Department for Business, Energy & Industrial Strategy

ofgem Making a positive difference for energy consumers

Transitioning to a net zero energy system

Smart Systems and Flexibility Plan 2021

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Ministerial foreword

The government recently announced its intention to set in law a world-leading climate change target, which will require significant effort across all sectors of our economy. Capitalising on innovative, low carbon technologies will be critical to achieving this.

The government is committed to leading the way in the transformation of our energy system. A smarter, more flexible system will utilise technologies such as energy storage and flexible demand to integrate high volumes of low carbon power, heat and transport and reach a carbon neutral future.

A smart and flexible energy system can deliver significant benefits for consumers, the system and the wider economy whilst lowering carbon emissions. As we build back better from the pandemic, taking advantage of opportunities to create jobs and help protect the planet is of paramount importance.

The Rt Hon Anne-Marie Trevelyan MP

Minister of State for Business, Energy and Clean Growth

Ofgem CEO foreword

A smart and flexible energy system is essential to hitting the UK's net zero climate goal while keeping energy bills affordable for everyone. This plan is an important step in transforming not just how we generate energy but also how we all use and pay for it.

As we change the way we fuel our cars and heat our homes, demand for electricity will increase from millions of new electric vehicles and heat pumps. Being more flexible in when we use electricity will help avoid the need to build new generating and grid capacity to meet this demand, resulting in significant savings on energy bills.

Consumers will be able to play an active role, taking up new tariffs and smart appliances like smart electric vehicle chargers so they can save money by using electricity at cheaper times. Ofgem will work together with government and industry, to help consumers make the changes needed. Innovative markets, products and services will help ensure the transition to net zero is affordable, fair and inclusive to all.

Jonathan Brearley

Chief Executive, Office of Gas and Electricity Markets

Executive Summary

Rapid, exciting, and fundamental change is happening across our energy system. We are on the cusp of a global Green Industrial Revolution.

In April, the UK government announced a world-leading climate change target (the sixth Carbon Budget) to reduce emissions by 78% by 2035 compared to 1990 levels, on a pathway to net zero greenhouse emissions by 2050. Our success in achieving this will rest on a decisive shift away from unabated fossil fuels to using clean energy. It will require harnessing energy from low carbon sources such as the sun and wind, to power our homes, businesses and vehicles. The government has already set out ambitious goals, including building 40GW of offshore wind by 2030, ending sales of petrol and diesel cars by 2030, and deploying 600,000 electric heat pumps per year by 2028 to replace fossil fuelled heating systems. All these technologies will need to be seamlessly integrated onto our energy system so that low carbon power is available in the right places and at the right times to meet our energy needs.

This Plan, a joint publication by the government and Ofgem, the energy regulator, sets out a vision, analysis and work programme for delivering a smart and flexible electricity system that will underpin our energy security and the transition to net zero. This system will need significant levels of flexibility and utilisation of smart technologies so that it can be almost entirely run on low carbon energy sources. Consumers will be able to shift demand to times of day when electricity is cheaper and more abundant. Variable renewable power will be stored for when it is needed. We will import power from other countries when they have more available electricity than we do – and vice versa. This flexibility will be facilitated by regulatory and market reform, investment in innovation, and system digitalisation. Each chapter of this Plan sets out a vision, and a series of actions, to deliver a smart and flexible energy system (for a full list of actions, see **Annex 1: Full list of actions**). Alongside this Plan, we have published the UK's first Energy Digitalisation Strategy, as digitalisation is an essential requirement for realising a smart and flexible energy system.

The transition to a smarter and more flexible energy system is an opportunity. It will be delivered by UK businesses and will benefit consumers across the country. It will reduce the costs of our system by up to £10bn a year by 2050, by reducing the amount of generation and network we need to build to meet peak demand. It will create jobs, perhaps 24,000 by 2050, and drive investment across the UK. The UK is a global leader in smart systems and there is significant export potential for the solutions that we will need to deploy at home. As nations confront the challenge of climate change, markets for new green products and services will spring up round the world. Taking action now will help position UK companies and our world class research base to seize the business opportunities which flow from it, creating jobs and wealth for our country.

We need to move quickly. It will be very difficult to achieve the deep power sector decarbonisation needed to achieve the sixth Carbon Budget without significantly higher levels of system flexibility. The need for flexibility will rapidly increase as variable renewable power replaces fossil fuel sources, and we electrify heat and transport. The illustrative scenarios in our analysis indicate the scale of deployment that could be needed. Around 30GW of total low carbon flexible capacity in 2030, and 60GW in 2050, may be needed to maintain energy security and cost-effectively integrate high levels of renewable generation. While these

scenarios are just examples of many possible pathways for the electricity system, we expect the requirement for low carbon flexibility to be significant in all decarbonisation pathways, with substantial increases in deployment needed from the 10GW of low carbon flexibility on the system today. If we do not achieve this, we risk having to build more fossil fuel generation instead, in order to maintain energy security in the 2030s.

This Plan has been developed in close co-ordination with the sector. Over the course of 2020 and early 2021, we carried out extensive stakeholder engagement to understand the barriers to a smart and flexible energy system, and we are extremely grateful for the levels of engagement we received from experts across the sector who generously gave their time and expertise, despite the difficulties faced due to COVID-19.

The **Introduction** explains what a smart energy system is, the benefits it will bring, and analysis on how much flexibility is required to meet our decarbonisation targets (this analysis is set out in greater detail in Appendix I). It also sets out our approach to driving flexibility, the scope of this plan, and includes actions on the cross-cutting areas of skills and innovation. Following the introduction we briefly consider **future thinking on the electricity market**, including areas beyond the scope of this Plan.

Chapter 1: Facilitating flexibility from consumers explores how to support consumers to provide flexibility to the system and reduce their energy bills: deployment and use of smart technologies, removing barriers to the provision of consumer flexibility services, appropriate regulation for flexibility service providers, protecting consumers in a smart energy system, and embedding cyber security. This chapter also sets out actions to drive flexibility in buildings and smart electric vehicles and considers how to facilitate local flexibility solutions.

Chapter 2: Removing barriers to flexibility on the grid: electricity storage and interconnection sets out how we will address policy and regulatory barriers facing electricity storage, in particular smaller and larger scale solutions. The chapter also explores the changes needed to support increased levels of interconnection capacity and how to facilitate efficient and flexible access to cross-border markets.

Chapter 3: Reforming markets to reward flexibility explores how electricity market arrangements can unlock the full benefits of flexibility and how we are driving forward improvements to these markets and signals. It considers national and local flexibility markets, the Contracts for Difference scheme, and the Capacity Market. This chapter also explores coordination between markets at all levels of the system and the carbon intensity of flexibility markets and services.

Chapter 4: Digitalising the system highlights the importance of data and digitalisation in managing the transition to a smarter and flexible energy system. More detail and a suite of actions can be found in the Energy Digitalisation Strategy which we are publishing alongside this Plan.

Chapter 5: Delivering this plan sets out how we will track progress towards delivering the actions in this Plan and explains how we will monitor flexibility with a robust and systematic monitoring framework (more detail on this is set out in Appendix II).

Annex 1 provides a full list of the actions set out across the document.

Appendix I: Electricity System Flexibility Modelling sets out our analysis of the impact of low carbon flexibility in a decarbonised electricity system. This assessment builds on the analysis published with the Energy White Paper.

Appendix II: Smart Systems and Flexibility Plan – Monitoring Framework is the first iteration of our smart monitoring report. It describes the data we have collected and our assessment of how flexibility is developing in the system. The initial report provides the baseline for future monitoring to be assessed against.

This Plan is an important part of the government's forthcoming Net Zero Strategy and Energy White Paper, and a core component of Ofgem's Forward Work Plan and future-facing work to enable the energy system transition. It is supported by the government's significant increase in public research and innovation spending, including on smart systems and storage technologies. It builds on the government and Ofgem's joint 2017 Smart Systems and Flexibility Plan and 2018 Progress Update.

This Plan represents the next phase in smart systems policy. It certainly won't be the last. We will continue to work closely with the energy sector and beyond, to identify barriers to a smart and flexible energy system, adapting our approach as necessary, and implementing new policies as appropriate.

Introduction

Since the industrial revolution, fossil fuels have dominated energy, whether it is oil in our vehicles to transport us, gas in our homes to keep us warm or coal in our power to energise our economy. However, due to the threat of catastrophic climate change, we need to rapidly shift away from fossil fuels to cleaner forms of energy. For the energy sector, this means generating energy from low carbon sources such as solar and wind power and hydrogen, and electrifying much of our energy demand, for example shifting to electric transport and heat.

In April, the UK government announced a world-leading climate change target (the sixth Carbon Budget) to reduce emissions by 78% by 2035 compared to 1990 levels, on a pathway to net zero greenhouse emissions by 2050. We have made considerable progress, reducing greenhouse gas emissions by over 40% between 1990 and 2019[1] while growing the economy by almost 80%,[2] the fastest rate in the G7. In 2020, around 60% of our electricity generation was from low carbon sources.[3] However, there is much more to do, and progress needs to accelerate.

The 2020 Energy White Paper and the Prime Minister's Ten Point Plan for a Green Industrial Revolution set out a strategy that transforms energy, supports a green recovery, and creates a fair deal for consumers. The UK has committed to building 40GW of offshore wind by 2030.[4] From 2030, the UK will end the sale of new petrol and diesel cars and vans, and from 2035 all new cars and vans will be zero emission at the tailpipe. The Government has set an ambition of installing 600,000 heat pumps per year by 2028.

This means that significant volumes of additional generation and demand will be added to our electricity system over the next few decades, and we will need major upgrades to our energy networks to transport the generation to consumers. This generation will increasingly be variable, dependent on the time of day, season, and prevalent weather conditions. Electricity demand will increase as heat and transport are electrified – potentially doubling by 2050.[5] Without action, this demand will often be 'peaky' – with households simultaneously switching on their heating systems when it gets cold and charging their electric vehicles when they get home from work. We need to ensure that these new technologies are integrated onto the system whilst maintaining the balance of electricity supply and demand and minimising the amount of generation and network needed to meet our demand needs. That requires a smart, flexible energy system.

This Smart Systems and Flexibility Plan ('the Plan') sets out how we will facilitate the transition to a smarter and more flexible energy system. It is supported by the Government's significant increase in public research and innovation spending. And it will be driven by innovative UK

[1] BEIS (2021), Greenhouse Gas Emission National Statistics, https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-national-statistics-1990-to-2019
[2] ONS (2021), GDP Quarterly National Accounts, https://www.ons.gov.uk/economy/grossdomesticproductgdp
[3] BEIS (2020), Energy Trends table 5.1, https://www.gov.uk/government/statistics/electricity-section-5-energy-trends
[4] BEIS (2020), Energy White Paper, https://www.gov.uk/government/publications/energy-white-paper-powering-our-net-zero-future
[5] BEIS (2020), Energy White Paper (page 42), https://www.gov.uk/government/publications/energy-white-paper-powering-our-net-zero-future

companies and our world class research base to seize the business opportunities which flow from it, creating jobs and wealth for our country.

What is a smart, flexible energy system?

A smart, flexible energy system reduces consumer energy bills by reducing the amount of generation and network assets that need to be built to meet peak demand. It gives consumers greater control over their energy bills, through access to smart technologies and services. It facilitates the integration of local solutions for low carbon power, heat and transport. It will create jobs and spur investment in UK companies. Smart systems and flexibility is a critical area for decarbonisation across the world, and an area of UK leadership and expertise, so there is significant potential for export abroad.

Smart means the ability of a device to respond in real time to communication signals, using digital technologies, to deliver a service.

Flexibility is the ability to shift in time or location the consumption or generation of energy.

A smart and flexible system is one which uses smart technologies to provide flexibility to the system, to balance supply and demand and manage constraints on the network.

To date, much of the flexibility that balances and provides stability to our system has been provided by fossil fuels, as we turn up or turn down coal or gas fired power stations. In the future we need an energy system that matches new sources of demand to renewable generation – both nationally and locally – by using low carbon flexibility across the system. Low carbon flexibility can be provided by different technologies:

- **Electricity storage:** Storing low carbon energy for when it is needed, for example in batteries on the wall of your home or business, or in facilities that pump water to higher reservoirs when electricity is abundant, and let it flow back down through a turbine when it is scarce. Electric vehicles with ‘vehicle-to-grid’ capability can also sell electricity back to the grid.
- **Flexible demand:** Shifting demand away from periods when it is scarce to when it is more abundant, cheaper and cleaner. For example, charging your electric vehicle at night when there is lower demand on the local network, or using your dishwasher during the day when there is lots of solar on the system. Some commercial buildings (e.g. factories and supermarkets) also do this, to take advantage of lower off-peak electricity costs. In future, this could include producing hydrogen through electrolysis at off-peak times.
- **Flexible generation:** Low carbon ‘peaking’ plants, for example biomass boilers or gas plants with carbon capture and storage, which can generate electricity at short notice. In future this could include burning hydrogen in turbines. Low carbon intermittent generation such as solar and wind can also provide flexibility.

- **Smart grids and interconnection with other countries:** Shifting electricity across grids and between countries to where it is needed. This allows differences in weather patterns to be levelled out across large areas, for example importing electricity from Europe when it is windy there, and vice versa.

Analysis: the role of flexibility in a net zero system

We used the BEIS model of the electricity sector, the Dynamic Dispatch Model to explore the cost of the future electricity system under a range of different flexibility assumptions.[6] This builds on the modelling work published with the Energy White Paper.[7] The objective of the analysis was to understand the role and value of flexibility in a decarbonised power sector, as well as identifying the amount and type of flexibility needed in that system.

The scenarios used in this analysis are just examples of many different possible pathways for the electricity system and should be treated as illustrative. Pathways will continually be developed in light of the Climate Change Committee's advice, changes in technology and wider market developments.

This analysis was completed prior to announcements on the UK's sixth Carbon Budget (2033 to 2037). Although the scenarios do not consider the impact of these decisions, they are still based on significant decarbonisation in the 2030s and therefore the strategic conclusions from this analysis remain relevant. We would expect faster or deeper decarbonisation to bring forward the need for flexibility, though we do not anticipate that the level of flexibility required by 2030 to be dramatically higher than the level set out here.

We modelled flexibility from short-term storage, flexible demand and interconnection. We also tested the impact of hydrogen-fired generation and the extent to which it could replace unabated gas-fired peaking generation. We have not explicitly modelled long-duration storage,[8] or the role that flexibility could play in managing local network constraints.[9]

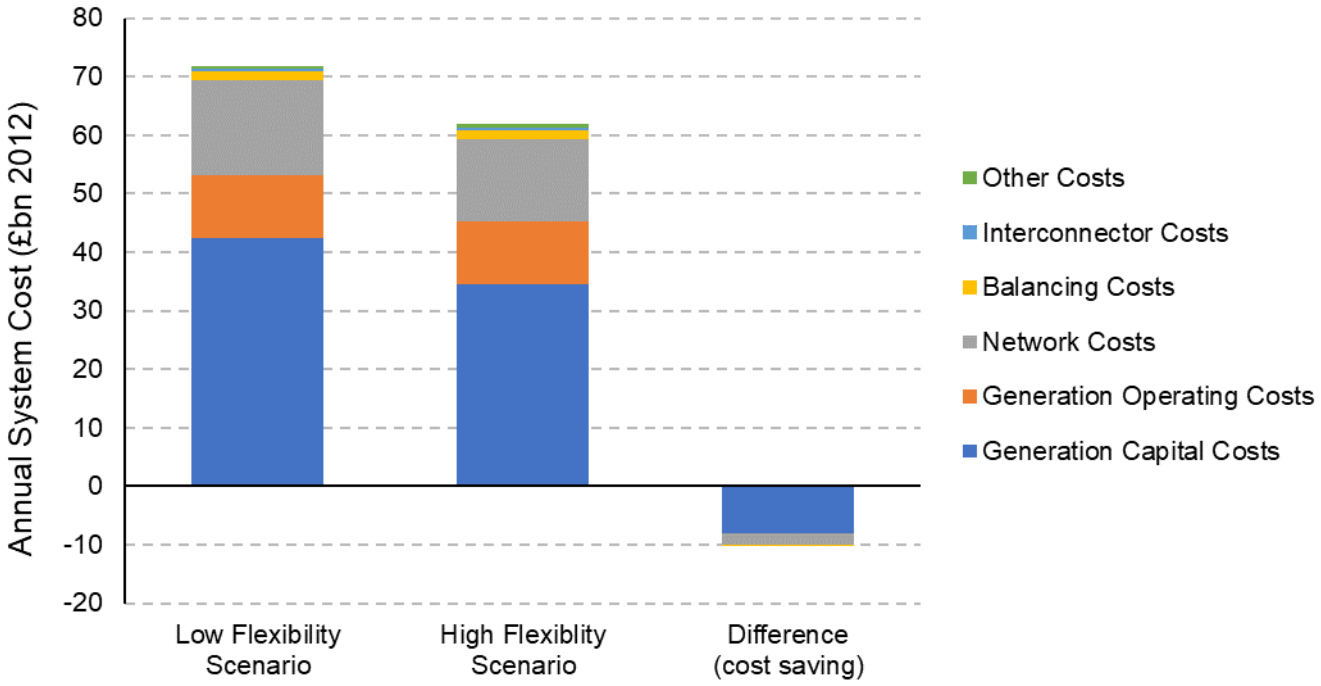
Our modelling shows that increased flexibility provides significant cost savings in a decarbonised power sector. In the scenarios we tested, increased system flexibility provided system cost reduction of up to **£10bn per year** (2012 prices, undiscounted) **in 2050** at a 5g/kWh emission intensity (see Figure 1).[10] Flexibility provided savings in all scenarios but in

[6] For further background information on the DDM please see: BEIS (2014), Dynamic Dispatch Model (DDM), https://www.gov.uk/government/publications/dynamic-dispatch-model-ddm
[7] BEIS (2020), Modelling 2050: electricity system analysis, https://www.gov.uk/government/publications/modelling-2050-electricity-system-analysis
[8] In our modelling demand side response and storage are limited to intraday transactions.
[9] Analysis includes the network benefits associated with lower peak demand and less installed generation capacity but does not consider the role of flexible technologies in alleviating locational network constraints, which could also provide substantial cost savings.
[10] Biomass with Carbon Capture and Storage (BECCS), which can provide negative emissions, is not considered in this analysis. This is because the amount of biomass that will be available, and the sector in which it is most efficiently used to meet net zero are both uncertain and under review as part of the work to develop a biomass strategy.

scenarios with lower demand, or with hydrogen-fired generation providing an alternative source of flexibility, cost savings were smaller.

We also assessed the cumulative value (from 2020 to 2050) of increased flexibility based on illustrative pathways to net zero. We estimate that increased flexibility could reduce system costs **between £30-70bn** across that period (2012 prices, discounted).

Figure 1: Illustrative system costs in 2050, showing that the system cost in a high flexibility scenario is ~£10bn lower than in a low flexibility scenario



Source: BEIS Analysis, 2012 prices

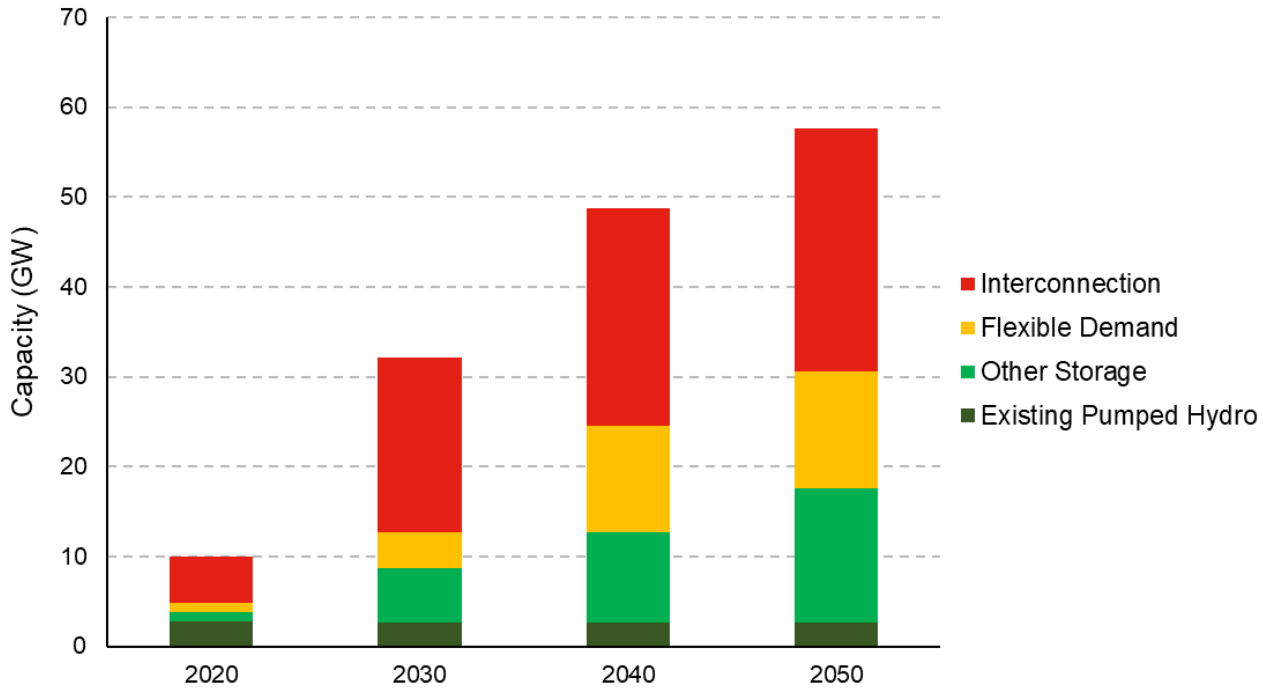
Flexibility is essential for cost-effective integration of renewable generation, while meeting increased demand from electrified heat and transport. The largest system savings are from lower generation capital costs. Flexibility allows for generation and demand to be shifted to avoid curtailment and results in better utilisation of low carbon generation and less overbuilding of capacity. Flexibility also lowers the peak demand on the system, reducing network upgrade costs.

The analysis also considered the scale of low carbon flexibility deployment that could be needed to ensure energy security as we transition to net zero, and the sources that could provide this flexibility. The need for flexibility will rapidly increase as variable renewable power replaces fossil fuel sources, and we electrify heat and transport. We estimate that **when we have 40GW of wind on the system in 2030, we will need around 30GW of low carbon flexible assets** (storage, demand side response and interconnection) to cost-effectively integrate high levels of renewables, which represents a threefold increase on today's levels. Without these low carbon flexibility assets, we risk either inadequate energy security or having to build more unabated gas in the same period. **It will be very difficult to achieve the deep power sector decarbonisation needed to achieve the sixth Carbon Budget without significantly higher levels of system flexibility.**

By 2050, our illustrative scenarios indicate that we will need around 60GW of total flexible capacity, with around 30GW of combined short-term storage and demand side response (DSR) and 27GW of interconnection leading to the lowest system cost.[11] The analysis indicated that short-term storage and DSR were broadly substitutable. In our scenarios we assume 15GW of each technology, but other combinations would likely lead to similar outcomes.

In our analysis new storage assets are assumed to be 4-hour duration (resulting in 60GWh storage capacity in 2050) and operate predominately in wholesale and balancing markets. In practice a range of different storage assets will be needed, with storage also likely to be deployed to provide a range of grid services and help alleviate local network constraints. If shorter duration assets (<4 hours) were deployed a greater power capacity (GW) would be required to reach the same storage capacity (GWh). We have not explicitly modelled longer-duration storage (see Chapter 2 | Removing barriers to flexibility on the grid: electricity storage and interconnection for more information on this), but analysis demonstrated that moderate levels of low carbon hydrogen could reduce system costs and we expect that longer-duration storage would have similar impacts.

Figure 2: Illustrative deployment of flexible technologies (high flexibility, high demand scenario)[12]



An integrated energy system with flexibility provided across power, heat and transport will be important to minimise costs. There is substantial potential for flexibility from smart charging of electric vehicles, flexible use of heat pumps, and hydrogen-fired generation in power. The

[11] DSR capacity is measured by the reduction in annual peak demand.
[12] 'Other storage' includes existing battery projects and new deployments. All new storage assets are assumed to be 4-hour duration and could be a range of technologies including new battery and pumped hydro projects.

analysis indicates that sources of short-term flexibility, particularly short-term storage and DSR, are broadly substitutable. Further details on our electricity system modelling, included the methodology and assumptions underlying the results are included Appendix I.

Journey so far

This Plan builds on previous joint publications between Government and Ofgem on smart systems and flexibility. Our 2017 Smart Systems and Flexibility Plan outlined 29 actions for government, Ofgem and industry to take to deliver a smarter, more flexible energy system. In 2018 we provided an update on progress against the actions in the Plan since its publication; this update also set out 9 new actions. These documents were the first steps in unlocking barriers to flexibility. To date, we have implemented 29 of the 38 actions across these two publications. The rest are on track to be delivered by the end of 2022 and we have included updated versions of these actions in this new Plan.

This Plan is the next phase in smart systems and flexibility policy and is the first major publication on this area since the government passed legislation requiring the UK to meet net zero carbon emissions by 2050. Over the course of 2020 and the first part of 2021 we carried out extensive stakeholder engagement to understand the barriers to a smart and flexible energy system, and actions to resolve them, which form the basis of this Plan. We are extremely grateful for the levels of engagement we received from experts across the sector who generously gave their time, insight and expertise, despite the difficulties faced due to COVID-19.

Our approach to driving flexibility across the system

This Plan sets out to drive smart systems and flexibility, based on the current energy market framework. We recognise that wider reforms to our market frameworks may be needed to drive decarbonisation beyond the 2020s (see Future thinking on the electricity market section at the end of this Introduction) and we will continue to discuss this with industry following publication of this Plan. In the meantime, it is essential that we maintain momentum in delivering flexibility.

Whilst we have considered multiple sectors when developing this Plan, it is necessarily focused on facilitating electrification of the energy system. In the runup to COP26, the government is bringing forward a series of sectoral strategies, including a Heat and Buildings Strategy, a Transport Decarbonisation Plan, a Hydrogen Strategy and an overarching Net Zero Strategy, which will set out more detail on how we will meet our net zero target and ambitious carbon budgets.

The system is constantly evolving, and so our measures to facilitate smart systems and flexibility will need to be adjusted frequently. To do this we are focusing on actions that remove barriers, facilitate change and spur innovation to allow the industry to evolve to respond to the needs of our future energy system. Following publication, we will continue to work closely with industry to identify and address barriers to a smart system. We will continually adapt our approach, as necessary.

Our visions for a smart, flexible energy system

Each of our four core policy chapters – on flexibility from consumers, flexibility on the grid, flexibility markets and digitalising the system – begin with a vision. Each vision is split into:

- what we aim to have achieved **by the mid-2020s**, for which we can have more confidence, and
- what we envisage needing **by 2030 and beyond**.

This Plan sets out broad areas of focus, and (where we have more certainty) specific actions, to lead us towards our visions. In many cases, further detailed policy development will be needed. It is likely that new evidence and opportunities will arise that indicate we need to do more in certain areas, which will be assisted by the development of our flexibility monitoring framework (see Chapter 5 | Delivering this Plan). As and when this happens, we will adapt our approach.

Maintaining energy security

The energy system must change substantially to meet net zero, and new patterns of generation and demand will impact how we deliver electricity security. Maintaining and delivering electricity security while meeting our decarbonisation targets will require a whole system approach. We are already undertaking a number of actions to support this aim, including significantly increasing levels of low carbon flexibility which will be essential.

Maintaining electricity security throughout this period will require ensuring there is both adequate capacity in the system to meet demand but also that the Electricity System Operator can find new ways to maintain the stability of the system as it decarbonises. Low carbon flexible technologies will be a key part of the Electricity System Operator's toolkit. Whilst increased demand is expected to be largely met by the deployment of additional low carbon generation, it is likely that some unabated gas will continue to play an important role in both meeting peak demand and providing system services, such as inertia and frequency management. However, it will be vital to bring on low carbon alternatives to unabated gas generation and ensure new gas power plants can convert to hydrogen or carbon capture, utilisation and storage as these technologies become available. Timely investment in networks to manage constraints will also be essential.

Wider economic benefits, skills and the supply chain

The transformation to a green economy will need to be delivered by a skilled workforce. The Prime Minister's Ten Point Plan mobilises £12 billion of government investment, and potentially three times as much from the private sector, to create and support up to 250,000 green jobs including those in the smart energy sector, all over the country.[13] The government will help people train for these new green jobs through our Lifetime Skills Guarantee.[14]

[13] BEIS, Prime Minister's Office, 10 Downing Street (2020), The Ten Point Plan for a Green Industrial Revolution, https://www.gov.uk/government/publications/the-ten-point-plan-for-a-green-industrial-revolution
[14] HM Treasury (2021), Build Back Better: our plan for growth, https://www.gov.uk/government/publications/build-back-better-our-plan-for-growth

By 2050 the domestic market for smart systems and flexibility solutions could be worth as much as £1.3 billion per year to GDP and create around 10,000 jobs.[15] These jobs cover a wide variety of sectors including installers, electricians, data scientists and engineers. These jobs are nationwide.

The UK is a world leader in the technology and science behind smart systems. As we build UK expertise to deliver our domestic objectives, we help position UK companies to seize the significant export opportunities arising from the global transition. The export potential in 2050 could be worth as much as £2.7 billion per year to the UK economy and create 14,000 jobs.[16] By driving forward UK action now through the policies in this Plan, we can build companies that can win a large share of these new global markets in the future.

The Green Jobs Taskforce, consisting of representatives from business, skills providers, and unions, delivered its independent report in July 2021. The report contained recommendations for how government, industry, the education sector alongside other stakeholders can work together to grasp the opportunities of a green industrial revolution and meet the challenges of supporting high carbon sectors, their workers, and the communities they support through the transition to net zero. The government will now consider the Taskforce's recommendations and our response, starting with the Net Zero Strategy later in the year.

The Smart Systems and Flexibility sector is dynamic and changing fast, and it needs a high-quality skilled workforce. To understand the skills and jobs landscape, we will undertake a smart skills gap analysis. This will allow us to understand which skills and qualification levels are required to grow the smart and flexible energy sector and provide good green jobs across the country. We will feed this into our broader considerations on jobs and skills, to help build the pathways from education to industry for the smart energy sector.

Investing in innovation

Innovation is crucial to decarbonising sources of energy and in transforming the UK energy system to meet carbon reduction targets and achieve our net zero ambitions. It brings costs down, enables us to preserve and develop options, brings forward information to reduce future uncertainty, and develops new markets to enable technologies to deliver benefits to the system and consumers. Innovation creates value by accelerating the commercialisation of key technologies which could significantly reduce the cost of meeting net zero, while generating positive economic impacts for the UK.

This is what the £1bn Net Zero Innovation Portfolio (NZIP) intends to do. The NZIP aims to accelerate the commercialisation of low-carbon technologies, systems and business models in power, buildings, and industry, and builds off the BEIS Energy Innovation Programme which ran from 2015-2021. Energy storage and flexibility is one of the priority areas under the £1bn portfolio, with at least £100 million of innovation funding. In March the government announced further details of a £68 million competition to support first-of-a-kind longer duration energy storage; and, the first phase of the Alternative Energy Markets programme which will explore

[15] BEIS (2019), Energy Innovation Needs Assessment, https://www.gov.uk/government/publications/energy-innovation-needs-assessments
[16] BEIS (2019), Energy Innovation Needs Assessment, https://www.gov.uk/government/publications/energy-innovation-needs-assessments

how a real-world testing environment for potential reforms to upstream energy price signals could affect the behaviour of both energy suppliers and consumers.

Ofgem's strategic innovation fund will make available £450m over the duration of the RIIO-2 price control.[17] The focus of the fund is to deliver network innovation that will support the attainment of net zero, including cross-sector initiatives. Flexibility, smart systems and energy storage are all in scope for this fund. Key priority areas of flexibility innovation will be to test and develop new system planning and operational approaches and low carbon alternatives to network build.

Our actions

I. The Green Jobs Taskforce published its recommendations in Summer 2021 which the government will consider ahead of publishing the Net Zero Strategy later this year. To support the outcomes of this work, we will undertake a smart skills gap analysis in 2021. This will inform our approach to closing the skills gap going forward.

II. The government will drive forward innovation through the £1bn NZIP to provide funding for low-carbon technologies and systems. This includes at least £100 million of innovation funding towards Energy Storage and Flexibility innovation programmes.

[17] For electricity distribution this is 2023-28, for electricity transmission 2021-26.

Future thinking on the electricity market

Achieving our net zero target by 2050 will require a significant transformation to many sectors of the economy, not least energy. This Plan sets out key reforms within our current market structures, to accelerate deployment of low carbon flexibility during the 2020s, to meet the demands of a system with significant volumes of renewables, electric vehicles and electric heat.

However, over time some of the fundamental characteristics of our energy system will change. We will shift to a system dominated by zero marginal cost fuels (the wind and sun), where prices to generate are frequently very low (for example when there are periods of high wind and low demand), and where actions by consumers to shift demand patterns are as essential as investing in new generation or network assets. All this while ensuring we have the capacity and operational tools to maintain security of supply in a very different electricity system.

Significant progress towards net zero can happen, and is already happening, within our existing market framework which combines a number of merchant markets for wholesale power, capacity, balancing and ancillary services with a Contracts for Difference scheme (CfD) for low carbon generation. However, it will be necessary to consider whether broader reforms to our market frameworks are needed to ensure that the merchant markets are genuinely open and effective. It is essential that market structures are designed to unlock the full potential of low-carbon technologies to take us all the way to net zero. We will also need to keep the CfD under review. While ensuring it remains an effective mechanism for supporting investment we will also consider its adaptation to incorporate greater merchant signals, as well as considering whether in the future there may be circumstances when the CfD is no longer a necessary investment incentive.

The government's recent call for evidence on the future of the Contracts for Difference scheme sought views on how to drive decarbonisation efficiently in the power sector, alongside the need to ensure continued investment to meet the delivery challenge of rapid low-carbon deployment. This has been complemented by a consultation on the future governance of the system and a forthcoming consultation on the UK emissions trading scheme that seek to clarify how a net zero system should be run and the role of carbon pricing in getting us there respectively, as well as a forthcoming call for evidence gathering stakeholder views on the longer-term future of the Capacity Market in the context of net zero. Ofgem and Government are working closely on these questions, and Ofgem's work on Full Chain Flexibility and Access and Forward-Looking Charging are key pillars of a strategic approach to markets. Our actions in this Plan (and the accompanying Energy Digitalisation Strategy) are intended to work both for current arrangements, and to facilitate broader change, should that be needed.

There are key questions that will need to be answered to determine the best approach to future market reform. Some illustrative examples are below:

- How to ensure long-term investment signals are provided to build the infrastructure we will need to meet our low-carbon objectives and maintain security of supply, and whether existing schemes and market signals are sufficient or need to be adapted.
- How to ensure the energy market rewards supply and demand equally for their contribution to balancing the system – for example building new generation vs installing energy efficiency solutions.
- How to develop more granular locational signals, to optimise assets across the network and incentivise consumers to use technology to manage their energy demand, and whether to seek these signals through further changes to the network charging regime and the continued development of local flexibility markets, or a more fundamental shift to regional or locational pricing.
- How to harness the benefits of closer to real-time signals in the wholesale market, including shorter gate closure and settlement periods, so that a broader range of actions can be taken to help manage the system.
- How the energy retail market can deliver innovative tariffs and products that work for consumers and contribute to net zero, and whether the existing retail market framework enables this.

These questions have implications far beyond smart systems and flexibility policy and cannot be answered in isolation. These questions could also have impacts on the governance arrangements underpinning our energy system (see Chapter 3 | Reforming markets to reward flexibility). We welcome the excellent work that has been undertaken by the sector already on future market design but note there are a wide range of external views on the best way to tackle the challenge of net zero markets, from fundamental reform to more ambition through existing mechanisms. Any future decisions will shape how markets operate in a crucial period for clean energy policy, and any major changes would necessarily come with significant transitional costs, therefore it is important we gather a wide range of evidence before deciding whether major structural reforms are needed – they may not be.

The government and Ofgem will consider the need for wider change in a balanced and holistic way. We will consider how our policies should continue to evolve, develop our approach as appropriate, and seek further views from stakeholders in due course.

Chapter 1 | Facilitating flexibility from consumers

Vision

In the mid-2020s consumers of all sizes will be able to provide flexibility to the system, supported by the right infrastructure and regulatory framework. The market for flexibility from large consumers will have matured, with increased and sustained participation from a wide range of industrial, commercial and public sector consumers. At the smaller customer scale, we will have reached market-wide rollout of smart meters to domestic and smaller non-domestic consumers across Great Britain. Consumers will be able to choose from a greater choice of innovative products like smart tariffs, as half-hourly settlement is implemented. Consumers will have access to a wide range of interoperable and secure smart appliances, and many will be rewarded for participating in demand side response. With rapidly rising numbers of electric vehicles, drivers will choose to smart charge because it is convenient and economical. Vehicle-to-grid technology will be close to becoming a commercial reality for fleet operators. Smart technologies will be incorporated across the government's energy efficiency, heat and fuel poverty policies. Consumers of all kinds (including those on low income and in vulnerable circumstances) will have the opportunity to choose and benefit from smart energy products and services, while those who do not participate will still receive fair and affordable outcomes.

By 2030 and beyond consumers will be providing significant flexibility to the system (potentially around 13GW in combination with intraday storage[18]), with the domestic sector expanding rapidly as low carbon heating deployment increases and drivers choose electric vehicles. Consumer flexibility will be normalised, with "energy smart" products and services commonplace. A culture of cyber security will be embedded across the smart and flexible energy system, supporting the resilience of the network and bolstering consumer confidence. It is expected that there will be over 15 million electric vehicles on the road by 2030,[19] and it will be the norm for drivers to use smart charging. Deeper integration between electric vehicles and the electricity system will be achieved by way of vehicle-to-grid technologies. Flexibility providers will have offers to cater for all levels of consumer engagement, with consumers in charge and able to choose how dynamic their participation should be. The consumer, system, and environmental benefits of consumer flexibility will be well established in the public consciousness. Localised low carbon solutions are optimised across power, heat and transport systems bringing positive outcomes for consumers, communities and the country as a whole.

[18] Based on illustrative scenarios – see analysis section in the Introduction
[19] Climate Change Committee (2021), The Sixth Carbon Budget, Surface Transport, https://www.theccc.org.uk/wp-content/uploads/2020/12/Sector-summary-Surface-transport.pdf

Why this area is important

A smart and flexible energy system will empower consumers. Smart meters, technologies, tariffs and services will enable consumers to change their consumption patterns to match times of cheap and abundant low carbon electricity, give consumers greater control over their energy use and comfort levels and save money by helping to balance the energy system. This is known as demand side response (DSR). These services will often be automated and programmed to meet consumer needs – for example, charging an electric vehicle overnight when prices are cheaper, so that it is ready for the commute to work, or storing cheaper renewable energy in a battery and using it to keep a home warm during pricier peak periods. As we set out later in our Chapter 3 | Reforming markets to reward flexibility chapter, flexibility markets and more cost reflective price signals will motivate system participants to change behaviour and optimise their impact on the system - from individual domestic and business consumers, up to network companies and generators.

These actions will become increasingly important and beneficial to consumers, as electricity demand rises due to the electrification of transport, heat and industrial processes. Consumer flexibility will help reduce the amount of generation and network capacity needed to address this additional demand and meet net zero targets. This, in turn, will reduce costs for all consumers. Consumer flexibility is one of the most cost-effective ways of reducing carbon emissions, as it will often be lower cost than building additional generation and provides large benefits to the energy system.[20] Similarly, recent modelling by the Carbon Trust and Imperial College London showed that a system that deployed flexibility, but without demand side flexibility, could cost around £5bn more per annum in 2050.[21]

To enable flexibility from consumers, they will need to have access to “energy smart” appliances that make it easier to change their consumption patterns, and tariffs and services that incentivise this change, including stronger price signals. Consumers need to have the technology and understanding to respond to these opportunities, and the confidence that they will be appropriately protected no matter how they choose to engage. We want consumers of all sizes and types to be able to engage in flexibility, so we need to ensure that participation leads to fair outcomes and that all consumers benefit from the opportunities available.

Case study: Flexibility from district heating (Flexitricity)

Flexitricity is proving the critical role district heating can play in balancing both transmission and distribution electricity grids, working with Gateshead District Energy Scheme and ThamesWey Central Milton Keynes.

Gateshead District Energy Scheme is a low-carbon energy centre owned by Gateshead Council, which provides low-cost heat and power to homes and businesses. The innovative

[20] Analysis by Frontier Economics. Recosting Energy – Powering for the Future Report (2020), http://www.challenging-ideas.com/wp-content/uploads/2021/01/ReCosting-Energy-Powering-for-the-Future.pdf (page 40)
[21] Carbon Trust and Imperial College London (2021), Flexibility in Great Britain, https://publications.carbontrust.com/flex-gb/analysis/ (page 106)

heat network includes battery energy storage, in addition to a 4MW combined heat and power plant. As Gateshead's energy supplier, Flexitricity's role is to identify flexibility and make it available to the Electricity System Operator, maximising revenue for the site in order to support an affordable energy offer for local customers.

The site made history as the first 'behind-the-meter' generation asset in the balancing mechanism, the real-time electricity market run by the Electricity System Operator, proving the value district heating can provide in balancing electricity supply and demand.

ThamesWey Central Milton Keynes is a 6MW combined heat and power plant that provides flexibility to both the local distribution network (Western Power Distribution) and the national Electricity System Operator. Flexitricity trades the heat network's capacity closer to real-time when it is not scheduled to meet local needs. By enabling flexibility providers to stack revenues from multiple sources, the project is demonstrating how low carbon district heating schemes can be more commercially attractive.

© Gateshead District Energy Council

Where are we now?

Today, industrial and commercial consumers are providing around 1GW of DSR to the system.[22] The market is gradually maturing, bolstered by industry initiatives like the Electricity System Operator's Power Responsive campaign[23] and the Association for Decentralised Energy's 'Flex Assure' code of conduct.[24]

Participation from domestic and smaller non-domestic consumers remains at an early stage. While there are 24.2 million smart and advanced meters in homes and small businesses in Great Britain,[25] there are relatively few smart tariffs available to consumers. The smart appliance market is relatively nascent, although the number of electric vehicles is increasing fast, and this is expected to provide a significant source of flexibility over the next decade and beyond. Implementation of market-wide half-hourly settlement in the mid-2020s will put incentives on energy suppliers and other parties to develop new tariffs and innovations that encourage consumers to shift their consumption to times when cheap, clean electricity is

[22] National Grid ESO (2020), FES 2020, https://www.nationalgrideso.com/future-energy/future-energy-scenarios/
[23] National Grid ESO (2020), Power Responsive programme, http://powerresponsive.com/
[24] The Association for Decentralised Energy, Flex Assure, https://www.flexassure.org/
[25] BEIS (2021), Smart meters in Great Britain, quarterly update March 2021: statistical bulletin, https://www.gov.uk/government/statistics/smart-meters-in-great-britain-quarterly-update-march-2021

plentiful.[26] The British Standards Institution has now published two standards (PAS 1878 and 1879), developed by industry, which set a technical framework for small-scale DSR, guided by the principles of interoperability, data privacy, grid stability and cyber security, and which is compatible with the GB Smart Metering system.[27]

What has been done so far

- The Electricity System Operator has driven engagement on DSR through its Power Responsive campaign, and the Association for Decentralised Energy published a code of conduct for industrial and commercial aggregators to enhance consumer confidence.
- The Crown Commercial Service launched a new framework to enable public sector consumers to access DSR.
- There are now 24.2 million smart and advanced meters in homes and small business in Great Britain and the government has confirmed that a new four-year smart meter policy framework with fixed minimum annual installation targets for energy suppliers will commence on 1 January 2022 to drive the consistent, long-term investment needed to achieve market-wide rollout.
- Ofgem published a full business case and a decision that industry should implement market-wide half-hourly settlement by October 2025.
- The government has taken powers to set regulatory requirements for electric vehicle smart chargepoints, and recently published a response to its 2019 consultation on using these powers.[28]
- The government introduced enhanced functionality to the smart metering system in November 2020, allowing greater precision in controlling loads such as electric vehicle chargepoints through a fully interoperable and end-to-end secure system.[29]
- The government funded the British Standards Institution to develop new technical standards to support the uptake of "energy smart" appliances and to facilitate DSR from smaller consumers.

[26] Electricity suppliers are required to buy enough energy from generators to meet their consumers' needs in each half-hour period, and 'settlement' is the process for determining whether what they bought matched what their customers used. Most domestic and smaller non-domestic consumers are currently settled based on estimates of how much they have used. However, the rollout of smart meters, which record the amount of energy consumed in each half-hour period, means information about customers' actual half-hourly consumption can be used in settlement. This will incentivise suppliers to offer smarter solutions to consumers, such as time-of-use tariffs.
[27] British Standards Institution (2021), Energy Smart Appliances Programme, https://www.bsigroup.com/en-GB/about-bsi/uk-national-standards-body/about-standards/Innovation/energy-smart-appliances-programme/
[28] Department for Transport and the Office for Low Emission Vehicles (2021), Electric vehicle smart charging consultation outcome, https://www.gov.uk/government/consultations/electric-vehicle-smart-charging
[29] BEIS (2019), Response to Consultation on Smart Metering System Proportional Load Control, https://smartenergycodecompany.co.uk/latest-news/beis-response-to-consultation-on-proportional-load-control-and-associated-smets-drafting-new-consultation-on-gbcs-and-chts-drafting/

- The government developed a tool for consumers to compare smart tariffs, and supported development of a framework for embedding flexibility into the SAP methodology that underpins energy efficiency policy.
- The government committed over £11 million towards demonstrations of domestic and non-domestic DSR, nearly £30 million to fund 20 'Vehicle-to-Grid' projects, and funded Project InvoLVe which identified how innovation may help enable low income and vulnerable consumers to participate in a smart energy system.
- The Go Ultra Low campaign launched, providing information about switching to an electric vehicle, including information on tariffs and charging.

We have worked closely with stakeholders to identify four key areas where attention is needed to unlock greater levels of flexibility from consumers.

What we will do

Smart energy technology

We will support the deployment and uptake of smart, digital technologies, to unlock opportunities for more control, choice and flexibility in how consumers use energy. Smart meters are a key enabler for these solutions, for example by enabling more granular measurement of energy usage and facilitating innovative tariffs that encourage use of excess renewable energy at times of low demand. A new four-year smart meter policy framework will commence on 1 January 2022, with fixed minimum annual installation targets for energy suppliers to deliver market-wide rollout.

"Energy smart" appliances can take advantage of cheaper prices and operate flexibly, automatically operating when prices are lower, providing balancing services to the grid and generating revenue for consumers. We will support industry uptake of PAS 1878, a voluntary standard for "energy smart" appliances, to encourage development and deployment of DSR-capable devices. We will take powers, when parliamentary time allows, to regulate energy smart appliances, to set requirements underpinned by the principles of interoperability, data privacy, grid stability and cyber security. We will ensure that our approach is compatible with wider government regulation of consumer connected products.[30]

Electric vehicles will become a large source of flexibility through smart charging. We will mandate minimum device-level requirements for private chargepoints, including smart functionality, to facilitate the opportunity for flexible demand.

For both energy smart appliances and chargepoints, we recognise that these actions are a first step in a nascent market. It is important that our approach is adaptable, supporting the growth of the market and allowing room for new, innovative solutions. We will need to closely monitor

[30] DCMS (2021), Regulating consumer smart product cyber security - government response, https://www.gov.uk/government/publications/regulating-consumer-smart-product-cyber-security-government-response

consumer uptake of smart technologies and engagement with flexibility services. We will work closely with industry to deliver on our core principles of interoperability, data privacy, grid stability and cyber security across the devices and flexibility providers in a smart energy system.

Flexibility providers

We will develop the right regulatory and technical environment for flexibility providers to deliver positive outcomes for consumers and the energy system. Flexibility providers, including aggregators, energy suppliers and electric vehicle chargepoint operators, have an increasingly important role in enabling consumer participation in a smart energy system, offering innovative technologies, services and tariffs, helping consumers manage their energy demand, and providing an intermediary function between consumers and system operators. They bring essential expertise and the ability to bundle DSR from multiple consumers, maximising benefits to the system while making DSR accessible to all.

Half-hourly settlement is a key requirement for the smart tariffs that support flexibility services and is already in place for larger consumers (industrial, commercial, and public sector). We want energy suppliers to offer smart tariffs to smaller consumers (domestic and smaller non-domestic consumers) too. Using smart meters' functionality, half-hourly settlement will unlock smart tariffs and other services which will help incentivise them to participate and benefit from a smart energy system. Ofgem recently set out its expectation for industry to implement market-wide half-hourly settlement by October 2025, and will put in place strong incentives and governance to ensure that implementation happens in a timely and effective manner.[31] Ofgem also published a baseline transition plan that will be reviewed in October 2021. Any proposals to change the length of the transition would need approval through governance arrangements being set up, and Ofgem has proposed that any delay of three months or more would require its approval. Ofgem is also looking at whether there are barriers to using elective half-hourly settlement, what they are, and what could be done to remove them to encourage suppliers to take it up.

Large consumers already participate in DSR, but there is scope for much wider engagement. We will continue to support industry-led initiatives, including the ESO's Power Responsive campaign and the Flex Assure code of conduct established by the Association for Decentralised Energy, to remove technical and cultural barriers to the increased participation of large consumers in DSR. For smaller consumers DSR remains at an earlier stage. The published voluntary technical standard PAS 1879 has helped to establish the technical framework for small-scale DSR, and we will support industry uptake of this standard to deliver DSR solutions that benefit consumers and integrate effectively with the electricity system.

Flexibility service providers are an example of a growing number of organisations that will play a key role in the decarbonisation of energy and transport. Some flexibility services will involve remotely controlling the electrical load of energy smart appliances and other technologies in

[31] Ofgem (2021), Electricity Retail Market-wide Half-hourly Settlement: Decision and Full Business Case, https://www.ofgem.gov.uk/publications-and-updates/electricity-retail-market-wide-half-hourly-settlement-decision-and-full-business-case

response to changes in price or renewable generation. Others will optimise at the local level through home energy management, with systems in place coordinating appliances, home energy storage and generation together to drive efficiency. We encourage industry to develop approaches to deliver home energy management services that are cyber secure, interoperable across devices, and utilise time of use tariffs. We will ensure that regulatory approaches for smart appliances, chargepoints, home energy management systems, flexibility service providers and load control systems are aligned. Government will aim to consult in 2022 on an appropriate regulatory approach for organisations performing this 'load controlling' role. We will also consider what legislative powers we will need to implement any solution, and look to take these when parliamentary time allows.

The government considers that a long-term solution is needed to ensure that adequate protections are implemented, for both the grid and consumers, by 2025. Given the part flexibility providers and electric vehicle chargepoint operators will play in the transition to net zero, we will need to balance support for their development, with robust protection for consumers and the electricity system.

Cyber security

We will embed a culture of cyber security across the smart energy system, giving consumers confidence to engage. A smart and flexible energy system is underpinned by digitalisation, with a complex, connected network of smart devices, infrastructure and operators forming a key pillar of the transition. Digitalisation of the system will enable the development of a dynamic, information-rich energy system, but will also bring new risks related to cyber security. The greater numbers of smart devices installed in homes and businesses, and the greater number of organisations able to access them for flexibility and other services, increases the risk of cyber attack. Cyber attackers may attempt to gain access to consumer data or seek to disrupt the energy system.

Though smart energy services and devices are not widespread today, we are on the cusp of a considerable increase in uptake. Cyber security remains a core principle of our approach, and we will work with industry and the cyber security community to develop a smart and flexible energy system that is cyber secure and gives consumers the confidence to engage. For devices, we will deploy a 'Secure by Design' approach as a minimum baseline, so that future energy smart appliances and electric vehicle chargepoints are designed with appropriate cyber security protections from the start.[32] We will develop assurance approaches to support manufacturers and flexibility service providers in meeting the necessary standards.

We recognise that there will be considerable evolution in the energy system over the next decade, and we must take a system-wide approach to integrating effective cyber security practices. We will continue work to understand and identify smart energy cyber security risks

[32] DCMS (2021), The government is working to ensure consumer "smart" devices are more secure, with security built in from the start, https://www.gov.uk/government/collections/secure-by-design. Connected 'Internet of Things' and smart appliances are in scope of DCMS's upcoming consumer connected product cyber security legislation. Cyber security requirements for smart electric vehicle chargepoints will be introduced as part of broader smart chargepoint legislation as described in the 2021 Smart Charging Consultation response.

today and in the future, so that the actions we implement are well-informed and developed with a view to securing the smart and flexible energy system for years to come.

Consumer protection and engagement

We will ensure the right frameworks are in place to protect consumers who participate in smart energy, support consumers to participate who might otherwise struggle to do so, and ensure consumers who cannot participate are not unduly penalised.

To rise to the challenge of meeting net zero, consumers need to be supported on a journey to new ways of interacting with the energy system. We want a regulatory framework for the energy retail market which accommodates emerging and innovative business models that deliver good outcomes for consumers and helps them to decarbonise the energy system. The market must deliver services and products that make it easy and rewarding for consumers to engage with energy and adapt their usage to support decarbonisation through offering information, support and services that provide benefits and value to consumers. No matter how they engage in the market, all consumers should pay fair prices for their energy as we transition to a smart energy system. These objectives will be set out in the government's forthcoming Energy Retail Market Strategy for the 2020s. We will progress reforms to the evolving energy retail market that improve outcomes for consumers; for example, by removing barriers to engagement and switching, and considering longer term reforms to the consumer protection and regulatory framework.

We want to ensure that as the market evolves, consumer protections for those who participate in smart energy offers, products and services remain adequate and robust, building on some excellent work already underway.[33] We also want to build and sustain consumer confidence in engaging with smart tariffs and services. We expect the sector to develop guidance and tools to provide appropriate advice to consumers on smart tariffs. We will collaborate with industry and consumer groups to develop consistent messaging across key areas of consumer engagement, for example the smart meter installation process, government advice services and switching campaigns, and collaborate with cross-cutting government campaigns on climate such as the Together for Our Planet Campaign.[34] We have recently published a smart tariff comparison tool,[35] and will shortly publish the project report. We will work closely with the sector to assess how the tool is deployed and to identify and address further barriers that could prevent consumers from making informed choices in switching to a smart tariff. To ensure our regulatory framework adequately covers the wider market as it evolves, we will consult on whether protections and clear options for redress are necessary for consumers engaging with a diverse range of third-party intermediaries.

[33] For example: the Centre for Sustainable Energy's Phase 1 Smart and Fair report (September 2020), which sets out customer capabilities and attributes that are likely to be required by the transition to a smart energy system; and the Citizens Advice, Association for Decentralised Energy and Energy UK domestic DSR risk register (January 2021), which outlines consumer protection risks, work currently underway on mitigations, and potential gaps.
[34] https://together-for-our-planet.ukcop26.org/
[35] Smart Tariff Comparison, http://www.smarttariffsmartcomparison.org/home

Health and safety is central to the energy smart consumer journey, including installation, maintenance, and use of such appliances in manual and automated modes. Work is underway to consider any such health and safety issues, including research commissioned by the Office for Product Safety and Standards (OPSS) to identify any risks that should be mitigated with regards to energy smart appliances that can shift their demand to different times.

We want to help remove barriers for consumers who may otherwise struggle to participate in smart energy. This is important to ensure that the benefits of flexibility are accessible to all households. Furthermore, if consumers of all types have access to smart technologies, then it facilitates the development of stronger price signals that they can take advantage of. We will use the findings of Project InvoLVe,[36] which identified how innovation may help enable low income and vulnerable consumers to participate, to help shape our future innovation initiatives. We are committed to ensuring that those in fuel poverty benefit from efforts to connect consumers with their energy use, and the importance of smart technologies is highlighted within 'Sustainable Warmth', the government's fuel poverty strategy for England.[37] We will incorporate smart technologies across relevant fuel poverty policies, for example the Energy Company Obligation. Where consumers remain unable to participate, we will ensure that appropriate protections are in place so that they are not unfairly penalised, through our broader retail market reform programme.

Case study: Flexibility from residential heat (4D Heat)

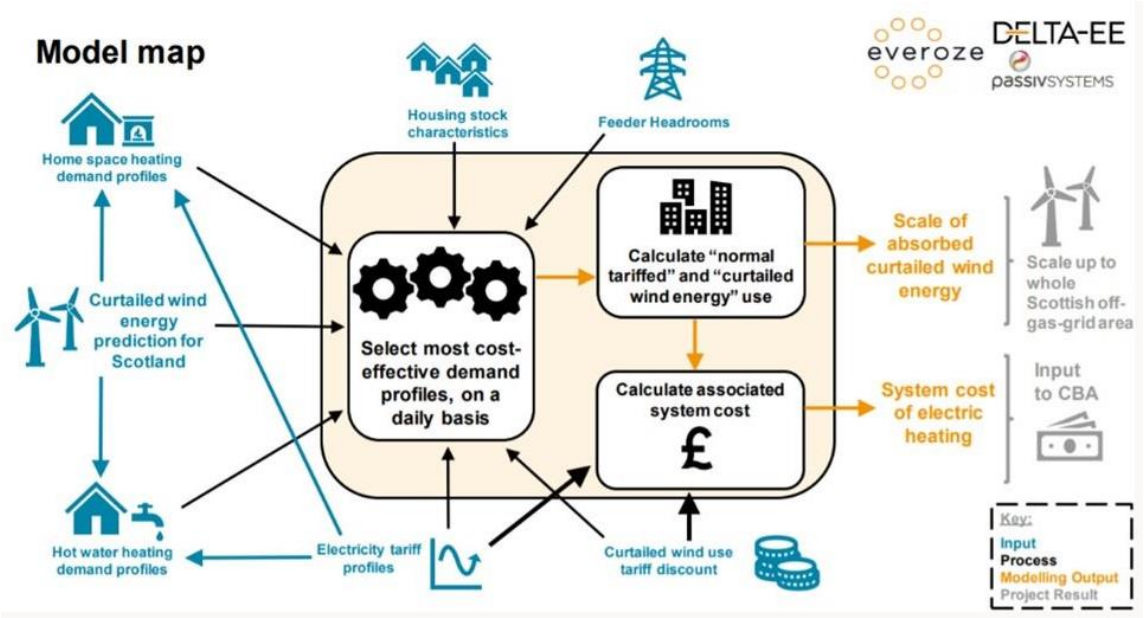
A network innovation project funded by the Electricity System Operator and the network company SSEN, and delivered by Delta-EE, PassivSystems and Everzone, looked at how flexible demand from residential heat can absorb wind power that would otherwise have been curtailed due to constraints on the transmission network.

The project focused on customers off the gas grid in Scotland, leveraging different low carbon heating solutions (hybrid heat pumps, air source heat pumps and storage heaters), smart controls, and price incentives. The project showed that smart low carbon heating can deliver significant customer value and materially reduce wind curtailment costs, with an estimated 9% reduction in curtailment by 2030 and an 18% reduction in energy bills.

4D Heat shows how smart-controlled heat pumps combined with local and national flexibility services can help to maximise the use of renewable generation in the system, reducing costs for all consumers.

[36] BEIS (2021), How can innovation deliver a smart energy system that works for low income and vulnerable consumers?, https://www.gov.uk/government/publications/participation-of-low-income-and-vulnerable-consumers-in-a-smart-energy-system

[37] BEIS (2021), Sustainable warmth: protecting vulnerable households in England, https://www.gov.uk/government/publications/sustainable-warmth-protecting-vulnerable-households-in-england



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Enabling smart buildings

Why this area is important

Buildings – our homes, businesses and public sector premises – are one of the largest sources of UK emissions, accounting for around 30% of greenhouse gas emissions and are therefore critical to meeting our net zero target.[38] To decarbonise them, we will need to reduce energy consumption and all buildings will need to transition to clean heat; the government has set an ambition for 600,000 heat pump installations per year by 2028. This has the potential to place significant demand on the grid. By using smart technologies, however, buildings can optimise consumption of electricity from renewable sources, reduce how much low carbon generation and network is needed to power them, and reduce the need for connection upgrades. Consumers will be able to reduce their bills – reducing the running costs of a heat pump, for example – and have more control over their comfort levels. Smart, flexible solutions can therefore facilitate the decarbonisation of heat and buildings, whilst acting as a significant source of flexibility for the wider energy system as well.

However, to enable this flexibility, buildings will need to be fitted with the right technologies. This includes:

- Smart and advanced meters which record usage in half-hourly periods, to help measure demand more precisely and enable cost-reflective tariffs and services.

[38] BEIS (2021), 'Final UK greenhouse gas emissions national statistics: 1990 to 2019', https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-national-statistics-1990-to-2019 and BEIS (2021), 'Energy Consumption in the UK' (ECUK), https://www.gov.uk/government/statistics/energy-consumption-in-the-uk

- Smart appliances, for example heat pumps, heating controls, air conditioning, electric vehicle chargers and white goods that can operate flexibly.
- Energy storage, so that buildings have a source of heat during periods when they do not draw electricity from the grid, or to store electricity from onsite renewables. Storage can take several forms, including the heat stored in the fabric of the building, hot water storage, phase change materials (also known as heat batteries) and electric batteries. This storage can be in individual homes, across multiple buildings (e.g. serving a block of flats) or at city scale in large heat networks.

These technologies will need to be appropriate for the building itself, and for the occupants. The right mix of fabric, heating, smart and generation technologies will change depending on the preferences of the consumer – for example, the time of day they inhabit the building – and the building physics – for example, how much sun it gets and how much storage space there is. There will not be a one-size-fits all solution.

The existing approach to decarbonising buildings is underpinned by a suite of assessment methodologies, regulations, and market and subsidy schemes. These will be set out in more detail in the government's forthcoming Heat and Buildings Strategy. It is important that these policies consider the need for flexibility and incorporate smart technologies.

What we will do

We will continue to work with industry to incorporate flexibility and smart technologies in the Standard Assessment Procedure (SAP) and, for non-domestic premises, Simplified Building Energy Model (SBEM). These are assessment methodologies that are utilised in Building Regulations, Energy Performance Certificates and a range of energy efficiency and heat schemes. The government will also work with stakeholders and international partners to consider the merits of introducing a separate 'smart readiness indicator' for assessing how optimised a building is for smart technologies.

We recognise that smart technologies, including energy storage and flexible heating systems, will likely have an important role to play for new buildings and this will be investigated as part of the development work of the Future Homes and Future Buildings Standards. In addition, the Office for Zero Emission Vehicles is working jointly with the Ministry of Housing, Communities and Local Government on proposed changes to the Building Regulations that would require new buildings to be fitted with an electric vehicle chargepoint; this would provide the opportunity for many more households to participate in the smart energy market.

We will ensure that flexibility is considered across the full range of energy efficiency, fuel poverty and heat subsidy schemes and market mechanisms, including the Energy Company Obligation, Home Upgrade Grant, Performance Based Policy Framework for large commercial and industrial buildings, Public Sector Decarbonisation Scheme, Social Housing Decarbonisation Fund, Heat Network Transformation Programme and Clean Heat Grant. We will also consider how smart technologies should be treated under our policy framework for energy-related products, which we will publish and engage with stakeholders on later this year.

Enabling smart electric vehicles

Why this area is important

In 2019, road transport accounted for around 24% of UK greenhouse gas emissions.[39] The emissions from cars and light vans make up around 79% of UK road transport emissions. The shift from petrol/diesel fuelled cars and vans to vehicles that can be powered by low carbon electricity is therefore a critical element of the plan to meet the UK net zero greenhouse gas emissions target.

As part of the Prime Minister's Ten Point Plan,[40] in November 2020 the government announced its intention to end the sale of new petrol and diesel cars and vans in the UK from 2030. As of September 2020, there were over 373,000 Ultra Low Emission Vehicles registered in the UK. The take-up of electric vehicles is expected to rise dramatically over the next decade, with estimates of approximately 15 million electric vehicles on the road by 2030.[41] This will increase electricity demand – the CCC's Sixth Carbon Budget suggests that electric cars and vans could increase total demand by approximately 30TWh in 2030, and by 65-100TWh in 2050. This compares to system-wide demand levels of 300-400TWh in 2030 and 600-900 in 2050.[42] The electricity requirement for an electric vehicle is almost three quarters of today's typical household consumption.[43]

This increase in demand will need to be managed by the system operator and local networks. It also represents a significant opportunity as a new source of low carbon flexibility to the system. It will be vital that electric vehicles are charged flexibly to manage system peaks and help balance the system at an affordable cost to consumers. These benefits will be made possible by smart charging technologies; the ability to manage the battery's charge based on signals such as energy prices, system capacity, and information on consumer needs and battery status.

[39] BEIS (2021), Final UK greenhouse gas emissions national statistics: 1990 to 2019, https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-national-statistics-1990-to-2019
[40] BEIS, Prime Minister's Office, 10 Downing Street (2020), The Ten Point Plan for a Green Industrial Revolution, https://www.gov.uk/government/publications/the-ten-point-plan-for-a-green-industrial-revolution
[41] Climate Change Committee (2020), The Sixth Carbon Budget, Surface Transport, https://www.theccc.org.uk/wp-content/uploads/2020/12/Sector-summary-Surface-transport.pdf
[42] Climate Change Committee (2021), The Sixth Carbon Budget Dataset, UK, scenario pathways electricity demand https://www.theccc.org.uk/wp-content/uploads/2021/02/The-Sixth-Carbon-Budget-Dataset.xlsx
[43] Calculated using the following assumptions: Ofgem Typical Domestic Consumption 2900kWh (Profile 1); total mileage averaged across all cars is 7400 miles (DfT annual National Travel Survey 2019); assuming 3.5miles/kWh estimated for popular electric vehicles (Nissan Leaf, BMW 330e, Tesla model 3)

Smart vehicle charging will result in lower bills for all energy customers (due to lower energy system costs) and for vehicle owners (who can charge their vehicles when electricity prices are low – for example overnight). Electric vehicle owners may be able to secure extra revenues from offering flexibility services to the grid via an aggregator. In future, electric vehicle owners may also be able to use their car batteries to export electricity to where it is needed, for example to support the grid (vehicle-to-grid, or V2G); home (V2H) or business (V2B).

Case study: Vehicle-to-grid (Powerloop, Octopus)

In September 2020, a consortium of companies led by Octopus Electric Vehicles, comprising Open Energi, ChargePoint Services, Energy Saving Trust, Navigant, Octopus Energy, and UKPN, launched Powerloop - the first customer-focused domestic trial of vehicle-to-grid charging in the UK.

The project aims to demonstrate the benefits of using domestic electric vehicle batteries to provide grid flexibility, cheaper transport and energy to homeowners, and faster decarbonisation of the UK's power and transport sectors. Customers who take part in the trial lease an electric car and receive a smart meter, a compatible vehicle-to-grid charger and 100% green electricity. They are then incentivised to plug in their vehicle at certain times so it can use its charge to provide electricity to the grid at periods of peak demand. If they do this 12 times per month they get £30 off their energy bill.

So far over 135 customers have signed up to the Powerloop bundle, and are in the process of helping to balance the grid using smart products and green electricity.

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What we will do

It is imperative that the energy, auto and charging markets understand that vehicle smart charging is an integral part of the expected EV transition. The government has recently published our response to the 2019 consultation on mandating that private electric vehicle chargepoints must have smart capability, and we will lay legislation later in 2021.[44]

Ofgem will deliver a regulatory electric vehicle strategy by the end of this year, undertaking a systematic review of the elements needed to deliver the vision for maximising the opportunities that electric vehicles create to deliver a smarter, more flexible energy system. This includes ensuring network/system operators are prepared for electric vehicle uptake, ensuring network

[44] Department for Transport and the Office for Low Emission Vehicles (2021), Electric vehicle smart charging consultation outcome, https://www.gov.uk/government/consultations/electric-vehicle-smart-charging

investment will be where and when it is needed, removing barriers for smart charging, and ensuring products and services are available to deliver benefits to all consumers.

The government and Ofgem will also publish a joint policy statement on maximising the opportunity for flexibility from electric vehicles, while protecting the electricity grid and consumers, in 2022. This will include considering how innovation can further improve integration of electric vehicles and the grid, for example through vehicle-to-X technologies. The government will gather feedback on the potential value and challenges for vehicle-to-X in the call for evidence that has been published alongside this document.[45]

The government and Ofgem will continue to work with the Electric Vehicle Energy Taskforce, which brings together policymakers, regulators, consumer organisations, academics and businesses from across the electricity, auto and electric vehicle charging sectors, with a goal of ensuring the electricity system enables and maximises the opportunities presented by the transition to electric vehicles.

The government and Ofgem will ensure that electric vehicle owners can get trusted information to make them aware of the benefits of smart charging. We will coordinate with the Electric Vehicle Energy Taskforce and industry to make sure that consumers have access to the right information and advice to choose the right goods or services for their needs and get products set up in line with their preferences. We will also review energy consumer protections to ensure these are appropriate for electric vehicle owners and users, to give consumers confidence in smart charging.

The increased power demand of electric vehicle charging will be mitigated, to a significant extent, by smart charging, however additional generation and network capacity will still be needed. Network operators will need to understand where chargepoints are on the system and how they are being used in order to prepare for new demand from electric vehicles and ensure security of supply. The government has recently published a response to our 2019 call for evidence on whether to mandate that data, such as energy consumption and location from public or private chargepoints, should be shared with specified parties.[46] We will also publish an Electric Vehicle Infrastructure Strategy this year to set out the framework needed to ensure that future electric vehicle infrastructure rollout takes appropriate account of energy system costs, user experience, and wider user costs, including any trade-offs between these.

[45] BEIS (2021), Call for evidence: Role of vehicle-to-X technologies in a net zero energy system, https://www.gov.uk/government/consultations/role-of-vehicle-to-x-technologies-in-a-net-zero-energy-system-call-for-evidence

[46] Department for Transport and the Office for Low Emission Vehicles (2021), Electric vehicle smart charging consultation outcome, https://www.gov.uk/government/consultations/electric-vehicle-smart-charging

Enabling smart local energy solutions

Why this area is important

Decarbonisation of our buildings, transport systems and energy system will require lots of action at a regional and local level. Generation and storage are becoming increasingly decentralised, with solar and batteries being deployed in individual buildings and by local communities. Heat and transport decarbonisation, in particular, needs to be delivered in a way that meets local needs and with the involvement of local decision makers. Decarbonisation will require strong co-ordination across electricity, heat, hydrogen, transport and buildings. That means local actors can be strong drivers of change, enabling coordinated planning and engagement with markets, and supporting cleaner, cheaper and more efficient energy whilst providing a significant contribution towards local economic strategy.

Smart local energy systems are local-based initiatives which bring together a range of energy issues, typically including heat, power and transport, to reduce emissions in an integrated way, while also promoting local jobs and businesses. Local Authorities have a key role to delivering these systems by combining energy into their wider statutory work on housing, transport, waste and planning, making delivery more cost-effective and preparing for a net zero future. The government committed over £100 million of funding through the Industrial Strategy Challenge Fund to drive the development of smart local energy systems through the Prospering from the Energy Revolution programme. The government also provides funding for Local Authorities to deliver programmes that support decarbonisation through the Local Energy Programme.

Case study: Local energy (Project LEO)

Project LEO (Local Energy Oxfordshire) is running trials in Oxfordshire to understand how new technologies and services can benefit local people, communities and the energy system. It is building robust evidence of the technological, market and social conditions needed for a greener, more flexible and fair electricity system. It is also learning what changes need to happen within national and local policy to enable this transition.

Project LEO is beginning a programme of trials to get enough flexible assets behind a potential network constraint to test a local market for flexibility. These assets include community developed hydro generation, batteries, solar PV, vehicle-to-grid technology, demand side response from buildings, and local groups forming ‘smart and fair’ neighbourhoods. Innovative services are being developed by the Ofgem-funded TRANSITION project to optimise use of the local network for when the system is forecast to be under strain with either generation or demand.

Project LEO benefits for having a diverse set of partners: network company SSEN, the Low Carbon Hub, Oxford City and Oxfordshire County Councils, the University of Oxford, Oxford Brookes University, Nuvve, Piclo and EDF Energy. This collaboration gives LEO a unique place exploring the potential of a smart local energy system.

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What we will do

Many of the actions we set out in this Plan, and our joint Energy Digitalisation Strategy, should aid local action. In particular:

- making energy data more open and accessible will assist identification of locally tailored solutions and support public engagement.
- improved locational signals – from local flexibility markets and network charging reforms – will provide a revenue stream to local businesses and organisations who develop solutions that help alleviate local constraints.
- reforms to the balancing mechanism, ancillary services and local markets for flexibility will broaden and facilitate access to markets for smaller assets, and
- consumer protection measures and including smart technologies in heat and energy efficiency policies will help normalise smart technologies for consumers.

The government will continue to work with Local Energy Hubs to support projects which are tailored and delivered to meet local needs, joining up work between local areas, investors and central government. The forthcoming Heat and Buildings Strategy will consider the key strategic decisions that need to be taken to establish how we deliver the most suitable and affordable low-carbon heating. A key part of this work will consider the role of area-based mapping and planning to enable further understanding of local energy infrastructure, inform decision-making and support local delivery plans for decarbonisation.

The Prospering from the Energy Revolution programme is demonstrating how a range of local actors including businesses, communities, local authorities and academics can accelerate decarbonisation through innovative business models that engage people and unlock system flexibility at the edges of the energy system. Learnings and evidence from these real-world demonstrator projects will be valuable for designing policies and regulation that can unlock system flexibility and decarbonisation at pace and at scale. The government will work with industry to closely monitor learnings from the programme through to its end in March 2023 and work with key organisations to ease barriers to the delivery of smart, local energy solutions. As part of the programme, UK Research and Innovation is also funding the Energy Systems Catapult to develop tools to help provide local capability in delivering smart energy projects.

Our actions

1.1. The government has confirmed that a new four-year smart meter policy framework with fixed minimum annual installation targets for energy suppliers will commence on 1 January 2022 to drive the consistent, long term investment needed to achieve market-wide rollout.

1.2. The government will work with industry to support the uptake of PAS 1878 and 1879 for “energy smart” appliances, to encourage development and deployment of DSR-capable devices and to establish a technical framework for small-scale DSR.

1.3. The government will take powers to regulate "energy smart" appliances when parliamentary time allows. The government will also mandate that all private chargepoints must have smart functionality and meet minimum device-level requirements, legislating later in 2021.

1.4. The government will aim to consult in 2022 on an appropriate regulatory approach for flexibility service providers and other organisations controlling load.

1.5. Ofgem expects industry to implement market-wide half hourly settlement by October 2025, and will put in place strong incentives and governance to ensure that implementation happens in a timely and effective manner. Ofgem will look at barriers to elective half-hourly settlement and what could be done to address them.

1.6. The government will commission further work to set an enduring approach to monitoring and mitigating cyber security risks across a smart and flexible energy system.

1.7. The government and Ofgem will protect consumers who participate in smart energy services, including via appropriate regulation for third party intermediaries. To build consumer confidence, we will collaborate with industry to develop consistent messaging for consumers, assess how our smart tariff comparison tool can be deployed, and consider how to implement the recommendations of OPSS research to identify how any health and safety risks from smart appliances can be mitigated.

1.8. The government and Ofgem will help consumers that would otherwise struggle to participate in smart energy, including through incorporating smart technologies in our fuel poverty strategy and policies, for example the Energy Company Obligation. We will use the findings of Project InvoLVe, which identified how innovation may help low income and vulnerable consumers to participate, to shape future innovation initiatives.

1.9. The government will incorporate flexibility and smart technologies into energy efficiency and heat policies, including regulations, assessment methodologies, subsidy schemes and market mechanisms.

1.10. Ofgem will publish a regulatory strategy later in 2021 to support the electric vehicle rollout and maximise consumer benefits. The government and Ofgem will jointly develop a policy statement on how we will maximise the contribution of electric vehicle flexibility while protecting the grid in 2022. The government will also publish a response to our call for evidence on vehicle-to-grid technology in 2022.

1.11. The government and Ofgem will work with the Electric Vehicle Energy Taskforce and industry to improve the provision of information and advice on electric vehicle energy issues such as smart charging, across the energy, automotive and charging markets, by 2023.

1.12. The government will work with Ofgem to progress policy development to ensure network operators have appropriate access to chargepoint data, responding to the 2019 call for evidence on electric vehicle data transmission in summer 2021.

1.13. The government will work with industry to closely monitor learnings from the Prospering from the Energy Revolution programme through to its end in March 2023 and work with key organisations to ease barriers to the delivery of smart, local energy solutions.

Chapter 2 | Removing barriers to flexibility on the grid: electricity storage and interconnection

Vision

In the mid-2020s we will have created a best-in-class regulatory framework for electricity storage at all scales; investors and developers will be confident in the framework, and this will trigger a marked increase in the deployment of storage. There will be a level playing field for domestic and small-scale storage. Customers will be confident in the benefits of, and framework for, installing storage in their homes and businesses. Supported by government innovation funding, first-of-a-kind longer duration storage technologies will be built and providing services to the system. An increased capacity of interconnection will be facilitating efficient and flexible access to cross-border markets across all timescales. Ofgem's interconnector policy review will have concluded and any consequent changes to the current arrangements for new interconnectors will have been implemented to ensure the full range of potential benefits and impacts have been captured. As we work towards realising our 2030 ambition of at least 18GW of interconnector capacity, we will have a consistent and scalable approach to interconnector operability. BEIS will have also concluded the Offshore Transmission Network Review and recommendations will be implemented to facilitate multi-purpose interconnectors.

By 2030 and beyond electricity storage will be deploying in the most optimal locations and at all scales. Storage will be providing significant flexibility to the system (potentially around 13GW in combination with flexible demand[47]) and helping to address many of the challenges presented by a low carbon system, including maintaining energy security; shifting when generation is needed, alleviating constraints, and providing system stability services. Storage will be replacing flexibility from traditional fossil fuelled generation as this is turned off. We will begin to see long duration storage help us to decarbonise the grid and wider economy further, providing key services to the grid to integrate and maximise the use of 40GW of offshore wind and other low carbon generation. We will have realised at least 18GW of interconnection capacity, and frameworks for interconnector operability will utilise the full potential of flexibility interconnectors can provide for the system, making it an essential part of the solution for an increasingly decarbonised flexible grid.

Why this area is important

Currently, flexibility on the electricity grid primarily comes from fossil fuel generation. Over the next decade this will increasingly need to come from electricity storage, which shifts electricity

[47] Based on illustrative scenarios – see analysis section in the introduction

in time, and interconnection which shifts electricity in location. Other sources of grid flexibility include dispatchable low carbon generation (such as biomass and – in the future – hydrogen) and intermittent low carbon generation (such as solar and wind)[48]. This chapter will primarily focus on removing existing barriers to flexibility provided by electricity storage and interconnection.

Electricity storage, simply put, stores electricity for when it is needed. It is essential to a net zero system as it can store electricity when it is abundant (e.g. when it is windy or sunny) for periods when it is scarce (e.g. when demand is higher). It can do this both to balance the system nationally, and to manage constraints in local areas. It can also provide specific services to help maintain the resilience and stability of the grid. The need for electricity storage will rise as we increase the volume of variable, non-dispatchable renewables on the system and increase peak demand through the electrification of heat and transport. It will be critical to maintaining energy security as we shift away from gas over the 2020s-30s.

There are a range of technologies that can provide electricity storage, each with characteristics that may be needed by a net zero system. Lithium-ion battery storage, which typically operates at durations of 30 minutes to 4 hours, has significantly reduced in cost – around 90% since 2010[49] – and can provide rapid response to changes in system needs. Lithium-ion is the most prevalent battery currently however other chemistries exist or are in development. Battery storage can be deployed on the grid, and also at a domestic and commercial scale enabling consumers to reduce their energy bills and support the integration of low carbon transport and heating. A further significant source of battery storage could be electric vehicles operating in two-way charging mode, known as vehicle-to-grid.[50]

Storage over longer periods of time, for example across days, weeks and months, can help to manage variation in generation and demand, such as extended periods of low wind or cold weather events. Such technologies are typically larger in size, and include pumped hydro storage, compressed air, liquid air, flow batteries, gravitational and the conversion of power to hydrogen and back to electricity. Long duration storage could help to support the wider decarbonisation of the energy system: reducing the amount of investment in generation and network assets that would otherwise be needed, and optimising the output from renewables e.g. through reduced curtailment costs.

Electricity interconnection is the connection of neighbouring markets through large underground or underwater cables so that when there is an abundance of electricity in one market, it can be exported to another – and vice versa. It delivers lower costs for consumers,

[48] Intermittent renewables can provide flexibility when they are available. They are able to respond quickly to market signals, and can be combined with supercapacitors and batteries to provide ancillary services such as synthetic inertia and reactive power. The Electricity System Operator's Power Available project is facilitating this by providing better visibility of the response and reserve capabilities of over 90 wind generators, with work underway to expand to solar generators too.

[49] BloombergNEF (2020), https://about.bnef.com/blog/battery-pack-prices-cited-below-100-kwh-for-the-first-time-in-2020-while-market-average-sits-at-137-kwh/

[50] National Grid Electricity System Operator Future Energy Scenarios 2020 describe that vehicle-to-grid technologies could offer up to 38GW of battery capacity from 5.5m vehicles in 2050. National Grid ESO (2020), FES 2020, https://www.nationalgrideso.com/future-energy/future-energy-scenarios/fes-2020-documents

enhances security of supply, and supports the integration of low-carbon generation sources. It provides access to a diverse pool of generation allowing the import or export of cheaper electricity by responding to changes in market signals; it can provide a range of system services, such as black start; and it also helps to reduce the curtailment of renewable energy.[51] Interconnection will be critical in realising our offshore wind target of 40GW by 2030 whilst maintaining security of supply, as multi-purpose interconnectors can further facilitate the efficient integration of offshore windfarms more quickly and in a coordinated manner.[52]

What has been done so far

- Ofgem published a modified generation licence for storage which exempts facilities from payment of certain policy costs, provides a regulatory definition for storage, and provides regulatory clarity for facilities below 50MW.
- The government passed legislation to make it simpler for larger storage facilities to acquire planning permission.
- Ofgem approved a series of code modifications to end the double charging of certain network costs for storage, and the government clarified how storage can be exempt from the Climate Change Levy.
- The government launched the Smart Export Guarantee which incentivises co-location of storage with solar; Ofgem provided guidance on how to co-locate solar and storage under the Renewables Obligation and Feed-in-Tariff schemes.
- Ofgem introduced licence changes to clarify that network operators cannot own or operate storage.
- Several innovation projects were launched: £20m to support deployment of large-scale storage, £9m on energy storage cost reduction and £317m on the Faraday Battery Challenge.
- The Energy Networks Association published queue management guidance for electricity distribution network connections[53] and networks operators set out a fast-track connections progress for storage.

[51] BEIS (2020), Impact of interconnectors on decarbonisation, https://www.gov.uk/government/publications/impact-of-interconnectors-on-decarbonisation
[52] Prime Minister's Office, 10 Downing Street, BEIS (2020), https://www.gov.uk/government/news/new-plans-to-make-uk-world-leader-in-green-energy
[53] ENA (2020), Open Networks Project Queue Management User Guide (v4), https://www.energynetworks.org/assets/images/ON20-WS2-P2%20Queue%20Management%20User%20Guide-PUBLISHED.23.12.20.pdf

- Government launched the Offshore Transmission Network Review and has engaged with industry and North Seas stakeholders on the future of multi-purpose interconnection.
- Ofgem launched the Interconnector Policy Review and has been engaging with stakeholders on whether there is a need for further GB interconnection capacity, and its approach to the regulation of future GB interconnection.
- The EU-UK Trade and Cooperation Agreement outlined the need for UK and EU Transmission System Operators to cooperate to develop technical procedures for new, efficient cross-border trading arrangements at all timeframes, including cross-border balancing, and to ensure the maximum level of capacity of electricity interconnectors is made available.
- The Electricity System Operator has held information exchange sessions relating to potential cross border participation in the Dynamic Containment market; a working group is currently developing a non-mandatory technical specification relating to Grid Forming and Virtual Synchronous Machine capability, including inertia; and, a consultation has been published on Reserve Product Reform.

Where are we now?

Today, there is around 4GW of electricity storage operational in Great Britain, made up of 3GW of pumped hydro storage and 1GW of newer lithium-ion battery storage that has been built since 2017.[54] There is currently 6GW of operational electricity interconnection, a 50% increase in capacity since 2018. There are strong and growing electricity storage and interconnector pipelines; nearly 10GW of storage (8GW of battery storage and 2GW of pumped hydro storage),[55] 3.8GW of interconnector projects currently under construction, and an additional 6.1GW of interconnection projects with an approved GB regulatory route under Ofgem's interconnector cap and floor regime.

Electricity storage technologies are deploying at different scales, from domestic batteries to larger grid-connected facilities, and the sector is providing a wide range of benefits to the system. Storage is now participating across a number of markets, including local flexibility markets and the balancing mechanism, and is dominating frequency response markets. In addition, there are continuing developments in a range of novel storage technologies as they work towards commercialisation. We have concluded from our engagement with industry that whilst some regulatory barriers remain for grid connected battery storage, many of the most significant barriers relate to our energy markets (see the next chapter). However, there is still not a level playing field for storage at all scales, and key policy and regulatory barriers remain

[54] National Grid ESO (2020), FES 2020, https://www.nationalgrideso.com/future-energy/future-energy-scenarios/fes-2020-documents
[55] Renewable Energy Planning Database (March 2021), https://www.gov.uk/government/publications/renewable-energy-planning-database-monthly-extract

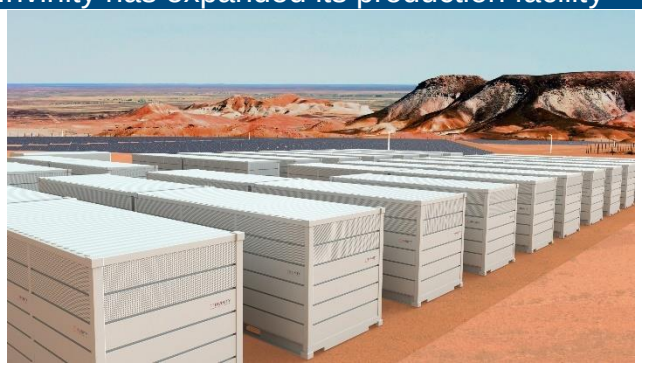
for specific types of storage, in particular smaller units in homes and businesses, and large scale and long duration storage.

For interconnectors, there are currently two routes for investment: a regulated route through Ofgem's 'cap and floor' regime,[56] or via a fully 'merchant route' where no support is provided. Further deployment of interconnection will help to position Great Britain as a potential future net exporter of green energy. Whilst there is the need to continue to support the development of further capacity, which includes removing barriers to the development of multi-purpose interconnectors, we also need to ensure the right tools and mechanisms are in place to fully realise the potential for interconnection to contribute to overall system flexibility. Interconnection can support a flexible system to rapidly respond to changes in demand and supply. However, without the appropriate frameworks in place to enable flexibility services, greater interconnection could result in system operability challenges. Even with the current level of interconnection, individual interconnectors are among the largest capacity assets on the system and can cause large system swings. Such issues are compounded by each interconnector operating to bespoke rules with the ESO. Additionally, there are several commercial and regulatory barriers to entry for interconnectors' participation in future ancillary services markets.

Case study: Vanadium Flow Batteries - Invinity Energy Systems

Invinity's vanadium flow batteries can help the transition from fossil fuels to low-carbon sources by delivering low-cost, low-carbon energy on demand, reliably, safely and economically. Flow batteries offer the potential for many hours of storage at low cost due to the fact that the storage medium (electrolyte) can be stored outside of the battery stack (unlike lithium-ion batteries). The volume of the electrolyte can be increased at relatively low cost. In 2018 Invinity's predecessor company, redT energy was supported by government innovation funding under the energy storage cost reduction competition.[57] As a result of the programme, Invinity has been able to reduce the total cost of its stack by 75% (on a £/kW basis).

Invinity is in the process of rapidly scaling its production capacity in line with increasing global demand. Since the beginning of the year, Invinity has expanded its production facility in Bathgate, Scotland and developed new manufacturing processes to enable significantly faster production, whilst increasing the number of 'green jobs' at the site. Invinity's factory is currently producing stacks for use in several projects being delivered this year, both in the



[56] Ofgem (2014), Electricity interconnectors factsheet, https://www.ofgem.gov.uk/publications-and-updates/electricity-interconnectors-factsheet

[57] BEIS (2021), Guidance: funding for innovative smart energy systems, https://www.gov.uk/guidance/funding-for-innovative-smart-energy-systems#funding-for-energy-storage-cost-reduction-and-feasibility-studies

UK and further afield, including Oxford, Orkney, Perth (all UK) and Yadlamalka (Australia).

What we will do

All storage

The regulatory framework was not built with technologies such as electricity storage in mind. We have made significant progress in clarifying and amending the treatment of storage within the framework, improving confidence for developers and investors, however there are still some barriers remaining.

It is important that we ensure there is clarity over the treatment of storage within the regulatory framework and therefore the government remains committed to defining electricity storage as a distinct subset of generation in primary legislation, when parliamentary time allows. This will ensure continuity with the current approach yet allow flexibility for treating storage differently to other forms of generation where it is appropriate to do so. In addition, the government will amend key planning guidance documents to set out the need case for storage and reflect the legislative changes made in 2020. This will support the planning permission process for planners and developers.

We will ensure there is a level playing field between storage co-located with generation, and standalone storage. Currently there are barriers to deploying storage alongside generation projects supported under the Contracts for Difference (CfD) scheme. In principle, storage should be able to provide grid services and store power from CfD generators, providing the metering arrangements can distinguish between the two. As stated in the 2016 consultation on CfD contract changes, CfD payments would therefore be calculated on the metered volumes at the point of generation, rather than the point of sale of the electricity. We will work with the Low Carbon Contracts Company to produce guidance to clarify co-location requirements, to better facilitate the addition of storage to CfD projects including offshore developments and, if necessary, we will consult on changes to the CfD contract requirements.

Storage can help facilitate the integration of renewable generation on the system by acting as a source of demand to alleviate generation constraints, deferring or avoiding the need for costly network build. Ofgem is committed to considering how the charging regime should appropriately treat storage when it is acting in this way. Ofgem is considering the role that network charges will play in ensuring efficient network usage in the future and, as part of our broader work on access and forward looking charges, we will consider how demand and generation charges should be applied where storage is acting in a way that benefits the system. Ofgem has also published an open letter clarifying how storage is treated under the

Transmission Constraint Licence Condition, which aims to reduce any uncertainty that could dampen the incentive for storage assets to locate behind, and alleviate, a network constraint.[58]

Large scale and long duration storage

One of the key barriers to deploying large scale, long duration storage is a financing challenge. Storage technologies at this scale have high upfront costs and can take longer to construct, or carry risks associated with investing in nascent technologies. These factors, combined with difficult-to-forecast revenue streams due to the merchant nature of storage investments, mean that storage at this scale can struggle to attract the investment that it requires. In addition to this, there are currently limited market signals for storage to operate as longer duration as opposed to cycling several times during a day. We expect these signals to increase over the coming decades, as renewable penetration increases, and traditional fossil fuel generation decreases.

Our analysis considers storage deployed across different scales; however, it is not able to account for the system needs and benefits of long duration storage.[59] We have commissioned external analysis to improve understanding of the role that this type of storage will play in the system, how much may be required at different points in time, and the benefits of different durations of storage. This will be key to informing how barriers to the deployment of this type of storage should be addressed.

A key aspect of the financing challenge is that some large scale and long duration storage technologies are novel and have not yet reached commercialisation or been demonstrated at scale, increasing the technology risk of investing in these technologies. To address this, the government has launched **a major competition worth up to £68m, to accelerate the commercialisation of first-of-a-kind longer duration energy storage**, through the £1bn Net Zero Innovation Portfolio.[60]

There are also a number of reforms being developed currently which could support the investment case for this type of storage:

- The Electricity System Operator is developing new and improved solutions (including stability pathfinders and trialling new balancing services) to ensure the right set of products are available to manage the system. Large scale and long duration storage could be well placed to provide many of these services. By March 2023, the Electricity System operator will develop and publish a plan, to implement regular,

[58] Ofgem (2021), Applicability of Transmission Constraint Licence Condition to generators that are importing power, Ofgem, https://www.ofgem.gov.uk/publications-and-updates/applicability-transmission-constraint-licence-condition-generators-are-importing-power
[59] BEIS (2021), Smart Systems and Flexibility Plan, Appendix I: Electricity System Flexibility Modelling, https://www.gov.uk/government/publications/transitioning-to-a-net-zero-energy-system-smart-systems-and-flexibility-plan-2021
[60] BEIS (2021), Longer Duration Energy Storage Demonstration (LODES) competition, https://www.gov.uk/government/collections/longer-duration-energy-storage-demonstration-lodes-competition

dependable, bankable markets for solutions to stability, voltage and thermal constraints.

- In addition, as part of the Electricity System Operator's five-point plan for managing network constraints, it will carry out analysis to understand how storage can cost effectively help manage network constraints. The technical analysis and final report is expected to be complete by December 2021.
- One of the new UK Infrastructure Bank's primary areas of focus for providing financing products is clean energy, including energy storage. The Bank can co-invest with the private sector to enable and accelerate the delivery of UK projects that are consistent with its mission to tackle climate change and support regional and local economic growth. The Bank will make independent investment decisions in line with its objectives.
- We will shortly publish a call for evidence on the Capacity Market. This will gather evidence on how we might support the participation of new build projects that have construction times which are longer than the time between the main capacity auction and delivery (approximately four years), for example pumped hydro storage. It will also request views on how the Capacity Market can better align with our net zero commitments.
- Ofgem is considering the role that network charges will play in ensuring efficient network usage in the future including how demand and generation charges should be applied where storage is acting in a way that benefits the system.

Alongside these reforms we will explore further the need and case for **more fundamental market intervention** to support the deployment of these technologies and address the financing challenge. The government has published **a call for evidence on facilitating the deployment of large scale and long duration electricity storage**.[61] This will collect evidence on the barriers faced by large scale and long duration storage, mechanisms to address these barriers and how to reduce the risk of distorting the market.

Domestic and small-scale storage

The domestic and small-scale storage sector is relatively nascent, and there are still some distortions and barriers impacting consumer uptake.

The introduction of market wide half-hourly settlement in the mid-2020s will increase the availability of smart tariffs which will drive uptake of smart technologies such as battery storage. We will also ensure that battery storage (as well as other types of smart technology) is considered across the full range of energy efficiency, fuel poverty and heat policies (see

[61] BEIS (2021), Call for evidence: Facilitating the deployment of large-scale and long-duration storage, https://www.gov.uk/government/consultations/facilitating-the-deployment-of-large-scale-and-long-duration-electricity-storage-call-for-evidence

Chapter 1 | Facilitating flexibility from consumers chapter).

Some households and businesses may choose to use their battery to provide flexibility services to the grid. Reforms to open up access to markets, as well as the introduction of local flexibility markets, are facilitating this. Whilst this creates new sources of revenue, it also presents new challenges that need to be addressed to level the playing field for smaller assets – for example, the overpayment of final consumption levies as well as uncertainty in market requirements for small, distributed assets. We will consider options for removing final consumption levies on electricity imported by domestic storage for the purpose of re-exporting back to the grid. We will also consider this for vehicle-to-grid technologies.

Industry has also reported possible distortions in the tax framework which are currently impacting the business case for storage, particularly smaller assets. The government committed to conduct a fundamental review of business rates and published the terms of reference for the review at the Spring Budget 2020. Stakeholders were invited to contribute their views on ideas for reform on all elements of the business rates system, including on how the business rates treatment of plant and machinery affects investment decisions and how the business rates system could support the decarbonisation of buildings. HM Treasury published a summary of responses in the Interim Report on 23rd March 2021. The Review will conclude this Autumn. The government will continue to work with industry to understand how the VAT regime impacts storage.

It is essential that the health and safety framework for electricity storage remains robust as deployment increases, to protect consumers, build consumer confidence, and to facilitate the inclusion of smart technologies such as storage in energy efficiency, heat and fuel poverty policies where appropriate. In 2020 the government commissioned a gap analysis which will be published soon of the health and safety framework, which has produced recommendations for standardisation on products and installation, installer training and certification, and data sharing with the fire service. The government is currently working with the industry-led Storage Health and Safety Governance Group to consider and address these recommendations, where appropriate, including supporting the development of a product and installation Publicly Available Standard for domestic/small-scale battery storage, developing guidance for grid-scale storage, and working with the fire service, in particular to facilitate data sharing.

Case study: Domestic and small-scale storage (Social Energy)

Social Energy has created a community of 6,500+ residential customers with solar and battery storage, generating additional savings by providing flexibility to the system. By operating as both a flexibility provider and energy supplier, Social Energy uses its ‘virtual power plant’ to optimise a range of revenue streams for households, including Firm Frequency Response contracts for the Electricity System Operator.

The Social Energy Hub in the home captures sub-second data streams which are fed into the cloud to provide forecasting of generation, demand and grid behaviour, which is then optimised against market signals. Savings are made through flexibility services, supplier cost avoidance and trading arbitrage, with 70% of any revenues passed back to the end consumer on top of savings from generating their own solar power. The Energy Saving Trust has independently verified that Social Energy customers get a 70% bill reduction on average. In 2021, installs for new housing developments and social housing are being rolled out.

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Increased electricity interconnector capacity

The Energy White Paper set out an ambition to realise at least 18GW of interconnector capacity by 2030.[62] Ofgem is currently undertaking an Interconnector Policy Review to establish whether there is a need for further GB interconnection capacity beyond those projects currently with regulatory approval.[63] If so, the second objective of the review is to consider Ofgem's approach to the regulation of future GB interconnection. Ofgem will review the cap and floor regime to date and undertake socio-economic modelling to determine whether further interconnection is in the interests of GB consumers. In addition, the review will consider the wider impacts of interconnection including the impacts of interconnectors on flexibility, decarbonisation, system operability and security of supply. The review will also consider options for the regulation of multi-purpose interconnectors.

In addition, BEIS is leading the Offshore Transmission Network Review which aims to identify and address the barriers to the realisation of multi-purpose interconnector projects, ensuring there is an appropriate legal and regulatory framework for these new assets.[64]

Enhancing the role of interconnection as a flexibility asset

To realise our vision of an increased level of interconnection facilitating efficient and flexible access to cross-border markets across all timescales, it is important to ensure the right tools and flexibility services are in place. This will ensure we make best use of the highly flexible high voltage direct current technology. It will be equally important for the government and Ofgem to support the development of more efficient cross-border market arrangements taking place closer to real time.

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[62] BEIS (2020), Energy White Paper, https://www.gov.uk/government/publications/energy-white-paper-powering-our-net-zero-future

[63] Ofgem (2020), Open letter: Notification to interested stakeholders of our interconnector policy review, https://www.ofgem.gov.uk/publications-and-updates/open-letter-notification-interested-stakeholders-our-interconnector-policy-review

[64] https://www.gov.uk/government/groups/offshore-transmission-network-review

The Trade and Cooperation Agreement sets out the basis for an efficient regional coupling trading model and requires the relevant EU and UK transmission system operators to cooperate to develop technical procedures for the allocation of capacity on electricity interconnectors.[65] Transmission system operators were asked to propose a timeline for developing the draft technical procedures for differing timescales.[66] Having effective and efficient trading arrangements and a cross-border balancing market will be integral to enabling interconnectors to react to changes in market fundamentals, and therefore facilitate system flexibility. The government and Ofgem, in collaboration with Northern Ireland's Department for the Economy and Utility Regulator, will support the transmission system operators with the development of these trading arrangements by providing regular input and where necessary establish a legal framework to underpin the arrangements.

In addition, the Trade and Cooperation Agreement requires that the maximum level of capacity on electricity interconnectors is made available to the market, whilst maintaining secure operation of the system through coordinated actions over interconnectors. As such, the government and Ofgem are supportive of actions taken by the ESO to make use of market-based control actions wherever possible to avoid interconnector capacity restrictions, ensure secure operation of the system and improve the set of market-based actions at their disposal to manage system needs and security. This will ensure that the benefits of interconnectors can be realised, and restrictions to interconnector capacity are kept to a minimum. Ofgem will work with the ESO and wider industry on future improvements to the control and stability of the GB electricity system.

It is important that all technology types can compete on a level playing field and interconnector participation in the ESO's ancillary and balancing services markets is enabled. The government and Ofgem will support the work of the ESO, during Summer 2021, to identify the barriers to interconnector participation in the Dynamic Containment market, and other ancillary and balancing markets. We expect that potential mitigating actions to reducing barriers – where such measures are thought to enhance overall value for consumers – will be shared in the ESO's next operability report, at the end of the year.

Additionally, a Grid Code working group, led by the ESO working with interconnector developers, is looking to offer an additional grid stability service, to provide the opportunity to take part in a commercial market-based system.[67] We also support the ESO's proposal to establish a Best Practice Expert Group, which will examine some of the more detailed technical aspects in particular the assessment of Grid Forming and its impact on the system and other users. This work will be key to better understand the capability of current and future

[65] Trade and Cooperation Agreement (December 2020), EU-UK_Trade_and_Cooperation_Agreement_24.12.2020.pdf

[66] BEIS (2021), Electricity trading arrangements, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/958195/secretary-of-state-electricity-trading-arrangements-guidance.pdf

[67] GB0137 is working on the development of a non-mandatory technical specification, which will be crucial to high voltage direct current interconnectors' potential contribution to GB Grid Forming or Virtual Synchronous Machine capability, including supporting inertia.

interconnectors to meet the technical specification and understand whether barriers to future market entry exist and how they could be mitigated.

A consistent and scalable approach to interconnector operability

To ensure a coherent approach to interconnector operability and their role in the electricity system, changes to arrangements for new interconnectors will need to be implemented to ensure the full range of potential benefits and impacts are captured. This includes reducing the reliance on bespoke operational rules for each interconnector and committing to reviewing frameworks and codes to ensure they are fit for a future in which there is a larger volume of interconnectors.

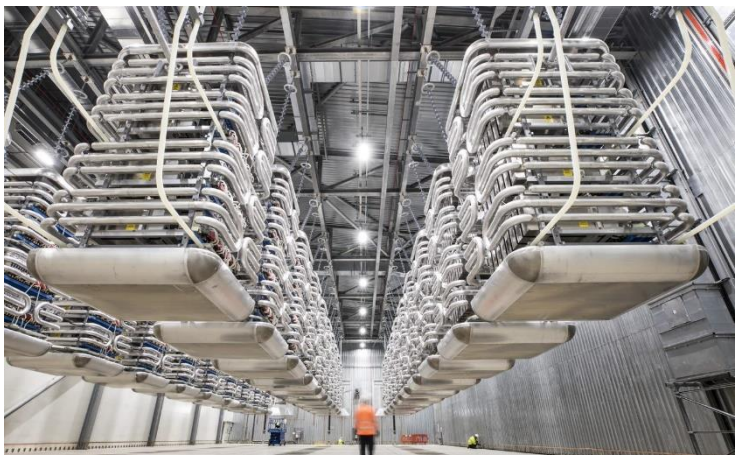
The historic approach of assigning interconnector fixed megawatt-per-minute ramping limits may not be as tenable as more interconnectors connect and flows become more volatile. Therefore, the government supports Ofgem's request for the ESO to update the GB Codes to ensure consistency with the 2019 'Electricity Network Codes and Guidelines (System Operation and Connection) Regulations',[68] including a definition of ramp rate restrictions between GB and other synchronous areas.[69] We support the ESO making initial proposals to the Grid Code Development Forum, to seek industry feedback and establish a respective industry working group to develop an enduring solution and the associated code changes.

Case study: Interconnection (IFA2)

In January 2021, the GB energy system experienced extremely cold weather coupled with a reduction in electricity generation from windfarms. As a result, there was a lower-than-expected supply of electricity to meet high demand.

The Electricity System Operator (ESO) subsequently issued several alerts to notify the market about the conditions, which resulted in the highest ever prices in the GB wholesale electricity market.

At the same time IFA2, a new 1GW interconnector between GB and France, was in its final commissioning phase. As part of the commissioning process, IFA2 was importing power into GB in the morning and afternoon of 13 January 2021. As a result of the market conditions, the ESO asked IFA2 to continue to import power from France at full capacity throughout the evening peak period. The additional electricity supplies from France significantly relieved the GB system



[68] Ofgem (2019), https://www.ofgem.gov.uk/system/files/docs/2019/08/article_118_and_119_final_decision.pdf
[69] The Electricity Network Codes and Guidelines (System Operation and Connection) (Amendment etc.) (EU Exit) Regulations 2019 https://www.legislation.gov.uk/uksi/2019/533/made

tightness and reduced the cost of operating the electricity system that evening – a cost saving that ultimately flows through to GB consumers.

Interconnectors like IFA2 offer system operators a dynamic and flexible tool to react quickly to changes in market conditions in the countries they connect, which helps integrate renewable electricity, mitigates potential wholesale price increases and strengthens security of supply.

Our actions

2.1. The government will use primary legislation, when parliamentary time allows, to define storage as a distinct subset of generation. The government will update and publish a new version of the Planning Practice Guidance, and aims to designate any amended energy National Policy Statements by the end of 2021. The government and Ofgem will work with industry to remove regulatory barriers to the co-location of storage with other forms of generation.

2.2. Ofgem is considering the role that network charges will play in ensuring efficient network usage in the future and, as part of our broader work on access and forward looking charges, we will consider how demand and generation charges should be applied where storage is acting in a way that benefits the system.

2.3. The government will deliver a competition worth up to £68m to accelerate the commercialisation of first-of-a-kind longer duration energy storage, with the intention of building at least six demonstrators by March 2025.

2.4. The government and Ofgem will take actions to de-risk investment for large scale and long duration storage including undertaking analysis on the system need and benefits, consider through a call for evidence how to facilitate the deployment of these technologies, and gather evidence on pumped hydro storage build times through a forthcoming call for evidence on the capacity market.

2.5. The government will conclude its review of business rates in the Autumn, and will continue to work with industry to understand how the VAT regime impacts storage.

2.6. The government and Ofgem will work to develop a system to prevent double charging of final consumption levies on electricity imported that is re-exported by domestic storage and vehicle-to grid.

2.7. The government will continue to work with the industry-led storage health and safety governance group to ensure there is a robust framework in place and implement recommendations from an independent gap analysis, including supporting the development of a Publicly Available Specification for domestic/small-scale storage.

2.8. The government and Ofgem will look to increase the level of GB interconnector capacity. Ofgem will continue to deliver projects under the current cap and floor regime and will publish recommendations for possible future interconnector regulation in autumn 2021. The government will address barriers to multi-purpose interconnectors as part of the Offshore Transmission Network Review, consulting on changes by the end of 2021.

2.9. The government and Ofgem will ensure that UK transmission system operators (TSOs) cooperate with their EU counterparts to develop the required technical procedures as outlined in the EU-UK Trade and Cooperation Agreement. TSOs will develop efficient cross-border electricity trading arrangements at all timeframes. The ESO will develop a coordinated process for remedial actions for electricity trading to support system operability and increased interconnector flexibility.

2.10. The ESO will identify and remove barriers to entry for interconnectors in balancing services by the end of 2023. The ESO will also work to allow interconnector contribution to GB Grid Forming capability, including supporting inertia, by the end of 2021.

2.11. The ESO will update the GB Codes to ensure consistency with UK transposed regulations on 'The Electricity Network Codes and Guidelines'. This includes a definition of ramp rate restrictions between GB and other synchronous areas. A ramping solution will be proposed by spring 2022 by the ESO.

Chapter 3 | Reforming markets to reward flexibility

Vision

In the mid-2020s flexibility technologies of all types and sizes will have improved access to flexibility markets and be able to stack revenues across multiple sources of value where this enables whole system optimisation. Greater utilisation of flexibility will reduce curtailment of intermittent low-carbon generation. Flexibility is widely used as an alternative to network build at both distribution and transmission levels, underpinned by transparent network investment decisions and competitive tendering. Implementation of new network access and charging arrangements incentivise more efficient and flexible network use.

A step-change improvement in coordination between electricity distribution and transmission systems will ensure that balancing and network management maximises overall benefits to the whole electricity system. The Electricity System Operator will have delivered reforms to existing markets for flexibility services, and the implementation of new markets will ensure that evolving system requirements are met to technically enable periods of zero carbon operation and support system security. Flexible technologies will play an increasing role in contributing to security of supply through participation in the Capacity Market.

We will have stronger investment signals for flexibility, which could include changes to the Contracts for Difference scheme to balance system needs with large-scale deployment of low-carbon generation. Carbon reporting and monitoring will be business as usual, and the carbon intensity of flexibility markets will be compatible with our net zero trajectory.

From 2030 and beyond we will have unlocked 'full chain' flexibility, meaning that all flexible supply and demand energy resources can contribute to their full potential, responding efficiently to available energy and network resources. Dynamic, close-to-real-time markets will play an important role in ensuring that the most efficient assets are dispatched. There will be clarity on how this will be delivered across wholesale and balancing arrangements, enhanced procurement of system services and improved locational and time-of-use signals, charging and access arrangements.

Stronger long-term investment signals will signal when and where flexibility will be needed, complementing operational signals and existing procurement mechanisms. Fair and consistent governance arrangements across transmission and distribution will guarantee full participation and market access for all energy resources, while transparent and clear processes will ensure market participants have confidence in the market. The price of carbon will be fully captured in all assets across all flexibility markets. We will have clarity on how the design of energy markets, including the wholesale market, Capacity Market and Contracts for Difference, will take us through to net zero.

Why this area is important

We need to ensure that providers of flexibility – whether that is consumers using smart heating or smart electric vehicle charging, grid scale storage facilities, electricity interconnectors or (in future) the production of hydrogen through electrolysis – are appropriately rewarded for the value they provide to the system. This will enable us to satisfy electricity system needs at least cost by unlocking the full benefits of flexibility. Ensuring that we have an effective suite of market signals is crucial to bringing new flexible technologies onto the system, underpinning their business case and incentivising flexible operation.

In GB, the main source of flexibility to the electricity system is our wholesale electricity market, where arrangements incentivise participants to balance supply and demand on a half-hourly basis to satisfy forward agreements to provide or consume energy. The wholesale electricity market was worth over £10bn in 2020.[70]

In recent years, there has been significant growth in the value and importance of other supplementary markets and signals – including the balancing mechanism, ancillary services and local markets for flexibility – that complement the national wholesale market for electricity. These 'flexibility markets' ensure that specific, additional needs are met including the real-time balancing needs of the system, management of network capacity, and other needs such as those relating to system stability. Collectively, these flexibility markets were worth over £1.5bn in 2020.[71]

In addition to these specific markets, there are other key factors that impact price signals for flexibility. Our electricity system includes several mechanisms that send investment signals for building new generation (for example the Capacity Market and Contracts for Difference scheme), a carbon price which incentivises lower carbon solutions, and various mechanisms for passing the costs of the system back through to system users (e.g. network costs and policy costs). All of these can influence the way flexibility is incentivised.

This chapter focuses on the improvements we are driving forward to flexibility markets and improved price signals, and demonstrates how we are considering the role of flexibility across the whole market context to deliver the needs of a net zero carbon electricity system at least cost.

Case study: Coordination of local and national markets (Electron)

Project TraDER, led by energy tech start-up Electron, is a first-of-its-kind real-time marketplace connecting renewable generators and flexible assets on the Orkney islands. The project aims to create new revenue opportunities for clean technology operators through the creation of local price signals and coordination with national energy markets.

[70] Assuming an average baseload prices of around £40/MWh, https://www.ofgem.gov.uk/data-portal/all-charts/policy-area/electricity-wholesale-markets and over 300TWh of generation. BEIS (2020), Energy Trends table 5.1, https://www.gov.uk/government/statistics/electricity-section-5-energy-trends

[71] National Grid, Monthly Balancing Services Summary, https://data.nationalgrideso.com/balancing/mbss.

TraDER's local market has been operational on the Orkney islands since March 2020. The market is integrated via ElectronConnect's interface with Kaluza's Virtual Power Plant, (building on Kaluza's and CES' existing project Heat Smart Orkney). The platform has two wind generators from CES, 114 electric water heaters from Kaluza, and two batteries from the ReFlex project on Orkney. The platform has seen over 20,000 trades in the past year.

TraDER's national market enables assets on the distribution network to participate in a national flexibility market instructed by the Electricity System Operator. Trials are starting in May, which will demonstrate the feasibility of assets with non-firm connection agreements (and could therefore be curtailed when there are network constraints) participating in national balancing services.

Where are we now?

The past year has been a window to the future for the flexibility we need from the electricity system. Lockdowns due to COVID-19 drove extended periods of low demand with a very high proportion of electricity generation from renewables and other low carbon sources. Whilst a challenging year for the country, the impact of our behavioural changes during this time resulted in a record-breaking year for the electricity sector in Great Britain – delivering the lowest carbon intensity in recent history.[72]

Whilst 2020 was the greenest year on recent record, the challenges of operating the electricity system also drove the Electricity System Operator (ESO) to unprecedented levels of intervention in the balancing mechanism during some periods in the summer, relying predominantly on high-carbon sources of generation to meet system needs.

This level of intervention underscores the importance of reforming flexibility markets and signals to ensure that emergent challenges are signalled and addressed through market-based mechanisms. The pandemic has aggravated many of the underlying technical challenges in operating a low-carbon electricity system and emphasises the importance of the ESO's ambition to be able to operate a zero-carbon electricity system by 2025.

Despite these challenges, 2020 has still been a year of progress. Distribution network operators advertised over 2GW of distribution flexibility services, resulting in over 1GW of procurement and contracts worth over £15m.[73] A variety of flexibility market platforms are now emerging at the distribution level, testing the concept of bringing together buyers and sellers of flexibility on a shared platform. These positive developments will streamline the experience of

[72] National Grid ESO (2021), Record-breaking 2020 becomes greenest year for Britain's electricity, https://www.nationalgrideso.com/news/record-breaking-2020-becomes-greenest-year-britains-electricity
[73] Energy Networks Association (2020), ENA Consolidated Flex Figures, https://www.energynetworks.org/assets/images/ENA%20Consolodated%20Flex%20Figures%202020-PUBLISHED.xlsx

offering flexibility services and make participation easier for a wider range of potential providers.

Smaller-scale distributed assets are now also starting to participate in the balancing mechanism which was previously limited to conventional large-scale providers. Some ESO flexibility services are now also being provided by distributed sources of flexibility, such as electric vehicles and domestic batteries. Despite these positive developments, there are a number of areas where more progress is needed.

What has been done so far

- The ESO has committed to an extensive programme to transform balancing services and open up markets to flexibility technologies. Key achievements include wider access to the balancing mechanism, implementing a new faster acting frequency response product, moving markets closer to real time with day ahead procurement and introducing new pathfinder projects to trial new ways to meet the evolving needs of the system.

- DNOs have developed new, rapidly growing markets that value flexibility at the local level. The development of standardised products and simplified processes means more flexibility providers are able to more easily access these markets and be rewarded for the value they can provide to the system.

- The government and Ofgem have made it easier for DSR providers to benefit from the Capacity Market, including through simplified metering requirements, access to long-term agreements, the ability to reallocate components, and a lower minimum capacity threshold of 1MW. The government and Ofgem have also made it easier to stack revenues between the Capacity Market and balancing services.

- The ESO lowered the minimum threshold to take part in the balancing mechanism from 100MW to 1MW. Ofgem approved code modifications to enable broader access to the balancing mechanism by independent aggregators opening up new opportunities for new providers and technologies, and Elexon has implemented a code change to enable access for smaller assets that sit behind the meter point (coming into force in June 2022), which will remove a barrier to consumers being rewarded for providing flexibility to the system.

- Ofgem introduced new distribution licence conditions to reflect the evolving needs of operating the distribution system. This includes new obligations for DNOs to procure flexibility where they are a cost-effective alternative to network build and to more clearly signal their future flexibility needs.

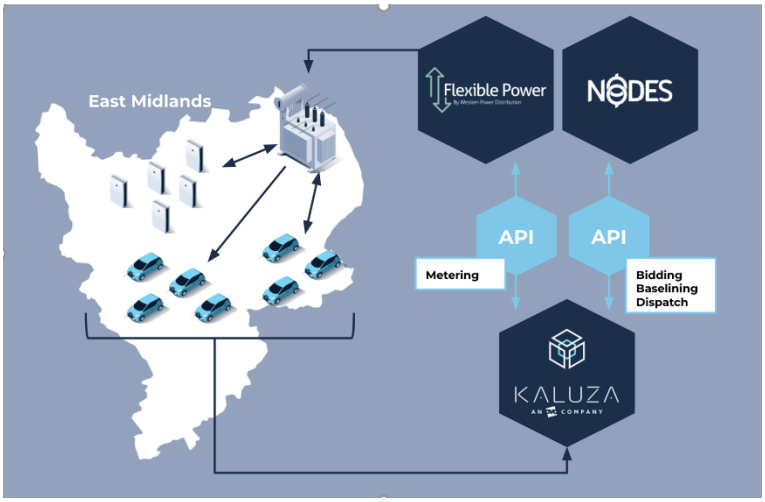
- BEIS awarded up to £4m in funding through the Energy Innovation Programme to two projects (Piclo and Electron) through the Flex innovation competition, supporting the development of digital flexibility marketplaces and trading platforms.

Case study: domestic flexibility supporting local grids (Kaluza)

The need for an effective way of coordinating charging across different types of domestic devices is becoming more important as increased electrification and use of intermittent renewables creates less predictable peak demand.

Kaluza is one of the first technology platforms in the UK to deliver local flexibility services using a mixed portfolio of domestic electric vehicle smart chargers, vehicle-to-grid chargers and home batteries. Providing a live service to distribution network operator Western Power Distribution, Kaluza's technology platform shifts electric vehicle charging away from times of high demand, so the devices import energy when it is cheapest and greenest for end customers and the grid. In addition, the vehicle-to-grid chargers and *sonnen* batteries support the network by exporting electricity to help the grid during high peaks in demand.

The service leverages Kaluza's AI technology to provide a fully automated, machine-to-machine operation that does not require manual intervention. Kaluza participates in the NODES market where flexibility is traded much closer to real time than the standard week or month-ahead timeframes. This offers superior accuracy when forecasting the availability of local flexibility and enables more effective use of flexible devices on a daily basis.



This service demonstrates the potential for many different types of home devices to be orchestrated in combination to support grid balancing, and will enable truly scalable flexibility as part of a net zero energy system.

An infographic showing how Kaluza connects with a number of electric vehicles and storage batteries. Data is fed back and forth between WPD's Flexible Power and NODES to allow flexibility to be traded in close to real time.

What we will do

New and improved national markets to enable zero carbon system operation

Operating a safe, low-carbon grid is an engineering challenge as well as an economic one. The rapid growth of low-carbon generation is changing the characteristics of the system, creating new operational challenges and uncertainties. Balancing services must evolve to meet these changing system needs, such as attributing more value to the speed of responses and market outcomes closer to real-time. The ESO is undergoing significant reforms to its balancing services to enable the transition to a sustainable energy system. By 2025, the ESO

intends to be net zero ready, ensuring it has the markets and tools in place to safely operate a zero carbon system.

Reforms are underway and include the development of a single integrated platform for all ESO balancing services markets, a new suite of frequency and reserve services, and a single day ahead market for response and reserves to be in place by 2023. The ESO will also present a clear and credible plan as to how it will deliver reforms beyond 2023 to achieve its objectives of zero carbon operability and market solutions across all services by 2025. This will include building on lessons learned from its innovative pathfinder projects and its Early Competition Plan, and publishing a clear plan by March 2023 on how it will develop these into regular, bankable markets for solutions to growing operability challenges such as stability, voltage, and thermal constraints.

Transparency and reporting will be key to building market confidence and ensuring the ESO is clearly accountable to its stakeholders. The new Zero Carbon Operability indicator will be crucial for tracking progress towards zero carbon operability by 2025. The new Electricity System Operator Reporting and Incentive arrangements, which were brought into effect by Ofgem from April 2021, will provide a clear framework for reliable reporting and create greater transparency around ESO operating decisions. Additionally, we expect the ESO to adopt a "presumed open" approach, so that all shareable data is available in an accessible format to inform efficient business decision making and facilitate market participation by September 2021.

We need market and regulatory frameworks which promote greater competition and more innovation in the construction and operation of energy networks. Allowing other parties to compete for onshore network projects will deepen the pool of capital available for the significant amount of investment needed in our networks as we transition to Net Zero. As set out in the Energy White Paper, BEIS therefore intends to introduce legislation, when Parliamentary time allows, to enable competitive tendering in the building, owning and operating of the onshore electricity network.

Driving local markets for flexibility, and ensuring coordination across all levels of the system

The electricity system is becoming more decentralised, as more renewables are connected to the grid at a local level, and consumers increasingly own electric vehicles, solar panels, heat pumps, and other assets that allow them to engage more actively with the system. Local sources of flexibility can provide significant value to both local and national markets, as shown by recent analysis by the Carbon Trust and Imperial College London[74], but only if there is sufficient investment and co-ordination with national markets.

Industry has developed new local markets for flexibility as part of the ENA Open Networks project. As these new markets mature, this work has taken initial steps towards standardisation, including the development of standard products, a common contract for

[74] Carbon Trust and Imperial College London (2021), Flexibility in Great Britain, https://publications.carbontrust.com/flex-gb/analysis/ (page 143)

distribution flexibility tenders, and a common valuation methodology for flexibility. Building on this work, networks must deliver and adopt a standardised approach to procuring flexibility and managing connections across all GB distribution networks, where the core set of flexibility products are identical across different networks wherever possible, including common approaches to valuing flexibility, baselining methodologies, pre-qualification, dispatch and settlement and monitoring requirements. The ENA Open Networks project should consider changes to the P2 planning standard that will release additional network capacity to accommodate flexibility and low carbon technologies whilst ensuring network security and reliability is maintained.

Networks and the system operator do not coordinate as effectively as they could do. This may lead to inefficient operational decisions. It also results in disparate approaches to flexibility procurement. Industry has delivered some improvements in coordination through the ENA Open Networks project, including improved approaches to network planning and developing Distribution Future Energy Scenarios to complement the national future energy scenarios produced by the Electricity System Operator.

It is essential that different parties procuring or selling flexibility at both local and system-wide level work together to optimise the electricity system as a whole, through the alignment of procurement processes across distribution, transmission and ESO ancillary services as well as improved coordination across parties. When procuring flexibility, we expect parties to align as soon as possible on contract terms, service requirements, frequency of procurement, procurement timetables as well as interfaces for the provision of flexibility services to the ESO or network operators. Networks have committed to delivering this by the start of RIIO-ED2 through the ENA Open Networks project.[75] To support this, we also expect the ENA Open Networks to deliver a framework for appropriate data sharing based on the presumed “open” principle to optimise procurement across the whole electricity system. Ofgem has also set out plans to reform the planning information DNOs publish to better inform flexibility providers of opportunities to provide services to the networks.

There is also a need to clarify how certain contracts affect the ability of assets to participate in national balancing markets. It is important that DNOs and the ESO work together to ensure that those within Active Network Management zones can participate in markets as far as reasonably practicable, to ensure the system benefits from all potential sources of flexibility. The ENA Open Network also needs to develop and implement a set of primacy rules to resolve service conflicts between ESO-procured and DNO-procured flexibility by the beginning of RIIO-ED2. Arrangements will need to be put in place for evaluating, reviewing, and amending principles and primacy rules when appropriate. We expect this should be supported by appropriate mechanisms for sharing real time data and operational forecasting as well as shared processes for monitoring distributed energy resources. The ENA Open Networks project should consider changes to the P2 planning standard that will release additional

[75] RIIO stands for Revenue = Incentives + Innovation + Output. It is the price control model used by Ofgem to ensure that regulated electricity network companies are incentivised to deliver a quality service for customers without earning excessive returns.

network capacity to accommodate flexibility and low carbon technologies whilst ensuring network security and reliability is maintained.

We expect networks to build on their work and further deliver open, transparent, accessible, and efficient markets for local flexibility by the beginning of RIIO-ED2. This must be done in a way that is coordinated between networks and the system operator, accounting for impacts across the whole system in line with new licence obligations for distribution network operators and the electricity system operator.[76] We expect network operators to work together proactively through the ENA and other relevant governance arrangements to deliver a step change in coordination, demonstrating a clear, long-term view of how flexibility services will complement each other at both the distribution and transmission level.

The long-term coordination of the system will of course be influenced by future governance arrangements, which are being developed by Ofgem and BEIS (see breakout box).

Governance arrangements that underpin flexibility markets

Energy codes

The energy codes are the detailed technical and commercial rules underpinning the operation of the electricity and gas networks and the wholesale and retail markets. The government and Ofgem conducted a review into energy codes which found that they are fragmented and complex and that there is a lack of coordination across codes. These challenges act as a barrier to entry for new market participants and innovation, and hinders the transition towards a more flexible energy system with net zero emissions while minimising costs and protecting consumers. Reforming the code governance framework could therefore better facilitate strategic changes in the sector, unlocking innovation and significant benefits to consumers.

BEIS and Ofgem are now working together to address those issues through reforming the governance of the codes. In 2019, we consulted on proposals to provide strategic direction to code development, increase independent decision making and simplify the content of codes. The consultation received a large range of feedback which will be considered as part of ongoing policy development. We have published a second consultation following the development of policy, taking into account stakeholder responses from our first consultation.[77]

[76] The modification of the ESO's licence to clarify its obligations to coordinate and cooperate with both transmission and distribution networks to deliver economic and efficient operation of the total system. Ofgem also introduced a Whole Electricity System licence condition requiring networks and the system operator to coordinate and cooperate with other network licensees and network users where this is in the interest of an economic and efficient energy system.
A new distribution licence condition (31E) that requires distribution networks to procure flexibility services where it is economic and efficient, and to do this in an objective and transparent manner using market-based procedures.
[77] BEIS and Ofgem (2021), Consultation on the Design and Delivery of the Energy Code Reform, https://www.gov.uk/government/consultations/energy-code-reform-governance-framework

Future System Operation

Earlier this year Ofgem published its review of GB energy system operation.[78] This review considered the current and future challenges to GB System Operation and assessed whether the right governance framework was in place to enable the system operators for electricity and gas to continue to deliver decarbonisation at the pace and to the depth required.

This report found that net zero will require a step change in whole system co-ordination and planning and that the system operators are uniquely placed to play an enhanced role as part of this. Ofgem recommended that, in order to take on these enhanced roles, greater independence for the system operators from the existing transmission network owner would be desirable.

The government is considering Ofgem's recommendations as part of our broader work on energy system governance and we have published a joint consultation with Ofgem on the future of system operation.[79]

Distribution System Operation

Following on from the actions set out in the 2017 Smart Systems and Flexibility plan, Ofgem has been updating distribution licenses and the price control framework to provide updated expectations to distribution networks as they develop distribution system operation capabilities in planning, operation and market facilitation. We expect the DNOs to include aspirational plans for progressing effective and efficient outcomes from more active distribution system operation, including how they will manage any real or perceived conflicts of interest, in their business plans. Concerns around actual and perceived conflicts of interest could undermine confidence in flexibility markets. Providing confidence that markets value flexibility fairly will be crucial to delivering investment in flexibility. We will continue to keep DNO conflicts of interest under review. We will take additional action should evidence arise that conflicts of interest are undermining confidence in flexibility markets, including legislating if appropriate.

Further improvements are still needed when it comes to optimal operational decisions across transmission and distribution and the coordinated design of flexibility markets. The government and Ofgem must ensure that governance arrangements are fit for purpose to deliver effective and coordinated flexibility markets in this regard. To that aim, Ofgem will undertake a review of electricity distribution system operation governance over the coming year, where governance in this area will be developed and consulted upon, with a view to making a recommendation on any necessary changes by 2023. This could

[78] Ofgem (2021), Review of GB energy system operation, https://www.ofgem.gov.uk/publications-and-updates/review-gb-energy-system-operation
[79] BEIS and Ofgem (2021), Energy Future System Operator Consultation, https://www.gov.uk/government/consultations/proposals-for-a-future-system-operator-role

include changes to the price control, distribution licence, or institutional change if necessary.

The interaction of flexibility with the Contracts for Difference Scheme and Capacity Market

To meet the needs of a net zero system at lowest cost, it is important to consider flexibility within the wider market context.

The **Contracts for Difference Scheme** is the UK's main tool for bringing low-carbon generation onto the system. Previous auction rounds have focused purely on increasing the overall capacity of low-carbon generation on the grid. This has been extremely successful, but as the proportion of renewables increases there is a need to think more holistically about how parts of the electricity system interact with one another, as outlined in the government's recent call for evidence on the future of renewable support schemes[80]. We are aware that the mechanism does not factor in all system needs, and therefore could be causing costs to rise elsewhere. Therefore we will continue to consider how best to strike the balance between supporting investment in essential generation technology and incentivising efficient behaviours at the system level.

The rollout of flexible technologies such as storage and DSR could also allow us to make better use of the low-carbon generation we build, as excess electricity is stored or demand is shifted away from peaks to periods of high renewable generation. This means building more flexible assets will lead to more useful low-carbon electricity on the system than building just generation. However, flexible technologies cannot compete directly in the scheme, and so are not on a level playing field in the market.

The government is building on responses to the call for evidence on the future of renewable support schemes and aims to ensure that the full range of low-carbon technologies are valued appropriately somewhere in the market framework. Should short-term changes to the CfD scheme be required, these would be consulted on for Allocation Round 5.

The **Capacity Market** (CM) delivers security of supply at least cost to the consumer. It is open to participation by all technologies and ensures there is enough capacity available to meet peak demand. Generators and flexibility providers receive payment for the provision of reliable capacity to ensure they deliver more electricity, or reduce demand, when required. To date, the CM has supported investment in around 13GW of new build generation and interconnectors, and around 900 MW of new build electricity storage has secured Capacity Market Agreements[81]. In the latest T-4 CM auction, over 1GW of DSR capacity won agreements.[82] We have made a number of reforms since its introduction in 2014, such as opening up participation

[80] BEIS (2020), Enabling a high renewable, net zero electricity system: call for evidence, https://www.gov.uk/government/consultations/enabling-a-high-renewable-net-zero-electricity-system-call-for-evidence

[81] De-rated capacity for new build assets. Capacity Market registers as at April 2021: https://www.emrdeliverybody.com/CM/Registers.aspx

[82] De-rated capacity for both proven and unproven DSR. Capacity Market registers as at April 2021: https://www.emrdeliverybody.com/CM/Registers.aspx

to wind and solar, implementing carbon emissions limits, and providing DSR with access to long term agreements. In our Five-year Review, published in 2019, we committed to retaining the CM as a guarantee of system reliability and to making further incremental improvements to its design.

Since publishing our five-year review into the Capacity Market, government ambitions on carbon reductions have increased, as demonstrated through the Energy White Paper and adoption of the CCC recommendations on Carbon Budget Six. The next full review will be completed by 2024 and will ensure that the mechanism acts in concert with other markets to incentivise investment in the right type of capacity, in the right place at the right time. The government commenced proceedings for the next Capacity Market Review earlier in 2021 and will engage with stakeholders in due course. In the interim, we intend to return to some of the issues and improvements identified through the Five-year Review, particularly those which can help ensure the CM is better aligned with our net zero ambition, such as reviewing the arrangements on agreement lengths, considering the role of split auctions, and reviewing evidence on the way in which technologies with long-build times, such as pumped hydro storage, can participate in the CM.

We will soon publish a call for evidence on the Capacity Market, to start gathering stakeholder views on the longer-term future of the scheme in the context of net-zero.

Addressing the carbon intensity of flexibility markets and services

A net zero future will require a significant amount of low-carbon flexibility, however most flexibility markets are currently dominated by high fossil fuel assets. In 2020, fossil fuel assets made up around 80% of accepted bids and offers in the balancing mechanism[83] and over 60% of de-rated capacity awarded in the latest 2020 T-4 capacity mechanism.[84] It is important to ensure the long-term trajectory of flexibility markets is consistent with the commitment to be net zero by 2050.

Robust carbon monitoring and reporting is essential to ensure flexibility markets are compatible with our net zero obligations and to facilitate low-carbon activities and business models. Network and system operators do not fully report on the carbon intensity of their markets, making it difficult to track carbon emissions. By 2023 we expect a consistent methodology in place providing full transparency on the carbon intensity of the actions and services procured by the networks and system operator. In addition, we expect them to explore options for forecast and actual carbon reporting. We are also working with the ESO to ensure emissions information measured in the Capacity Market's reporting and verification mechanism is publicly available by 2022.

Across all markets, we must identify and address potential gaps in carbon policies. Certain thresholds and exemptions inadvertently shield some high-emitting generators from carbon

[83] Elexon, Balancing Mechanism Report Service https://www.bmreports.com/bmrs/?q=help/about-us
[84] National Grid ESO (2021), Capacity Market Auction T-4 DY2024-25 Final Report, https://www.emrdeliverybody.com/Capacity%20Markets%20Document%20Library/Capacity%20Market%20Auction%20T4%20DY2024-25%20Final%20Report.pdf

policies, distorting market signals, and blocking investment in low carbon flexibility technologies. For example, in recent auctions a high percentage of Capacity Market agreements were awarded to carbon emitting gas generators smaller than 20MW, which are exempt from the UK Emissions Trading Scheme (UK ETS). To help maintain a level playing field, we will work through the UK ETS Authority to review the 20MW UK ETS exemption in 2022. Potential changes, where appropriate, will be implemented by 2026. The carbon intensity of flexibility markets is intrinsically connected to operation and investment signals from the wider market framework, meaning the issue must be approached holistically.

We have committed to exploring expanding the UK ETS to the two-thirds of uncovered emissions, and will explore the role of carbon pricing for flexibility markets in this wider context. This will complement the government's thinking on the Contracts for Difference scheme and Capacity Market, to ensure we are considering how the power system will be decarbonised in a holistic way.

The role of network and policy costs in driving flexibility

The costs of building, maintaining and operating our electricity networks (network costs) and of ensuring security of supply and the transition to low carbon generation (policy costs) are passed on to system users. The way that these costs are recovered influence the signals that consumers and other users of the electricity system receive to behave flexibly.

Network costs

Network costs are passed on to network users, with costs split between generators and consumers. However, not all network users create the same cost to the system. Generating electricity at times of high supply or consuming it at times of high demand puts greater strain on the network, but current network charges frequently do not reflect this and so users have limited incentive to change their behaviour. Passing network costs on in a way that better reflects one's impact on the system could reduce overall costs and create savings for businesses and consumers. This must be done in a way that guards against unfair outcomes or burdens vulnerable consumers.

Ofgem's Access and Forward Looking Charging Significant Code Review (SCR) seeks to improve the cost-reflectivity of network access and charging arrangements in a manner that better reflects variations in network costs associated with location and time of use. We expect that this will better enable suppliers, facilitated by smart meters and the transition to market-wide half-hourly settlement, to offer more innovative tariffs to network users that will lower bills overall and incentivise flexibility that leads to lower costs for consumers. The SCR also seeks to address high upfront costs of connecting to the network, which can act as a barriers for low carbon technologies, for example electric vehicle charging hubs and windfarms.

The potential savings associated with using flexibility to alleviate network constraints and drive efficient network investments are very significant. When Ofgem launched the SCR in 2018,

Imperial College/Carbon Trust modelling identified potential savings of up to £4-15bn cumulatively to 2050 from reduced capital expenditure on electricity network reinforcement.[85]

Ofgem is consulting on proposals in two phases. On 30 June we consulted on three areas of the significant code review:[86]

- **Transmission network charges (TNUoS)**, including equivalent charges for distributed generators and the possible need for a wider review of transmission charging arrangements. This also considers the appropriate treatment of electricity storage.
- **Distribution network connection charges**, including reforms to reduce the upfront costs of connection to the distribution network, to facilitate investment in low carbon heat, transport and generation.
- **Access rights**, including options for flexible network access to support quicker and cheaper connections, with improved clarity on the extent to which the flexible connection could be curtailed.

Later this year, Ofgem intends to consult on:

- **Distribution network charges (DUoS)**, including charges that better reflect the value of flexibility in different locations at different times in the distribution network.

Ofgem will make a decision on each of these areas by the end of this year.

Policy costs

Many of the policies that ensure our energy system is low carbon, affordable and secure, are paid through our energy bills. The way that these costs are passed through to bills can incentivise or disincentivise certain behaviour that is important for net zero, for example switching to electric heating, or providing flexibility to the system. The government will begin a strategic dialogue between consumers, industry and government on how to fairly allocate future costs as the UK transitions to net zero, by publishing a call for evidence on Affordability and Fairness soon. This work will create a common evidence basis and consider known but complex policy trade-offs, helping the government to make funding decisions in a way that keeps the wider public committed to our net zero goals.

Alternative Energy Markets Programme, Energy Price Signals Study

The Alternative Energy Markets Programme is aimed at understanding what an alternative system of network and policy price signals in Great Britain could look like, based on principles consistent with cost-effective decarbonisation, whether those signals

[85] Imperial College London and Carbon Trust (2016), An analysis of electricity system flexibility for GB, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/568982/An_analysis_of_electricity_flexibility_for_Great_Britain.pdf

[86] Ofgem (2021), Access and Forward-looking Charges Significant Code Review - Consultation on Minded to Positions, https://www.ofgem.gov.uk/publications/access-and-forward-looking-charges-significant-code-review-consultation-minded-positions

could be trialled in a real-world environment, and how to undertake any potential trial. These alternative signals should allow energy suppliers and other third parties to develop innovative energy products which then incentivise consumers to adopt smarter technologies and reward them for shifting their energy demand.

In March BEIS commissioned an Energy Price Signals study[87], expected to complete in February 2022, to provide an evidence-based menu of options for price signals. The study is being undertaken by CEPA LLP with support from the Energy Systems Catapult, and the findings from this work will be used to support BEIS to shape the next steps of the programme. This was funded through the government's £1 billion Net Zero Innovation Programme.

Case study: battery storage in the balancing mechanism (Habitat)

Habitat Energy, a battery optimisation company based in Oxford, is among the first market participants to become a Virtual Lead Party (VLP), a new role created to enable wider access to the balancing mechanism.

The balancing mechanism is one of the Electricity System Operator's (ESO) tools to balance electricity supply and demand. The new VLP role enables participants who are not traditional suppliers or generators (e.g. customers or flexibility providers) to participate in this market, enabling more flexible assets to provide valuable balancing services. This is important because as renewable penetration increases and the ESO has to manage a greater degree of intermittency, the need for that flexibility will increase.

Balancing mechanism access enabled Habitat Energy to participate in the ESO's Reserve from Storage trial in September 2020. This showcased how effective storage can be in providing reserve supply and demand, saving £1.2m. In addition, in January 2021, the ESO enabled market participants to simultaneously operate in the balancing mechanism while delivering its flagship fast-acting frequency response service, Dynamic Containment. This stacking of services means that participants like Habitat Energy can provide two vital services to the ESO at the same time: managing the frequency of the grid, and helping balancing supply and demand.

[87] BEIS (2021), Alternative Energy Markets, Energy Price Signals Study: invitation to tender, https://www.gov.uk/government/publications/alternate-energy-markets-energy-price-signals-study-invitation-to-tender

Our actions

3.1. The ESO will deliver on its ambition for net zero operability by 2025, including a new suite of ancillary services, and implement a single day ahead market for response and reserve by 2023. The ESO will also deliver and build on its pathfinder projects, and present a clear and credible plan to deliver reforms beyond 2023 to achieve its objectives of zero carbon operability and market solutions across all services by 2025.

3.2. Distribution networks will deliver and adopt a standardised approach to procuring flexibility and managing connections across all GB distribution networks, where the core set of flexibility products are identical across different networks wherever possible, by the start of RIIO-ED2 in 2023.

3.3. Distribution networks and the system operator will deliver a step up in alignment between distribution flexibility, transmission flexibility procurement and ESO ancillary services by the start of RIIO-ED2. Networks and the system operator will develop and implement a set of primacy rules to resolve service conflicts by the start of RIIO-ED2.

3.4. The government and Ofgem will ensure that institutional arrangements governing the energy system are fit for purpose for the long term to deliver coordinated and effective flexibility markets. Ofgem and government have published joint consultations on system operation and energy code governance, and Ofgem will undertake a review of electricity distribution system operation governance over the coming year, with a view to making a recommendation on any necessary changes by 2023.

3.5. The government will continue to engage with industry on how best to balance strong investment signals for low-carbon generation with wider system needs in the Contracts for Difference scheme, in the lead up to Allocation Round 5. We will soon publish a call for evidence on the Capacity Market later to start gathering stakeholder views on the longer-term future of the CM in the context of net-zero.

3.6. Network and system operators will develop consistent methodologies for carbon reporting and monitoring of their actions and markets. We expect that carbon monitoring and reporting will be in place by 2023. We expect the ESO to publish emissions data for the Capacity Market by 2022. The government will review minimum thresholds and gaps in current carbon policies, including working through the UK ETS Authority to review the UK ETS exemptions threshold of <20MW by 2022, with relevant changes implemented by 2026. We have committed to exploring expanding the UK ETS to the two-thirds of uncovered emissions, and will explore the role of carbon pricing for flexibility markets in this wider context.

3.7. Ofgem will improve price signals for flexible network usage through network charging reform, including consultations on DUoS, TNUoS, connection charges and access rights.

3.8. The government will explore how some network and policy costs may be recovered differently in the future, through the Alternative Energy Markets Programme and our response to the forthcoming Affordability and Fairness call for evidence.

Chapter 4 | Digitalising the system

Vision

In the mid-2020s we will have standards and regulatory frameworks in place that ensure energy data collection and applications meet best practice and that data assets are treated as open and accessible by default while privacy and security is protected. There will be a significant step-up in the visibility of assets across the system and new digital services will make it easier for people to know what data exists and how they can gain access to it. These services will ensure datasets can be combined with minimum time and effort for the user. The next steps for digitalising the energy system will have been identified, including what new data governance, market frameworks and institutional designs need to be developed to ensure data privacy and cyber security while increasing market access and services.

By 2030 and beyond system operators will have visibility of all energy assets, making planning, forecasting and operations quicker, more accurate and cheaper. Greater data access in the marketplace will support new business models and services developing and new market entrants participating in the energy sector. These new entrants will be able to tailor energy services to consumers using sophisticated digital platforms, address system needs via software rather than hardware, and create predictive models that prevent issues before they happen. A digital energy system will provide a modern platform for entrepreneurs and innovators to revolutionise how we interact with and conceive the energy system and how it integrates with our wider national infrastructure and services. These capabilities will underpin a secure decarbonised energy system, create market opportunities and new markets for information services and insights, provide confidence to investors, support research and benefit consumers from new products and services.

Why this area is important

Our future net zero energy system will comprise millions of assets – including solar panels, electric vehicles, heat pumps and batteries. These will need to be optimised, primarily through open and transparent markets, across our transmission and distribution networks, and co-ordinated with other sectors such as transport. We also need to unleash innovation across the sector, including in the low carbon services offered to consumers. This will only be possible by harnessing the power of data across a digitalised energy system.

The benefits this will bring include the ability to decarbonise the energy system at least cost; stimulating economic growth across all sectors; and creating fair, more targeted services for consumers, including society’s most vulnerable.

In 2019 the Energy Data Taskforce set out its findings, including a lack of common data standards, no openly shared data repository, and a culture of data hoarding.[88] This impedes competition, innovation, and new business models. The Taskforce set out a series of recommendations for how to harness the power of data in delivering a net zero energy system: embedding a culture of 'presumed open' across the sector, and developing digital tools, such as a data catalogue, digital systems map and asset registration strategy.

Since publication, good progress has been made in delivering against these recommendations, however there is much more to do, and further barriers have been uncovered. BEIS, Ofgem and Innovate UK are delivering this work through their partnership called the Modernising Energy: Digitalisation programme.

What we will do

BEIS, Ofgem and Innovate UK are publishing, alongside this Plan, the UK's first Energy Digitalisation Strategy and Action Plan. This strategy delves into the urgent need for, and benefits of, digitalising the energy system. It provides an update on how far we have come since the Energy Data Taskforce made its recommendations; discusses the barriers to digitalisation that the sector continues to face; outlines a strategic approach to addressing these barriers; and identifies a series of actions for the government, Ofgem and industry that provides a clear vision and direction that the sector has called for. This includes supporting an Energy Digitalisation Taskforce (EDiT) to ensure that we maintain momentum in creating a flexible, digital net zero energy system. Our approach to addressing the barriers is categorised into three core themes: leadership and coordination; incentivising change; and development of digital solutions.

[88] Energy Systems Catapult (2019), Energy Data Taskforce: A Strategy for a Modern Digitalised Energy System, https://es.catapult.org.uk/reports/energy-data-taskforce-report/

Chapter 5 | Delivering this Plan

This Plan has been developed by the government and Ofgem with close engagement from stakeholders across the sector. Developing and publishing the plan is the first stage, but implementing it, in a way that is efficient, transparent and co-ordinated with the sector and other policies is critical. The actions set out in the Plan (see Annex 1) form the basis for the next phase of delivery, however we will also need to be mindful of our vision for each of the core areas, intended outcomes for our actions, and be able to monitor progress both in terms of delivering our actions, but also the take up of flexibility across the system (see Monitoring Flexibility below).

We have, to date, adopted a transparent approach to policy making, working across government, Ofgem and industry. Over the course of 2020 and early 2021 we have conducted comprehensive stakeholder engagement and co-creation. We commit to maintaining an open dialogue and to ensure this collaboration continues, we will review the purpose, membership and Terms of Reference of our joint Smart Systems Forum following the publication.

The system is constantly evolving, and so our measures to facilitate smart systems and flexibility will need to be adjusted frequently. The value of flexibility should be recognised across the energy system and our approach should be adaptive to remain effective as industry grows and changes.

Following publication, we will continue to work closely with industry to identify and address barriers to a smart system. We will continually adapt our approach, as necessary.

Monitoring flexibility

To be effective, smart energy policy needs to be able to adapt to an evolving system. A robust and systematic monitoring framework is a tool for identifying the changes in the market and understanding how smart and flexible technologies are progressing.

It will help us to know how much flexibility is coming forward, and how it performs in markets; what barriers exist to flexible technologies participation in the energy market; whether we are on the right trajectory and if government and Ofgem need to take further, or different, action.

Why this area is important

Monitoring is an essential part of the policy cycle.[89] It allows the government and Ofgem to establish whether intended outcomes have been achieved and enables corrective action to be

[89] BEIS (2020), BEIS Monitoring and Evaluation Framework, https://www.gov.uk/government/publications/beis-monitoring-and-evaluation-framework

taken where necessary. The learnings from monitoring provide a timely and consistent source of evidence to inform future policy design.

Our smart energy policy approach is about removing barriers, facilitating change, and spurring innovation. This approach relies on markets and industry working effectively once the identified barriers have been removed. We need to monitor changes in the market to track how technologies and competition are developing. This enables us to assess whether policy is effective and ensure the market-led approach remains fit for purpose.

Monitoring can help us to identify both where flexibility is successfully performing in markets and where barriers still exist. Having a comprehensive set of monitoring data will allow us to spot future policy challenges early on and provide the evidence base for effective future policy design.

Our monitoring approach

This Plan sets out many actions that are needed to enable a smarter more flexible system. The impacts of these actions are overlapping, and complex, multiple actions will contribute to a single outcome. There are also factors outside of direct policy control that will affect flexibility outcomes (e.g. falling technology costs, price volatility). We therefore do not consider it appropriate to track separate indicators for every policy action, and it will not be possible to robustly attribute impacts to single policy interventions.

To overcome these monitoring challenges, we have chosen a ‘market monitoring’ approach. We have identified a set of key outcomes that we expect multiple actions in the Plan to contribute towards. At a high level, our chosen outcomes are the deployment of flexible technologies and the performance of these technologies in markets. We expect that these outcomes will demonstrate the overall progress of flexibility in the electricity system. Greater deployment and participation of flexible technologies will be a direct sign that the electricity system is becoming more flexible and will be better able to cost-effectively integrate increased penetration of renewable generation and increased demand from transport and heat electrification. The aim is to provide a holistic assessment of the progress of flexible technologies, to be able to understand if policy outcomes are on track to be met.

Given the uncertainty in future energy system development, we do not consider it appropriate to set targets for our indicators. However, the strategic modelling in Appendix I sets illustrative scenarios that demonstrate the scale of deployment of flexible technologies that may be needed. These scenarios provide the context in which we will consider the monitoring data.

What will we monitor?

Our monitoring will be underpinned by the selection of appropriate indicators. Indicators will be based on good quality established data sources and be proportionate, while reflecting outcomes that are important for meeting policy objectives. The full set of indicators can be found in Appendix II, our initial monitoring report.

We have chosen a set of indicators that cover two broad areas: i) the deployment of flexibility technologies, and ii) the participation of flexibility technologies in markets. The deployment indicators will cover the capacity of different flexible technologies that are available on the system, including the rollout of domestic technologies such as smart meters and electric vehicles. The participation indicators track the performance of these technologies across different markets, including the proportion of Capacity Market, balancing mechanism and ancillary services fulfilled by flexible technologies. These indicators will provide up-to-date information across a range of markets and reflect the revenue stacking business model we expect most flexible technologies to follow.

Our indicators must adapt to the changing landscape. As energy markets develop, monitoring will need to keep pace with the changes. We will review the indicators prior to data collection to ensure they are fit-for-purpose as new markets develop and new data becomes available.

How will we use monitoring data?

Monitoring data will be a consistent and timely source of evidence. It will form part of our evidence base, complemented by wider information gathering such as stakeholder feedback and system modelling. The monitoring will be used to understand high-level trends, to reassure that progress is as expected or highlight areas where more detailed analysis may be needed. Where indicators show that progress has been limited or that markets are not developing as expected, this will warrant further investigation to identify potential challenges. Ultimately monitoring evidence will be used to inform future policy changes and to identify priorities for unblocking remaining barriers.

Findings from our first monitoring framework

The first version of the smart monitoring report can be found at Appendix II. It describes the data we have collected and our assessment of how flexibility is developing in the system. The initial report provides the baseline for future monitoring to be assessed against. Our key findings from the report are as follows:

- **There is a clear and rising need for flexibility in the GB energy system.** An important driver of flexibility requirements, the share of renewables in the generation mix, is rising year on year. This will continue to increase with the ambition of 40GW of offshore wind by 2030. The electrification of heat and transport will also increase the demand on networks, growing the requirement of flexibility to avoid costly reinforcement. Most markets providing flexibility services—the balancing mechanism, ancillary services, local flexibility markets—are growing, demonstrating the increasing need for flexibility.
- **Consumer flexibility is relatively nascent, but the rollout of new technologies provides opportunities for growth**. Today, industrial and commercial consumers are already providing demand side flexibility. Participation from domestic and smaller non-domestic consumers remains at an early stage, but the ongoing rollout of smart meters and the future implementation of market-wide half hourly settlement are key

enabling factors. The number of electric vehicles and heat pumps is increasing fast, indicating a growing potential for consumer flexibility.

- **The deployment of grid scale flexibility has increased, but greater progress will be needed as the electricity system decarbonises.** New deployments of batteries have slowed after an initial rush in 2018. The pipeline of storage projects, both pumped hydro and batteries, remains large, but there is uncertainty in the number of projects that will progress to construction and operation.
- **The participation of flexible technologies has increased but is inconsistent across markets. The coming years could see new markets and new business models develop.** Batteries now dominate frequency response markets and new products have increased the revenue opportunities in these markets. The share of bids from storage and demand side response (DSR) in the balancing mechanism remains very small, though DSR volumes are increasing. Distribution Network Operator flexibility tenders are a nascent, but growing market. Evidence of a shift towards longer (2h) duration batteries winning Capacity Market agreements could suggest a change in business model. It is likely that merchant revenue in the balancing mechanism and wholesale market will become more important for new flexibility assets.

Next steps

We recognise that the first iteration of our monitoring framework is only the first step to an effective monitoring strategy. We will need to adapt our indicators as markets develop and stakeholder feedback is key to doing this. Stakeholders are best positioned to identify market barriers and suggest key indicators. We will work closely with stakeholders to understand the areas that are important to consumers and industry and reflect these in our monitoring strategy.

Going forward we will continue to engage with stakeholders across all aspects of our monitoring strategy. We will provide opportunities for stakeholders to give feedback on our first monitoring report and gather views on areas for future work. We will also seek views on how to share monitoring data with stakeholders on an ongoing basis, including which organisation should be responsible for maintaining the monitoring strategy and the format of the report.

Our actions

III. The government will work with stakeholders to develop the monitoring framework by identifying new indicators and data sources. We will gather stakeholder feedback and share an updated version of the monitoring indicators. We will also decide the longer-term process for the monitoring framework, including which organisation should have responsibility for the strategy and how it should be shared with stakeholders.

List of annexes and appendices

Annex 1: Full list of actions

Appendix I: Electricity System Flexibility Modelling

Appendix II: Smart Systems and Flexibility Plan Monitoring Framework

Annex 1: Full list of actions

Overarching actions	
	Issue: A smart, flexible energy system will need significant investment in innovation to accelerate the commercialisation of key technologies and services, and a larger, skilled workforce to deliver them. The system is evolving rapidly and policies made today may not be suitable for the policy landscape of tomorrow. **Outcome:** Innovation and skills develop at pace to deliver a smart, flexible energy system in line with our net zero ambitions and with significant benefits for the UK economy. The government, Ofgem and industry can monitor and adapt flexibility to a changing policy landscape.
I.	The government will drive forward innovation through the £1bn Net Zero Innovation Portfolio to provide funding for low-carbon technologies and systems. This includes at least £100 million of innovation funding for energy storage and flexibility innovation programmes.
II.	The Green Jobs Taskforce published its recommendations in Summer 2021 which the government will consider ahead of publishing the Net Zero Strategy later this year. To support the outcomes of this work we will undertake a smart skills gap analysis in 2021. This will inform our approach to closing the skills gap going forward.
III.	The government will work with stakeholders to develop our flexibility monitoring framework by identifying new indicators and data sources. We will gather stakeholder feedback and share an updated version of the monitoring indicators. We will also decide the longer-term process for the monitoring framework, including which organisation should have responsibility for the strategy and how it should be shared with stakeholders.

Facilitating flexibility from consumers	
	Smart energy technology **Issue:** Consumers do not have access to the right technologies needed to enable flexibility in homes and small businesses. **Outcome:** Smart meters are installed in homes and small businesses, and consumers will have access to a wide range of interoperable and secure smart appliances, giving them the technical capability to participate in providing flexibility to the system.
1.1.	The government has confirmed that a new four-year smart meter policy framework with fixed minimum annual installation targets for energy suppliers will commence on 1 January 2022 to drive the consistent, long-term investment needed to achieve market-wide rollout.
1.2.	The government will work with industry to support the uptake of PAS 1878 and 1879 for “energy smart” appliances, to encourage development and deployment of DSR-capable devices and to establish a technical framework for small-scale DSR.
1.3.	The government will take powers to regulate "energy smart" appliances when parliamentary time allows, to set requirements underpinned by the principles of interoperability, data privacy, grid stability and cyber security. The government will also mandate that all private electric vehicle chargepoints must have smart functionality and meet minimum device-level requirements, legislating later in 2021. We will ensure that our approach is compatible with wider government regulation of consumer connected products.
	Flexibility providers **Issue:** The technical and regulatory framework does not incentivise the provision of a wide range of innovative flexibility services and tariffs, and must evolve to support the development of flexibility providers, while protecting consumers and the energy system.

	Outcome: Consumers have a greater choice of smart tariffs and flexibility services, and the appropriate regulatory and technical environment is in place for flexibility providers to deliver positive outcomes for consumers and the energy system.
1.4.	The government will aim to consult in 2022 on an appropriate regulatory approach for flexibility service providers and other organisations controlling load. We will ensure that regulatory approaches for smart appliances, chargepoints, home energy management systems, flexibility service providers and load control systems are aligned, and work closely with industry to deliver on our core principles of interoperability, data privacy, grid stability and cyber security. We will also consider what legislative powers we will need to implement any solution, and look to take these when parliamentary time allows. We will continue to support industry-led initiatives, including the ESO's Power Responsive campaign and the Flex Assure code of conduct established by the Association for Decentralised Energy, to remove technical and cultural barriers to the increased participation of large consumers in DSR.
1.5.	Ofgem expects industry to implement market-wide half hourly settlement by October 2025, and will put in place strong incentives and governance to ensure that implementation happens in a timely and effective manner. The baseline transition plan will be reviewed in October 2021. Any proposals to change the length of the transition would need approval through governance arrangements being set up, and Ofgem has proposed that any delay of three months or more would require its approval. Ofgem will look at barriers to elective half-hourly settlement and what could be done to address them.
	Cyber security **Issue:** Digitalisation of the energy system brings new risks related to cyber security, which will increase and evolve as more smart devices are installed in homes and businesses and more organisations access them for flexibility and other services. **Outcome:** Improved visibility of cyber security risks informing a system-wide approach, and cyber security protections are integrated into smart energy devices, organisations and systems, giving consumers the confidence to engage and protecting the energy system.

1.6.	We will embed a culture of cyber security across the smart energy system. For devices, we will deploy a 'Secure by Design' approach as a minimum baseline, so that future energy smart appliances and electric vehicle chargepoints are designed with appropriate cyber security protections from the start. We will develop assurance approaches to support manufacturers and flexibility service providers in meeting the necessary standards. The government will commission further work to set an enduring approach to monitoring and mitigating cyber security risks across a smart and flexible energy system.
	Consumer protection **Issue:** An evolving energy system will present new risks and opportunities for consumers. The existing consumer protection framework needs to evolve to keep up, to ensure all consumers are both protected and able to participate. **Outcome:** A robust consumer protection framework that gives consumers the confidence to participate, and those who might otherwise struggle to participate are supported to do so.
1.7.	The government and Ofgem will protect consumers who participate in smart tariffs and services, and help build and sustain confidence in engaging with these smart energy offers. We will consult on whether protections and clear options for redress are necessary for consumers engaging with a diverse range of third-party intermediaries, which will be set out in our forthcoming Energy Retail Market Strategy, which will commit to removing barriers to engagement and switching, and considers longer term reforms to the consumer protection and regulatory framework. We will collaborate with industry to develop consistent messaging across the key areas of consumer engagement – for example the smart meter installation process, government advice services and switching campaigns, and collaborate with cross-cutting government campaigns on climate such as the Together for Our Planet Campaign.

	We will work closely with the sector to assess how our smart tariff comparison tool can be deployed, and to address further barriers that could prevent consumers from making informed choices in switching to a smart tariff. The government will consider how to implement the recommendations of research being undertaken by the Office for Product Safety and Standards to identify how any health and safety risks to consumers from smart appliances can be mitigated.
1.8.	The government and Ofgem will help consumers that would otherwise struggle to participate in smart energy. We will incorporate smart technologies in our fuel poverty strategy and policies, for example the Energy Company Obligation. We will use the findings of Project InvoLVe, which identified how innovation may help enable low income and vulnerable consumers to participate, to help shape our future innovation initiatives.
Enabling smart buildings	
	Issue: Buildings are a major source of carbon emissions, and electrifying heat will add significant demands on the electricity system. Ensuring buildings are 'smart' will mitigate these issues and could offer considerable flexibility to the system. **Outcome:** Buildings will utilise smart and flexible technologies to optimise demand, support the electrification of heat, reduce consumer bills, reduce impacts on the electricity grid and support power sector decarbonisation.
1.9.	We will ensure that flexibility is considered across the full range of energy efficiency and heat policies: • **Regulations:** we will investigate the role of energy storage and smart technologies as part of the development work of the Future Homes and Future Buildings Standards. • **Assessment methodologies:** We will continue to support industry to incorporate flexibility and smart technologies in the Standard Assessment Procedure and, for non-domestic premises, the Simplified Building Energy Model. We will also consider the merits of introducing a separate 'smart readiness indicator'. • **Subsidy schemes and market mechanisms:** We will consider flexibility across subsidy schemes and market mechanisms, including the Home Upgrade Grant, Performance Based Policy Framework for large commercial and

	industrial buildings, Public Sector Decarbonisation Scheme, Social Housing Decarbonisation Fund, Heat Network Transformation Programme and Clean Heat Grant. We will also consider how smart technologies should be treated under our policy framework for energy-related products, which we will consult on later this year.
Enabling smart electric vehicles	
	Issue: Electric vehicles will add significant demands on the electricity system. Smart charging and vehicle-to-X technologies could reduce these impacts and reduce consumer bills and act as a significant source of flexibility. **Outcome:** Charging technologies and services enable convenient and affordable smart charging for domestic and business consumers, reducing demands on the system. Consumers understand the benefits of smart charging, and choose to do so.
1.10.	Ofgem will publish a regulatory strategy later in 2021 to support the electric vehicle rollout and maximise consumer benefits. The government and Ofgem will jointly develop a policy statement on how we will maximise the contribution of electric vehicle flexibility while protecting the grid in 2022. The government will also publish a response to our call for evidence on vehicle-to-grid technology in 2022.
1.11.	The government and Ofgem will work with the Electric Vehicle Energy Taskforce and industry to improve the provision of information and advice on electric vehicle energy issues such as smart charging, across the energy, automotive and charging markets, by 2023.
1.12.	The government will work with Ofgem to progress policy development to ensure network operators have appropriate access to chargepoint data, responding to the 2019 call for evidence on electric vehicle data transmission in summer 2021.
Enabling smart local energy solutions	
	Issue: Decarbonisation needs to be delivered in a way that meets local needs and with the involvement of local decision makers.

	Outcome: Join up between government, Ofgem, industry and academia in a productive way to create an innovative local energy environment. Smart, local energy solutions are coordinated across electricity, heat, hydrogen, transport and buildings to facilitate decarbonisation.
1.13.	The government will continue to work with the Local Energy Hubs to support projects which are tailored and delivered to meet local needs, joining up work between local areas, investors and central government. The government will consider the key strategic decisions that need to be taken to establish how we deliver the most suitable and affordable low-carbon heating. A key part of this work will consider the role of area-based mapping and planning to enable further understanding of local energy infrastructure, inform decision-making and support local delivery plans for decarbonisation. The government will work with industry to closely monitor learnings from the Prospering from the Energy Revolution programme through to its end in March 2023 and work with key organisations to ease barriers to the delivery of smart, local energy solutions. As part of the programme, UK Research and Innovation is also funding the Energy Systems Catapult to develop tools to help provide local capability in delivering smart energy projects.

Removing barriers to flexibility on the grid: electricity storage and interconnection	
Electricity storage	
	All storage **Issue:** The regulatory framework was not built with electricity storage in mind. We have made significant progress in clarifying and amending the treatment of storage within the framework however there are still some barriers remaining. **Outcome:** A best-in-class regulatory framework for electricity storage at all scales.
2.1.	Government will use primary legislation, when parliamentary time allows, to define storage as a distinct subset of generation.

	Government will update and publish a new version of the Planning Practice Guidance, and aims to designate any amended energy National Policy Statements by the end of 2021. The government and Ofgem will work to address barriers to the co-location of storage with other forms of generation. We will work with the Low Carbon Contracts Company to produce guidance to clarify co-location requirements, to better facilitate the addition of storage to CfD projects including offshore developments and, if necessary, we will consult on changes to CfD contract requirements.
2.2.	Ofgem is considering the role that network charges will play in ensuring efficient network usage in the future and, as part of our broader work on access and forward looking charges, we will consider how demand and generation charges should be applied where storage is acting in a way that benefits the system.
	Large scale and long duration storage **Issue:** Storage that can provide flexibility over longer durations will be essential for achieving net zero. Currently, large scale and long duration storage faces barriers that are preventing it from deploying. Novel technologies have not yet reached commercialisation or been demonstrated at scale. **Outcome:** Large scale and long duration storage will help us to decarbonise the grid and wider economy further, providing key services to the grid to integrate and maximise the use of 40GW of offshore wind and other low carbon generation.
2.3.	Through the Net Zero Innovation Portfolio, the government will deliver a competition worth up to £68m to accelerate the commercialisation of first-of-a-kind longer duration energy storage. We expect to announce winners by the end of 2021, with the intention of building at least six demonstrators by March 2025.
2.4.	The government, working with Ofgem will take actions to de-risk investment for large scale and long duration storage, including: • In 2021 the government will undertake analysis on the system need and benefits of a range of long duration storage technologies in a net zero system; • The government has published a call for evidence on how to facilitate the deployment of large scale, long duration storage. We will evaluate options and aim to respond in early 2022;

	• The government will soon publish a call for evidence on the Capacity Market. This will gather evidence on how we might support the participation of new build projects that have construction times which are longer than the time between the main capacity auction and delivery (approximately four years), for example pumped hydro storage. It will also request views on how the Capacity Market can better align with our net zero commitments.
	Domestic and small-scale storage **Issue:** Domestic and small-scale storage is important for providing flexibility to the system and ensuring that energy from small-scale renewables can be used at peak times, lowering demand from the grid. However, this market is nascent and there are barriers preventing domestic and small-scale storage from operating on a level playing field. **Outcome:** Consumers will be confident in the benefits of, and framework for installing storage in their homes and businesses.
2.5.	The government and Ofgem will work to develop a system to prevent double charging of final consumption levies on electricity that is re-exported by domestic storage and vehicle-to grid. As part of this, industry should continue to develop code modification P395 to set out a methodology for how to identify load that should avoid final consumption levies when storage is co-located with final demand, including domestic storage.
2.6.	The government is conducting a formal review of business rates, including on how the business rates treatment of plant and machinery affects investment decisions and how the business rates system could support the decarbonisation of buildings. The Review will conclude in Autumn 2021. The government will continue to work with industry to understand how the VAT regime impacts storage.
2.7.	To ensure a robust health and safety framework for storage and facilitate the inclusion of smart technologies in energy efficiency, heat and fuel poverty policies, the government will work with the industry-led storage health and safety governance group to implement, where appropriate, recommendations from an independent gap analysis. This will include: • The government will support the production of a Publicly Available Specification for domestic-scale storage to ensure manufacturers and installers are easily signposted towards the relevant standards for their work, and that there is a robust consumer protection framework; • The government, with the storage health and safety governance group, will support the development of guidance for grid-scale storage; and

	• The government will work with the storage health and safety governance group to enable the Fire Service to receive data on battery asset locations, including through co-ordinated asset registration. The storage health and safety governance group will support the Fire Service, where appropriate, to develop best-practice guidance for fighting lithium-ion fires.
Interconnection	
	Issue: Without the appropriate frameworks in place to enable cross border flexibility markets and services, greater interconnection could result in system operability challenges. **Outcome:** An increased capacity of interconnection will contribute to system operability and will facilitate efficient and flexible access to cross-border markets across all timescales.
2.8.	The government and Ofgem will look to increase the level of GB interconnector capacity. Ofgem will continue to deliver projects under the current cap and floor regime and will review its interconnector policy to consider an approach to possible future GB interconnector regulation, with recommendations to be published in autumn 2021. The government will address barriers to the realisation of multi-purpose interconnectors as part of the Offshore Transmission Network Review, consulting on changes by the end of 2021.
2.9.	The government and Ofgem will ensure that UK transmission system operators (TSOs) cooperate with their EU counterparts to develop the required technical procedures for day ahead trade under the EU-UK Trade and Cooperation Agreement. TSOs will develop efficient cross-border electricity trading arrangements at all market timeframes, including day ahead, intraday, balancing and forwards. The ESO will develop a coordinated process for remedial actions across electricity interconnectors, including re-dispatching and counter trading. Development timescales will initially be proposed by TSOs but will in accordance with decisions/recommendations from the Specialised Committee on Energy.
2.10.	The ESO will aim to create balancing services markets that meet our changing system needs, and in which all technology types can compete on a level playing field. The ESO will identify the barriers to entry for the Dynamic Containment market for

	interconnectors and will work with industry to remove barriers by the end of 2023. The ESO will also work with interconnectors to agree the potential for High Voltage Direct Current interconnectors to contribute to GB Grid Forming or Virtual Synchronous Machine capability, including supporting inertia, by the end of 2021.
2.11.	The ESO will update the GB Codes to ensure consistency with 'The Electricity Network Codes and Guidelines (System Operation and Connection) (Amendment etc.) (EU Exit) Regulations 2019'. This includes a definition of ramp rate restrictions between GB and other synchronous areas. A ramping solution will be proposed by spring 2022 by the ESO, subject to GB code governance. The market design and implementation for new reserve services remains a priority for the ESO.

Reforming markets to reward flexibility	
	Issue: The rapid growth of low-carbon generation is changing the characteristics of the system, creating new operational challenges and uncertainties. The existing suite of balancing services is complex and increasingly unable to meet the operability challenges of a low carbon energy system. A more decentralised electricity system has also led to fragmented processes and inadequate coordination across markets. There is a need for improved alignment of procurement processes across distribution, transmission and ESO ancillary services as well as improved coordination across parties. **Outcome:** By 2025, the ESO will be net zero ready, ensuring it has the markets and tools in place to safely operate a zero carbon system. Networks will deliver open, transparent, accessible and efficient markets for local flexibility, in coordination with the system operator and accounting for impacts across the whole system.
3.1.	The ESO will deliver all balancing and ancillary service reforms to the specifications and timelines outlined in its 2021-23 RIIO-2 Business Plan (and previous Forward Plans), including: • Implementation of a single integrated platform for all ESO balancing services markets • Implementation of a new suite of frequency and reserve services • Implementation of a single day ahead market for response and reserves • Completion of existing pathfinder projects

	The ESO will present a clear and credible plan as to how it will deliver reforms beyond 2023 to achieve its objectives of zero carbon operability and market solutions across all services by 2025. The ESO will track progress towards being able to operate a zero-carbon system using a new Zero Carbon Operability (ZCO) indicator to measure the proportion of zero carbon transmission connected generation that the system can accommodate. Actions include defining a maximum limit, reporting quarterly on the actual ZCO (as provided by the market and after ESO actions), and outlining actions that will impact the ZCO limit in the future. The ESO, by March 2023, will develop and publish a plan, based on the lessons learned from its pathfinder projects and its Early Competition Plan, to implement regular, dependable, bankable markets for solutions to stability, voltage and thermal constraints.
3.2.	Distribution networks will deliver and adopt a standardised approach to procuring flexibility and managing connections across all GB distribution networks by 2023, where the core set of flexibility products are identical across different networks wherever possible, including common approaches to valuing flexibility, baselining methodologies, pre-qualification, dispatch and settlement and monitoring requirements.
3.3.	Networks and the system operator will, through the ENA Open Networks project, deliver a step up in alignment between distribution flexibility services and ESO balancing and ancillary services. By 2023, we expect these services to draw from a common framework with respect to contract terms, service requirements, frequency of procurement, procurement timetables and processes, as well as interfaces for the provision of flexibility service to the ESO or network operators. To support this, we also expect the ENA Open Networks to deliver a framework for appropriate data sharing based on the presumed “open” principle to optimise procurement and operational coordination across the whole electricity system. Networks and the system operator should, through the ENA Open Networks project, develop and implement a set of primacy rules to resolve service conflicts between ESO-procured and DSO-procured flexibility by 2023, in line with commitments in the ENA Open Networks forward plan. We expect this should be supported by an appropriate mechanism for sharing real time data and operational forecasting, as well as shared processes for monitoring distributed energy resources. We also expect

	the ENA Open Networks project to put in place arrangements for evaluating, reviewing and amending principles and primacy rules when appropriate. We expect the ESO to coordinate with DNOs to ensure ESO dispatch of distributed energy resources and distribution network management actions do not conflict, and deliver whole electricity system benefits. The ENA Open Networks project should consider changes to the P2 planning standard that will release additional network capacity to accommodate flexibility and low carbon technologies whilst ensuring network security and reliability is maintained.
	Issue: The system is rapidly changing and new roles and responsibilities are required, and existing ones need to be updated. Current governance arrangements mean that distribution networks and the system operator do not coordinate as effectively as they could do. This makes it more difficult to achieve the best outcomes for the system as a whole. Concerns around potential and perceived conflicts of interest could also undermine confidence in flexibility markets. **Outcome:** The government and Ofgem will ensure that appropriate governance is in place to deliver coordinated and effective flexibility markets.
3.4.	The government and Ofgem will ensure that the institutional arrangements governing the energy system are fit for purpose for the long term, via consultations on system operation and energy code governance. Ofgem will undertake a review of electricity distribution system operation governance over the coming year, where governance in this area will be developed and consulted upon, with a view to making a recommendation on any necessary changes by 2023 The government and Ofgem will continue to keep DNO conflicts of interest under review. We will take additional action should evidence arise that conflicts of interest are undermining confidence in flexibility markets, including legislating if appropriate.
	Issue: Signals from the existing market framework are unlikely to bring forward the level of flexibility required to achieve net zero at lowest cost. No government scheme rewards low-carbon flexibility per se, and flexibility technologies cannot compete in the Contracts for Difference scheme.

	Outcome: The energy market framework appropriately values the full range of low-carbon technologies for the value they provide to the system, allowing GB energy needs to be met at lower cost in a Net Zero future. Flexibility technologies can compete effectively in market structures that drive investment in low carbon technologies and ensure capacity adequacy.
3.5.	The government will continue to engage with industry on how best to balance strong investment signals for low-carbon generation with wider system needs in the Contracts for Difference scheme, in the lead up to Allocation Round 5. The government will shortly publish a call for evidence seeking views on how to balance security of supply with new decarbonisation ambitions in the Capacity Market.
	Issue: A net zero future will require a significant amount of low-carbon flexibility. However, most flexibility markets are dominated by high fossil fuel assets. There is a risk that this will undermine net zero ambitions in the power sector if these services are not decarbonised. **Outcome:** A standardised approach to carbon monitoring and reporting is implemented across the transmission and distribution levels, allowing full transparency over the carbon intensity of flexibility markets. Potential market distortions are addressed, and low carbon flexibility technologies are optimally utilised to support the system on its path to net zero.
3.6.	Networks and the system operator will develop consistent methodologies for carbon reporting and monitoring of their actions and markets. We expect that carbon monitoring and reporting will be in place by 2023. In addition, we expect them to explore options for forecast and actual carbon reporting. The government and Ofgem will monitor progress. We expect the ESO to publish Capacity Market emissions information, measured in the reporting and verification mechanism, by 2022. The government will review minimum thresholds and gaps in current carbon policies, including a review of the ETS exemptions threshold of <20MW by 2022, with relevant changes implemented by 2026. We have committed to exploring expanding the UK ETS to the two-thirds of uncovered emissions, and will consider the role of carbon pricing for flexibility markets in this wider context.

	Issue: Price signals to incentivise electricity assets to locate efficiently do not fully reflect differences in system impacts. Network and policy costs are not passed on in a way that incentivises the optimal flexible behaviour among network users. **Outcome:** Network users will receive better price signals through network access and charging arrangements about where to locate on the network. We will have a stronger understanding of options for how policy and network costs could help consumers lower bills and offer flexibility to the system.
3.7.	Ofgem will improve price signals for flexible network usage through network charging reform. In June Ofgem published consultations on: • **Transmission network charges** (TNUoS), including equivalent charges for distributed generators and the possible need for a wider review of transmission charging arrangements. This also considers the appropriate treatment of electricity storage. • **Distribution network connection charges**, including reforms to reduce the upfront costs of connection to the distribution network, to facilitate investment in low carbon heat, transport and generation. • **Access rights**, including better options for flexible network access to support quicker and cheaper connections, with improved clarity on the extent to which the flexible connection could be curtailed. Later this year, Ofgem intends to consult on: • **Distribution network charges** (DUoS), including charges that better reflect the value of flexibility in different locations at different times in the distribution network. Ofgem will make a decision on each of these areas by the end of this year.
3.8.	The government will explore how some network and policy costs may be recovered differently in the future, through: • delivering the Alternative Energy Market Programme, building on the findings of an Energy Price Signals Study commissioned in March and which is expected to complete in February 2022, and • the forthcoming call for evidence on Affordability and Fairness, which will consider how to fairly allocate future costs as the UK transitions to net zero.

This publication is available from: www.gov.uk/government/publications/transitioning-to-a-net-zero-energy-system-smart-systems-and-flexibility-plan-2021

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