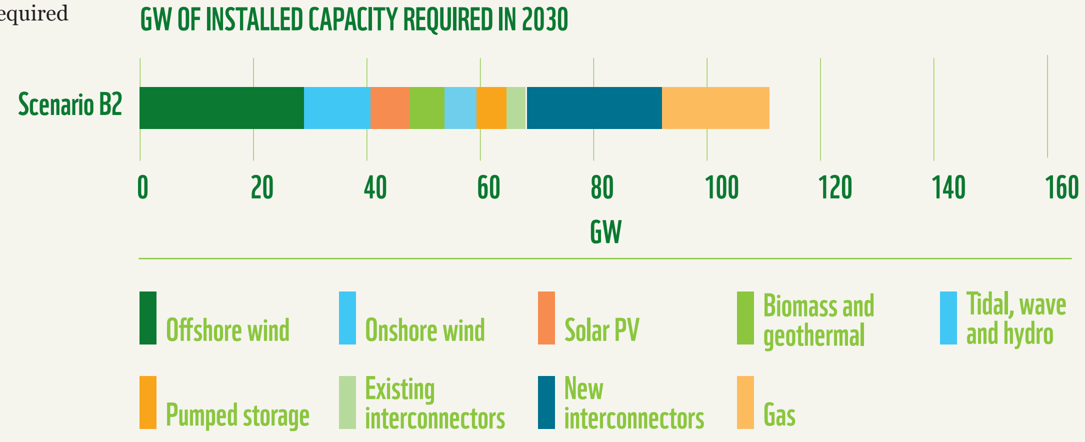
Under this scenario, electricity demand is the same as in scenario A1, at 425TWh/a with peak demand at 70GW. However, interconnection capacity increases to an ambitious 32GW above current levels. Only 24GW of installed gas generation providing 164TWh/a of electricity is needed. The UK imports electricity from Europe at times of low renewable output and exports at times of surplus electricity generation. It is assumed for modelling purposes that annual exports of electricity are equal to annual imports. Gas generation runs at a relatively high capacity factor. Most of it must be equipped with CCS technology to meet the 50gCO_2/KWh decarbonisation target for 2030. As in scenario A1, UK renewable electricity meets 61% of net demand totalling 261TWh.

Figure 8: Pathway to 2030: scenario B1



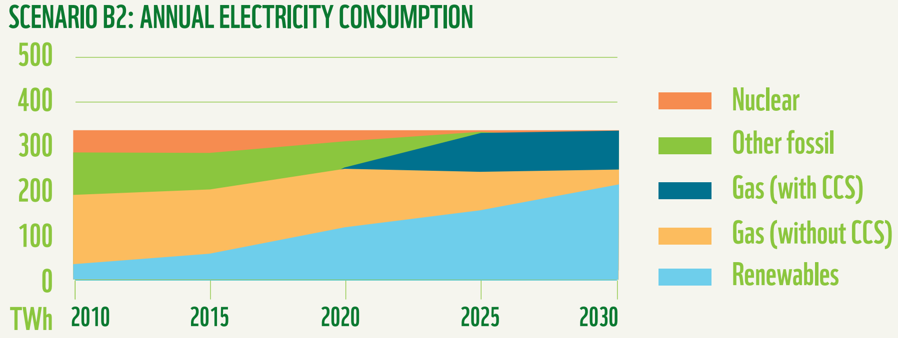
Scenario B2: Ambitious demand scenario with high interconnection

Figure 9: GW of installed capacity required for scenarioB2



This scenario combines the high level of interconnection in B1 with the ambitious reductions in demand in scenario A2. Total demand is 338TWh/a with peak demand at 56GW. 20GW of installed gas generation providing 128TWh/a of electricity is required. The majority of this needs to be equipped with CCS technology to meet the decarbonisation target. Interconnection, as in B1, allows the UK to import and export electricity to balance supply and demand. It is again assumed that annual exports of electricity are equal to annual imports. As in scenario A2, renewables meet 62% of net demand totalling 210TWh/a. Of the four main scenarios, this one requires the least conventional capacity for system security.

Figure 10: Pathway to 2030: scenario B2

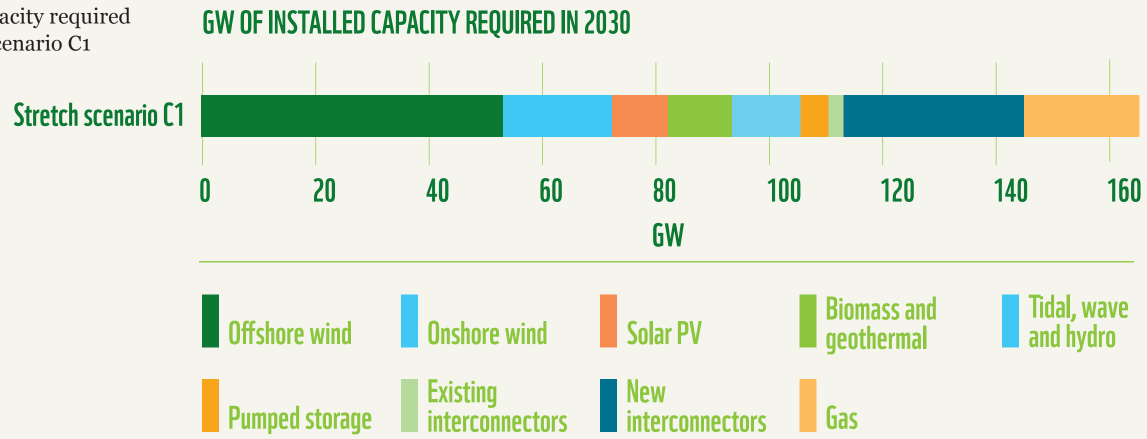


The stretch scenarios

In addition to the four scenarios set out above, GL GH modelled two stretch (C) scenarios, one for each level of demand. In these, interconnection is equal to that assumed in the high interconnection B scenarios. However, in contrast to B1 and B2, in the stretch scenarios, it is assumed that there is an export market for surplus electricity generated at times of high renewable energy production. In the stretch scenarios GL GH therefore assumes that it is economic to build renewables in excess of domestic demand or up to maximum UK electricity demand plus total interconnector capacity. This means it's feasible to build more renewables than GL GH assumes in the four main scenarios. The viability of the stretch scenarios rests on the assumption that increased interconnection with European grids would provide an export market for the UK's surplus renewable generation, as well as helping secure the UK electricity system at times of high demand.

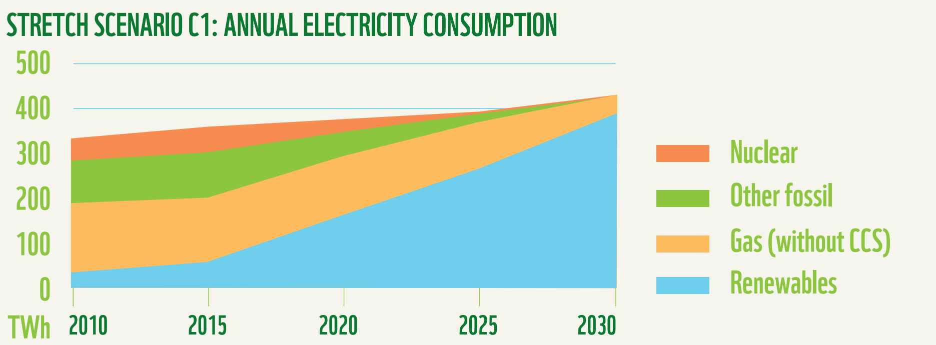
Stretch scenario C1: Central demand, high renewables

Figure 11: GW of installed capacity required for stretch scenario C1



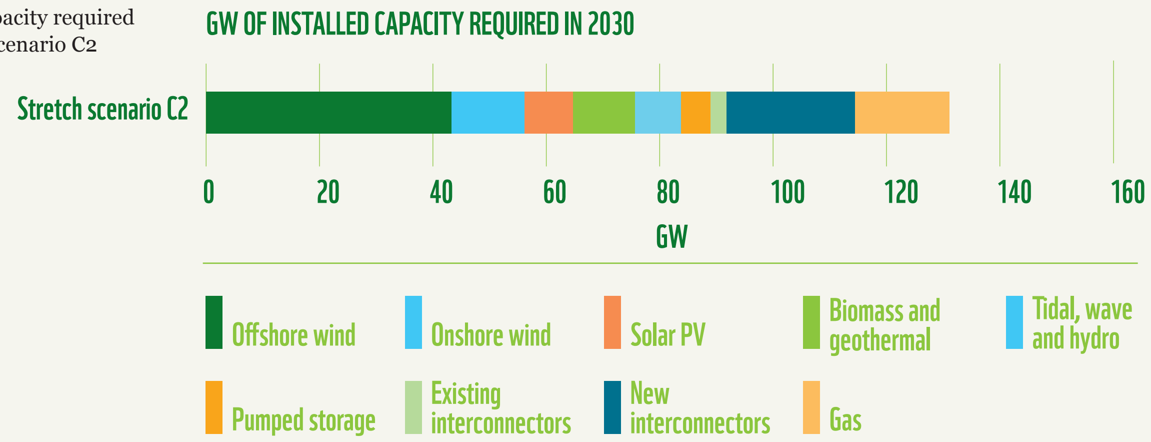
In this scenario, renewable energy meets 88% of demand. Due to the high proportion of demand met by renewables, there is no need for CCS technology to be installed on any remaining gas plant. Annual output from gas generation is 52TWh with 373TWh from renewables.

Figure 12: Pathway to 2030: stretch scenario C1



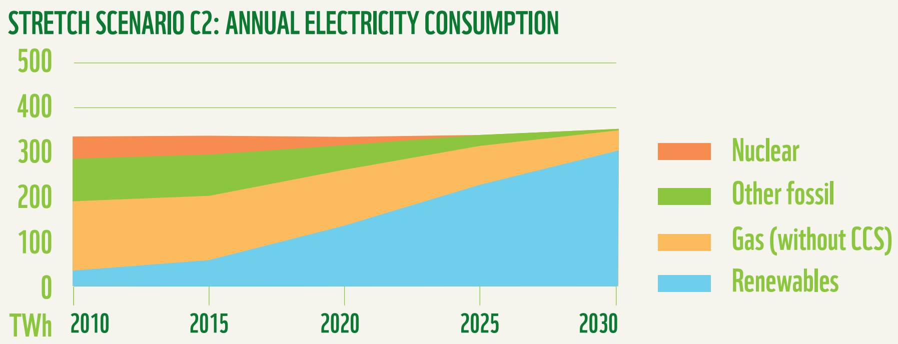
Stretch scenario C2: Ambitious demand reduction, high renewables

Figure 13: GW of installed capacity required for stretch scenario C2



In this scenario, renewable energy meets 87% of demand. Due to the high proportion of demand met by renewables and ambitious reductions in demand, there is no need for remaining gas plant to be equipped with CCS. Annual output from gas generation is 43TWh with 295TWh from renewables.

Figure 14: Pathway to 2030: stretch scenario C2



These scenarios are clearly ambitious. But GL GH makes it clear that they are technically achievable. Build rates in these scenarios are mainly in the DECC's level three, with on and offshore wind deployment nearer DECC level two in the ambitious demand reduction stretch scenario (C2).

The benefits of reducing demand

The contrast between the scenarios shows the importance of demand reduction. Under scenarios A2 and B2, which assume ambitious demand reductions, the generation capacity needed for system security is 27GW less than in scenarios A1 and B1, which use central demand assumptions. That's approximately equivalent to needing 18 fewer new gas fired power stations.

Other benefits of ambitious demand reduction include saving £40bn in building interconnection and generation capacity, lower costs for consumers, reduced greenhouse gas emissions and less environmental impact.

Keeping the system secure

The GL GH scenarios include varying amounts of gas generation and interconnection capacity to make sure there is always enough power to meet demand. Gas generation capacity mainly ensures system security in the A scenarios. Much of this operates relatively infrequently at times when demand is high. In contrast, the B scenarios and the stretch or C scenarios need significantly less gas generation capacity. Instead, interconnection to Europe makes sure supply meets demand.

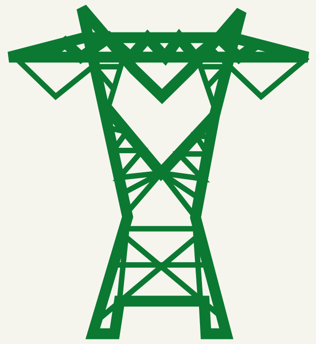
WWF has a clear preference for the high interconnection scenarios because there's less need for gas generation capacity cutting the risk of 'lock-in' to too much gas. Building excess unabated gas capacity is risky. It could only run very infrequently if we are to meet 2030 decarbonisation targets. Curtailing the output of excess plant or requiring it to retire early would mean generators lose revenue. The cost of this would likely be passed on to consumer bills. A recent Green Alliance report highlighted that "current and planned gas capacity will either lock the UK into higher carbon levels, or result in gas power station investments of up to £10bn being retired early or needing costly CCS retrofit if these power stations are run as baseload"[26].

A high volume of unabated gas fired generation currently has planning permission or is going through the planning system. National Grid estimates that there could be 45GW of gas on the system by 2018[27]. Only scenario A1, which WWF doesn't favour because it risks lock-in to high levels of gas, needs more than 45GW of gas capacity by 2030. Of this, a significant proportion must be fitted with CCS to meet carbon targets. WWF's preferred B and C scenarios need a maximum of 24GW of gas generation capacity in 2030.

The scenarios show that by 2030 a large proportion of frequently running plant will need to be equipped with CCS to meet the decarbonisation target recommended by the CCC. But the future cost and viability of CCS remains uncertain. It is very unclear whether the location of most unabated plant planned or in operation today is well suited to CCS retrofit. Also, in practice, requirements to demonstrate "'CCS readiness' are not very credible. CCS has not yet been commercially proven and repeated delays have hit the government's CCS demonstration programme. For this reason WWF particularly prefers the stretch scenarios. These require no CCS but instead rely on higher levels of renewable energy capacity which could be built if increased interconnection means it is economic to export surplus power to Europe.

Table 1: Breakdown of gas generation capacity requirements

	OCGT	CCGT	GAS CCS	TOTAL
Scenario A1	9GW	29GW	18GW	56GW
Scenario A2	7GW	23GW	14GW	44GW
Scenario B1	2GW	5GW	17GW	24GW
Scenario B2	2GW	5GW	13GW	20GW



BETTER INTERCONNECTION WITH EUROPEAN GRIDS CAN SIGNIFICANTLY REDUCE THE NEED FOR CONVENTIONAL GENERATION

Table one shows the relative proportion of different types of gas plant needed to meet the carbon intensity target of 50gCO2/kWh recommended by the CCC under the four main scenarios. Given their higher cost to build and lower emissions, CCS plants would run most frequently, with load factors of 80-85% anticipated. Load factors of Combined Cycle Gas Turbine (CCGTs) and Open Cycle Gas Turbines (OCGTs) are significantly lower under the lower interconnection A scenarios meaning that, as discussed above, output would have to be curtailed with possible implications for consumer bills.

Interconnection and why the share of renewables could be even greater

Lack of interconnection to European grids in scenarios A1 and A2 means that a significant volume of conventional generation capacity, in this case gas, is needed for system security. This is undesirable because of the risks of lock-in to excess gas capacity.

A high level of interconnection to European grids, sometimes referred to as a European supergrid, significantly reduces the conventional generation needed to secure the UK electricity system. It would allow for more efficient sharing of electricity resources across Europe[28], help to avoid wasting excess electricity and cut the back up generation capacity each member state needs.

The GL GH stretch scenario shows the potential to meet a higher proportion of UK electricity demand with renewables than in the four main scenarios. GL GH made conservative assumptions on the potential contribution of renewables in scenarios B1 and B2 because of uncertainty about whether increased interconnection with European grids could increase future export markets for surplus UK electricity. If by 2030 European electricity market conditions make it economic to export renewable electricity to Europe at times of surplus supply in the UK, investment in renewables will increase, allowing the UK to move from a 60% share of renewables in the main scenarios up towards the high levels of renewables in the stretch scenario.

As shown in figure fifteen below, growth in renewables in the WWF scenarios is lower than the projections made in the *UK National Renewable Energy Action Plan (NREAP)* to 2020. This shows the technical feasibility of these scenarios. Our scenarios then project continued growth in renewables forward to 2030, as shown in figure sixteen, a necessity to create certainty for the sector.

Figure 15: Scenario comparison: renewable growth to 2020

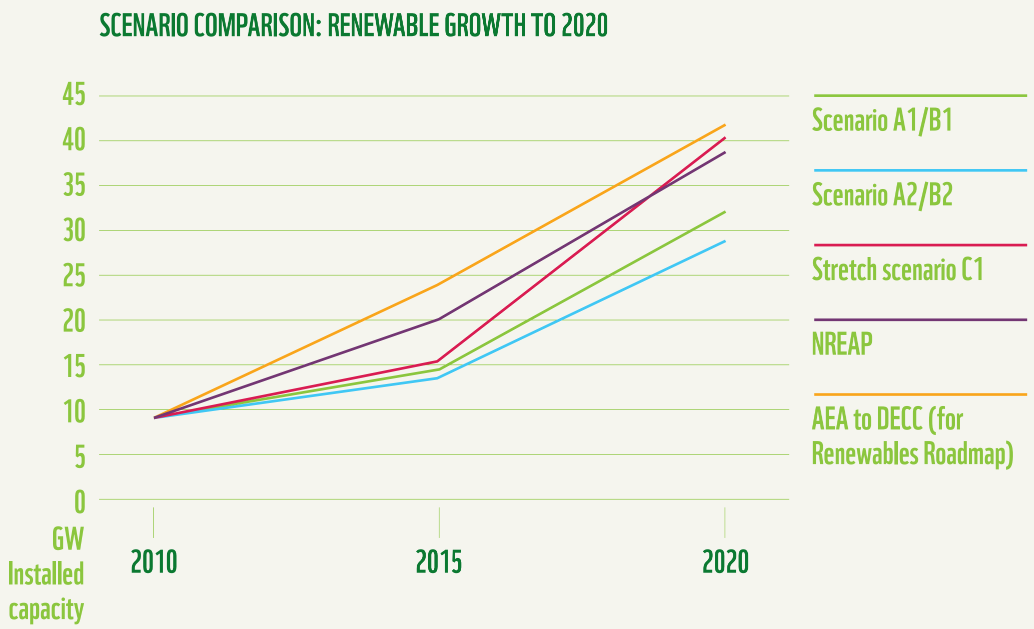
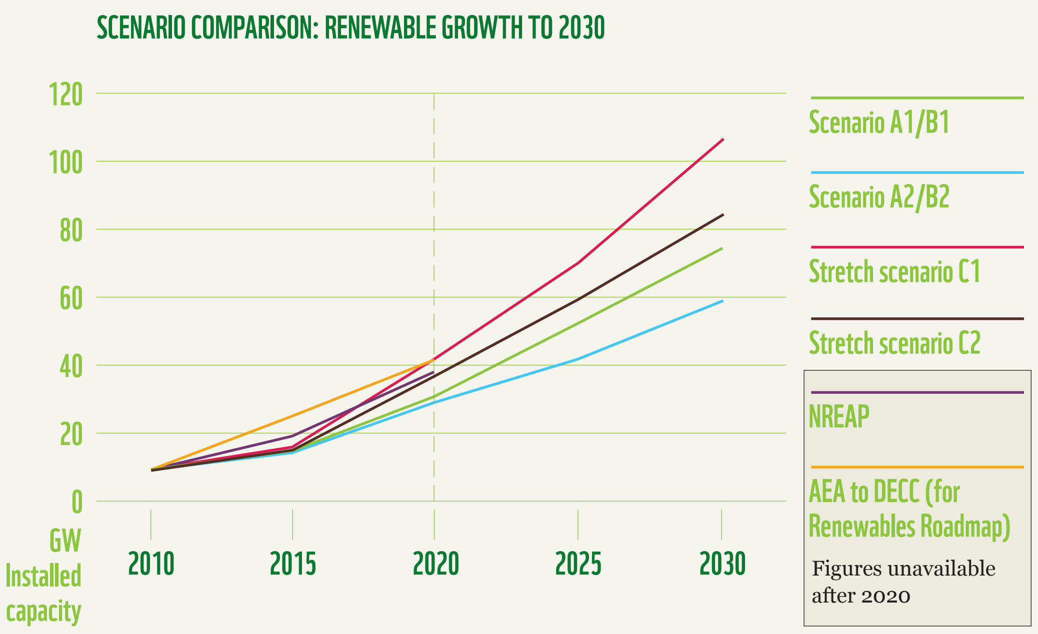


Figure 16: Scenario comparison: renewable growth to 2030



Costs

Cost projections in GL GH's analysis are drawn from projections by Mott Macdonald, which were used by the CCC in its *Renewable Energy Review*[29] and in a more recent report by Arup[30].

There is significant uncertainty about the future capital costs of renewables and other technologies. The costs for GL GH's scenarios (table two below) are only indicative. Table two provides an indication of the investment required. However, it doesn't provide information on potential revenue streams to the UK, benefits for industry or job growth. Quantifying the projected economic implications for the B and C high interconnection scenarios would require complex modelling of future European electricity markets and is beyond the scope of this analysis.

Scenarios B1 and B2 assume for modelling purposes that the electricity imported into the UK annually is equal to the amount exported. Therefore, despite higher levels of interconnection in the B scenarios, the same amount of electricity is produced by gas plant in the B scenarios as in the A scenarios (albeit in a smaller number of plants, more efficiently used).

In reality, it is likely that building the high levels of interconnection infrastructure modelled in scenarios B1 and B2 would mean the UK would be either a net importer of electricity or a net exporter of electricity depending on what was most economic. Importing would reduce the amount of electricity UK gas plants generate in the B scenarios. The UK would only export surplus renewable power if it was economically beneficial. Chapter three of this report sets out in more detail the economic benefits of a highly interconnected electricity system, as shown in recent technical and economic studies on the European electricity system.

Table 2: Capital costs of new build generation to 2030

	LOW INTERCONNECTION		HIGH INTERCONNECTION	
	SCENARIO A1	SCENARIO A2	SCENARIO B1	SCENARIO B2
% Renewables capacity	61%	62%	61%	62%
Gas generation	£51BN	£40BN	£28BN	£23BN
Renewable generation	£165BN	£133BN	£165BN	£133BN
Interconnection	0	0	£19BN	£14BN
Total capital required	£216BN	£173BN	£212BN	£170BN

Charles Hendry, Minister of State for Energy, has acknowledged that "over £100bn of investment in secure, low carbon and affordable electricity generation capacity is required in the period to 2020[31]". GL GH's scenarios and therefore the costs set out above stretch to 2030. Capital costs will be significantly lower than those presented above if the government realises its ambition to cut the cost of offshore wind to £100/MWh by 2020 outlined in the *Renewable Energy Roadmap*.

Scenarios conclusion

The amount of renewables installed in GL GH's four main scenarios to 2020 is lower than that envisaged in the government's NREAP. It's broadly in line with the projection of 29GW of renewable power generation capacity by 2020 in the government's *Renewable Energy Roadmap*[35]. The difference is that the rate of renewables deployment in the GL GH scenarios continues at a similar pace beyond 2020. In contrast, the Redpoint analysis[36] underlying the government's original Electricity Market Reform consultation envisaged investment in renewables slowing significantly post-2020, with only 35% of electricity coming from renewables in 2030, up from 29% in 2020.

Of the four main scenarios, WWF's preferred future electricity system is scenario B2. This scenario includes high levels of ambition for reducing demand and creating interconnection with Europe, and the lowest capital costs. Scenarios B1 and B2 also need much smaller gas generation capacity than the A1 and A2 scenarios. This reduces the risk of the UK building surplus long-lasting gas generation infrastructure, which might require subsidy to operate at low load factors (as required in the A scenarios) or risk locking the UK into carbon intensive generation infrastructure.

However, as made clear in the additional stretch scenarios C1 and C2, there is scope for renewables to provide much more than a 60% share of UK electricity. UK policy influence at EU level could be key in helping create the right market conditions to allow for substantial exports of surplus UK power to Europe (this was also highlighted in the government's recent *Offshore Valuation report*[37]). In these conditions, the high levels of renewable energy envisaged in the stretch scenarios (up to 88% of electricity demand) could become a reality, particularly when combined with ambitious action on the demand side.

The level of renewable energy deployment envisaged in all scenarios will require bold policies to encourage investment in the UK's renewable energy industry. Action needed is discussed in depth in chapter three.

THE SPIRALLING COST OF NUCLEAR

In its report on generation costs, Mott Macdonald highlights that its nuclear projections "must be considered highly uncertain given the limited and troublesome track record of the two reactor models currently being considered for the UK and the lack of recent experience in the UK[32]".

New nuclear builds have experienced significant delays and cost overruns. In Finland, the Olkiluoto EPR project is running three years behind schedule and 55% over budget. And in France another EPR project at Flamanville is expected two years late, with actual costs estimated at £6bn, almost double the £3.3bn originally forecast[33]. Given these continued cost escalations, it is by no means certain that nuclear will be cheaper than renewables, particularly as renewable technologies move towards maturity and come down in cost.

An independent report from Jackson Consulting found that if cost escalation for disposal of nuclear waste continues at historic rates, subsidies for radioactive waste management and disposal could range from approximately £0.45bn (for a reactor with a 40-year lifetime) to £1.5bn (for a reactor with a 60-year lifetime) per new nuclear reactor. This is down to government price caps on generator liability and underestimation of disposal costs[34].

NEW NUCLEAR BUILDS HAVE EXPERIENCED SIGNIFICANT DELAYS AND COST OVERRUNS

CHAPTER 3 HIGH RENEWABLES UK: HOW DO WE GET THERE?

Reducing demand should be on a par with incentivising renewable generation.

In addition to technological improvements, social and lifestyle changes from now until 2050 could cut the cost of delivering a low carbon energy system by up to £70bn, according to a report by the UKERC[38]. Reducing demand could also play a key role in cutting energy costs for consumers and businesses. For example, CCC analysis[39] estimated that the cost of meeting the UK's 2020 renewable energy target could increase domestic energy bills by up to 4% by 2020. However, it also highlighted that energy efficiency could reduce residential energy consumption by up to 14% by 2020 – more than offsetting the costs of meeting the renewable energy target.

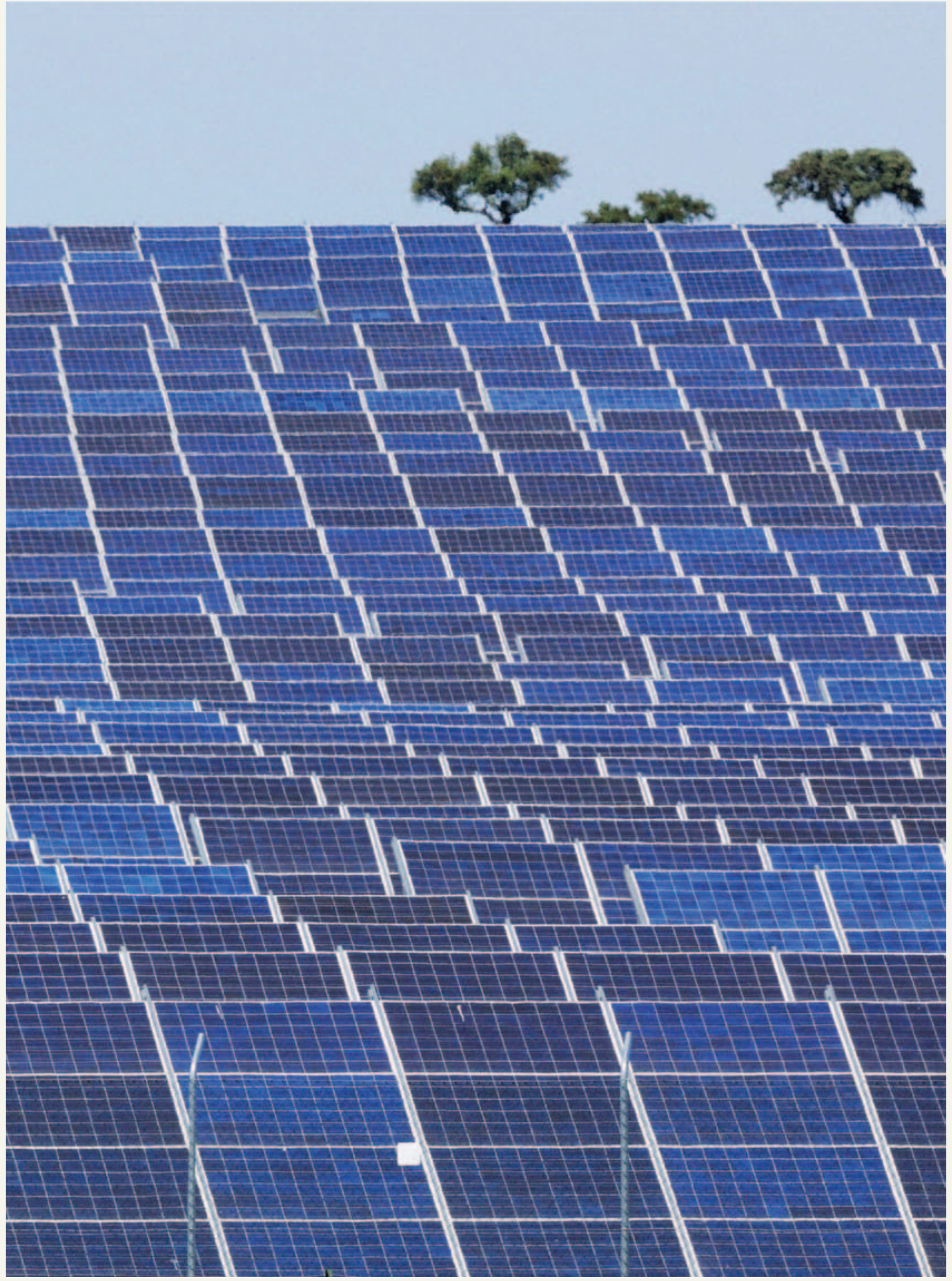
The difference between the costs and volume of generation capacity required in the GL GH central and ambitious demand scenarios shows the huge benefits of reducing demand. Behaviour change can reduce demand for electricity, but it could also be done through incentivising energy efficiency. This could be achieved for example by introducing policies which allow those seeking to help consumers, business and industry to cut their energy use to compete with firms seeking to build new power generation.

Structuring the electricity market to allow demand reduction to compete on an equal footing with the supply side could be a highly effective way of achieving tangible reductions in demand. This could be done, for example, by providing bankable revenue streams for demand reduction, similar to the long-term contracts proposed for low carbon generators. This would incentivise large energy users to make the energy efficiency investments needed to permanently reduce their energy demand.

The demand side is currently underdeveloped and relatively diffuse. There is no established demand side industry because there has been limited market or revenue certainty up until now for products and services in this area. To successfully drive demand reduction, it has been suggested that an agency mandated to seek out and support innovation would be required.

Policy recommendation: The UK must adopt ambitious absolute targets for reducing electricity demand.

Policy recommendation: The government should make the take up of energy efficiency measures happen by, in particular, investing an amount equivalent to the carbon floor price revenues into energy efficiency support measures.



The rising tide of renewable energy generation needs to be matched by measures to drive a reduction in demand for energy. In particular, large energy users need to be given incentives to invest in energy efficiency measures that will permanently reduce their energy demand.

Interconnection – pathway to 2030

Building more interconnection to European grids, as modelled in the B scenarios, could bring significant economic and environmental benefits to the UK. It would allow greater opportunities to import electricity into the UK and export surplus green power to Europe. That means the UK would have to build fewer domestic peaking plants to meet demand at times of lower renewable energy output.

According to a recent European Commission (EC) non-paper on energy markets[40], high levels of interconnection, coupled with harmonised market rules across the EU, would lead to significantly more open, integrated and competitive European electricity markets. This would help make sure that prices remain competitive while the EU transitions towards a low carbon power sector.

The *Roadmap 2050* report from the European Climate Foundation examined scenarios with 80% and 100% electricity from renewables by 2050 and found that "neither nuclear nor coal-with-CCS is necessary to deliver decarbonisation while maintaining the current standard of reliability". In the 80% renewable energy scenario, increased interconnection between European grids could reduce the amount of back up generation needed by up to 35-40%[41]. Given that the cost of building interconnection infrastructure is lower than the cost of building generation capacity it could play a key role in reducing energy prices for European consumers and businesses in an electricity system with high levels of renewables.

It becomes more economic to invest in renewable generation capacity in the UK when there are high levels of interconnection with Europe. In particular, another EC paper concluded that developing offshore wind could be 20% more expensive without EU interconnection and co-ordinated grid arrangements[42]. The European Climate Foundation found that high levels of interconnection would limit the instances where renewable generators are asked to reduce their electricity production (known as 'curtailment') to less than 3%[43].

The UK currently has 3GW of interconnection[44]. It was beyond the scope of this report to analyse what volume of interconnection could be built to which country in an optimal 2030 world. However, there are several interconnection routes open to the UK. The country could benefit from investing in a portfolio of interconnection options. In addition to interconnection with the UK's closest neighbours (such as northern Germany, France, Belgium and the Netherlands), these could include interconnection to Norway (which offers energy storage benefits in the form of hydropower)[45], Iceland (which has significant dispatchable geothermal resources) and Spain (which has large solar resource and may in the future be connected to North African concentrated solar power resources).

With a relatively low capital cost compared to generation infrastructure, interconnection is economic to build – provided its owners can be confident that it will be used sufficiently and there will still be price differences between European markets to ensure an acceptable return on investment. However, it is unlikely that levels of new build interconnection will approach those in our two high interconnection scenarios unless there is a change from the current merchant model, where the interconnector owner takes all the commercial risk. A more regulated model would be needed, where some or all of the commercial risks is taken away from the interconnector owner, who is guaranteed a more predictable rate of return. A more strategic approach to grid planning will also be necessary to keep up progress in developing a North Sea grid and further expansions to form a supergrid.

WITH A RELATIVELY LOW CAPITAL COST, INTERCONNECTION IS ECONOMIC TO BUILD

Policy recommendation: The UK should review regulation governing interconnection to maximise future build rates and reap the benefits of better integration with European grids

Policy recommendation: The government should play a leading role in European supergrid negotiations and in developing regional interconnection initiatives such as the North Seas Countries Offshore Grid Initiative

KEY FINDINGS OF THE ROADMAP 2050 REPORT:

The European Climate Foundation's Roadmap 2050 report looked at scenarios for decarbonising the European electricity system. Its key findings included

- Energy efficiency measures could reduce the cost of decarbonising the European power sector by up to 30%, thus avoiding the construction of 440 mid-sized coal power stations.
- A future European electricity supply system based on 100% renewable energy and enhanced interconnection is technically feasible. Nuclear and coal CCS plants "are not essential to decarbonise the power sector while safeguarding system reliability".
- Increased interconnection between EU member states can substantially reduce the costs of building a European renewable electricity system. In the 80% renewable energy scenario, increased interconnection at EU level reduces the amount of back up power stations needed by up to 35% to 40%.
- Building interconnection infrastructure amounts to a small part of total infrastructure spending in the EU power sector (0.5% to 1.6% of total power sector costs, according to the report's 40% to 80% renewable energy scenarios).

CAN STORAGE PLAY A BIGGER ROLE?

Energy storage is a technology which can provide flexibility, helping system security in a high renewable energy scenario. Currently, all significant UK storage capacity is pumped storage. This generates hydro-electricity during hours of peak consumption by using water that has been pumped into an elevated reservoir during times of surplus generation.

No new storage plant has opened in the UK since the 1970s, although Scottish and Southern Electric (SSE) do have new pumped storage in the pipeline, providing 100GWh of storage capacity and a peak output of 60 MW. SSE are also considering two further pumped storage projects[46].

A recent ENDS Report article on storage[47] highlighted that although there is a clear benefit to building additional storage capacity, it is currently less economic than building flexible generation or interconnection. As a 2009 House of Lords Economic affairs committee report pointed out, "a breakthrough in cost effective electricity storage technology would help solve the problem of intermittency and remove a major stumbling block to wider use of renewable energy in the longer term".[48]

THE ECONOMIC CASE FOR STORAGE WILL BECOME STRONGER AS MORE RENEWABLE ENERGY GOES ON THE GRID

One likely effect of increasing how much renewable energy we use is that electricity wholesale prices will fluctuate, with greater day-to-day price variations. This gives storage capacity a potential opportunity to compete in the market, as there could be significant returns on investment when output from renewables is low. In a 2010 report addressing flexibility for the low carbon power sector, Pöyry[49] highlighted that "dedicated storage collects its revenues from arbitrage between prices at different times". However, a large volume of storage would reduce price differentials.

It appears that the economic case for storage will become stronger as more renewable energy goes on the grid. As storage becomes more economic, we can expect technologies such as heat and flow cells which, according to National Grid[50], are "the ones to keep an eye on", to significantly improve and their cost to substantially fall. Storage has limitations as it needs to recharge but its role in providing flexibility could significantly increase.

Renewable energy: economics and opportunities

Attracting capital investment

Decarbonising the UK power sector and retaining system security will need substantial capital investment. It is worth noting that substantial capital investment in the UK power sector would be required in any event, given that over a quarter of the UK's generation capacity is to retire over the coming decade.

Whether the UK adopts the ambitious targets for renewables set out in GL GH's scenarios or lower levels such as 40% by 2030 recommended in the CCC's review, the level of investment needed is significantly above the balance sheet capacities of the UK's major utilities – in particular those of the 'big six' energy companies.

Attracting the necessary capital investment in clean energy technologies (especially energy efficiency and renewables) within the necessary timescales is a vital challenge to meet. Barriers and market failures preventing investment in low carbon generation include the perception of emerging renewables as high risk, given that many technologies are at early stages of development and lack of confidence around future policy support.

INVESTMENT CERTAINTY IS KEY TO INCREASING THE CAPITAL FLOWING INTO RENEWABLE ENERGY INFRASTRUCTURE

The importance of clear policy support signals

A recent policy brief led by the Grantham Research Institute/LSE[51] argued that the UK economy has a stock of financial reserves available to support investment in the low carbon power sector and that **"the issue is a lack of confidence to invest rather than a lack of liquidity".** The report referred in particular to the £110bn surplus generated by the UK's private sector in 2010. Only £2bn of this was invested in clean energy (both private and public). The Grantham Research Institute/LSE brief also concluded that "credible long-term policy signals could leverage finance and unlock private investment in renewable energy, smart networks and communities, energy efficiency and low carbon vehicles on a great scale[52]". Improving investment certainty in the clean energy sector is key to increasing the amount of capital flowing into renewable energy infrastructure.

Policy recommendation: The reformed electricity market must include well designed, long-term financial support mechanisms for renewable technologies

There are several measures which could help increase investment in new renewable technologies. We look at some of these below.

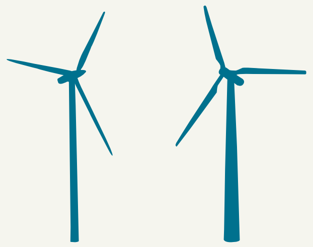
The Green Investment Bank

The coalition government has recognised that intervention is needed to open up the flow of investment needed to decarbonise the UK power sector. As a recent report from SSE pointed out, while the government's Electricity Market Reform proposals aim to provide certainty on revenues for developers once renewable projects are operational, they do not address the initial construction and development risks for these projects[53]. Investors see some renewable projects as risky because they involve new technologies. To tackle this, the government is in the process of setting up a Green Investment Bank (GIB). It will lend money to renewables projects at very preferential interest rates, reducing risks for developers and accelerating private sector investment in the renewables sector.

GIB investment at the construction stage reduces risks for project developers. After the construction and commissioning stages, risk diminishes, and a project funded by the GIB will become attractive to third party investors. The GIB can then sell its shares in a project – and recycle its capital into new renewable energy projects.

However, under current proposals, the GIB will not be able to borrow before the 2015/2016 financial year and so will have limited funds. This will clearly undermine its effectiveness in addressing the financing challenge facing the UK. In WWF's view, this needs to be tackled. We fully agree with the CCC's recommendation that the GIB should be able to borrow money from its inception to make it fully effective from the start.

Policy recommendation: The Green Investment Bank must be able to borrow now



AS TECHNOLOGIES MATURE, WE CAN EXPECT THEIR COST TO FALL

How do we drive down the cost of renewables?

Most renewable technologies are relatively new. That means they have not yet been widely deployed or enjoyed the same amount of research and development and economies of scale as more mature technologies. They are expensive relative to fossil fuel generation and perceived as risky by investors.

As technologies mature, we can expect their cost to fall. This phenomenon was clearly highlighted by the CCC in its recent *Renewable Energy Review*[54]. We are also now seeing it with the increased cost competitiveness of onshore wind, a technology that was initially seen as risky and expensive to invest in. A recent UKERC report stated that "the costs of onshore wind energy fell fourfold in the 1980s and halved again in the 1990s through a combination of innovation and economies of scale[55]".

Improving access to capital (as discussed above) and high levels of investment in research and development will help improve the economics of renewable energy projects. Large-scale deployment and the development of a domestic supply chain to reduce reliance on importing components should also drive down costs. However, the renewables industry is unlikely to commit to the high levels of research and development investment needed to make the technological improvements to bring costs down if there is only a limited market for renewable technologies. Nor will they be prepared to invest in the development of a supply chain in the UK. As one renewable supply chain industry expert told us in respect of offshore wind: "The industry requires a large volume of offshore projects in the pipeline to justify the necessary investments needed to make more efficient technologies...and also to bring costs down."

UK energy policy needs to give far bolder support to the UK's renewable energy industry. Introducing stable financial support mechanisms specifically designed for renewable technologies and a clear volumes target for renewable energy for 2030 could play a key role in providing the certainty needed to attract high levels of investment – generating economies of scale and stimulating competition (as more projects are built). Such policies would also help incentivise research and development investment, which will help drive technological improvements required, including more efficient generation. All these factors will push towards substantial reductions in the cost of renewable technologies (especially offshore wind, wave and tidal technologies). Additional benefits include stimulating employment growth in new sectors of the economy, such as manufacturing.

Policy recommendation: The reformed electricity market must include well, designed long-term financial support mechanisms for renewable technologies

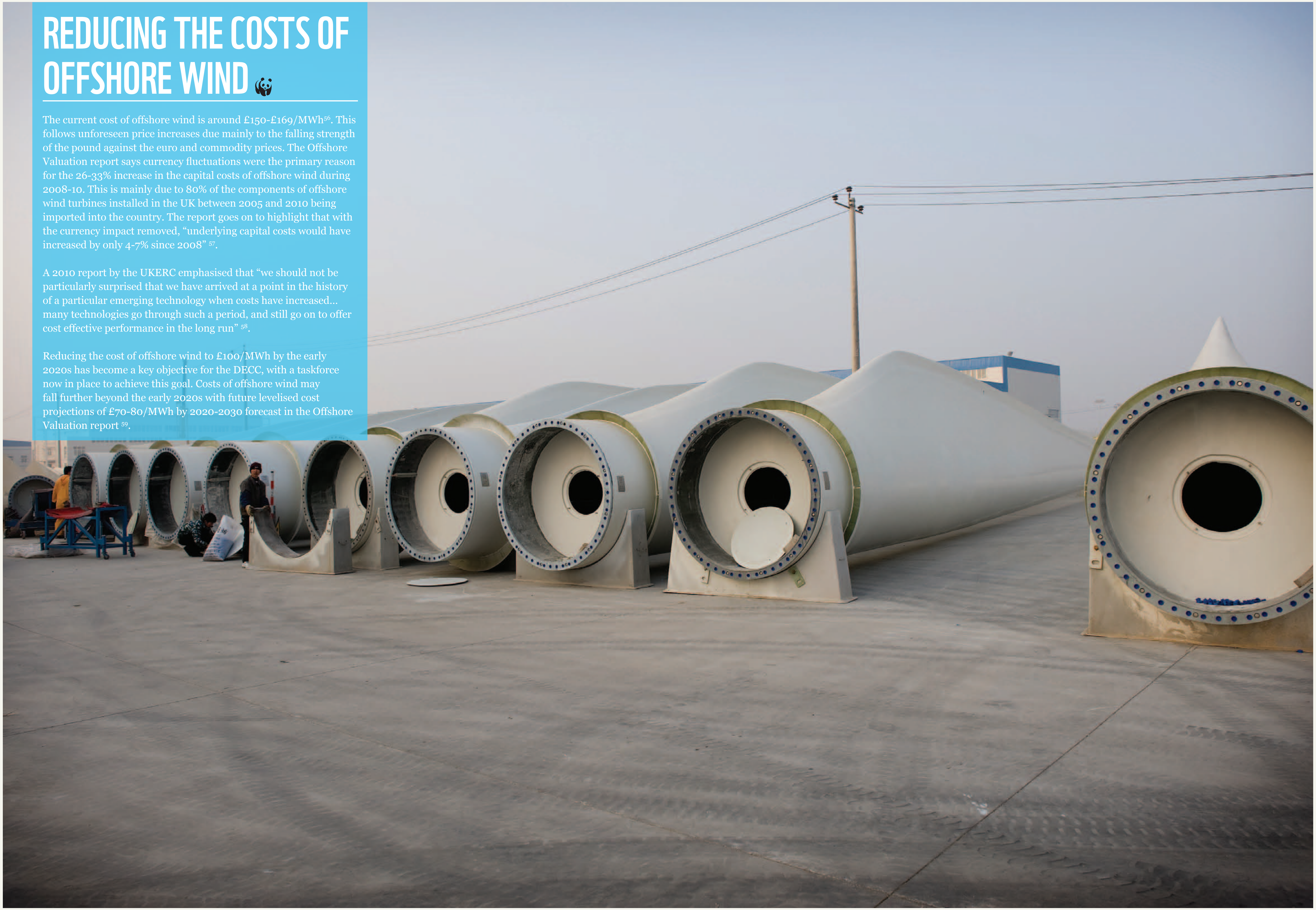
Policy recommendation: The government should set a target for renewables to provide at least 60% of the UK's electricity demand by 2030

REDUCING THE COSTS OF OFFSHORE WIND

The current cost of offshore wind is around £150-£169/MWh[56]. This follows unforeseen price increases due mainly to the falling strength of the pound against the euro and commodity prices. The Offshore Valuation report says currency fluctuations were the primary reason for the 26-33% increase in the capital costs of offshore wind during 2008-10. This is mainly due to 80% of the components of offshore wind turbines installed in the UK between 2005 and 2010 being imported into the country. The report goes on to highlight that with the currency impact removed, "underlying capital costs would have increased by only 4-7% since 2008" [57].

A 2010 report by the UKERC emphasised that "we should not be particularly surprised that we have arrived at a point in the history of a particular emerging technology when costs have increased... many technologies go through such a period, and still go on to offer cost effective performance in the long run" [58].

Reducing the cost of offshore wind to £100/MWh by the early 2020s has become a key objective for the DECC, with a taskforce now in place to achieve this goal. Costs of offshore wind may fall further beyond the early 2020s with future levelised cost projections of £70-80/MWh by 2020-2030 forecast in the Offshore Valuation report [59].



Can we really create 'green jobs'?

There is strong evidence that the renewables industry could create many jobs if the UK takes the opportunity to be an early mover in the sector.

Several reports have said that the UK has the potential to be a market leader in offshore wind, wave and tidal technologies[60]. We have huge natural resource, capable of servicing the domestic market and exporting to the burgeoning European markets and beyond[61]. Significant growth in green jobs is a key potential economic benefit of building a strong UK supply chain. Germany is already benefiting from this, with over 367,000 people currently employed in its renewables industry.

367,000 PEOPLE CURRENTLY EMPLOYED IN GERMANY'S RENEWABLES INDUSTRY

The Carbon Trust's recent *Marine Renewables Green Growth Paper*[62] highlighted that over a quarter of the universities working on marine renewable technologies worldwide are based in the UK. The Paper said that with extensive industrial expertise in operating in difficult offshore environments, the UK is in an ideal position to substantially reduce the costs of marine renewable technologies and become a leader in the sector. As the recent Grantham Research Institute/LSE brief made clear: **"In general, early movers will reduce costs associated with low carbon technologies more quickly, and will become exporters of goods, ideas, knowledge and skills[63]".**

The UK needs to move fast if it wants to make the most of this opportunity. We agree with Chris Huhne that failing to take up this opportunity would be akin to economic suicide for the UK.

Policy recommendation: The reformed electricity market must include well designed, long-term financial support mechanisms for renewable technologies

Policy recommendation: The government should set a target for renewables to provide at least 60% of the UK's electricity demand by 2030

The box opposite sets out some of the most recent findings on the potential for substantial job creation in the UK's renewable energy sector:

A green future for UK jobs

- **Offshore Valuation report (DECC/Crown Estate/industry – July 2010)[65]:** by using 29% of the UK's practicable marine renewables resource, the UK could become a net exporter of electricity by 2050, generate up to 145,000 jobs in the marine renewable sector and £62bn of annual revenues for the UK economy.

- **Working for a Green Britain: Vol 2 (RenewableUK – July 2011)[66]:** by 2021, the wind and marine renewable energy industry could employ from 44,000 (lowest deployment scenario) to over 115,000 full time employees (highest deployment scenario). 21,000 full time employees currently work directly or indirectly in these industries.

- **Marine Renewables Green Growth Briefing (Carbon Trust – May 2011)[67]:** The UK could capture 22% of the global market in wave and tidal stream technologies (worth £76bn), which would provide £15bn to UK GDP between 2010 and 2050. This could result in the creation of 68,000 jobs in the UK: 48,000 in wave and 20,000 in tidal. A lot of these jobs would be tied to exports (70% in the case of tidal and 85% in the case of wave).

The potential benefits of the UK's renewable energy industry are in addition to the potential of the energy efficiency sector to create jobs, should the right policy signals be put in place to stimulate the sector. For example, Chris Huhne announced at the start of the latest Energy Bill[68] that up to 250,000 jobs could be created in the UK's insulation sector by 2030.

Are there risks to existing jobs?

Any risk of jobs in existing industries being driven out of the UK or EU as a direct result of climate policies (known as 'carbon leakage') needs to be addressed carefully. However, we need real facts and data about competitiveness. In a recent Point Carbon article, Guy Turner (director of carbon market research at Bloomberg New Energy Finance) stated that: "If the steel sector (on aggregate) did not sell any of its surplus [of emission allowances] it would not have a need to purchase emissions until 2023". A report by Sandbag on 'Carbon Fat Cats' showed that several large companies in the iron, steel and cement sectors are profiting from the EU Emission Trading Scheme. The top 10 companies, which include Tata Steel, currently have surplus carbon allowances estimated to be worth £4.1bn[69].

The brief from the Grantham Research Institute/LSE argued that the risk of "relocation of carbon-emitting activities abroad is small and manageable" and that "it is confined to a narrow set of tradable industries". The report went on to argue that given the long-term growth benefits of the UK moving early to support the development of low carbon technologies (which would likely put the UK's heavy emitters in a more competitive position in 10 years' time), it would "not seem wise to make the prospects for growth captive to the short-term concerns of a small set of industries"[70].

For those sectors genuinely at risk of carbon leakage, there is a range of policy measures available to protect competitiveness if concerns prove to be valid. Impact on these industries could be managed in a variety of ways such as using sectoral agreements, border adjustment taxes and using allowance auction revenues to fund energy efficiency measures.

What about consumer bills?

84% RISE IN GAS PRICES BETWEEN 2004-2009

Given the relative youth of the technologies involved, there will clearly be a cost to consumers in supporting the commercial deployment of new renewable energy projects. Transparency about this is important. **However, government statistics show that fluctuating wholesale gas prices have caused the overwhelming majority of consumer price rises in the last decade – including rises announced this summer.** For example, the price of gas for electricity generation rose 84% between 2004 and 2009. This meant domestic electricity bills rose 63%[71]. In contrast, policies to support renewable energy currently make up around 3% of electricity bills and around 1% of total energy bills[72].

Continued reliance on fossil fuels leaves the UK far more exposed to steep price rises than mechanisms which support renewable energy and energy efficiency. Both of these improve energy security, diversify the generation mix and reduce demand for energy, meaning the UK isn't as vulnerable to fluctuating prices. The government's *Energy White Paper* shows that Electricity Market Reform proposals are expected to curb increases in energy bills by reducing bill increases that can be expected by 2030 from £200 under business-as-usual assumptions down to £160.

There is considerable uncertainty about the impact of renewables on consumer bills post-2020. It is reasonable to assume that given the falling costs of renewable generation and the rising carbon price during the 2020s, renewables will eventually become more economic than unabated gas. **As the CCC highlighted in its *Renewable Energy Review*, "investment in renewable generation could be, or could become, part of a least-cost solution[73]".** For this to happen, costs, particularly for offshore wind, must fall significantly over the next decade. As explained above, there is substantial potential for this to happen in the UK.

As mentioned above, the costs of renewable technologies which are not currently mature can fall substantially through more research and development, economies of scale and the development of a UK-based supply chain. The impact of financial support mechanisms on consumer bills can be mitigated if the government puts the same focus on improving energy efficiency as it intends to put on supporting low carbon generation. However, these costs reductions will not happen unless there's enough political and financial support for renewables and energy efficiency over the coming years.

CLEAR SAFEGUARDS ARE NEEDED TO PREVENT A DANGEROUS NEW DASH FOR GAS

Financial support mechanisms can and should be designed in a way that provides the right balance between providing investor certainty on the one hand and confidence for consumers that they will not be locked-in to an endless subsidy regime on the other. Support for renewable technologies should gradually decrease as technologies mature. For example, some German feed in tariffs give gradually less financial support to investors over a fixed number of years.

Policy recommendation: Clear safeguards, such as a strong Emissions Performance Standard, are needed to prevent a dangerous new dash for gas

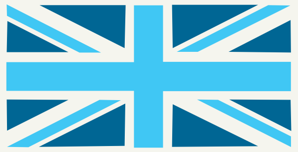
Policy recommendation: The reformed electricity market must include well designed, long-term financial support mechanisms for renewable technologies

CONCLUSION

The GL GH scenarios show that the UK can meet the CCC's recommendation for near decarbonisation of the power sector by 2030 without building any new nuclear generation capacity.

Furthermore, it is possible for renewables to meet over 60% and up to 88% of demand in 2030 without compromising security of supply and without going beyond what is technically feasible, according to government forecasts to 2020 and industry projections.

The importance of reducing energy demand should not be underestimated. As our ambitious demand reduction scenarios show, cutting energy demand reduces the estimated capital costs of generation capacity by around £40bn. Demand reduction will also help to mitigate impacts on consumer bills and reduce the cost and volume of transmission infrastructure needed. Demand reduction can be achieved by better incentivising long-term energy efficiency in different sectors of the economy. Incentivising behavioural change also has an important role to play.



THE UK IS A GOLDMINE OF RENEWABLE RESOURCES AND STRONG RESEARCH CAPABILITIES

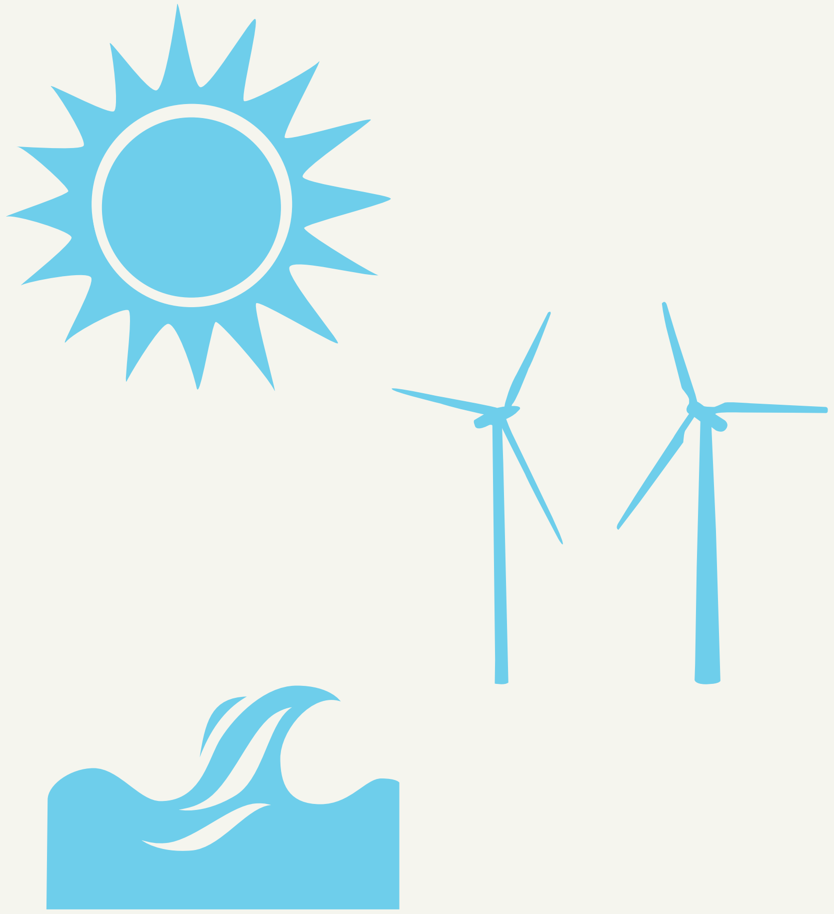
The UK is a goldmine of renewable resources and strong research capabilities. It is ideally placed to become a leader in offshore renewable technologies. Building a strong domestic supply chain and becoming an industrial leader in renewables would help meet the UK's decarbonisation objectives, generate substantial growth in green jobs, reduce the UK's exposure to volatile imported wholesale fossil fuel prices and make the cost of renewable technologies fall faster. Bold action, including setting a target for over 60% renewables by 2030, backed up by long-term, stable financial support mechanisms, is key to attracting investment and reducing costs.

Of the GL GH scenarios presented, WWF has a clear preference for the high interconnection scenarios, which need significantly less gas generation capacity for system security. The amount of unabated gas fired generation currently with planning permission and going through the planning system risks locking the UK into excess gas generation capacity in 2030 and seriously threatens the UK's ability to meet future decarbonisation targets. Curtailing the output of excess plant while ensuring that it is still available as backup would almost certainly require a subsidy. The cost of this would pass on to the consumer.

The scenarios show that by 2030 a large proportion of frequently running plant will need to be equipped with CCS to meet the decarbonisation target recommended by the CCC. The future cost and viability of CCS is uncertain, given that it has not yet been commercially proven and repeated delays have hit the government's CCS demonstration programme. WWF has a particular preference for the stretch scenarios which require no CCS. High levels of interconnection in these scenarios enable renewables to meet up to 88% of demand as long as it is economic to export power to Europe at times of excess.

It is clear that the UK is in an ideal position to transition towards an energy efficient economy overwhelmingly powered by renewable energy. Nuclear is more of a poisoned chalice than a silver bullet after decades of cost overruns, nuclear accidents and no satisfactory long-term storage solution for high level waste. Sustainably decarbonising the UK power sector requires the government to implement – and stand by – long-term policies which provide a strong signal to renewables developers and the energy efficiency sector that the UK is open for business.

THE UK IS IN AN IDEAL POSITION TO TRANSITION TOWARDS AN ENERGY EFFICIENT ECONOMY OVERWHELMINGLY POWERED BY RENEWABLE ENERGY



GLOSSARY

Anticyclone – A weather condition involving large-scale circulation of winds around a central region of high atmospheric pressure. Effects of surface-based anticyclones include clearing skies and low wind speeds.

Arbitrage – The practice of taking advantage of a price difference between two or more markets: striking a combination of matching deals that capitalise on the imbalance, the profit being the difference between the market prices.

Back up plant – Electricity generation capacity kept in reserve to maintain system security and only used infrequently at times of high demand.

Capacity mechanism – A mechanism to ensure security of supply by paying for capacity (generators, for example) to be available.

Combined Cycle Gas Turbine (CCGT) – A form of power generation with higher levels of efficiency than OCGT (see below).

Committee on Climate Change (CCC) – An independent body set up to monitor the UK's progress towards the Climate Change Act targets and advise the government on how to meet these targets.

Curtailment – The practice of reducing the output of a generator to below what it is capable of producing.

Decarbonisation – The practice of reducing the volume of carbon dioxide emitted per kWh of electricity produced.

Demand side management – The practice of encouraging consumers to use less energy during peak hours through methods such as financial incentives. This may be done through ex ante tariffs which are fixed in advance based on expected demand at different times of day (Economy 7 tariffs work in this way) or 'active' pricing based on real time fluctuations in actual supply and demand patterns.

Dispatchable generation – Electricity generation which can be turned on or off at any time in response to demand.

Electricity Market Reform – In December 2010, the government submitted proposals on the reform of the UK electricity market for consultation. The proposals include setting an upper limit on emissions from power generations (an Emissions Performance Standard), scrapping the Renewables Obligation in favour of Feed in Tariffs for low carbon generation, a Carbon Floor Price to top up the carbon price under the EU Emissions Trading Scheme and a Capacity Mechanism to ensure sufficient generation capacity on the system for security of supply.

Feed In Tariff – A long-term contract for electricity generators providing a fixed payment for every kWh produced.

Gigawatt (GW) – A unit of electricity equivalent to 1,000 MW or 1,000,000kW.

Green Investment Bank – The coalition government have committed to setting up a new bank which will act as a catalyst for green investment, addressing certain barriers and market failures which prevent investment in some green technologies.

Indirect Land Use Change (ILUC) – The unintended consequence of releasing more carbon emissions due to land use changes caused by the increased global demand for biofuels. Biofuel production can displace feed and food crops, leading to the clearing of pristine lands for its crops.

Levelised cost – The present value of the total cost of building and operating a generating plant over an assumed financial life, converted to equal annual payments and expressed in real terms to remove the impact of inflation.

Load factor – A measure of power output from a generator as a percentage of its maximum capability.

Open Cycle Gas Turbine (OCGT) – A form of power generation which is less efficient than CCGT (see above) and often used infrequently at times of peak demand.

Supply led – Renewable electricity sources such as wind and solar whose outputs are based on weather conditions.

Terawatt hour (TWh) – The use of 1TW of electricity for one hour. Equivalent to 1,000GWh, 1000,000MWh, 10^9 kWh and 10^12 watt hours. Average annual household electricity consumption is 3,300kWh .

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9 Unconventional fuels include tar sands and shale gas. There are concerns that shale gas carries unacceptably high risks of water contamination and evidence that lifecycle greenhouse gas emissions may be higher than or equal to those of coal. (Howarth, RW, Santoro, R, Ingraffea, A. 2011. Methane and the greenhouse-gas footprint of natural gas from shale formations. *Climatic Change, 2011.*)

10 Some radioactive waste remains dangerous for over 100,000 years. Spent fuel stays toxic for 200,000 years and plutonium can remain toxic for up to 250,000 years.

11 Economics Newspaper, 2011. *Two year delay for Flamanville.* [online] Economics Newspaper. Available from: http://economicsnewspaper.com/economics/two-year-delay-for-flamanville-48228.html

12 Where biomass is used as a renewable source of energy it is important that there are clear sustainability criteria in place. Lifecycle greenhouse gas emissions, including indirect land use change impacts, must be taken into account. Biomass should only be used if resulting emissions offer significant benefit over all fossil fuels, and negative social and environmental impacts are avoided or minimised.

13 Committee on Climate Change. 2010. *The Fourth Carbon Budget.*

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16 Figure was 320TWh for 2009, but 340TWh assumed here to account for bounce back after the recession.

17 WWF-UK. 2011. *Electric avenues: Driving home the case for electric vehicles in the UK.*

18 Committee on Climate Change. 2010.The Fourth Carbon Budget.

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Renewable energy in numbers

100% RECYCLED

£40bn

Ambitious demand reduction measures could cut capital costs of electricity generation by £40bn

60%

Renewables can meet at least 60% of the UK's electricity demand by 2030

88%

The reduction in the carbon intensity of the power sector needed by 2030 to meet UK's carbon targets

70,000

The Carbon Trust believes the UK offshore wind sector can create 70,000 jobs in 10 years

Why we are here
To stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature.

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