



Energy and our Environment

A collection of essays marking the tenth anniversary of the Climate Change Act

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Foreword by Lawrence Slade, Chief Executive, Energy UK



Ten years after its introduction, the Climate Change Act has effected a profound and radical transformation in a way that few pieces of legislation could claim. It has turbo-charged decarbonisation of the power sector in the UK to a degree few would have thought possible

at the time. Last year, total UK carbon emissions fell to the level they were in 1890, half of our electricity generation now comes from low carbon sources and so far this year Britain has generated electricity for the equivalent of more than two months without coal.

Extraordinary changes which show how the Act has shaped today's energy industry – its influence undiminished and continuing into its second decade. As you will read, it was not a straightforward path to the Act but its legacy results from a government showing moral leadership and vision backed up with bold, long-term commitments. The Act is a major reason why the UK can justifiably claim to have led the way on tackling climate change – resulting in other countries seeking to emulate the legislation.

What is also striking from these essays is how the Act's commitments and the consensus behind them have survived – most notably through the acid test of an economic recession where expediency and the immediacy of a crisis could have trumped so-called longer-term concerns. It's not the case in some other countries but whilst there are differences of opinion (some aired in these pages) about how we best reach our emissions targets, there are very few voices in the UK questioning the why. That those contributing to this publication span the political spectrum is ample proof of that.

There is of course an overwhelming moral and environmental imperative to tackle climate change but the last decade has shown the economic case to be equally strong. There has been no trade-off between decarbonisation and economic growth – quite the opposite. Clean energy has been a driver of investment and opportunities - not the onerous and expensive burden which some had feared. As the ever-falling costs for renewables show, tackling climate change needn't cost the earth - whilst inaction certainly will.

An unusual feature of the transformation to a low carbon energy market is that many customers may scarcely have noticed. The source of the power may be cleaner and more sustainable and the falling cost of low carbon generation will mean less impact on bills but the difference to their daily lives has been negligible. However, the relatively seamless nature of this transition is going to change.

You will read here about how our innovative sector has led the drive to decarbonise our economy. We're rightly proud but whilst celebrating the achievements, our contributors also look at the huge challenges we still face.

As the recent Intergovernmental Panel on Climate Change (IPCC) report made clear, we have much, much further to go – and time is running short. Other sectors need to follow our lead whilst we must redouble our efforts. The future will mean electric vehicles slashing emissions, the decarbonisation of heating, comprehensive energy efficiency measures, localised generation, carbon capture and potentially even more ambitious targets than those enshrined in the Act.

This rapid change to the way we generate, move, store and use energy will make the transition far more evident. So we need to keep making the case for tackling climate change – morally, environmentally, economically – and underlining that it's an opportunity as much as a challenge.

I'm therefore particularly pleased and honoured to have such a diverse and eminent collection of contributors: new and established suppliers and generators (some of whom didn't exist when the Act came into force), other participants in this increasingly diverse market, EV manufacturers, politicians, regulators, academics, scientists and environmental groups. While naturally much of the content looks at the fantastic achievements of the industry, we also have a wider perspective on what is at stake here - nothing less than the future of the planet and everyone and everything that exists on it.

It's testament to their common commitment that our writers have taken the time to contribute and I must thank each of them for that. Massive challenges lie ahead but I hope one of the lessons from this publication is that great things can be achieved with commitment and a united purpose.

I hope you all enjoy reading it as much as I have.

Lawrence Slade
Chief Executive, Energy UK

The age of clean growth

Claire Perry MP, Minister of State for Energy and Clean Growth



The UK has led the world in tackling climate change. As a result of this, we are now enjoying a new age of clean growth - in which innovation and investment in a new generation of low carbon sectors are creating prosperity and jobs. There is a real opportunity for the UK to continue to drive

domestic ambition by exporting our clean growth model, providing the world with low carbon goods and services and leaving our environment in a better state than we inherited it.

The UK has been at the forefront of the global shift to clean growth from as early as 1988, when Margaret Thatcher said, “stable prosperity can be achieved throughout the world provided the environment is nurtured and safeguarded”. This belief in the value of the natural world and the huge risks associated with disrupting the earth system brought Parliament together ten years ago to pass the Climate Change Act. This landmark legislation cemented our position as world leaders and has been a template for other countries looking to enact climate frameworks by setting a long-term target for emissions reductions and establishing the innovative carbon budgets process.

But ambitious targets are only part of the story. We have not just legislated - we have taken action. We have demonstrated that clean growth is possible. You do not have to take my word for it. PWC’s independent assessment states that since 2000, the UK has led the world in decoupling emissions from growth.

By acting to cut emissions, the UK has developed a thriving low carbon economy employing around 400,000 people in low carbon businesses and their supply chains. Companies across the economy, from car manufacturing to financial services, are innovating and investing, radically changing their business models to seize the opportunities of clean growth.

The UK power sector has led the way through expertise, ambition and engineering excellence. These qualities underpin the great businesses delivering the electrons which power our economy. Our innovative approach to technology, finance and policy has driven the development of low carbon energy sources such as offshore wind and game-changing reductions in the price of cleaner power. This has enabled us to supply over 50% of our electricity from low carbon sources and to produce electricity without burning any coal for the longest time since the Industrial Revolution.

We have also galvanised action internationally. We’ve helped to secure the landmark Paris Agreement in 2015, launched the Powering Past Coal Alliance in 2017, and committed £5.8 billion of international climate finance between 2016 and 2020, supporting decarbonisation and development in less well-developed countries whilst creating new markets for clean products and services.

While our performance to date has been impressive, the clean growth revolution is only beginning. The need for action has never been clearer - the prolonged heatwaves, severe storms and forest fires across the globe this year are a stark reminder of the serious consequences of climate change.

Delivery of our low carbon future requires concerted action across the economy. As the Committee on Climate Change recently reported, although we have made huge strides in decarbonising the power generation and waste sectors, there is still much to do in continuing the pace of change in those sectors, and replicating it in our transport, homes and businesses.

Even within the power sector, huge challenges remain. The electricity system is going through a transformation driven by technology and consumer demands.

With the cost of storage falling rapidly, data is helping consumers better engage with their bills, and innovative solutions both behind the meter and across the networks are competing to help manage loads and improve efficiencies. Zero marginal cost renewable power is making an ever greater impact in the mix and a small but growing electric vehicle (EV) fleet is starting to make its presence felt.

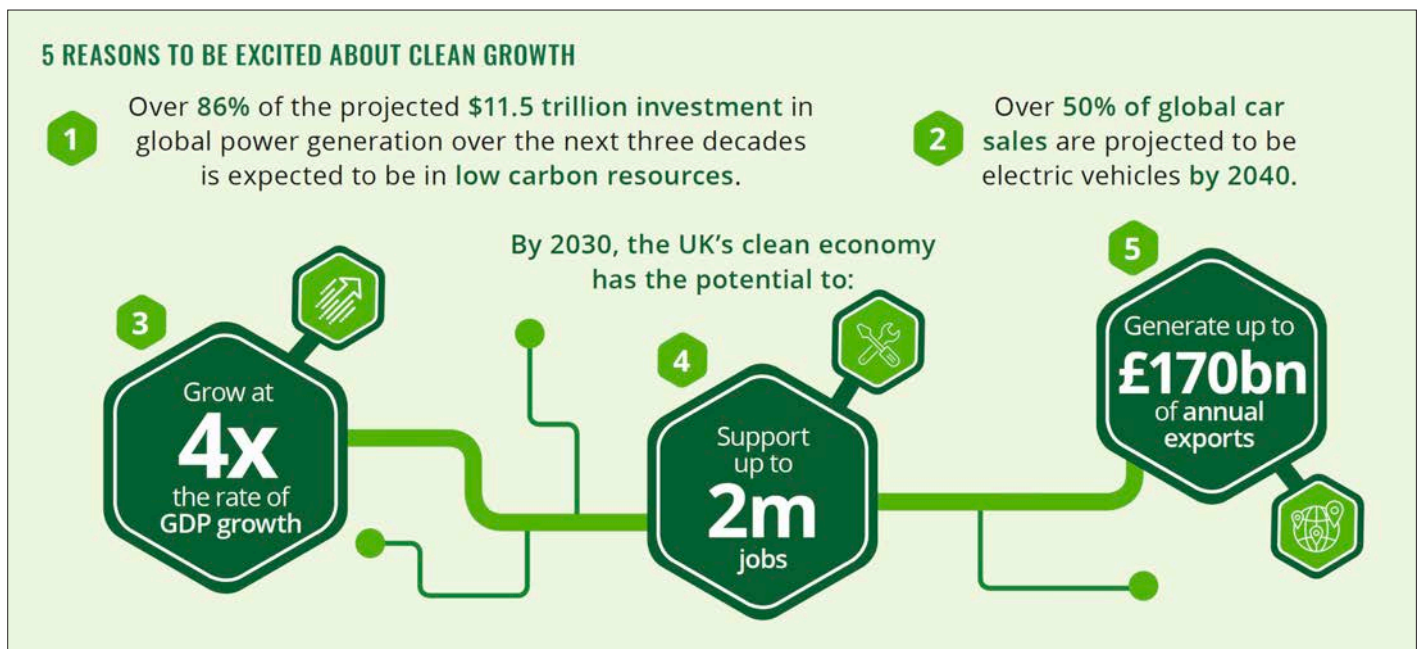
While our performance to date has been impressive, the clean growth revolution is only beginning. The need for action has never been clearer.

We must ensure that the UK economy can take advantage of further technological change and innovation in the power sector, boosting our productivity by lowering costs for users. We will deliver this through cheaper generation costs and more efficiently managed networks, continuing to decarbonise an ever smarter power system as loads grow in the 2020s from the electrification of heat and transport.

Other sectors will follow where the energy system has led. Our world-leading Clean Growth Strategy builds on our successes to provide an ambitious blueprint for the UK's low carbon future. We are investing more than £2.5 billion in low carbon innovation, part of the largest increase in over three decades in public spending on science, research and innovation, helping the UK become a world leader in new technologies like carbon capture, smart grids and hydrogen fuel cells, as well as other innovations that will help us tackle carbon from transport, buildings and industry.

The troubling conclusions from the latest IPCC report will have given further impetus to the global momentum behind clean growth. As other countries start to move to mitigate and adapt, our clean growth model can be an exemplar of the decoupling of pollution and prosperity. Our modern Industrial Strategy has created the right conditions for businesses to seize the opportunity to deliver prosperity and high-quality jobs across the UK, tackling the big challenges of the coming decades - and we should be excited about the opportunities that lie ahead (as shown in the diagram below).

Last month we held the first ever Green GB and NI Week. Businesses, academics, civil society groups and the Government joined forces across the country to tell the story of clean growth, and how acting to tackle climate change is an extraordinary shared opportunity for communities and businesses across the country. The power sector is in the vanguard of this dawning age of clean growth and I hope the experience and successes earned by leaders and innovators in your sector will help guide the wider economy in our continuing, world-leading decarbonisation story.



A lasting Act

David Miliband, Secretary of State for the Environment 2006-2007



A decade on, the confluence of circumstances out of which the Climate Change Act emerged is striking. The scientific consensus was firm. Economists were making the case that the costs of inaction were greater than reducing greenhouse gas emissions.

The security establishment was beginning to identify the global threat from resource scarcity and extreme weather events. Civil society was ramping up the pressure - from the 'Big Ask' campaign for a Climate Change Bill led by Friends of the Earth to major FTSE100 businesses promoting sustainability. All of this was in the context of work towards a global agreement at the Copenhagen Summit. Environmentalists were no longer the main voice championing change and building momentum.

These forces shaped the political environment. Within government, there was a growing recognition that the old way in which climate change policy was put together was failing. The Government's watchdog, the Sustainable Development Commission, had concluded that Government policy was falling dramatically short of the 2050 emissions reduction goal set by Tony Blair in 2003. The Climate Change Programme Review initiated by DEFRA in 2004 had failed to develop policies that got more than halfway near the modest ambition of reducing Greenhouse Gas emissions by 20% on 1990 levels by 2010. With David Cameron's election, climate change became an issue over which the main political parties were fighting for, which gave me, as Secretary of State for the Environment, more leverage than previous incumbents. Good environmental policy had finally become good politics.

I had a strong inkling that we needed to act quickly and boldly. One of the key factors in being able to introduce a Climate Change Bill and policy framework in under six months was an institutional innovation - the creation of the Office of Climate Change as a shared resource across departments. In my first weeks as Environment Secretary I was involved in fractious negotiations to set the emissions cap of the EU Emissions Trading Scheme, where not only could none of the departments agree on a level of ambition, but none could even agree on the fact base and modelling underpinning a decision. The Office of Climate Change, and the network of advisors across Government that supported the inter-departmental process, allowed us to move much faster than civil servants in my department and the Cabinet Office had envisaged.

Looking back on the impact of the Climate Change Act, it's clear what a difference it has made. The legislation triggered a critical shift in the machinery of government. Energy policy and climate change policy came together within the Department for Energy and Climate Change in 2008, a merger which remains in place even while being subsumed now within a larger Business department. Energy policy over the last decade has been decisively shaped by the need to live within the Carbon Budgets defined by the Climate Change Act and achieve a least cost trajectory of emissions reductions towards our long term 2050 goal. The policymaking apparatus, in part through the critical role of the Committee on Climate Change, has been transformed.

When creating the Climate Change Act, we knew the real test of whether it locked in a new consensus was how it would fare during a recession. It could not have faced a more severe test than the financial crash, and ensuing economic austerity under the Coalition Government. Despite growing opposition to environmental targets among Conservative MPs and Ministers, the fourth Carbon Budget recommended by the Committee on Climate Change was eventually accepted. More remarkable still was that the Treasury agreed to major increases in electricity levies - to the tune of nearly £9 billion pounds by 2020 - despite concern over rising energy bills. Not all of this was due to the Climate Change Act, with the EU Renewable Target being equally if not more significant. Nevertheless, the dramatic change in the UK's electricity sector is remarkable, with the share of low carbon power increasing from 20% in 2008 to 45% by the end of 2016.

Climate change became an issue over which the main political parties were fighting for... Good environmental policy had finally become good politics.

The Act has contributed to a complete decoupling of economic growth from greenhouse gas emissions, with the UK economy growing by more than 65% since 1990, while annual greenhouse gas emissions fell by 41% by 2016.

The next stage in the transition to a low carbon economy will be tougher still. There is a gap between our projected emissions in the mid-2020s and the 4th Carbon Budget. The dramatic investments in low carbon electricity will need to be extended into how we heat our homes, and power our transport and industry. The long term goals within the Act will need supplementing to include a target for 'net zero' emissions.

Ten years on, the Climate Change Act stands the test of time as a landmark achievement. It locked in ambitious environmental policy changes despite the worst economic and political headwinds. If progress is to be maintained however, the next decade of big asks will need us to reassemble the broad coalition of leaders from across all parts of society that were the spur to political action.



Keeping the consensus

Lord Deben, Chair of Committee on Climate Change



The Climate Change Act was a benchmark achievement – an endorsement of the Parliamentary process itself. In 2008, it passed through Parliament to make the UK the first nation to set legally-binding targets for reducing carbon emissions. We faced up to the problem of conflicted timing. Climate change can only be countered by long term consistent policies, democracy demands regular renewal of its mandate. The one is about 50 years, the other about five.

By creating a continuing framework, an independent arbiter and long-term targets, we meet the demands of the first. By ensuring that Parliament votes on the budgets and the Government determines the methods used to meet those budgets, we ensure democratic legitimacy. The link is the Committee on Climate Change (CCC) which sets and monitors the budgets and without whose agreement Parliament cannot change the budgets once approved. The key concepts are independence; specific and timed reporting requirements; and a justiciable system supported by a cross-party consensus. As a result, all five budgets so far presented, up to 2032, have been confirmed by Parliament.

This has contributed to the certainty that business and civil society have demanded and enabled the UK to cut our emissions significantly while growing our economy – against all the predictions of the naysayers. And we have done this more effectively than any other G7 nation. UK emissions are down 43% compared to 1990 levels, while the economy has grown by two-thirds over the same period.

Beyond this, the Act has brought benefits to many aspects of our lives – what economists refer to as the ‘co-benefits’ of climate action. Warmer homes for those most in need, reduced air pollution in our cities, reduced reliance on imported fuel and lower energy bills. It has put the UK at the forefront of global climate action and in a position to benefit as future markets make the shift to a low carbon future. Other countries have watched closely. More than 60 have implemented their own climate legislation, some modelled on the UK Act.

Perhaps the most remarkable achievement of our first ten years has been political support across three Westminster administrations where a clear consensus has been achieved – no one now seriously doubts the need for ambitious policy.

The CCC has also played a key role in mapping a path towards the long-term emissions reduction targets set out by the Act. The Act gives us a unique role: independent adviser to Parliament on the appropriate target for carbon reduction; independent assessor of Government’s plans and independent appraiser of climate risks to the UK. Our advice continues to offer the highest standards in objective analysis of policy and data. In energy, we have played an important role in the UK’s decisive shift towards low carbon electricity generation. The energy sector can take great credit for responding in kind. The lion’s share of the UK’s greenhouse gas emissions reductions to date have come from this sector.

We should celebrate those achievements. In 2008 the Committee called for a focus on reducing emissions from the power sector as one of the top priorities in decarbonising the economy. Since then emissions from power have fallen by 55%. Offshore wind costs have plummeted by 50%, in part thanks to fundamental reform of the electricity market that has taken place since the Act – again, in line with the CCC’s recommendations.

We’ve seen the introduction of long-term contracts for the generation of low-carbon electricity and a shift to competitive approaches supporting dramatic reductions in the cost of renewable power. Offshore wind is on track to provide over 10% of UK generation by 2020 and 20% by 2025, with the UK having the largest installed capacity in a growing global market. All of this has benefited the consumer. Not least, it has meant that energy saving appliances have reduced the average bill by £20 a month, while the additional payments to bring in a low carbon system have cost only £9 a month - a net saving every month of £11 for 85% of bill payers.

Perhaps the most remarkable achievement of our first ten years has been political support across three Westminster administrations.

The UK's 'carbon price floor' has put a minimum price on polluting emissions from the power sector and helped to drive the transition away from coal to lower carbon sources of energy. No new coal-fired power stations have been built since the Act was passed, in line with the CCC's recommendation that new coal plants should only be constructed if they include Carbon Capture and Storage (CCS). That has meant that already, in 2018, the UK was powered for a 72-hour period without burning coal.

But we must not be complacent. Where, for example, are the much-needed routes to market for onshore and solar in the current environment? We believe that a government-backed long-term contract continues to offer the best route to low cost investment at best price to the consumer. We will continue to present the evidence to Government and encourage the cost-effective approach to our long-term aims. We need the continued cooperation of the energy sector in this mission as we enter uncharted territory - new forms of energy storage and low carbon routes to secure supplies. It will be vital that we have enlightened commercial actors from all sectors, who are willing to step up to the market opportunities beyond electricity generation, in transport and in the built environment.

The recent Clean Growth Strategy signals the Government's renewed commitment to the targets set out in the Act, but the ambitions contained in the Strategy must be delivered in full and then exceeded if we are to be successful. Every Government department, every sector of the economy, indeed the whole of the UK, must play its part.

The Climate Change Act is an achievement of which the UK can be rightly proud. We must now look beyond the achievements of the first decade and grasp the economic opportunities that the Act presents for the next ten years and beyond to 2050.



The long road to the Climate Change Act

Sir David King, former chief scientist to the UK government



The Climate Change Act was internationally ground breaking. The all-party commitment to reduce the UK Greenhouse Gases (GHGs) emissions by 80% by 2050 was seminal in reaching the 2015 Paris Agreement. But the paths to that Act were tortuous and lengthy.

My objective after accepting position as Chief Scientific Adviser 2000, was to raise the profile of the global threat caused by our continued use of fossil fuels, together with deforestation, on a vast scale. Key to this was the Foresight Programme I initiated on Flood and Coastal Defences for the UK.

In 2003, I was able to show a meeting of Parliament the consequences of global business-as-usual emissions out to 2080. Put simply rising sea levels caused by climate change coupled with storms at sea and inland would lead to severe flooding from rivers in flood and coastline attack. The response required improved flood defences and all countries to rapidly defossilise their economies. But it was a further five years before the Act followed through.

We did however make significant progress. 165 FTE Climate Attaches were assembled in our embassies abroad. Our aid commitment included a shift towards support for climate resilience and green growth. Under David Cameron's Government, the International Climate Fund was established, with a total of nearly £9bn to be spent by 2020/21. When I rejoined Government as Climate Envoy, our effectiveness in negotiations was underlined by three factors: The commitment shown by the 2008 Act, Our Climate Attaches and the British International Climate Fund. As a result, Britain led the way in the run-up to Paris.

Over 190 nations made a mutual commitment in Paris to "hold the increase in global temperatures to well below 2 deg C and to pursue efforts to limit the increase to 1.5 deg C". However we have left it precariously late to manage the problems and it is beyond alarming that our actions and plans still fall far short of matching up to the magnitude of the threat. The gravest consequences will be rising average sea level, together with more severe drought and extreme rainfall in different parts of the world. Where will the 110 million people who live around the Ganges estuary relocate to when Bangladesh and Calcutta become unliveable?

For a 50:50 chance of hitting the 1.5C target, global carbon emissions need to fall by at least 7% a year from 2020, and reach net zero by 2035-2045. However, the most optimistic analysis by the International Energy Agency forecasts that GHG emissions in 2040 will only be slightly lower than today. This puts even the 2 deg C ambition beyond reach and bequeaths future generations an unknowable future of rapid and irreversible environmental change

People may think that if climate change really is an existential threat, responsible governments would already have it at the top of their agenda. But they haven't. Our future depends on a sea-change in attitude which equips voters to insist that policy makers urgently dismantle the fossil-fuelled economic model we inherited.

Renewable primary energy sources demonstrate the impact that actions in a few regions of the world can have on the global energy market. These were initially costly, but today in all areas of the world between the tropics, renewable energy is price competitive with unsubsidised fossil fuels. Even in 2015 more than half of the world's installation of primary energy for electricity production was from renewable energy.

This shows that market forces along with coordinated and transparent international regulation can drive beneficial change. In Britain today, the fastest growing sector in our economy is the Clean Energy sector, employing over half a million people with a turnover of £50bn.

Our future depends on a sea-change in attitude which equips voters to insist that policy makers urgently dismantle the fossil-fuelled economic model we inherited.

Regulations will also be needed to conserve peatlands and forests. Reforestation and protection and restoration of mangroves will become a critical pathway to reaching net zero by 2040.

The New York Forests Declaration now has 35 forested nations signed up to a programme which aims to create new forested areas equal to the size of India by 2030. This would create new carbon sinks equal to the USA's current emissions and has now been approved for further funding from all G7 countries.

A major development while I was in Government was a new global programme, Mission Innovation, to accelerate disruptive, new technologies to entirely de-fossilise the global economy. This coordinates government investment from 22 countries and the EU to accelerate research and development. Now in its third year, it has an annual budget of \$17bn, rising to \$26bn by 2020. Even with all these initiatives, GHG levels in the atmosphere are currently on course to rise from 410ppm today to 450ppm by 2040. It is critical that the international community recognises the attention which scientists are now giving to going beyond reducing GHG emissions and reforestation. Merely decarbonising energy supply won't be sufficient to manage the severe risks we are facing.

The missing piece of the jigsaw is substantial investment for research into technologies that can work at the scale required to bring the levels of GHG down to 350ppm. This should be our new target. It will mean developing every available technology along with energy saving strategies, like raising the carbon content of farmlands around the world through radical composting and no-till methods and doing similar with the most remote and deepest areas of ocean, through iron fertilization or marine permaculture. By 2050, we need to have deployed technology and techniques that can remove billions of tons of these gases from the atmosphere.

Humanity and the ecosystems we all live by are faced with an existential challenge, as never before. In line with what is needed globally, it is time for the British Government to refresh our actions and commitments and once again lead the world on this issue. We should now aim for net zero emissions by 2040.



Above: Preserving and expanding forested areas to act as carbon sinks is essential to tackling climate change

Ambition is critical

Michael Lewis, Chief Executive, E.ON UK



It is right to look back with pride on the significant contribution the energy industry has made to decarbonising the UK economy: carbon emissions from power generation are falling in both absolute and relative terms, the amount of renewable and lower carbon electricity on the grid continues to grow, networks

are getting smarter and more dynamic, and business and domestic customers are more engaged with their energy use.

Carbon emissions have declined to levels last seen at the end of the nineteenth century, falling 42% since 1990, and in that time our economy has grown by more than two-thirds – the best of any G7 nation – which shows you don't need to sacrifice commercial performance for environmental gain.

Part of this success over the last decade came from focusing on technologies with the greatest capacity for scale and cost reductions. We've seen previously unthinkable reductions in the prices of offshore and onshore wind as well as solar, meaning some renewables are beginning to truly compete with fossil fuels without subsidy. Backed by the right framework it was possible to decarbonise the power system at a much lower cost for consumers than was ever imagined when the UK put into law its world leading carbon reduction targets in 2008.

In my view, there is no industry more vital than energy. Every aspect of modern life relies on it: our economy, our wellbeing, our work and our leisure. It affects all aspects of politics and government, from the international geopolitics of energy security, climate change or Brexit to the everyday importance of helping people to properly insulate their homes.

So far so good.

It may not have felt like it, but that was the easy part. It took significant effort, but from a relatively small number of players set on reducing the emissions involved in the production of electricity. We now have the opportunity to fundamentally transform the wider energy system for and with consumers across the UK and Europe. At E.ON we believe our capabilities are better deployed where there is a problem to be solved, that means turning our attention to the way we heat our homes, tackling emissions from transport - now the largest polluting sector - and supporting our businesses to become more competitive on the world stage. This is arguably a more difficult challenge.

It will require the support and contribution of a far wider range of players: politicians, consumer groups, local authorities and communities, technology providers and supply chains, but also – and most importantly – customers, homes and business of all sizes across the country.

The benefits far outweigh the challenges – in terms of cost, wider emissions ambitions and new economic or social opportunities. For effective progress to be made, and for the UK to meet its carbon budgets, we must lay the foundations for this change now.

We need to educate consumers on the need for change, the options available and the real-world benefits. We need to improve the UK's housing stock – already among Europe's oldest and least efficient – to a level fit for the 21st century, to relieve customers of the burden of higher heating bills and also tackle the knock-on effect on their physical health. Customers living in the most energy efficient homes today are already seeing hundreds of pounds of savings on their annual heating bill. A step change will make this the new norm for the many.

That is why energy efficiency should be a national infrastructure priority, so we can tackle the seven million plus customers with solid wall homes currently without adequate insulation. Without such ambition it will be impossible to decarbonise heat at the scale needed over the next few decades.

The way we heat our homes, tackling emissions from transport and supporting our businesses to become more competitive is arguably a more difficult challenge.

Then there is smart metering.

I make no apologies for being an evangelist for smart. Smart gives people the information they need to make better choices. It offers the opportunity for better service and more responsive, more personalised tariffs. It opens the door to connected technologies in our homes.

The alternative is doing nothing, leaving people with outdated equipment, scrambling under stairs to get a meter reading to receive an accurate bill. We all need to get behind this major infrastructure project and make it a success so our customers get a better experience.

Smart metering will play a crucial role in helping to transform energy to a more flexible, decarbonised and decentralised system. We've also seen customers benefit from installing solar panels, smart thermostats and battery storage, but this is only the start. Technology is increasingly allowing our homes and businesses to play a key role in the way the energy system operates and helping keep energy bills as affordable as possible.

But if there is one area which I believe can fundamentally turn the energy system on its head, it is the transition to electric vehicles. Transport is now the largest emitter of carbon dioxide, but again we are in reach of being able to change this. It will require leadership and ambition, for example bringing forward the date for banning the sale of petrol and diesel cars to 2030. The electricity industry is ready to meet this challenge, to provide low carbon energy alongside smarter customer friendly solutions which will allow millions of motorists up and down the country to choose EV.

We need to provide clarity to industry and consumers on the direction of travel and, on the policy and regulatory framework, focussing specifically on how to improve the customer experience, learning from the UK and other countries.

We're transforming ourselves into a company concentrating entirely on customers and networks, delivering the innovative, personalised, smarter solutions rightly expected of a modern innovations business. We're putting all of our knowledge, all of our drive, to make that new energy world happen and make it great for our customers. We are at the beginning of another energy revolution - our biggest yet.



Smart metering will play a crucial role in helping to transform energy to a more flexible, decarbonised and decentralised system

Setting the stage for optimism

Emma Howard Boyd, Chair of the Environment Agency



It's my business to find reasons for optimism in the face of climate change. The Environment Agency designs and builds climate resilience into the English landscape. In my work for the government's Green Finance Taskforce, I'm looking for ways to ensure the country's investments in infrastructure and environment are climate proofed.

This isn't a fruitless task, there are reasons for optimism. Climate change does not necessitate ruin. The Governor of the Bank England says: "It implies a sweeping technological revolution, including investments in long-term infrastructure at roughly quadruple the current rate."

If the government meets its ambition "that all policies, programmes and investment decisions take into account the possible extent of climate change this century", the UK could protect its economic prosperity with expertise, technical innovation, and leadership, at the same time as providing a secure base for global corporations. However, optimism without realism is fantasy. On current emissions trajectories, global temperature rise is expected to exceed the Paris Agreement's target of 2°C by 2100, and a 3 to 4°C rise is likely. The UK Climate Change Risk Assessment in 2017 identified flooding, coastal change, water availability and freshwater ecosystems as the priority risks.

Of course, that only refers to the UK. As far back as 2006, the then head of the armed forces, Sir Jock Stirrup, said: "The spread of desert regions, a scarcity of water, coastal erosion, declining arable land, damage to infrastructure from extreme weather: all this could undermine security."

Such warnings are a stark reminder that people bear the cost of climate change: mothers and fathers, sons and daughters. But, there's no room for despondency. We must find reasons for optimism.

Laurence Tubiana, chief executive of the European Climate Foundation, said: "The UK's Climate Change Act - celebrating its 10th birthday this year - set the benchmark for countries across the planet to follow."

The Act was an internationally ground-breaking piece of legislation and made the UK the first nation to set legally binding targets for reducing carbon emissions. It is flexible to the needs of the economy, but has a clear target: an 80% reduction of greenhouse gas emissions by 2050 compared

to 1990 levels. It is still transforming our power sector. Its carbon budgets reduced greenhouse gas emissions to 43% below 1990 levels by 2017. The share of electricity generated from fossil fuels has decreased from 80% to 50% between 2008 and 2017, and no new coal fired power stations have been built since the Act was passed. It has created cross-party consensus and improved the political debate. This is informed by the reports of the Committee on Climate Change (which the Act created to separate climate action from short term politics), and allowed the UK to play a leadership role in the negotiations for the Paris Agreement. More than 60 countries have now created their own climate legislation with some, like Sweden, basing it closely on the Climate Change Act.

What next?

The lifespans of the investment and infrastructure choices we make today will be affected by climate change. High end climate change scenarios should therefore be considered as part of our decision making. One example of this is the Thames Estuary 2100 Plan. This covers the maintenance and improvement of tidal flood risk management structures until the end of the century. It is adaptable to changes in predictions for sea level rise and is internationally recognised as a leading example in climate adaptation.

There is an obvious commercial opportunity in investing early to protect against future threats, but how to set and measure resilience targets is an embryonic science, and there is a gap between environmental and financial expertise. Resilience isn't just about meteorological conditions, it's also about changing population, increased urban development, and agriculture.

Such warnings are a stark reminder that people bear the cost of climate change... But, there's no room for despondency. We must find reasons for optimism.

Two years before the Climate Change Act, The Stern Review demonstrated the requirement for low carbon transition from an economic standpoint. Today, it would be timely to quantify the costs and impacts of not climate proofing our future. In June, the Chancellor announced a Green Finance Institute in London to provide firms with a one-stop shop for climate science and capital - a step in the right direction.

The Climate Change Act provides a long-term legal framework to do this and more. So, let's take a moment to consider a dynamic piece of legislation that is a model for how to use the law for environmental gain and sustainable economic growth. We welcome the government's intention to give effect to key environmental principles under UK legislation after we leave the EU. With the anniversary of the Climate Change Act arriving in the same year as the 25 Year Environment Plan, perhaps it's worth asking if a similar legislative framework for the natural environment would also advance our green ambitions.



Above: The Thames Estuary 2100 Plan covers the maintenance and improvement of tidal flood risk management structures until the end of the century

Leading the way to low carbon prosperity

Professor Sam Fankhauser, Director of the Grantham Research Institute on Climate Change



At a time when the UK is redefining its position in the world, one area stands out where the UK has consistently led the world: climate change. From Margaret Thatcher becoming the first world leader to warn of the risks of rising greenhouse gas levels in 1989, to a world first in the 2008

Climate Change Act which laid down legal binding emissions reduction targets, the UK has been at the forefront. Cross-party commitment to action on climate change has remained steadfast, backed by a public which wants to see political ambition on the issue.

A global leader in climate policy

This commitment has translated into results. The UK has reduced its emissions faster than any other country and has proven that emissions can be decoupled from economic growth. UK emissions have fallen 43 per cent since 1990; at the same time GDP has increased by 71 per cent. Taking these statistics together, the UK now uses three times less carbon to produce a unit of GDP than it did 28 years ago. It is policy that is driving this change. The UK is a policy leader on climate governance and the first to pass a framework law on climate change 10 years ago with the innovative Climate Change Act. Its key features are studied – and often copied – by other countries contemplating their own climate change legislation, from Sweden to Mexico and New Zealand. Work at the Grantham Research Institute has found that central to its success are a clear long-term target, statutory five-year carbon budgets and the establishment of a powerful independent advisory body in the Committee on Climate Change.

The Climate Change Act has transformed the way in which political debate on climate change is conducted, creating a routine of target setting, parliamentary scrutiny and reporting. Fierce arguments about policy continue – on fracking, on-shore wind, airport expansion – but they are more informed and evidence-based. The delivery of later carbon targets is not yet guaranteed but there is a broad consensus and ambition on the long-term objectives as a result of the Act.

The crucial role of clean energy

Within this framework it is the energy sector, more than any other, which has contributed to the ground-breaking reduction in emissions. The Climate Change Act, which defines targets for reduction, has triggered important follow-on legislation, which supports implementation.

Much of this has been in the energy sector, including a wide-ranging reform of the electricity market. The energy industry has engaged constructively with the new regulatory context and it has delivered. According to the Committee on Climate Change, 75 per cent of emission reductions since 2012 have come from the power sector. Electricity generation is the only sector besides waste where emissions have consistently come down.

In particular the UK has rapidly reduced its use of coal. In April this year the UK was powered by coal-free electricity for three consecutive days, and in July a new milestone was reached when the UK went 1,000 hours without burning coal. True, some of this success was fuelled by the ‘dash for gas’ in the 1990s. Yet more recent reductions are due to a significant growth in wind and other forms of low carbon power. Between 2008 and 2016 the UK saw the share of low carbon electricity generation rise from 20 to 45 per cent.

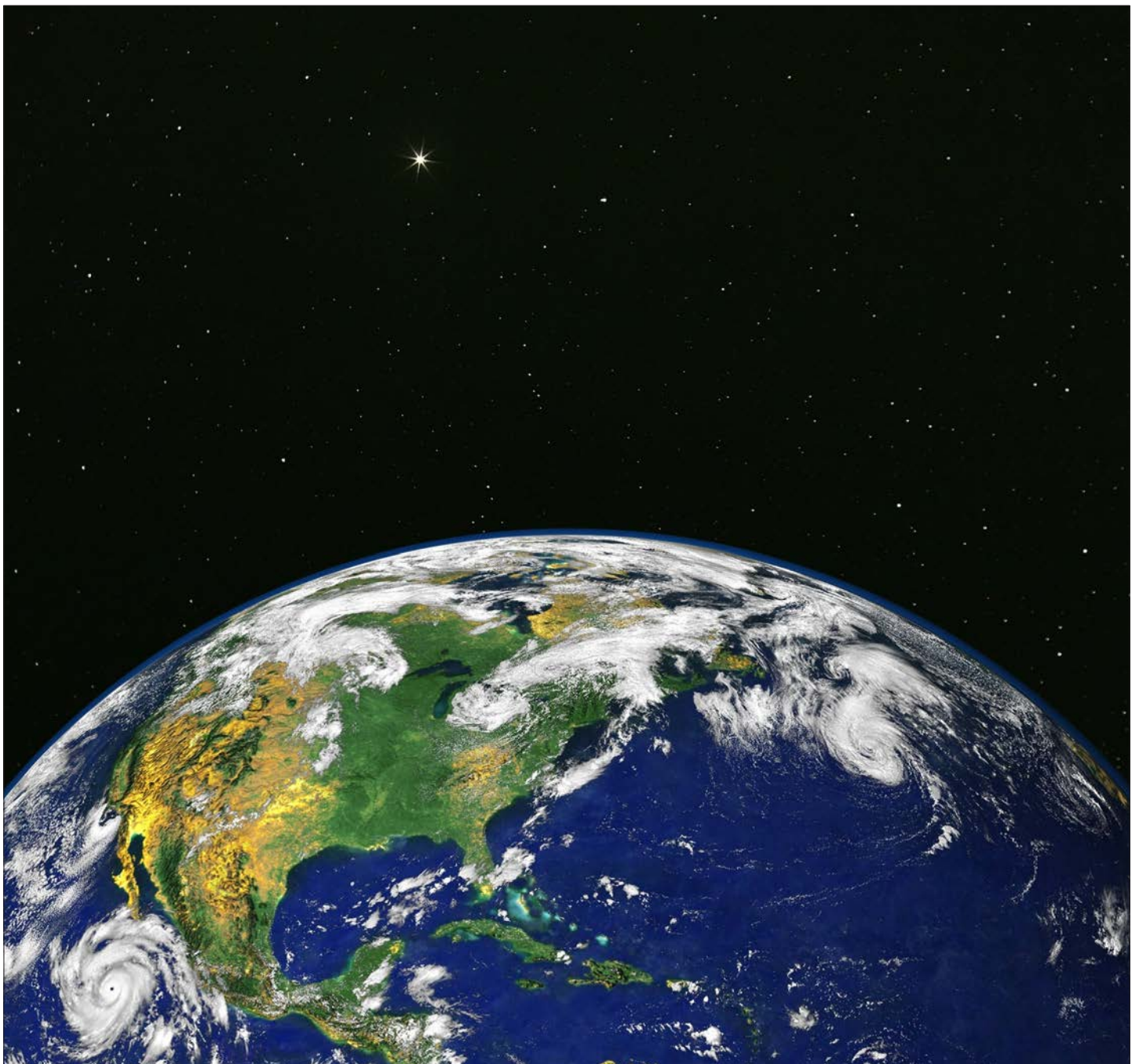
The energy sector had to, and will continue to have to, adapt to accommodate an increasingly high penetration of renewables. However, the challenges are becoming more familiar. Technologies to deal with intermittency of supply are becoming available and the rapid drop in the cost of renewables, including offshore wind, suggests they may soon no longer require subsidies to compete with fossil fuels, particularly if coal and gas face an appropriate carbon price that reflects the cost of carbon pollution.

The Climate Change Act has transformed the way in which political debate on climate change is conducted...Fierce arguments about policy continue...but they are more informed and evidence-based.

Toward low-carbon prosperity

The UK's next step must be to turn environmental leadership into economic leadership and take advantage of clean growth opportunities. According to one estimate, global trade in low-carbon goods and services could grow from around £150 billion in 2015 to £1.0–£1.8 trillion in 2030, and to £2.8–£5.1 trillion in 2050. This corresponds to an annual growth rate of almost 10 per cent every year for 35 years. The green revenues of listed companies worldwide is already on a par with total revenues in the oil and gas sector, according to FTSE Russell.

The UK economy is open and outward-looking, so to be successful in the future global low carbon economy, UK exports must be low carbon too. The Government recognises this in its Clean Growth Strategy, but these commitments must now be implemented. The UK has many strategic advantages, not just on clean technologies like electric motors, but also, crucially, in low carbon services like energy management, consulting and sustainable finance. The path-breaking transformation of the energy sector over the past decade is at the core of this success and forms the basis of our future prosperity.



Honouring the Act requires another united front

Caroline Lucas MP, Former Leader of the Green Party



The Climate Change Act was an historic piece of legislation that led the world. For all major political parties to come together in support of the Act, and to do so in the face of fierce lobbying from fossil fuel firms, was a marker of a kind of politics that's all too often missing here in Britain. Ten

years after the law was passed, it's worth considering how far we've come - and how much further we have to go.

To appreciate the significance of the Climate Change Act, take a look at what's happened to coal power. The same year the Act passed saw thousands of people, myself included, descend on Kent to protest the expansion of a coal fired power station at Kingsnorth. The arguments made against us were fierce - the lights would go out if we don't expand coal, renewables would always be too expensive, too unreliable. Ten years later, and thanks in part to the targets in the Climate Change Act, and we've seen coal generation down to a 135 year low, and making up less than 2% of contributions to the Grid. Not only were we right about not expanding Kingsnorth - but a whole dirty industry has been as good as shut down in a decade and none of the doomsday predictions have come true.

On the flip side of the coal shutdown has been the rise of renewables. The cost of wind and solar have plummeted, and hugely successful projects like the Rampion Windfarm in the English Channel near Brighton, have seen power companies put Britain well and truly on the leaderboard when it comes to newly installed renewable power. The effects of the changes in our power sector have been profound - leading to UK greenhouse gas emissions being about 42% lower than in 1990, around halfway to the 2050 commitment to reduce emissions by at least 80% on 1990 levels. Of course, these figures cover up the fact that UK emissions have to some extent been outsourced to India, China and others, who increasingly produce many of the goods we now consume.

That's the good news, then. The bad news is that the first tranche of emissions reductions would always be easier, and that the current government's plans are likely to make meeting our next set of targets harder. Looking at the power sector, for example, and we can see that support for renewables has been scrapped while fossil fuels incentivised. Not only is the false solution of fracking still being pushed by the Government, but the North Sea gas and oil industry isn't being allowed to die.

Support for solar has been cut - and there's a de facto ban on onshore wind being built. It's no wonder that investment in renewables as a whole has cooled so much recently, and that Britain is no longer considered a leader for renewables investment for the first time in recent years.

Outside of the power sector the challenges in meeting our targets are even starker. The Climate Change Committee has pointed to the fact that emissions from transport and building stock are still rising - a situation which is surely set to worsen with Government plans to expand Heathrow airport and plough billions into roadbuilding while continuing a freeze on the fuel duty escalator. It does feel as though the political momentum which fed into the Climate Change Act has been lost to some extent - whether that's simply because the easiest changes have happened, or the Conservative simply don't see climate change as a priority or because Brexit is sucking energy from almost all other aspects of policymaking in the country.

We know that the next few years will define this country, and not just because we're negotiating our future relationship with the European Union. We will also be defining what kind of economy we want - and whether that economy fits within the limits of our planet and the targets of the Climate Change Act.

To truly honour the legacy of the Climate Change Act we need another moment of political unity, which sees politicians agree that it's not just the low hanging fruit of climate policy that needs picking, but that we must also now pledge a deep clean of the dirty elements of our economy - and redirect resource towards clean, sustainable energy and transport.

The arguments made against us were fierce - the lights would go out if we don't expand coal, renewables would always be too expensive, too unreliable.



Above: E.ON's Rampion Windfarm in English Channel near Brighton

Climate change is lapping at our shores

Gareth Redmond-King, Head of Climate Change, WWF



When we discovered that burning fossil fuels could deliver power, heat and propulsion, we simultaneously unleashed a huge driver of human development, and an existential threat to humans and almost every other species on the planet. We have known for a long time, therefore, that we

cannot tackle climate change without transforming our energy system.

How does that transformation look here in the UK? Well, we've cut emissions by more than 40% since 1990, and we've done that whilst maintaining economic growth. We certainly have transformed our power sector, but progress on decarbonising buildings is tentative, and we're going backwards on transport.

Commitment to the transformation became most tangible with the introduction of the Climate Change Act in 2008 – whose 10th birthday we celebrate this year. And we should celebrate – not just because of what the Act has achieved at home, but because of the example it has set for the rest of the world, with many countries following the UK's lead. But we shouldn't celebrate too hard. Like getting through a particularly difficult exam, we shouldn't paint the town red when we've another exam tomorrow – and another the day after. We're a long way from avoiding the worst impacts of climate change. You might expect WWF to point to polar bears, penguins – even pandas – to prove this. But you don't need to go further than the British coastline to see the devastating effects on our world.

As Adam Nicolson writes in his beautiful book *The Seabird's Cry*, "over the last sixty years, the world population of seabirds has dropped by over two-thirds. One third of all seabird species is now threatened with extinction. Half of them are known or thought to be in decline," with one 2012 study suggesting that seabirds are more in danger than any other class of vertebrate. Overfishing, invasive species and plastic pollution all have their part to play in this crash. But climate change is warming our oceans, so driving seabirds' prey further from nesting sites – threatening birds' ability to feed themselves, never mind rear chicks. It's also changing seasons, weather and sea currents, affecting birds' migration patterns. In short, it's killing these amazing creatures.

Puffins and kittiwakes – beautiful, fascinating and familiar summer visitors to breeding colonies on UK cliffs and islands – are listed by the IUCN's Red List as being vulnerable to extinction. 2018 saw falls in puffin numbers that threaten the future of some UK nesting sites and there are kittiwake colonies around the UK that have seen populations fall by more than 90%.

Globally, one in six species are at risk of extinction if we carry on our current trajectory of emissions. WWF's 2018 Living Planet Report shows that wildlife populations have fallen 60% on average since 1970. A 2018 study showed that the 7.6 billion humans on Earth account for 0.01% of living things – but that our presence on the planet has caused the loss of two fifths of wild mammals, and half of all plants. If you doubt the concept of the Anthropocene, then consider the study's conclusion that 96% of all mammals on Earth are humans and livestock, with wild mammals making up a mere 4%; for birds, 70% are poultry and 30% wild.

We're heading towards Earth's sixth mass extinction. Climate change isn't the only threat – but it is a growing one, and if we solved every other human assault on wildlife, but failed to check climate change, then we might as well not have bothered.

We are bothering – of course we are. 195 parties signed up to the 2015 Paris Agreement to keep warming well below 2°C, pursuing efforts towards 1.5°C. But the commitments made under Paris so far still leave the world on track for around 3°C (a level already surpassed on the Antarctic peninsula, incidentally).

You don't need to go further than the British coastline to see the devastating effects on our world.

Here in the UK, carbon budgets aim for 80% emission reductions by 2050: in line with a 2°C world. But we're not on track for those targets, and we don't yet have plans that will deliver on Paris.

Polling in the UK, and internationally, shows deep concern for climate change impacts on nature and wildlife, as well as strong support for climate action, and for the best-known solutions – renewables. That support is strongest amongst the youngest – those who will face the worst impacts, and highest costs, if we don't act.

So let's celebrate what we've achieved. But nature can't afford for us to celebrate for too long, and therefore nor can we. The challenge ahead is bigger than what we've achieved. If the UK's emissions are not net-zero well within the next three decades, then nature and wildlife face a very uncertain future; and therefore so do we. Celebrate, but continue fighting for our world.



The climate laws are working - so far

Martin Pibworth, Director of Wholesale, SSE



Many happy returns to the UK's Climate Change Act. Ten years ago this country set itself the most ambitious carbon reduction target in the world and enshrined it in law, committing the UK to a low carbon future.

As one of the UK's leading energy providers, SSE was not simply a passive participant in this journey. Back then, we advocated hard, alongside the Climate Coalition, in favour of tough legislation. We did that because SSE was a part of the challenge that faced the UK's energy sector, and we knew we had to be among the first in line to help deliver the UK's transition to a low carbon economy.

In 2008, our electricity generation capacity was split three ways: one third renewable energy sources, one third gas generation and one third coal. We took a stand and committed to halving the carbon intensity of the electricity we generated in 2006 – one of the first energy firms to do so.

Since then, SSE has invested heavily to deliver the vital, cleaner and greener infrastructure the UK energy system needed. Around £11bn has been invested in renewable generation and supporting infrastructure to help meet that ambitious carbon target. We've increased our renewable generation capacity from 2.4GW to 3.7GW by building projects all over the UK, from the Greater Gabbard offshore wind farm off the coast of Suffolk to the Slieve Kirk wind park in Northern Ireland.

These investments – and many others – enabled SSE to reach its own ambitious target two years early. Now, having played our part in helping the UK meet its first two carbon budgets, we are determined to up the ante and go further. That is why, in line with our vision “To be a leading energy provider in a low carbon world”, we have set out a new ambition for a further 50% reduction in carbon intensity from today's levels to around 150g/kWh by 2030.

And we're pushing the boundaries to help us do it. With our Beatrice offshore wind farm - the largest private investment in Scotland - we're installing turbines in some of the deepest waters in Britain. We've more offshore wind farms in the pipeline, such as Dogger Bank and Seagreen windfarms totalling over 4GW, and we've just committed to building the UK's cleanest combined cycle gas turbine (CCGT) power station at Keadby in North Lincolnshire enabling the UK to close coal stations and integrate more renewables into the grid.

At a UK level it has been a mixture of policy tools which have enabled the UK to get to where it is today. The right government support has worked to deploy renewables at scale, bringing down costs and creating thousands of skilled jobs. This must continue, with regular CfD auctions to keep building an industrial strategy for offshore wind, and I would like to see onshore wind allowed to compete too. However, I want to call out the role of one particular policy tool which often doesn't get the same attention – the UK's Carbon Price Floor.

A huge amount of the carbon saved so far has been down to the UK being willing to go above and beyond other countries in putting a higher price on carbon. It's served to make burning coal more expensive than burning gas, which has led to the biggest decrease in emissions, and also incentivised companies like SSE to invest in renewables. The UK Government may have already announced coal phase out by 2025, which SSE supports via its participation in the Powering Past Coal Alliance, but the Carbon Price Floor is on course to deliver it ahead of schedule.

It would be easy to think that carbon pricing's role in the power sector would be done once coal is out of the way. But nothing could be further from the truth. We still need to get to a carbon intensity level close to zero by 2050. We also need to make sure that renewables are investible in a post-subsidy world and that there is a strong price signal throughout the system's daily workings. It will be a lot harder and costlier if we do it without maintaining a strong carbon price.

A huge amount of the carbon saved so far has been down to the UK being willing to go above and beyond other countries in putting a higher price on carbon.

It is understandable there is concern about the impact on the UK's competitiveness if the carbon price is higher here than in the rest of Europe. But maintaining climate leadership isn't about going down to the lowest common denominator – as the UK recognised 10 years ago. The latest World Bank report on carbon pricing schemes found countries are seeing the benefits of going further and the EU has clearly seen the need to strengthen its emissions trading scheme, the benefits of which are reflected in a higher carbon price. All the more reason for the UK to stay in the scheme longer term.

But if other countries do not go far enough, we have to be bold enough to ensure that UK Plc does not lose out. One flaw in the way the current carbon budgeting works is that only emissions produced in the UK count. That is creating a perverse incentive to rely on importing more electricity to meet carbon targets even though no one verifies that these imports are actually zero carbon. Assuming that they are undermines the credibility of our targets and needs to change. Dieter Helm in his Cost of Energy Review proposed a potential carbon price border adjustment tax as a way to maintain competitiveness. Even if that is challenging to implement, it's surely worth exploring.

The UK took bold steps 10 years ago to deliver the Climate Change Act. Bold and decisive action will be needed again if we are to truly create a low carbon world.



Above: SSE's Slieve Kirk Wind Park, the largest in Northern Ireland

From left field to centre stage

Jeremy Sainsbury OBE, Director, Natural Power Consultants



Natural Power are based in Scotland. Our company is made up of over 370 renewable experts based in 4 different countries (UK, US, France, Ireland) with headquarters based in Rural Dumfries and Galloway, where over 90 people work. This is also the home to our Control Centre (CC).

Like the Climate Change Act, the CC is also celebrating its tenth anniversary. Its evolution echoes how much has changed in the renewable sector. During the decade renewable power has stepped up from a set of small embedded projects (which were taken off the network at the first sign of system stress) to large grid connected projects playing a central role in balancing the National Grid (NG).

The transition so far gives us all confidence that the change needed to deliver the future clean economy is deliverable. The next decade will see an acceleration of the transition from the old system of big transmission connected thermal plant to a smarter distributed system which plays a much larger role in energy management across the economy. The CC story starts when wind was not deemed to have any role to play in system management. The first few larger sites had been constructed but NG did not envisage needing to use them to balance the network - however we were ready to take an instruction from NG should that day ever arrive. In 2011 the first call came, and by the end of 2012 we had handled 598 instructions.

In 2017 the level of calls reached 9,710, each one changing the output of a site to help balance the network. Now NG's preference is to call on wind to balance, as it has proven to be much more flexible, responsive and cost effective than thermal plant, and it is not uncommon for CC to be managing 8-10 % of the capacity generating on the GB network.

In 2008 the CC's main role was the management of people on site overseeing various tasks in support of the company's site reps. The following year the CC went to 24/7 operation and took on a more active role in monitoring sites for clients, making sure the sites we managed were top of the list of work orders for maintenance crews every morning by registering faults immediately. This quickly led to certain simple turbine resets being done by the CC, thus saving lost generation overnight. These were early signs of the industry becoming more efficient.

Today CC monitors sites 24/7, analyses data, predicts faults, helps manage timing for work to maximise market prices and power output, provides clients with close to real time feedback on the site's performance and forecasts outputs for despatching capacity to the market. The volume of calls has reached 135,000 per annum with over 5,600 faults reported to the turbine operational teams. This is much closer to the functioning of a thermal control centre in a mature market - CC is the information hub around which all site decisions and operations revolve.

As responsibility grows, so does the team, including our in-house dedicated software support staff who turn an input of over 2,000 signals per site management system, for numerous manufacturers (all using different systems and protocols) into a simple set of safe instructions and alarms for the controller. This enables our team to handle a high volume of calls efficiently and safely. The team has grown eightfold during this time, while capacity has grown from around 400 MW to over 5,000 MW.

As both the team and our experience grew, clients increasingly asked for similar services in other areas where they had developed projects. This has led to CC managing assets in the USA, France and Ireland and expanding the technology covered from onshore wind to include, biomass, PV, offshore wind and hydro whilst complying with different countries' grid rules and security. As renewables have grown they have become a larger target for hackers and cyber terrorism.

Our Control Centre is also celebrating its tenth anniversary and its evolution echoes how much has changed in the renewable sector.

CC is meeting the challenge of new EU rules on cyber security by running off separate servers; while a mirrored facility based 30 miles away, run off a separate part of the network, incorporates several fail-safe systems at both operational locations, making CC as robust as the NG's own facilities.

With renewables moving from the distribution system to the main transmission network, their management has had to mature. One sign of this is the CC's ability to remotely switch up to 400 KV power lines (the largest transmission voltage in the UK). 24/7 there is a 400KV qualified switching engineer on duty within CC supplying support to 7 offshore transmission owners. This service is backed up by emergency response to sites where trips and resets occur to back up the CC's initial reports and alarms.

This all shows how CC has grown from 2 people in the corner of a room with laptops to a facility which can rival any conventional control centre operated by grid or large thermal plant owners. This however is just the beginning. CC will continue to improve forecasting data, offer aggregation of assets to maximise market price and flexibility, predict faults and manage sites for different weather and environmental conditions. All the time managing sites to maximise output, minimise costs, keep everyone safe and supply the market what it needs, when it needs it.

I very much hope and believe that in 10 years' time, we'll be celebrating another decade of rapid progress as part of the wider transition to a clean energy economy.



Above: Natural Power's headquarters in Dumfries and Galloway which houses its Control Centre

Community energy is the key to our renewable future

David Bird, Chief Executive, Co-op Energy



We need to increase the momentum in decarbonising our economy to meet Climate Change Act targets. There's still a lot more to do, but we've made good progress in electricity generation. Coal is close to disappearing from our energy mix (Co-op Energy has not contracted for electricity

from coal since February 2016); the UK's offshore wind programme is ambitious and growing; and domestic energy demand has fallen due to energy efficiency improvements. Transport is lagging behind and we need to transition quickly to electric vehicles (EVs): this will both reduce emissions and clean up our air.

More EVs mean more electricity is needed, even with continued efficiency improvements. National Grid estimate peak demand could be 8GW higher in 2030 if we charge EVs during the evening peak. Even if we charge off peak, or at times of energy abundance – enabled by smart meters – we will probably need another 3.5GW of peak capacity. This needs to be low carbon if we don't want to undo the progress we have made, and low cost, if we want to keep bills down. The National Infrastructure Commission's recent assessment of the UK's future economic infrastructure says half the UK's electricity should be from renewables by 2030 and this won't add to bills.

Opinion polls consistently find people support renewables (76% support onshore wind). Prices for renewables continue to fall and we are on the path to renewables being cheaper than conventional generation. But construction of new onshore wind (and to a lesser extent new solar) has almost come to a complete standstill. Why are we not building more of this low carbon, low cost source of electricity? The main impediment to more renewables, in England at least, is planning permission.

Co-op Energy believes community energy can be the key to unlocking this untapped potential. Community energy enjoys widespread support and the planning regime should take this into account fully. An ICM poll commissioned by us in June, found two-thirds of adults would support local community-owned renewable energy projects such as wind turbines, with only 8% opposing. 72% also thought the government should do more 'to help local communities generate their own energy, with profits staying in the area'.

This clear support is not matched by planning policy and contrasts with the government's approach to fracking. The government is attempting to 'fast track' the planning process for new fracking drill sites, despite low levels of public support (18%). This is a 'democratic deficit', which for Co-op Energy, with democracy hardwired in our DNA, does not seem right.

Community energy works differently, by building support from the ground up. A great example is the Westmill Windfarm Co-operative in Oxfordshire, founded in 2004 and supported by Co-op Energy for a number of years. This small scale windfarm, consisting of 5 modest-sized turbines, was funded by individuals through a share issue scheme. Some of the income from Westmill funds an outreach programme, actively encouraging visits from local school children. After an exciting visit to the inside of a wind turbine, these children often become the best ambassadors for community energy: an enthused grandchild returning home can quickly convert a previously resistant grandparent to the benefits of renewable energy! Community energy turns NiMBYs (Not in My Back Yard) into YiMBYs (Yes! In My Back Yard). Subject to other environmental considerations, where communities want renewables, the planning process should not unduly prevent this.

Community energy can be the key to unlocking this untapped potential. It enjoys widespread support and the planning regime should take this into account fully.

Recent changes to government support for renewables have created uncertainty in how new projects will be funded. The government's Contract for Difference auctions (where generators compete for a guaranteed minimum income for wholesale power) should be open to community energy on preferential terms, reflecting its wider benefits. Tax relief through the Enterprise Investment Scheme (EIS) and Seed Enterprise Investment Scheme (SEIS) would also help.

Of course, the easiest way for an energy supplier to be green is to buy Renewable Energy Guarantee of Origin certificates. 'REGOs' demonstrate a supplier's electricity has come from renewable sources and allow a supplier to say they are 'green'. We do this too and REGOs play an important role in encouraging investment in renewables. But the transformative powers of community energy mean that buying REGOs alone is not enough for Co-op Energy and its members. When you put your investment in communities, you are not just building turbines; you are changing hearts and minds as well.



Above: Westmill Windfarm Co-operative in Oxfordshire

Give heat a chance

Dr Alan Whitehead MP, Shadow Minister for Energy and Climate Change



I had a hand, albeit a minor one, in the passage of the Climate Change Bill onto the statute books in 2008. Sitting on both the Joint Parliamentary Committee scrutinising the draft Bill and recommending improvements, and then on the committee that advanced the Bill through Parliament.

It was an odd experience – there we were, talking at great length, often about very small issues in the bill, but locked into an overwhelming sense that we were trying to pull out of the process at the end a piece of legislation that would define our nation's approach to the imperative of action to mitigate the possible global disaster of runaway climate change. For which we needed clear targets and way markers for progress, up to and beyond 2050, whilst at the same time knowing we could not bind anyone to do anything beyond the life of a single parliament.

The resulting structure, which is essentially advisory in nature and with considerable leeway for differential action on different fronts within the packages of progress represented by the carbon budgets represents, I think, a masterpiece of law making which substantively (and morally) binds governments to keep on doing the right thing on climate change. It also manages to not go beyond the conventions of legislation that normally lasts until the next group of law makers come along and amend or replace it.

The Act was also – something that cannot easily be claimed for all legislation – advised by the science. Indeed the target for UK greenhouse gas reduction by 2050 was altered during the passage of the Bill from the 60% reduction advised by the Royal Commission on Environmental Pollution some ten years before to the 80% now in the Act as science appraised and advised upon. The Act retains mechanisms to revise targets upwards if the science suggests we should, and I hope will be robust enough to incorporate the more stringent targets rising from the more up to date climate science, proceedings and agreements from the Paris Climate Change Summit pushing the global ambition on temperature increase from 2°C by 2050 down to 1.5°C.

Looking back to what we thought would happen after the Bill had become law, I do not think anyone was anticipating quite what a spectacular contribution to the adherence to those targets that the energy sector, or rather part of it, would make.

In a way, the progress that has been made within the energy sector illustrates both the strength and limitations of the architecture of the Act. Governments and industry have badged power supply as falling squarely within a low carbon imperative – and the results have been astonishing. As the Climate Change Committees report to Parliament 2018 shows – emissions from the power sector have fallen by half since the passing of the Act and yet as the report also shows, pretty much every other sector is static: power, as the report states, has single handedly been responsible for 75% of all emission reductions since 2012. Emissions from buildings – mostly through heat have only fallen by a couple of percentage points. In other words, in the energy sector the 20% of energy coming from power production is doing all the heavy lifting, and the 80% of energy we use on heat and hot water in our homes is hardly changing in its CO₂ intensity.

Now that variation is in principle accounted for by the structure of the Climate Change Act – after all, the achievement of each carbon budget is a must, whatever the mix is that goes into the final totals. But when there is such a grotesque disparity in achievement not only between sectors but within it, there comes a point when over achievement from one source cannot in the end fully compensate for under achievement by another. That is the position we are close to placing ourselves in within the energy sector.

Successive Governments have, frankly, hidden heat away in the white papers, plans and documents on energy decarbonisation that have passed in front of us, and the extent to which any action has been taken at all, is down to a relatively few industrial heroes who have persevered with district heating, green gas production and energy efficiency activity against the prevailing sense of governmental inertia on the issue.

The 80% of energy we use on heat and hot water in our homes is hardly changing in its CO₂ intensity.

We really need to place heat decarbonisation onto the same footing that has served power decarbonisation so well for the last ten years – a sense of urgency backed by resources, with a buy in across government and industry that has made the spectacular strides in power decarbonisation such a success story.



The road ahead for the UK – ten years since the Climate Change Act

Chaitanya Kumar, Senior policy adviser, Green Alliance



In 2008, I was a young person making my foray into the climate sector in India. Climate change was still a fringe issue and it was dominated by the question of equity, with India squarely and rightly placing maximum responsibility on the developed countries to reduce their carbon footprint.

This was a time when leadership from the United States was not forthcoming, China was building two new coal plants every week and the global economy was entering a long and painful recession. Amidst this, the UK cross party consensus that passed the Climate Change Act was a watershed moment and a source of much needed optimism.

I remember briefly interacting with the then energy and climate secretary Ed Miliband, as a youth representative, on his visit to India prior to the Copenhagen climate summit. Bolstered by a strong domestic ambition, the impression I got was the UK attempting to position itself as a leader trying to broker a global agreement. After ten years of sustaining that leadership, it is now on shaky grounds and could potentially unravel from the turmoil of Brexit.

The act wasn't without its detractors when it was passed. An 80 per cent reduction in emissions by 2050 was initially deemed unachievable without building a large fleet of nuclear plants (ten sites by 2025), massively scaling up renewables and building 'clean coal' capacity – fast forward to today and we all now know how things transpired. The UK government is now on track to outperforming its third carbon budget and embarking on greater ambition through a preliminary consideration of a 'net zero' target. 2017 was the greenest ever year for electricity with more than half of it being produced from low carbon sources and carbon emissions fell to levels last seen in 1890.

The UK is leading from the front on a global coal phase-out through its Powering Past Coal alliance and beginning to embrace the flood of distributed technology that is set to change the face of the energy sector for ever. All this goes beyond just emission reductions as the UK now enjoys a world leading offshore wind industry, contributing up to £2bn in gross valued added terms and supporting over 10,000 jobs, proving that tackling climate change also creates wealth.

This is all good news that is worthy of celebration but it cannot mask the unpreparedness of the industry and the government for the scale of the challenge ahead.

The Committee on Climate Change, another fruit of the climate change act, warned of the yawning policy gaps in meeting our fourth and fifth carbon budget. The plan to ban conventional vehicles by 2040 is ten years short of what is necessary, energy efficiency has seen public spending cuts of up to 60 per cent since 2012 and is in desperate need of a reboot, onshore wind and solar - two of the cheapest sources of energy have the door shut on them, plans to reduce our dependence on natural gas for heating are moving at a snail's pace and new investments in energy infrastructure have plummeted in the last two years. Uncertainty on the UK's participation in the EU internal energy market, effort sharing for mitigating carbon, disruption to the Irish integrated energy markets and an investment hiatus can apply brakes to the UK's climate goals, especially at a time when we need to accelerate.

But with an enthusiastic climate minister at the helm, a vibrant civil society to hold government to account and a progressive industry that can innovate and rise to the occasion, there is yet scope for optimism. What is necessary, however, is bold regulation that can capture the industrial benefits of rapid clean growth. Going fast on electric vehicles isn't just good for climate change and air quality but opens up the opportunity for the UK to reorient its manufacturing sector and become a hub for batteries and clean vehicles.

The world today is significantly different to 2008. The UK's claim to climate leadership will require it to decarbonise faster and sooner.

We need to mandate our financial services sector to factor in climate risks and double down on financing clean growth. Where private finance is failing to deliver warm, affordable low carbon homes, public resources should tackle energy efficiency head on. Limiting global warming to well below 2 degrees requires radical changes that involves regulation to force oil and gas majors, large utilities and other incumbents to clean up their act, change their business models and invest heavily in cleaner alternatives.

The world today is significantly different to 2008. The UK's claim to climate leadership will require it to decarbonise faster and sooner while supporting a global transition. I moved to the UK 3 years ago and I am amazed at my host country's continued celebration of its response to the Second World War and in fighting fascism. Our climate crisis is arguably equally severe and at the risk of making a dire analogy, I dare say we need similar leadership from Britain today. Whether we overcome the current Brexit chaos and come out the other side with renewed vigour remains to be seen.



Electric vehicles are not only good for climate and air quality but open up the opportunity for the UK to reorient its manufacturing sector

No carbon. No excuses.

Greg Jackson, Chief Executive, Octopus Energy



The Climate Change Act was the UK's moment of truth when we as a nation accepted climate change was definitely real – it wasn't a debate but a fact. Our nation's political consensus was enshrined in legislation and set a trajectory for the UK to reduce its impact on CO2 levels.

The Act presaged financial incentives to drive renewables which had a profound and permanent impact. They brought new companies and vast streams of new investment into the energy sector. The Octopus Group capitalised on the new economic incentives to source funds from tens of thousands of individual investors. Octopus was able to deploy over £2bn of such 'crowdsourced' investment in renewable generation. Such was the scale of change that over a 30 day period this summer, Octopus's solar farms generated 155GWh of clean electricity. This sort of achievement wouldn't be possible without the Climate Change Act.

This precedent is key: society must use the 10th anniversary to double down on our ambition. As we see signs that climate change is coming fast and hard, with exponential growth in extreme events, and the very real threat of multi-meter rises in sea levels over the course of a few decades, we need to be targeting zero carbon in any sector that can do it.

And domestic power is one such sector. We should be targeting zero emissions within a decade.

It sounds impossible - central planners and legacy generation businesses will laugh it off. But the scale of investment and delivery enabled by the Act itself demonstrates that non-linear progress is possible and affordable. If energy suppliers were mandated to deliver zero emission electricity within a decade, and simultaneously freed from the shackles of our current energy infrastructure, this is eminently feasible.

Currently, energy retailers experience about 93% of their supply chain as a 'given'. Everything from transmission and distribution to metering and generation is orchestrated and often priced by the government. This central-planning mindset creates paucity of ambition, enshrines incumbency and profiteering, and relinquishes suppliers from the responsibility to source their power from renewables.

If the supermarket industry were structured the way energy is today, Tesco would be in control of stacking their shelves and operating the tills, but little else. Warehousing, haulage - even the choice of tomatoes - would all be down to contracts centrally negotiated by the government. Instead of the daily price wars among supermarkets that push down food prices, we would see rip-off prices, creaking technology, indifferent customer service and bad quality, dirty products. Sound familiar?

A sector in which companies genuinely live or die based on whether they can negotiate the best prices with their supply chains or offer the best service for their customers, while sourcing products that comply with strict environmental standards, is one that innovates fast and aggressively drives value.

Modern energy retailers are demonstrating the same ability to reform the sector as Amazon has in e-commerce and Uber in transport. Companies like Octopus Energy have driven down the costs we're in control of by as much as 70% compared to incumbent suppliers, while supplying 100% renewable electricity. We want to be let loose on the other 93% of our supply chain, pushing our providers like DNOs and generators to do more to optimise the grid for a smart, clean energy future.

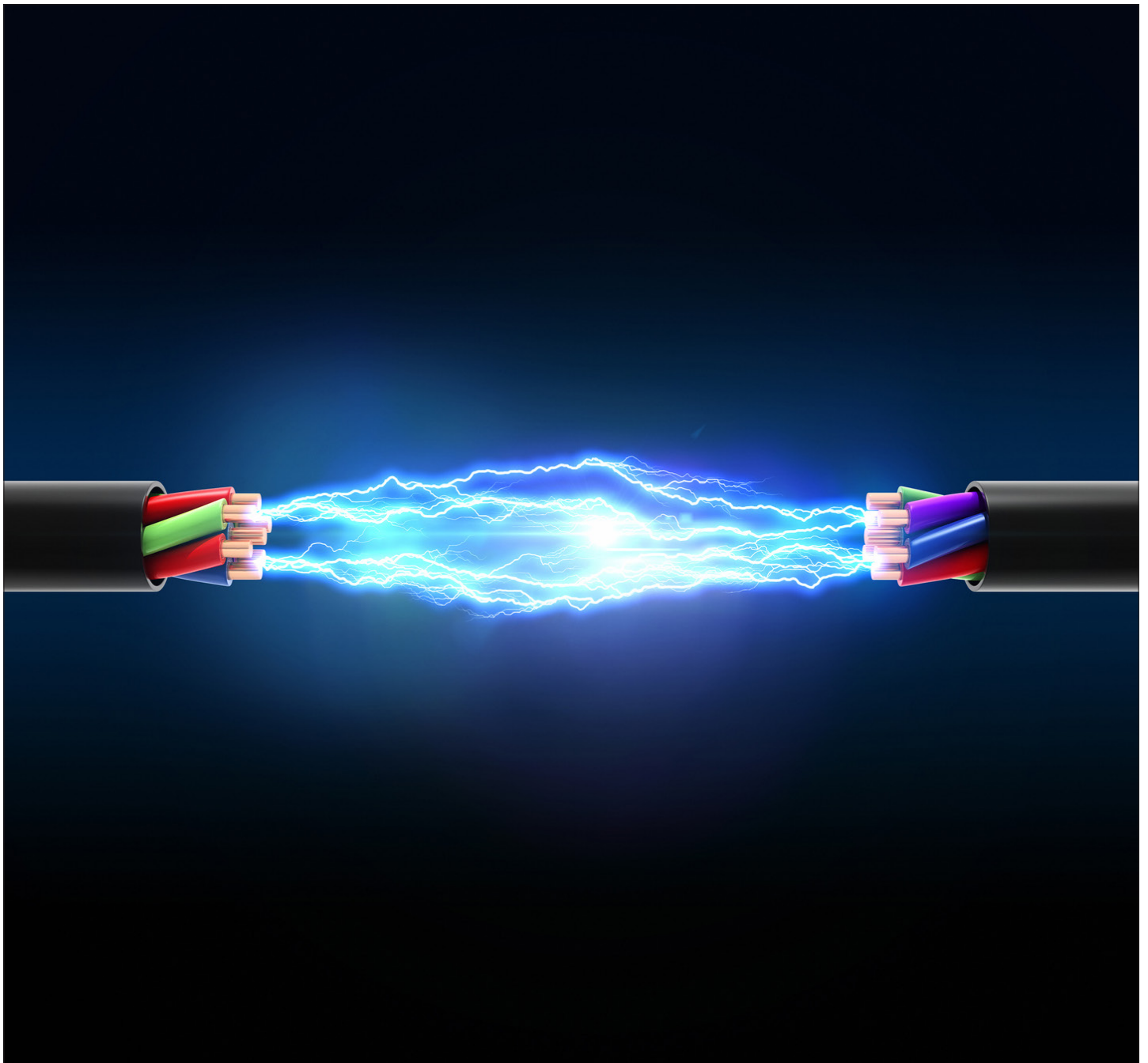
Some claim that energy is in some way 'special' – that it needs to be centrally managed to stop the lights going out. But if we can trust Tesco to put food on the shelf, we need to trust energy retailers to deliver energy – and empower them to source environmentally responsible products.

Modern energy retailers are demonstrating the same ability to reform the sector as Amazon has in e-commerce and Uber in transport.

This absolutely does not mean the end of regulation. Just as we have rules to protect the environment and consumers in the production of food, so we need similar rules in energy. In fact, some of these rules need to be much, much more ambitious than they are today. Tease and squeeze pricing must be abolished, and suppliers need to be held accountable for cleaning up our power.

But by opening up the framework to allow companies to compete and multiple technologies to offer solutions, we will achieve these aims much more quickly and affordably than we are currently. To attract capital, talent and enterprise into the decarbonisation of energy, we need to end the command and control, centrally planned approach to the energy market, while mandating the transition to clean electricity.

Make dirty electricity illegal in the next decade – and empower energy retailers to lead the way.



Long tails and net-zero emissions

David Hone, Chief Climate Change Adviser, Shell International Ltd



One of the features of life in many smaller towns and remote locations within the United Kingdom is the regular delivery of coal to homes and small businesses. It is used for home heating, in small furnaces and for various applications requiring high temperatures or a source of carbon.

On a larger scale, there is still demand in the UK for metallurgical coal in the blast furnaces of the iron and steel industry. While much is made of the periods, now extending into days, when coal is not used to generate electricity for the national grid, there exists modest, but important underlying demand that could extend for decades into the future as a long tail. Further, industrial emission sources tend to be quite dispersed across the UK, rather than concentrated in coastal hubs as is the case in a location such as Rotterdam in the Netherlands.

As the government reviews the year in which the UK should achieve an end to anthropogenic greenhouse gas emissions and considers, in the light of the Paris Agreement, to bring it forward, there remains the prospect of an extended period of demand for fossil fuels. This will occur in sectors where energy dense hydrocarbons have no immediately available replacement options, because the technology step required for change hasn't been taken or hardly exists. Factors such as feasibility, cost and convenience all play a role.

In short, there is a significant timing gap between the need to stop adding carbon dioxide to the atmosphere and our collective ability to stop using fossil fuels. The long tail of oil, gas and even coal use could perpetuate for up to a century. For this reason, the term 'net-zero emissions' has emerged, emanating from the Paris Agreement, which calls for a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases. Over the long term, the most suitable sink for fossil carbon dioxide is geological storage, in that this removes any warming risk associated with what might be temporary storage in the biosphere using a sink such as enhanced uptake of carbon in soils.

Capture and geological storage of CO₂ (known as CCS) could start to become a commercial proposition with a government implemented CO₂ pricing mechanism surpassing £30-£40 per tonne. Although the required carbon price for a specific project might be substantially higher, especially if that project requires new infrastructure such as pipelines, some low-cost opportunities will likely exist within the economy.

The Sky scenario, published by Shell in March 2018, depicts a world which meets the goals of the Paris Agreement. Net-zero emissions in the energy system is achieved globally in 2070, for an 85% chance of limiting the rise in surface temperature to 2°C or a mid-range temperature rise in 2100 of 1.75°C. The world in 2070 still makes considerable use of fossil fuels, albeit declining, with various forms of carbon removal by then constituting a major global industry. In Sky, the UK follows a similar pattern, with continuing fossil fuel use in the 2050s and beyond requiring some 50-60 million tonnes per year of CO₂ either captured and stored, used or removed from the atmosphere as a direct offset. This compares with current UK energy system emissions of around 400 million tonnes per year.

Although CCS comprises a recognised and well understood set of technologies, there remains a chasm between the technology as it stands today and a mature global industry that can deal with billions of tonnes of CO₂ over the course of the century. That industry needs to start building capacity now, such that it has sufficient scale to deliver the required carbon removal service by the 2030s and 2040s. Building capacity sooner rather than later, also provides an important option for a subsequent government to consider an even earlier date for net-zero emissions, should changes in the climate dictate the necessity for such a move.

Carbon capture and storage will be part of the UK journey to net-zero emissions, yet its development today is far from that required for success.

The UK is uniquely positioned to develop CCS, given its significant storage potential and subsurface expertise, to the extent that storage of CO₂ could develop into an export service. Using biomass to produce energy, including electricity, hydrogen and liquid fuels, in combination with capture and geological storage of CO₂, provides a valuable removal option. Trade in carbon sink units, utilising the cooperative mechanisms under Article 6 of the Paris Agreement, could then become important to the UK economy, but only if the mechanisms are developed such that this can happen.

Carbon capture and storage, in some form, will be part of the UK journey to net-zero emissions, yet its development today is far from that required for success under the Paris Agreement. The industry needs encouragement commensurate with the importance of its future role in the energy system, as has been seen for wind and solar over the past decade and more recently for electric vehicles. On this 10th anniversary of the Climate Change Act, it is time to respond to that need.



Above: The steel and iron industries could extend the demand for fossil fuels

Scotland makes the most of a natural advantage

Paul Wheelhouse MSP, Minister for Energy, Connectivity and the Islands



Over the last decade Scotland has acted decisively to demonstrate global leadership in tackling climate change and supporting climate justice. In 2009 the Scottish Parliament unanimously passed the Climate Change (Scotland) Act – establishing a comprehensive framework of statutory annual emissions reduction targets self-imposed, limits on the use of international credits and regular reporting.

Over the intervening years, the Scottish Government has made further, wide ranging public commitments and established publicly-funded delivery programmes, all with the aim of setting out and driving delivery of our commitment to tackling climate change and making the most of economic opportunities that will arise on the route to a low carbon economy.

Scotland has nearly halved its greenhouse gas emissions since 1990. We generated 69% of Scotland's electricity needs from renewable sources in 2017 (we have 56.5% of UK onshore wind and 90.4% of hydro), have a rapidly expanding network of publicly-funded electric vehicle charging points and have increased the size of Scotland's woodlands by 140,000 hectares (56% of the UK total increase in woodland) since 1998 (helping us increase Scotland's carbon sink' by 62% since 1990).

Scotland's abundance of natural resources make it an ideal place for renewable energy generation so it is no surprise that Scotland's energy sector is where we have seen the greatest reduction in emissions. We are well-known for our engineering and innovation skills and fully intend to continue building on these strengths.

In energy innovation, in particular, we are proud to have many world-firsts: the world's first floating wind farm, Hywind, is in Scottish waters; and we have attracted (and invested in) projects like Meygen – the largest tidal stream project in the world – to the European Marine Energy Centre on Orkney.

In February 2018, the Scottish Government published our third Climate Change Plan setting out how we will deliver the emissions reduction targets given in the Act, sector by sector. This Plan shows what Scotland will do to meet our target to reduce emissions by 66% by 2032, and sets out our domestic plans to ensure we continue to be leaders and collaborators in the global effort to deliver a transformational low carbon society.

Alongside the Plan, Scotland's new Energy Strategy, 'The Future of Energy in Scotland', published in December 2017, set out the Scottish Government's long-term vision for the future energy system in Scotland, including a new commitment to deliver 50% of our energy needs across electricity, heat and transport, from renewables by 2030.

Together, Scotland's Energy Strategy and the Climate Change Plan provide the strategic basis for Scotland's low carbon transformation over the coming years, with the intention of providing certainty and credibility to the businesses, industries and investors that are vital partners in our transition to a low carbon economy. I encourage anyone interested in how to plan for, and maximise the benefits of, transformational change to read them both.

In addition to the Plan and Strategy, and in direct response to the Paris Agreement, the Scottish Government introduced a new Climate Change Bill in May, ahead of the tenth anniversary of the Climate Change (Scotland) Act. The UK Committee on Climate Change advises that the ambition set out in the Bill is consistent with limiting global warming to 1.5°C and Laurent Fabius, former French Foreign Minister and architect of the Paris Agreement, has described the Bill as a "a concrete application of the Paris Agreement".

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The Bill raises our ambition, and on the basis of expert advice from the UK Committee on Climate Change, it sets a greenhouse gas emissions reduction target of 90% (from the 1990 baseline) by 2050.

Achieving this will mean achieving 100% reduction in carbon dioxide emissions by the same date, so Scotland will be 'carbon neutral' by 2050. The Bill also sets the world's most ambitious targets for 2020, 2030 and 2040 and requires regular reviews of the earliest feasible date for a net-zero target for all greenhouse gas emissions as UK CCC advice evolves.

The Bill increases our long-term ambition while maintaining our unique framework of annual targets. Climate change is the defining challenge of our time and, to address it, action will have to increase across every sector of the Scottish economy – we cannot wait until 2050 to act. By maintaining our evidence-based approach, based on expert advice from the UK CCC, we know that we can tackle climate change while simultaneously meeting our social and economic obligations.

The targets we are proposing are credible and achievable, but at the same time they are very stretching reflecting our ambitions. We know that Scotland will rise to the challenge, but to do this we need to start a wide and inclusive conversation around what all players in the economy – individuals, businesses, NGOs, the finance sector households and individuals – are going to do about it. As the Scottish Government, we will provide the support and enact the policies that are needed to remove barriers to action, but a challenge on this scale cannot just be left to Government - everyone needs to do their bit for Scotland to meet its goals and to fulfil the moral obligation to address climate change.



Above: SSE's Pitlochry hydro-electric power station

Nuclear power as a bedrock of a diverse, low carbon energy mix for UK customers

Paul Spence, Director of Strategy and Corporate Affairs, EDF Energy



The extreme weather this year has powerfully demonstrated why we must do more to tackle climate change and highlighted the benefits of a diverse energy mix that includes nuclear power. When the “Beast from the East” chilled most of Europe in February, the UK could call on wind, coal and nuclear to keep our homes, shops and factories lit and warm.

This June, with soaring temperatures and still days and nights, it was solar, gas and nuclear that allowed Britain to meet its energy demands. As older power stations close, keeping a diverse mix of low carbon energy sources is the best guarantee that our country can meet any challenge that the changing climate sends our way.

When the Climate Change Act gained Royal Assent in 2008, the UK had about 5% fewer households. Each consumed about 28% more gas and 20% more electricity, with an average CO₂ electricity intensity of 543g/kWh. The energy supply market was heavily dominated by just six large companies. Renewables played a limited role and new nuclear was a far-off dream.

A decade later, new investors have joined traditional utilities and intense competition and new players have dramatically reshaped the energy retail market. Distributed energy solutions are increasing, electric cars are more desirable, and digital solutions including smart meters, smart phones and connected devices are unleashing innovation. Wind and solar generation have expanded to contribute 18% of the UK's energy mix. The construction of Hinkley Point C is well underway and it is on track to be the first operating new nuclear power station in a generation. EDF Energy's nuclear fleet is producing 50% more than it did in 2008, and coal is producing 76% less. The carbon intensity of UK electricity has halved.

We have made real progress in the fight against climate change in this past decade, but there is much more to be done. Our economy must rely much less on carbon and embrace electric-oriented energy solutions. We will need to redouble our efforts on innovation and energy efficiency. Without carbon capture, gas generation must be limited to play an even smaller role. Wind and solar must deliver more, hopefully soon complemented by smart charging of batteries in our homes and our cars, to help smooth day-night demand and supply fluctuations.

To be confident that customers' needs for low carbon electricity will be reliably met at a fair price, even during future European heatwaves or winter freezes, there must also be a backbone of home-grown, reliable, low carbon electricity.

This is what nuclear power delivers.

Experience in Germany suggests that dogmatically ruling out nuclear results in higher costs for customers to sustain the investment, higher emissions as more coal is burnt and very real challenges in operating the grid.

By contrast, we can draw on the UK's nuclear heritage to meet our future energy needs. This is what EDF Energy has been doing with the construction of Hinkley Point C, in Somerset. Nearly two-thirds of the construction spending is with UK suppliers, 25,000 roles will be created and over 1,000 apprentices will be trained during the power station's construction, demonstrating the many benefits it will bring to the local area, and to the UK overall.

Having invested in rebuilding industrial capability to deliver this first project, there is a compelling case to follow on and repeat at Sizewell C.

Sizewell C is an ideal site as it is well-located on the transmission network and able to draw on a strong energy heritage and capability in the East of England. And critically, reusing the same design, skilled workforce and suppliers from Hinkley Point C will help to reduce costs and risks significantly during Sizewell C's development and construction.

There must also be a backbone of home-grown, reliable, low carbon electricity. This is what nuclear power delivers.

Capitalising on experiences with Hinkley Point C also opens the door to future innovative financing approaches that will drive down costs for consumers. Careful design of regulation, incentives, risk-sharing and the approach to remote risks have delivered cheaper, competitively sourced funding for the Thames Tideway Tunnel. The energy sector can learn from this innovation as it seeks to attract future generation investments. With this mix of reuse and innovation, UK customers have the chance of a diverse mix including low carbon nuclear at a lower cost than other options.

The Climate Change Act, carbon pricing and electricity market reform are key examples of where the UK has led the world in tackling climate change. Britain needs a smart electricity system and a secure, diverse, low carbon domestic mix that includes nuclear power. Polling tells us that the majority of the public see the benefits of such a diverse mix. Policymakers, regulators and industry need to move confidently and quickly to deliver what the country needs and expects.



Above: Construction work at Hinkley Point C

How a decade of the Act changed an industry

Mark Somerset, Former Vice President, Strategy, InterGen



In 2010 – two years after the Climate Change Act came into force - I was quoted by Utility Week as advocating the “horizontalisation” of the electricity industry. Apart from being congratulated for creating a new word, the point was seriously made.

I argued that competition in the industry was being undermined by the vertical nature of the Big Six (they hated that BS term), enabling them to cross-subsidise within their structures (for example, selling generated power at or below cost to their captive customers). In turn this was making life for horizontal players – such as InterGen – unreasonably and unfairly difficult, was suppressing competition and ultimately this was not in the interest of consumers.

How times have changed. The market has seen to that. If we re-brand the Big Six as six VIUs (vertically integrated utilities) then currently there are the Big Three (EDF, Scottish Power, SSE). Centrica has turned to a market-facing model, focused on retail and the consumer as they dispose of the generation hardware. RWE and Eon continue to re-structure into separate generation and retail structures. SSE and Npower intend to merge their retail operations with SSE separating out its physical assets. We could be down to a Big Two, maybe even a Big One. Vertical integration is no longer a concern and it didn't need regulation to dismantle it.

What are the lessons to be learned from this? First, being big is no guarantee of safety or prosperity. A marketing tutor on my 1987 MBA extolled the virtues of the world's biggest computer company, IBM: big, dominant in their fields and using this dominance to bully and crush new entrants – but a couple of years later they were forced to re-design their business model as competitors sold similar hardware at much cheaper prices.

The second lesson: you have to embrace change and act nimbly; this has knock-on effects throughout any organisation, not least on recruitment and risk appetite. Many of the Big Six are demonstrating these qualities, but somehow this doesn't feel as if it's enough. That is because the pace of change (for which read disruption) in the electricity industry is exponential, and change in company culture will always lag.

Third, decarbonisation has been a game-changer, unleashed by the 2008 Climate Change Act. Not only has the penetration of low carbon generation undermined the traditional profitability of fossil fuels, thereby encouraging the Big Six to review (and change) their business models, it has had other major impacts. It has seen the disappearance of the liberalised market, as subsidies insinuate their way into every investment decision. It has seen the emergence of central government as the dominant procurement force. It has seen the emergence of a myriad of new players in the industry, and not only those with big balance sheets – witness the emergence of small companies promoting reciprocating engines and rooftop solar. Decarbonisation has also seen the rise of the unintended consequence: decarbonisation leading to the rise of intermittency, in turn to uneconomic thermal generation, then on to security of supply concerns, the emergence of a capacity market and hey presto the emergence of diesel engines ... how on earth does that square with decarbonisation?

Let me return to the “Big” in Big Six, for without question, size does matter. It helps to have a big balance sheet to invest millions in new generation, not least the mind boggling sums needed to build out offshore wind or nuclear, and not least to avoid the expensive and time-consuming process of project (or limited recourse) financing. It helps to run an infrastructure fund billions strong where a low cost of capital is your strongest single competitive advantage. It helps to be able to post large financial collateral to back your trading strategy when hedging two to three seasons out, thereby reducing exposure to market volatility.

Decarbonisation has seen the emergence of a myriad of new players in the industry, and not only those with big balance sheets.

And then look at the other end of the size spectrum. I believe there is now more opportunity than ever for small, fleet-of-foot companies to emerge and prosper, whether their success is based on technology, innovation or the internet. But these companies need to know their limits and avoid the age-old trap of expanding beyond their means.

And then look at the unfortunates stuck in the middle – companies too small to reap true economies of scale but too big and too set in their ways to adapt to the pace of change. These are the companies that will look over the abyss before anyone else. Whether they jump (sell or merge) or are pushed (go bust) is the only open item for discussion.

The Climate Change Act is celebrating its tenth anniversary this year. Its effects have been felt far beyond the reduction in carbon emissions as renewable generation has expanded. It has forced incumbents to re-evaluate the core of who they are and what they are good at, and has facilitated a level and nature of competition unthinkable ten years ago. From an industrial, rather than environmental, perspective, this is the Act's legacy.



Working to support a low carbon future

John Pettigrew, CEO National Grid



Wherever I go I'm always asked about renewable forms of energy and electric vehicles. This is because people are excited by the potential renewables and EVs have to fundamentally transform the way society generates and consumes energy. Luckily for me, they are two subjects I find

fascinating and so I'm always happy to discuss them, and also to talk about the important work National Grid is doing to promote and support their large-scale uptake.

At National Grid we're keenly aware and proud of the opportunity we have to play a leading role in the UK's transition to the truly low carbon economy envisaged by the 2008 Climate Change Act. As the electricity transmission owner in England and Wales, and system operator for Great Britain, we understand it's vital we do everything we can to ensure the opportunities to harness low carbon energy from wherever it's generated are maximised. At the same time, as Great Britain's gas transmission and system operator, we recognise the crucial role gas - which is a reliable, flexible and cost effective energy source - will continue to play in our national transition story.

Often people talk about energy transition as if it's something that will happen at an unspecified point in the future, but that's wrong. Energy transition is happening already, all around us. The pace at which it's occurring is incredible. Did you know, for example, British wind-farms collectively produced more electricity than was produced by coal plants on three of every four days in 2017? Or that over the course of the year low carbon generation, such as wind, solar and nuclear at times generated more power than coal and gas combined? Only a decade ago such statements would have seemed unthinkable. Since 2008, in fact, the UK's sources of low carbon electricity generation have increased by around 90 percent. On April 21, 2017, the UK achieved a major milestone on its transition journey when it had its first day entirely free of coal-generated power since the Industrial Revolution.

Of course, adapting our nationwide energy network infrastructure, much of which was created more than fifty years ago, to the reality of energy transition is not without challenges for National Grid. Where once our main focus was on large power stations and planning to ensure we were able to meet demand peaks, today the reality of distributed energy means we must also work to match consumer

demand with the constantly changing output of sources of carbon-free power generation, from relatively small-scale solar to large scale offshore wind. To be successful, we must innovate and work closely with a wide range of traditional and non-traditional providers of energy.

While responding to this type of challenge is exciting for us, it also highlights the imperative to create smart grids able to give people more choice about how they consume their energy while also making the balancing of network supply and demand more efficient. Over the last decade, we have invested £13 billion into modernising UK network infrastructure, and we are committed to investing another billion pounds every year in future.

It is impossible to consider a low carbon future without making mention of the coming EV revolution, which will be game-changing in terms of energy transition. Today on our roads there are 38 million vehicles, driving a total 317 billion miles a year, using carbon emission-causing fuel equivalent to 37 million tonnes of oil. The benefits for the environment of going entirely electric are well documented, but doing so won't be straightforward. There are many hurdles to clear first, not least issues such as range anxiety and recharging methods.

National Grid has worked hard to address these issues. For example, we're developing plans to establish a strategic rapid charging network across the UK's motorway system and we've also put significant effort into considering how we will respond to electricity demand spikes caused by recharging.

This means understanding where and when demand will be greatest, and then making sure we have the infrastructure in place to supply it. It also means considering important questions such as what the best model for charging vehicles will be. Will people top-up charge incrementally, for example? Or will they charge in one go?

Energy transition is happening already, all around us. The pace at which it's occurring is incredible.

Today, as we seek answers to these questions, we are working proactively with a wide range of stakeholders to ensure as many people as possible will be able to experience the benefits of EVs, and that their positive impact on the environment is maximised.

While the challenges of facilitating the renewables and EV revolutions are great, so too are the opportunities. National Grid supports the decarbonisation, digitisation and decentralisation of power and we are aware of the potential the work we do now in these areas has to benefit millions of people for generations to come.

We are also proud and delighted to see energy transition becoming reality in our lifetimes. The targets of the 2008 Climate Change Act once seemed almost impossibly ambitious, but today they appear less so. This is uplifting because it shows society at its best: working together to create a better future for everyone.



Above: One of National Grid's power tunnels in Highbury, London

A flexible future

Sam Wither, Head of UK Power Reserve



The introduction of the Climate Change Act in 2008 cemented the UK's ambitions to reduce emissions and facilitated the rise of renewables in the electricity system. The ensuing growth of solar, wind and other forms of renewable energy generation have resulted in a lower carbon energy mix, but

also a more volatile market. UK Power Reserve was founded in 2010 to meet the new demands of this changing system.

Renewable energy is intermittent. There are times when the wind doesn't blow and the sun doesn't shine and so renewables are unable to generate electricity – and as their share of the energy mix increases, so does the volatility on the energy system. UK Power Reserve is designed to manage this volatility, with its rapid response gas engines and batteries responding to changes in supply and demand on the system.

The long-term policy framework in the Climate Change Act sets out a clear destination without providing strict rules or restrictions on how to get there. This has allowed creativity to thrive – resulting in the current boom in disruptive technology in the energy market, such as energy storage, blockchain and peer-to-peer trading. There are a growing number of companies investing in smaller scale responsive engines and other new, flexible technologies, as the framework highlights the need to offer lower carbon solutions.

UK Power Reserve has grown rapidly over the last few years into the leading flexibility provider in the country, primarily driven by consistent and meaningful success in the Capacity Market. These annual auctions, designed to ensure security of supply for the future, have enabled the growth of distributed energy – the fastest growing sector in the UK power market. Energy will become more local with different regions and towns taking a greater interest in contributing to a low carbon economy, partly driven by shifting patterns of demand and the growth of smart tech and renewable energy. The market is constantly investing in new technologies and innovations. Energy storage is one of the success stories of recent years.

This linchpin technology will be essential for the smart, flexible future of the future and its importance in the UK's energy system will only continue to grow. Lithium-ion batteries are currently the most common technology, but there are innovations in flow batteries, gravity storage and liquid air storage.

This wave of innovation and investment is testament to private companies driving down carbon emissions to reach Government mandated targets set out in the Climate Change Act. UK Power Reserve is currently developing 120MW of battery storage technology in the UK – one of the largest portfolios in Europe – and is constantly looking for ways to continue to support renewable technology in the UK and provide flexibility to the market.

Every month we see new records being broken: the length of time coal is off the system, the number of solar hours or percentage of wind on the grid. These records will continue to tumble as renewable energy sources continue to grow their share of the grid and investment in new cleaner technology continues. The sector has already made significant contributions to reducing its carbon emissions – recently pushing transport to the most polluting sector. These achievements are to be celebrated, and the UK has a leadership position after taking an early, bold stance in tackling climate change, but Government needs to ensure a green future remains central to their vision.

As we transition away from EU membership, we are in a unique position to become the world leader in climate action. The EU can be constrained by the views of more polluting countries, which we will no longer need to accommodate. The Paris Agreement has set a global framework and standards, but there is nothing to prevent our ambitions going further and faster.

The market is constantly investing in new technologies and innovations. Energy storage is one of the success stories of recent years.

The UK has busted the myth that decarbonisation comes at a cost to growth and we must continue to highlight what can be achieved by decarbonising the economy.

The system will continue to become more decentralised with a greater percentage of renewables in the mix and UK Power Reserve will continue to lead the transition to a smarter, flexible grid.



Above: One of UK Power Reserve's battery storage sites

Enabling the new generation in Wales

Lesley Griffiths AM, Cabinet Secretary for Energy, Planning and Rural Affairs



This is a time of huge opportunity and unprecedented change. Our economy is being reshaped by the need to respond to the challenge of climate change. Wales has a long legacy as a UK powerhouse and we have big ambitions to secure a prosperous low carbon future. Wales' ability to

prosper during this unprecedented change will depend on a number of factors. We must lead with ambition, identifying and securing the benefits from transition for Wales. This requires collaboration, integration and accepting calculated risk.

The Paris Agreement sets the context for tackling the causes and consequences of climate change and for decarbonising the global economy. The UK Government ratified the Agreement last year and was the first member state to introduce legally-binding national legislation to tackle climate change through the Climate Change Act.

In Wales our 2010 Climate Change Strategy provided initial momentum. The Environment (Wales) Act 2016 and the Wellbeing of Future Generations (Wales) Act 2015 have significantly changed the legislative landscape, introducing ambitious long term targets. We now have a cross cutting Cabinet group reviewing our policies in the context of decarbonising our economy.

The Environment Act commits Wales to achieving at least 80% reductions in our carbon emissions by 2050. However, our industrial heritage presents significant challenges. Wales generates electricity for the UK system, largely from fossil fuels. Currently Wales hosts 18% of the UK's gas fired electricity generation capacity but uses only 6% of the UK's total electricity. With energy policy and planning consents for generators larger than 350 megawatts reserved to the UK, achieving reductions within our current powers looks challenging. Wales needs to use our powers and influence in creative ways.

We have strengthened Planning Policy Wales, our national land-use planning policy document, to align them with our energy ambitions and establish an energy hierarchy. We want local planning authorities to see renewable resources as valuable assets. We have introduced new requirements for local authorities to identify areas for new wind and solar generation developments and to set local targets for renewable energy in their local plans.

Wales has made great progress in decarbonising power supplies. We hosted the first UK offshore wind project, with 726 megawatts of capacity off the North Wales coast. We hope further offshore wind development will deliver opportunities in construction and maintenance. Our policies have been successful in bringing forward onshore wind, both locally owned by farms and communities, and commercial developments such as Brechfa West, which can produce the power needed by 38,800 homes.

As set out in Taking Wales Forward, our Programme for Government, we maintain a robust and unequivocal opposition to fracking. Welsh Ministers will use the mechanisms currently available to us to control oil and gas developments in line with our preferred policy position.

In September 2017 we announced ambitious targets for energy generation in Wales:

- Wales to generate electricity equal to 70 per cent of its consumption from renewable sources by 2030
- 1 gigawatt (GW) of renewable electricity capacity in Wales to be locally owned by 2030
- New renewable energy projects to have at least an element of local ownership from 2020

Since 2010, renewable electricity generation has trebled. Last year generators in Wales produced electricity equating to 43% of Wales' use. However, achieving the 70% target will be challenging, particularly without a route to market which enables investment decisions.

As transport and home heating become more electrified, we need increased energy efficiency and generation.

Our industrial heritage presents significant challenges...Wales needs to use our powers and influence in creative ways.

We are collecting evidence on Wales' renewable resources and the impacts of harnessing them in order to inform national spatial planning. The Marine Energy summit this autumn will contribute further evidence on how that sector can contribute to the mix of energy generation in Wales.

We have frequently raised concerns about the impact of UK Government's decision to exclude onshore wind and solar technologies from Contracts for Difference and reduced levels of Feed in Tariffs. These support mechanisms have driven mass uptake of renewable generation and enabled dramatic cost reductions. UK and devolved Governments have invested in the renewables industry, often using European Union funding. As the UK prepares to exit the EU, potentially losing funding, we believe providing certainty to our renewable industry is essential.

The transition to a more distributed energy system is a significant opportunity to retain benefit, if more new development is owned by Welsh businesses. Global research undertaken by the Centre for Low Carbon Futures shows significant export of economic value, with 5.9% - 18% of GVA being exported from UK regions studied, by paying energy bills. Locally owned generation provides a strong opportunity to retain economic value, contributing to prosperity. We are working with communities and developers to increase locally owned generation in Wales.

Action is needed to decarbonise whilst managing costs. Firstly, we must develop different ways to support innovative, early stage renewables, smart technology and grid to maintain a secure, affordable supply. The opportunity to develop and export world leading technologies and management systems will only exist if Government at all levels is prepared to fund early stage risk, involving a wide range of organisations. Innovation programmes in Wales are already seeing some success, notably in new solar technologies and integrating existing products into whole house systems.

Secondly, we must manage the costs of transition by ensuring most of our electricity comes from the most cost-effective sources. Onshore wind is the cheapest form of large new-build electricity generation in the UK, capable of meeting a huge portion of demand and delivering decarbonisation whilst benefitting the UK economy. It presents the best opportunities both to manage the cost of energy bills and to build the resilient local energy structures necessary to weather the future in a low carbon market outside the EU. We look forward to working with governments across the UK to create the certainty needed to deliver a prosperous low carbon future.



Above: Abergwynfi, Wales

Science and policy advancing together

Professor Stephen Belcher, Chief Scientist, Met Office



The passing of the Climate Change Act (CCA) in 2008 saw one of the world's first framework laws on climate change, with targets for reducing emissions of greenhouse gases and monitoring climate impacts and action in the UK. The legal targets that were set remain some of the most ambitious in the world.

At the time of the CCA, ten years ago, the scientific evidence for changes in the Earth's climate and the human role in driving this was already strong. Clear warming trends in the environment were seen, not just in measurements of temperature, but in diminishing snow and ice cover, rising sea levels, and changes in the behaviour of damaging extreme weather events.

Just a year before in 2007, the Intergovernmental Panel on Climate Change (IPCC) had published their Fourth Assessment Report (AR4), a comprehensive survey of the state of climate science at the time based on the published scientific literature. It concluded that "Most of the observed increase in global average temperatures since the mid-20th century is very likely (90% confidence) due to the observed increase in anthropogenic greenhouse gas concentrations." Alongside its emission reduction targets, the CCA also sets out a schedule for the government to produce a Climate Change Risk Assessment (CCRA) to assess the risks and opportunities facing the UK from climate change.

The first CCRA, published in 2012, was underpinned by a set of numerical climate projections for the UK (known as UKCP09) produced by the Met Office Hadley Centre. These projections were ground-breaking at the time, with the climate models used reproducing the climate of the UK in unprecedented detail. Evidence from UKCP09 fed into decisions on climate adaptation across both public and private spheres, for example, informing decisions around the Thames Barrier.

So the background of scientific evidence around climate change in 2008 was robust. In the ten years that have passed since, this evidence has grown only stronger. Observational evidence of physical changes in our climate system has grown. In 2015 global average temperatures reached 1 °C above pre-industrial levels. During 2017 atmospheric carbon dioxide concentrations did not drop below 400 parts-per-million for an entire year. And satellite observations have shown that rates of sea level rise continue to accelerate.

The most recent report from the IPCC, the Fifth Assessment Report (AR5), which was published in 2015, provided an update to its previous statement in AR4 to reflect this strengthening of evidence. It stated that "it is extremely likely (95% confidence) that more than half of the observed increase in global average surface temperature from 1951 to 2010 was caused by the anthropogenic increase in greenhouse gas concentrations and other anthropogenic forcings together." This evidence, provided in AR5, was key to driving the negotiations behind the historic Paris Agreement, at which 196 countries agreed to "keeping a global temperature rise this century well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius."

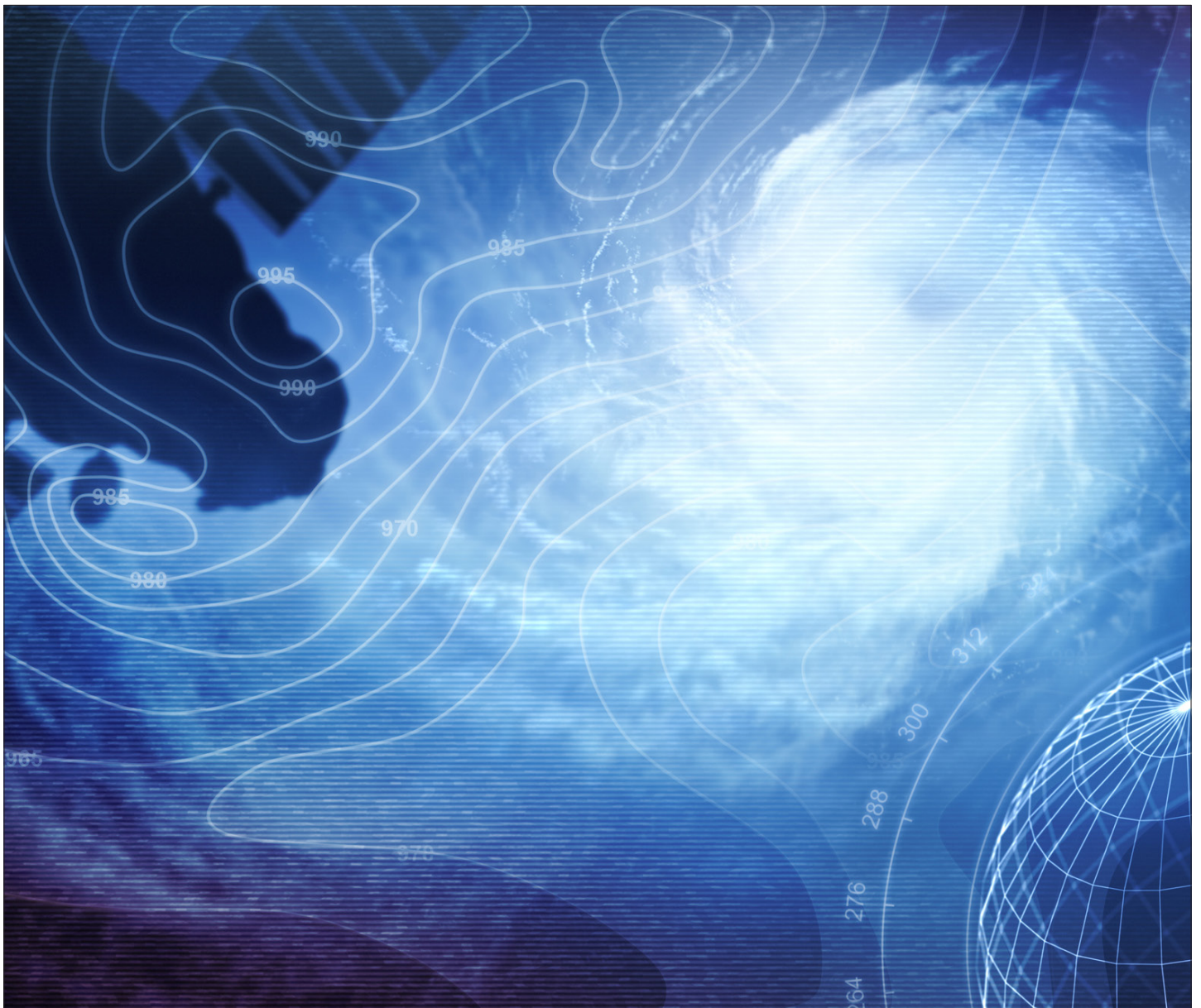
Consequently, as scientific confidence in global climate change has grown, climate science's focus has shifted towards better understanding of possible emissions pathways that would keep global temperature within the ambitions of the Paris agreement and how the impact of global climate change will manifest itself in high impact weather at regional and local levels. Progress in these areas has come from the tremendous advance in supercomputing technology and capacity over the last decade, alongside scientists' ability to harness the power of these machines. To give an example, the computer simulations used in UKCP09 were state-of-the-art at the time, reproducing the Earth's weather patterns and climate with a resolution (the size of the grid boxes over which the model performs its calculations) of about 100 km.

The scientific evidence around climate change in 2008 was robust. In the ten years that have passed...this evidence has grown only stronger.

The Met Office's newest climate simulations for the UK, the bulk of which are due to be launched in November 2018, will include results with a resolution of just 2.2 km, finely detailed enough that the model will be able to resolve individual thunderstorms. This detail was previously the realm only of short-term weather forecasts and will provide valuable information for decisions around resilience and flooding.

The latest climate models also include much more sophisticated representations of the processes that determine how the climate could change in the future. The latest 'Earth System Models' (ESMs) will include components that simulate not only the atmosphere and the oceans, but the polar ice sheets, vegetation, soil chemistry, biology in the oceans (such as plankton blooms) and much more. Understanding these processes will allow scientists to answer the big questions that policy asks of us, in particular those around carbon budgets: how much carbon can we emit into the atmosphere if we are to meet the ambitions of the Paris Agreement?

Both the scientific and the policy landscape have moved a long way in the ten years since the Climate Change Act passed into legislation in 2008. And of course things do not stand still, as we look forward to continued advances in our understanding of the climate system and development of new policy.



The winds of change

Matthew Wright, Managing Director, Ørsted UK



I recently stood on a boat next to a 200 metre high wind turbine, one of the 87 that make up Walney Extension, the largest offshore wind farm in the world. The project, situated off the coast of Barrow-in-Furness, was opened in Autumn 2018. It is a phenomenal achievement where engineering skill and political will have come together to create a step change in how we produce our energy.

Joining Ørsted a year ago, I was attracted by both a company and an industry in transformation; a transformation that has been driven directly by the Climate Change Act.

The offshore wind industry is unrecognisable from the one that existed in 2008. Today, the Committee on Climate Change, the National Infrastructure Commission and the Government are all saying that by 2030 offshore wind should be generating around a third of the UK's electricity. To have a coherent and affordable pathway to this outcome was inconceivable 10 years ago. The speed at which the industry has been able to reduce the cost of offshore wind generation is phenomenal, and again, this success owes so much to policies put in place as a result of the Climate Change Act.

At Ørsted, we are currently building the Hornsea Project Two wind farm which will have a capacity of 1,386 megawatts (MW) – almost twice the size of Walney Extension. And we and others are developing projects greater than 2,000MW. These are utility-scale offshore wind farms, each of which will power millions of homes. It's certainly a long way from the first offshore wind farm ever built, which had a total capacity of 5MW!

This increase in size is contributing to the remarkable progress on cost reduction. The 2017 Contract for Difference auction was won by projects with a strike price of £57.50 – less than half that of the winning bids in the 2015 auction. Most in the industry predict that prices will continue to fall even further.

This cost reduction is an outcome of the industry and Government working together. Mechanisms such as Contracts for Difference have provided the stable framework for renewable energy investors, developers and supply chain partners alike to pull together and build globally competitive industries. These policies, and the achievements of the industry, are enabling the UK to rapidly decarbonise its power sector.

And the benefits are even bigger than just a reduction in carbon emissions. The industry is having a hugely positive economic impact across the country – creating thousands of jobs, helping to grow local businesses and regenerating coastal communities. Increasingly, our supply chain expertise presents a global export opportunity too.

Last year alone, Britain accounted for more than half of the new offshore wind power capacity built in Europe, making up 53% of the net 3.2GW of capacity installed across the continent. And we are learning more and more with each new project.

Whilst this transformation in the offshore wind industry has been taking place, there has also been a transformation within Ørsted. Indeed, until recently Ørsted was known as DONG Energy – short for Danish Oil and Natural Gas. Yet following the sale of our oil and gas business and a commitment to creating a world that runs entirely on green energy, we are now Ørsted – an innovative, global and commercially successful business devoted entirely to green energy. The fact that Ørsted is investing billions of pounds in UK renewable energy projects epitomises the success of the Climate Change Act.

The UK should be extremely proud of the offshore wind industry it has created and the leading role it has taken in the development of the technology. We should also be excited by the opportunity to bring our leadership and experience to bear on the development of more nascent technologies.

The speed at which the industry has been able to reduce the cost of offshore wind generation is phenomenal.

We believe energy storage, demand side management and waste-to-energy will all play an important role in moving us closer to targets set out by the Climate Change Act. What's important now is the direction we are heading in and that we collectively work to capitalise on the opportunity of the green economy. As the UK begins to concentrate on decarbonising the heat and transport sectors, it should look to the success achieved to date in the decarbonisation of the power sector.

Yes, there is much more to do undoubtedly – decarbonisation is a decades-long process. However, we should look back on the past ten years with a sense of pride in what we have achieved and a sense of excitement about what we can achieve by 2028. For the renewable energy industry, it truly is an exciting time.



Above: Walney Wind Farm off the coast of Barrow-in-Furness

Targets and policy go hand-in-hand

Keith Anderson, Chief Executive, ScottishPower



Targets matter. They give focus to government policy. They spur action by business. But they cannot achieve everything on their own. Ten years on from the Climate Change Act we can celebrate that targets in the UK's carbon budgets have helped reduce emissions whilst ensuring the economy continues to grow.

With the help of the carbon tax, the UK has led the world in targeting reductions in emissions from power generation. Iberdrola, ScottishPower's parent company, has mirrored the government's target setting approach. In parallel to the Climate Change Act we are committed to reduce emissions by 30% by 2020, 50% by 2030 and to be carbon neutral by 2050.

Today, 60% of the installed capacity of Iberdrola is renewable generation. In the UK we have closed our coal powered stations and have constructed over 30 windfarms. Our renewable capacity exceeds 2GW.

That switch from coal to wind was enabled not only by targets but by government policy that delivered the right support mechanism. The Renewables Obligation (RO) gave much needed line of sight to the likely returns to trigger the capital investment.

The introduction of Contracts for Difference (CfDs) performed a similar function for offshore wind, with the auction design driving costs down. The 714MW East Anglia One windfarm we are currently building has a CfD for £119/MWh. With technological improvement, and as the supply chain matures, the next round of auctions announced by the government should deliver offshore wind projects for around half of that. In offshore, targets and policy are working hand-in-hand. The target of 30GW of offshore wind by 2030 is achievable with clarity from the support mechanism enabling investment to sustain the supply chain.

But for onshore wind, now the cheapest form of any new electricity generation, there is no longer a mechanism to underpin investment, and as a consequence construction projects are drying up.

Without some form of contract, which all other power generators can compete for, there will never be sufficient confidence for investors to raise the up-front capital. Some say Power Purchase Agreements (PPAs) for big businesses will be the saviour.

But why should only business benefit from the cheapest form of renewable power generation and not domestic customers? A CfD for onshore would likely settle at a price similar to the wholesale cost of electricity. A competitive auction process would ensure that only the most efficient projects would be built. But the certainty of the CfD would once again give the confidence for capital investment to flow. And for those concerned that onshore wind would be built in the wrong place, the tightening of the planning system should ensure that it only gets built with the support of local communities.

Onshore wind matters if the government is to meet its carbon targets. National Grid's future energy scenarios for 2018 show only two that can achieve our carbon targets. One of these featured the inclusion of onshore wind. If onshore wind is ruled out all our eggs could be in one basket.

A decade of success of the Climate Change Act should be marked by good government policy going hand-in-hand with targets. If we want to achieve our carbon reduction ambitions we must find a way to include onshore wind in the next CfD auction so we can benefit from clean electricity, the growth to the economy as well as costs reductions for consumers. Targets matter. Creating an environment that allows us to achieve them matters more.

Why should only business benefit from the cheapest form of renewable power generation and not domestic customers?



Above: Scottish Power's Whitelee windfarm – the largest in the UK

Stepping up a quiet revolution

Mary Creagh MP, Chair of the Environmental Audit Committee



In the ten years since the Climate Change Act 2008, there has been a quiet revolution in the way we produce and use energy. As well as spurring climate action in the UK, that landmark piece of legislation has echoed in Parliaments around the world as countries followed our lead. But while

we should celebrate a lot done, we should take this opportunity to step back and look again at the urgency and opportunity of the climate challenge.

The summer of 2018 has been one of the hottest, driest and deadliest. Deadly wildfires in Greece, a ‘natural disaster’ in Japan, and temperatures of more than 30 degrees Celsius in the Arctic, which has had its third winter heatwave in a row. These events are not coincidence. The dice is loaded. 17 of the hottest years have been in the last 18 years. The Greenland ice sheet loses enough water to submerge the UK by almost 3m of water every year. This is the reality of what the science has been telling us. These events will become more common and more extreme for as long as we carry on using our atmosphere as a sewer.

This is not cause for despair, it is a rallying cry. Ten years have shown us what we can achieve when we work together and unleash the power markets and human ingenuity. The UK now has a renewable energy sector which is displacing conventional energy. Around the world the growth of renewable energy is unstoppable. This revolution has been kickstarted by laws and regulations, and the arrival of new technologies. It has been influenced by people – no less passionate than those who protest on the streets – who have chosen to engage our economic system and divert it to more sustainable ends.

Investors, businesses and markets, guided by the long-term targets in the Climate Change Act, are abandoning fossil fuels in favour of low or no carbon alternatives. That is welcome, but this transition carries risks as well as opportunities. Two thirds of the assets on oil company books cannot be burned. This sub-prime carbon bubble needs to be carefully deflated, but the UK’s financial regulators are only just waking up to this challenge. Laggards will suffer, but progressive companies that make the transition to clean technology will reap rewards. The challenge is universal. In all parts of the economy, everyone should ask: what does the low carbon transition mean for me?

For policymakers, we should look at how the Act could be improved. In 2015 the world came together at the Paris climate change conference to agree to keep temperatures to well below two degrees. Around the world, countries are transitioning to clean energy. China’s coal consumption has stalled, and its Government plans a massive rollout of renewables. Realising renewable energy is the fastest to deploy, bar none, India is electrifying by taxing coal to pay for renewables. Chile has become the first South American country to tax carbon emissions, but an abundance of sun and high energy prices is also driving a solar revolution.

In the UK we should ask: are our laws still good enough? Our Climate Change Act sets a target for 80% emissions reductions by 2050. The Paris agreement recognizes that if we do not achieve ‘net zero’ emissions then we will not stop climate change. We should look at whether the Act needs amending to ratchet up ambition. Ten years on, the agents of change remain the same: laws and technology. Our challenge is to seek to find new ways to use them to unleash change and reclaim UK global leadership on climate change.

The challenge is universal. In all parts of the economy, everyone should ask: what does the low carbon transition mean for me?



Above: The Summer of 2018 has seen deadly wildfires and other 'natural disasters'

The energy revolution - the next chapter

Will Gardiner, CEO, Drax Group plc



A decade ago, the energy sector was at a crossroads. Climate change had risen rapidly up the political agenda and policies were implemented to help reduce the carbon emissions of an energy system largely reliant on coal.

New policies meant that cleaner renewable technologies received the support and investment they needed to be viable. As a result, the UK has seen a dramatic fall in power generation from coal and a major shift towards lower carbon technologies.

Drax embarked on an ambitious plan to transform its coal fired power station from the country's biggest polluter to the largest decarbonisation project in Europe. Four of the six generating units now run on sustainable biomass – a renewable fuel.

Solar, wind and biomass technologies all received support and investment; today they supply a huge proportion of our power. Wind power alone accounted for 15 per cent of UK generation in 2017.

But even more ambitious goals have now been set – the EU's latest target is that 32 per cent of all energy should come from renewable sources by 2030. So how will we achieve that?

Take biomass as an example: By using compressed wood pellets, Drax has been able to reduce carbon emissions by more than 80 per cent compared to when we used coal. Biomass provides reliable thermal generation, which plugs the gaps on the system left when the wind doesn't blow and the sun doesn't shine. It also provides a range of vital system support services to the Grid such as voltage control and inertia – helping to keep the lights on during times of system stress.

It's an important technology, but to make biomass carbon neutral – or even carbon negative – others are needed. Bioenergy carbon capture and storage (BECCS) – which Drax is piloting – will be necessary to decarbonise this thermal generation.

The pilot is the first of its kind in Europe and would take the biomass conversion at Drax to the next stage. If successful, BECCS has the potential to deliver 55 million tonnes of negative emissions across the UK by 2050.

This means power generation would no longer contribute to climate change but would actually reduce the carbon accumulating in the atmosphere – essential if the world is to achieve the targets agreed in Paris.

The main challenges with BECCS are associated with the fact that the technology is very much in its infancy – and as a result it would be very costly to roll it out at scale. Further work is needed to explore the capabilities of this technology – something we are determined to do. We have a proven track record in delivering pioneering engineering projects having transformed two thirds of the power station from coal to biomass. BECCS is the next step for us.

Similarly, battery technology is another part of the decarbonisation puzzle. It is only logical that we should store surplus energy produced on particularly sunny or windy days, but it's currently uneconomic to do so. Battery technology that will allow large amounts of energy to be stored does not exist yet.

Batteries can also provide power for generators looking to ramp up their production and provide power quickly to the grid; also necessary if we are to have an efficient and decarbonised system.

As with BECCS, battery technology simply isn't viable at scale yet. However, the falling costs of biomass, wind and solar show that the costs of new technologies do come down as advancements are made and competition is created in the marketplace.

Power generation would no longer contribute to climate change but would actually reduce the carbon accumulating in the atmosphere.

It is undeniable that vast change has occurred in the energy sector over the past decade – we are seeing new renewables records broken every few weeks and have reduced UK carbon emissions by 12 per cent in the past year alone.

The policies put in place to support renewables allowed these changes to happen. There now needs to be investment in more new technologies and we must work together as partners to ensure the advancements we need, are made.

As investment comes in, competition increases, and costs then fall.

What we have done so far has worked – and we should be proud of this as energy generators, suppliers and policy makers, but our work is not done yet.



Above: Biomass domes at Drax's power plant in North Yorkshire

The future is electric

Gareth Dunsmore, Electric Vehicle Director, Nissan Europe



As recently as 2010, two years after the Climate Change Act passed, our industry was openly sceptical about an electric future. Today, you would be hard pressed to find anyone in our industry who maintains this viewpoint with the evolution of electric vehicles (EVs) speeding ahead and the evidently crucial role they will have to play if we are to meet the Act's targets over the coming decades.

Since 2010, Nissan has been a global leader in providing mainstream, accessible electric vehicles for consumers. More than 340,000 Nissan LEAF have been sold around the world, and it is the best-selling electric vehicle in Europe. Being able to build and develop the next generation of electric vehicles is only possible through innovation and commitment. Nissan was a pioneer in the field, investing \$4bn dollars in electric vehicle research and development, a foresight our competitors did not have, enabling Nissan to own the evolution of EVs.

In the UK, our LEAF and e-NV200 – an electric light commercial vehicle - are best sellers in their sectors. The LEAF – which is also built at Nissan's state-of-the-art manufacturing facility in Sunderland, has also transformed customer expectations of what an electric vehicle is like. Across Europe, sales of our new second generation Nissan LEAF will double in this fiscal year. The model enjoys a 96% customer approval rating which - for comparison - is far higher than conventional internal combustion engine cars. We are currently selling a Nissan LEAF every ten minutes in Europe - exemplifying the pace of change and how consumers have engaged with our electric vehicles.

The Nissan LEAF's success is simple: consumers are actively seeking zero emission solutions and Nissan is providing the answer through innovative technology, such as the revolutionary e-Pedal. By harnessing the power of the vehicle's regenerative energy to provide one-pedal driving, drivers can accelerate, decelerate or come to a complete stop with a simple increase or decrease of pressure applied to the accelerator pedal. Customer benefits include reduced fatigue and stress in daily city driving.

Getting to this stage in the EV market has not come without its challenges. Initially there were concerns from consumers about the range of electric vehicles and the practical implications on journeys. The new Nissan LEAF is now a vehicle that is in a credible position to be used

for every day driving, with 168 miles capability under the latest WLTP (Worldwide Harmonised Light Vehicle Testing Procedure) testing cycle. With this in mind, range anxiety is fast becoming a thing of the past. Nissan is also actively addressing the barriers to acceptance of electric vehicles to ensure sustainable driving is as accessible as possible. As a leader in charging infrastructure, Nissan has more than 2300 quick charge stations in Europe, with this number predicted to reach 5500 by 2020. Providing quick charging services on motorways across the UK has been a priority for Nissan, as is offering customers convenient solutions for home charging by extending their electric ecosystem beyond their car.

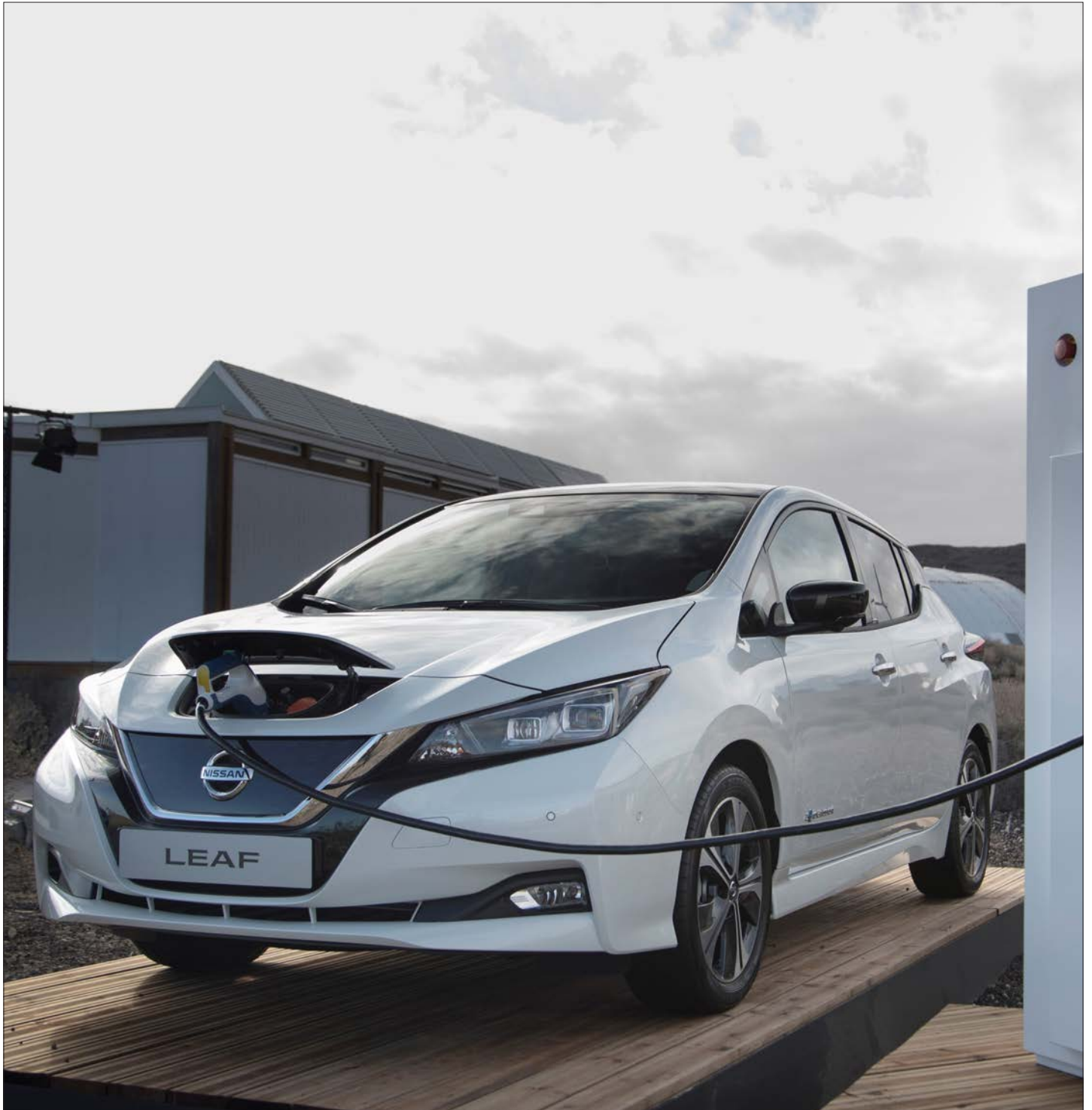
UK customers can now optimise the way their properties create, store and consume energy using world-class integrated solar panels, battery storage using 2nd life Nissan EV batteries and a home energy management system provided by Nissan. We call it X-Storage and it provides a framework for customers to take control of their domestic energy use.

Nissan holds existing partnerships with energy providers and is piloting the effectiveness of the vehicle to grid system (V2G) in different European cities, ahead of a wider deployment across Europe. In addition, drivers can connect their electric vehicles to the grid during cheap-tariff periods and can use the electricity stored in the vehicle's battery either at home, while driving, or even to sell back to the grid. This is all part of our mission to provide our customers with low cost, clean, sustainable energy for domestic use.

We are currently selling a Nissan LEAF every ten minutes in Europe - exemplifying the pace of change and how consumers have engaged with our electric vehicles.

Our vision is to one day give our customers the capability to run their EV with virtually no cost for electricity.

The future is most definitely electric. At Nissan, we firmly believe we have the best products, but for us leadership in the electric space extends far beyond our cars and vans. We call the future Nissan Intelligent Mobility, and its purpose is not just to transform the way we drive, but also transform the way we live.



Above: The Nissan LEAF

The capital and climate change

Shirley Rodrigues, Deputy Mayor of London for Environment and Energy



The UK has come a long way since the Climate Change Act was introduced in 2008. We've met our first two carbon budgets comfortably, and look on track to meet the third. Renewables that supply our grid have increased to nearly 30 percent, we have cut gas demand by 27 per cent, and

offshore wind is a UK success story. We should rightly celebrate this success.

But we cannot be complacent. We need to start preparing now for meeting the next set of carbon budgets; achieving these will require harder, more complex choices, over and above picking up the pace and scale of existing schemes. We will no longer be able to continue with our heavy reliance on decarbonising the grid through large-scale renewable projects, or through cutting our emissions through ever-shrinking energy efficiency programmes.

The solutions required to meet future carbon budgets will be more dispersed, often requiring decisions and action at the regional, building or even individual level. We need to take a fresh look at our approach, and enable and empower local action to deliver the required solutions.

Since 2008, around 30 percent of the UK's carbon emission reductions have been through decarbonisation of the national grid, with the vast remainder delivered by more efficient use of gas through improving boiler standards and energy efficiency schemes.

But to reach the UK's fourth and fifth carbon budgets we cannot rely on the solutions we have used to date. It will require us to decarbonise our heat and transport, as well as using energy far more efficiently.

Heating buildings is the single largest source of greenhouse gas emissions in London, accounting for over a third of total emissions in 2015. But progress to decarbonise heat has been limited. With the overwhelming majority of our heat demand currently being met by gas-fired boilers, decisions to switch these to low carbon heat sources will require local decisions, often made at the individual, household or business level. Although grid-level solutions may be developed, London produces enough waste heat locally to meet the demand from buildings, so there is an opportunity to use sources such as air-source heat pumps and waste heat either at the building-level or connected to local heat networks.

Transport accounts for a relatively small amount of London's carbon emissions (24 per cent), but will nevertheless need to be reduced if we are to be a zero-carbon city by 2050. Investment decisions on public transport, cycling and walking infrastructure, required to enable people to switch from higher carbon forms of transport, are taken at the local level. And decisions on charging and refuelling infrastructure for low emission vehicles, such as electric and hydrogen vehicles, will need to be made at a local level to reflect local needs.

Critically, many of the solutions for decarbonising heat and transport, predominantly electrification, have the potential to increase demand on local distribution grids. One in ten London substations are approaching capacity, so managing the impacts of electrification through smart demand side response solutions, as well as energy efficiency measures to reduce overall demand will be essential. For example, in London we need to retrofit approximately 150,000 buildings per year, but we are well behind this figure. Decisions to invest in and install insulation, particularly more expensive, intrusive solid wall insulation will be made either at the stock-level or individual building level. As we have learnt from the Government's failed Green Deal scheme, this is not simple or straightforward, and will need dispersed individuals to opt to install these measures.

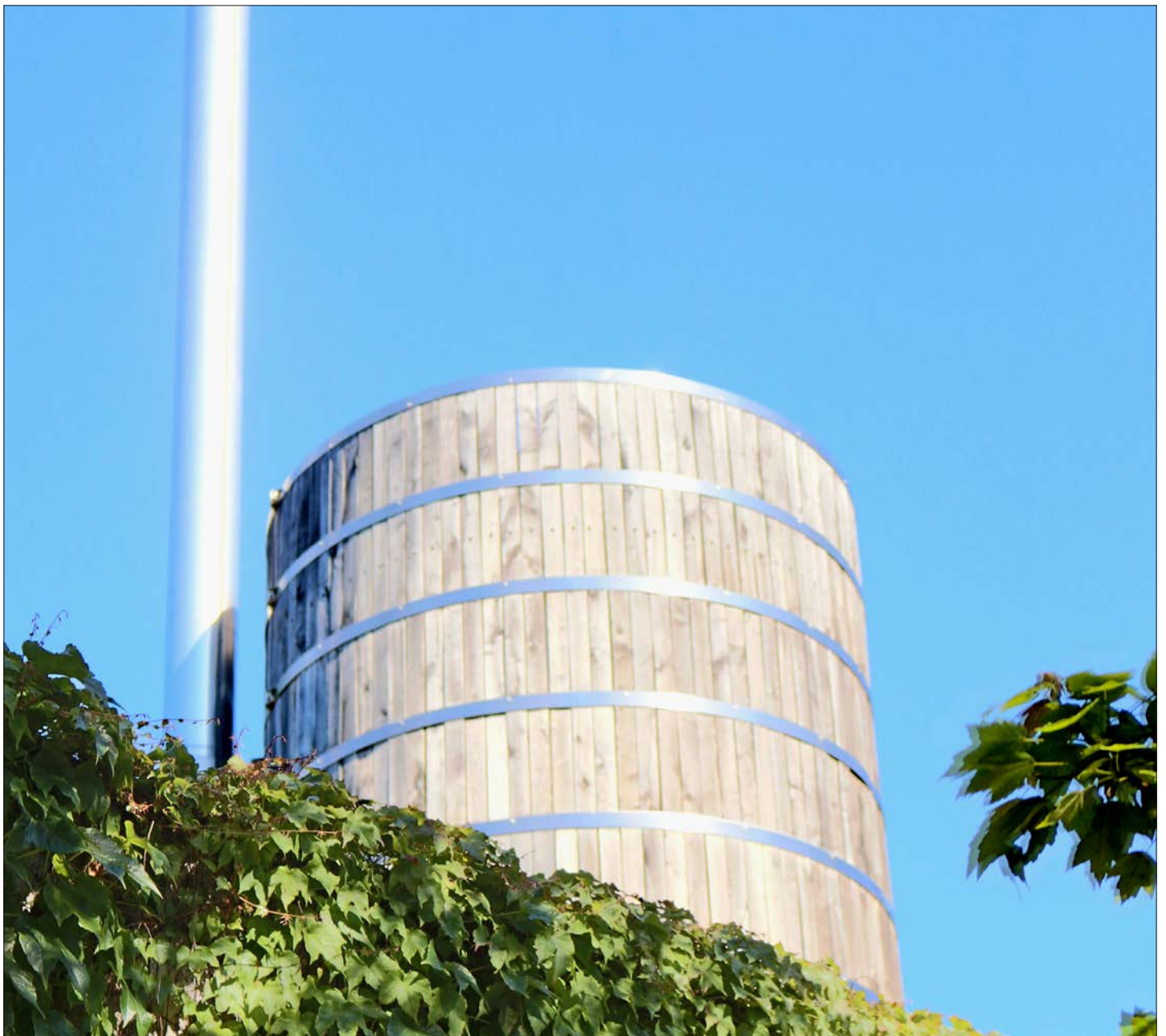
Cities and local authorities across the UK are well aware of these challenges and are taking action now. In London we are utilising zero-carbon waste heat from the London Underground to heat over 450 homes on the Bunhill estate in Islington.

Local authorities require the freedom and funding to start scaling local action at pace so that the already proven technologies and supply chains can deliver in time.

We have already installed a network of over 100 rapid charge points, alongside the thousands of standard charge points in key locations across London to enable taxi drivers, businesses and individuals to use electric vehicles. And we're working with large energy users to assess how their usage could be shifted to reduce demand on the local grid at peak times.

However, restrictions on local powers means the current scale and pace of action is too small and too slow. National Government must empower us to take action at scale, setting the long-term policy framework. Effective minimum energy efficiency standards are needed to create the scale of demand for retrofitting of buildings, and certainty around the Feed-in-Tariff, particularly for small scale renewables, would set the framework to enable local action.

To meet the fourth and fifth carbon budgets cities and local authorities require the freedom and funding to start scaling local action at pace so that the already proven technologies and supply chains can deliver in time. Cities have the solutions - what we need is the power.



Above: Waste heat facility used to heat homes on the Bunhill Estate (Credit: London Borough of Islington)

Powering Britain: a local, low carbon future

Jorge Pikunic, Managing Director, Distributed Energy & Power, Centrica



Ten years on, it is easy to forget just how revolutionary the Climate Change Act was. The first legislation of its kind in the world, introducing legally binding emissions reduction targets, establishing the independent Committee on Climate Change to advise government and hold it to account. By putting in law the target of at least a 80% cut in emissions by 2050, government policy sent a signal for a low carbon transformation.

In the last ten years the energy sector has been at the forefront of that transformation. Emissions in the power sector have fallen by almost 60% since the Climate Change Act became law. In April 2017, the UK enjoyed its first coal-free day for the first time since the 1880s.

Attention is now turning to the decarbonisation of mobility, and heating and cooling, both of which bring new challenges and will require considered policy responses. However, it is important to understand that the low carbon transition is taking place in a global revolution for the energy sector, driven by three key trends.

The first is the growth of renewables in response to climate change, which has far outstripped predictions; The second is our customers' changing attitudes towards energy. People want the ability to take control of how much they pay, how they generate energy and how they store energy - as examples; and the third is availability of technology.

New energy technology is enabling customers to generate and store their own electricity in a way that is more affordable than ever before. The growth of digital technology has also been huge and is enabling meaningful insights, including for energy. These global trends have created fundamental changes to the energy system and two areas are particularly interesting.

The first change is the location of energy, which is becoming decentralised as renewable and other distributed technologies are deployed. Large, fossil-fuel power plants that have characterised our energy system for over a century are giving way to smaller, more flexible energy technologies such as renewables and battery storage. The second is the need for flexible power, in a world with far more renewables, far more flexibility is required to maintain the delicate balance of our grid.

As a British company with roots dating back to 1812 this is not the first time that Centrica has seen the energy sector transform. We are at the forefront of this transformation and are working with these current trends to contribute to a decarbonised energy future. Three illustrations from our business exemplify this.

Firstly, we aim to help businesses find better ways of managing their energy, delivering a variety of products from energy insights and optimisation through to comprehensive energy solutions such as on-site generation and battery storage. We can provide businesses with a single view of their energy estate through our digital platform, which enables them to optimise their energy use and open new revenue streams by shifting, reducing or even increasing demand. In addition, our Energy Marketing and Trading business specialises in energy trading for a variety of renewable and low carbon generators, using Big Data to build an accurate picture of energy demand and algorithms to judge weather, predict renewable energy production and optimise utilisation.

Secondly, we are bringing flexibility to the grid through a combination of building our own assets, such as our 49MW Roosecote Battery, and customer projects. Our long-standing relationship with Gateshead Council is a good example of this and has seen the installation of solar PV, CHP and battery storage. These contributions are helping to maximise the generation and utilisation of renewable and low carbon power.

The location of energy is becoming decentralised as renewable and other distributed technologies are deployed.

Finally, our pioneering £19m Cornwall Local Energy Market project, part funded by the European Regional Development Fund, is using flexible demand, generation and storage to test how local energy markets could reduce grid constraints and enable connection of renewables. We are developing a virtual marketplace to enable peer to peer trading and access for local energy. The outcome is a glimpse of an energy future that is local, low carbon, and delivers choice.

Ten years on it is fitting to pause, look back, and appreciate how far we have come since the passing of the Climate Change Act. Our sector is looking to the future, and so is Centrica. The challenge posed by decarbonisation continues to motivate us as a company, and has unleashed technological innovation that is transforming the products and services that we offer our customers. Centrica is on track to produce 80% less carbon per unit revenue than we did a decade ago, and enabling other businesses to reduce their emissions. By the time we come to celebrate twenty years of the Climate Change Act, we really will have undergone a transformation.



Above: Battery storage installed as part of Centrica's relationship with Gateshead Council

Closing the gap - Meeting the skills demand for the UK's low carbon future

Peter Bryant, EDF Energy and Young Energy Professional of the Year



The Climate Change Act 2008, recognised the UK Government's commitment to significantly reduce greenhouse gas emissions by 2050. Central to meeting these ambitions has been the investment in the development and implementation of low carbon technologies.

Crucial to the delivery of the existing and future investments is the need for a "skilled" workforce, in particular across Science, Technology, Engineering and Mathematics (STEM) subjects. However, the scale of the low carbon ambitions, coupled with increasing demand throughout the energy sector, high average age of the existing workforce and fast pace of technology development highlights concerns of a skills gap.

A number of initiatives have been implemented within the UK over the last 10 years to combat these concerns such as the launch of National Skills Academies, various organisations investing in training programmes, and an increase in STEM engagement - however is this enough? Stereotypes around the STEM subjects need to be challenged. People often think that STEM related careers in the energy sector such as engineering are boring and not very well paid.

However, the extent to which our current skills crisis can be tied to these perceptions is perhaps questionable. From my perspective, while these stereotypes exist, there is evidence that they are changing.

Through my work with the University of Bath and the University of Surrey, I've seen general statistics that show that student enrolment on STEM courses have actually been increasing in recent years. What's more, the gender gap between men and women in respect of STEM subjects has begun to show improvement.

So if there is a general improvement in the number of students studying STEM subjects, why are we seeing heightened concerns of a skills gap in the energy sector? Many of the STEM students I've spoken to have expressed an interest in occupations such as banking or finance. In terms of purely technical fields, pursuing a career in STEM sectors such as energy has started to take second place to IT and software development, sectors which have become more fashionable due to high profile success stories such as Google and Facebook.

As a sector, the question we need to be asking ourselves is why aren't STEM students seeing the energy sector as a viable career option?

Perhaps the problem is a failure of communication? To quote Lord Browne, Chairman of the Queen Elizabeth Prize for Engineering: "People think they know what engineering is but the evidence is they don't – and in the UK the evidence is that we are very, very bad at telling them."

According to the Society for Radiological Protection (SRP), a Chartered Professional Body in the STEM field, engagement is crucial prior to University. It is for this reason the SRP like other professional bodies and employers have active outreach programmes, supporting events such as the Big Bang Fair in Birmingham. But are these events more focused on encouraging students to study subjects such as STEM rather than providing guidance on careers?

Furthermore, with the limited resources of these organisations can they reach a large enough audience? Could a greater use of Social Media such as YouTube or Instagram be the solution?

Even with the large investments into outreach and marketing, these initiatives are primarily being approached in silos. Would it not be more effective to get Employers, Government, Academia and Professional Bodies to all work together? This would certainly help ensure a more coordinated approach in terms of messages being communicated and more effective use of resources. So why aren't we doing it? I am sure there would be concerns around how much each party would benefit, in particular with employers competing for future employees.

The question we need to be asking ourselves is why aren't STEM students seeing the energy sector as a viable career option?

However, could this be where the chartered professional bodies have an independent leadership role? And what support would Government need to provide to allow this to happen?

Sector wide collaboration could also offer many benefits in relation to retention of individuals within the Energy Sector. Development of training programmes are costly but imagine if a National Training Programme existed supported by Industry and the Professional Bodies?

Would this not allow individuals within the energy sector to get a much wider appreciation of the low carbon technologies such as wind farms and nuclear energy? Not to mention keep them challenged, interested and more likely to stay in the sector?

In summary it is fair to say that there is a lot more work that still needs to be done in closing the skills gap in the Energy Sector. However, it is important to recognise the good work that has been done to date. From my perspective the question that needs to be considered is “Could we be more effective by encouraging collaboration between employers, government, academia and professional bodies?” And if so “What can the Sector and UK Government do to help support these initiatives?”

In the words of Henry Ford: “Coming together is a beginning; keeping together is progress; working together is success.”



Above: Talking to potential apprentices about opportunities in the energy sector

Finding our balance

Professor Chris Rapley CBE, Department of Earth Sciences,
University College London



We have upset the energy balance of our planet. Less heat is being lost to space than is being gained from the Sun. As the energy accumulates the Earth is warming. Weather patterns are changing and seas are rising. The modern world was designed to function within the climate system we

inherited. It is not adapted to the one we are provoking.

Fossil fuels are the main culprit. Their use has raised human prosperity and wellbeing to unprecedented levels. Yet they are responsible for a cascade of unintentional and damaging consequences. These range from direct impacts on the atmosphere and ocean, through melting ice, to disrupting ecosystems, water supplies and agriculture. The effects are global. They touch every one of us. In an already troubled world, they are a 'threat multiplier', driving social instability, human migration and conflict.

There is an irony. The size of the energy imbalance is an order of magnitude greater than its cause - the energy generated from burning carbon-based fuels. Yet it is tiny compared with the total incoming solar energy. This exceeds current human use ten thousand fold. It is an opportunity to be tapped. Who wouldn't wish to live in a world powered by clean, free and limitless energy? And the costs of utilising it are plummeting. In many instances wind and solar power are already cheaper than fossil fuels. This is despite the fact that subsidies to coal, oil and gas exceed those to renewables by as much as a factor of 38.

We are confronted with the ultimate risk management challenge. The threats cost less to prevent than to deal with. And studies of past climates reveal the possibility of sudden and severe surprises. We need to act with urgency and scale to 'Avoid the Unmanageable and Manage the Unavoidable'.

There is some good news. In December 2015 in Paris the leaders of 195 nations agreed to limit the warming of the planet to 'well below 2oC relative to pre-industrial levels' and 'to pursue efforts to limit the warming to 1.5oC'. In doing so, they committed to achieving what has been called the 'Greatest Collective Action in History'. The emissions reductions pledges they made are insufficient. But initiatives are under way to increase ambition and delivery. These include Mission Innovation, a collaboration by 22 nations and private investors to drive down the costs of renewables and raise finance so as to achieve a massive acceleration of their roll out.

They also include the actions of the C40 group of Mayors of major cities, who are seeking to lower emissions, build resilience against climate impacts, and improve the quality of their residents' lives.

Governments are acting too. China has committed to achieving 1000GW – or 20% - of non-fossil fuels in its energy mix by 2030. This is equivalent to the entire base load generating capacity of the USA. India aims to provide solar electricity to 300 million of its citizens who have no access to power at the present. And the UK Climate Change Act, the world's first long-term, legally binding national framework for reducing emissions, has been successful in keeping the UK on track to cutting its emissions by 80% by 2050. UK production-based emissions are already 40% lower relative to 1990, whilst the economy has increased in size by over 60%.

We are in a race against time. If we are to meet the Paris commitments there is a limit on how much more fossil fuel carbon we can burn. At current rates we will exhaust the remaining budget within 30 years. The rest we must leave in the ground. In addition we must draw down and sequester carbon dioxide from the atmosphere on a massive scale. As yet, no-one knows how to do this.

What if we fail?

Warming could exceed 4oC by 2100, and be double that in the Arctic. A 4oC world would be one of unprecedented heatwaves, severe drought and major floods in many regions, with serious impacts on infrastructure, ecosystems, food and water supplies. Coastlines would be inundated. No nation or elite would be immune to that level of climate change.

We are confronted with the ultimate risk management challenge. The threats cost less to prevent than to deal with.

Recent assessments suggest that, with optimistic assumptions, it is still just possible to meet the Paris limits. But the increase in scale and pace necessary to do so is unprecedented. How we respond will determine the future of the climate system for thousands of years. It will define our balance with the planet. That isn't an issue of science, economics and politics; it's an issue of moral identity.

What sort of people are we?

For the sake of our children, grandchildren, and all future generations, NOW is the time to rise and act.

