March 2021

Future Energy Scenarios

# Bridging the Gap to Net Zero

Peaks and troughs: how data and digitalisation, technology and markets can help meet the new challenges of a decarbonised electricity system

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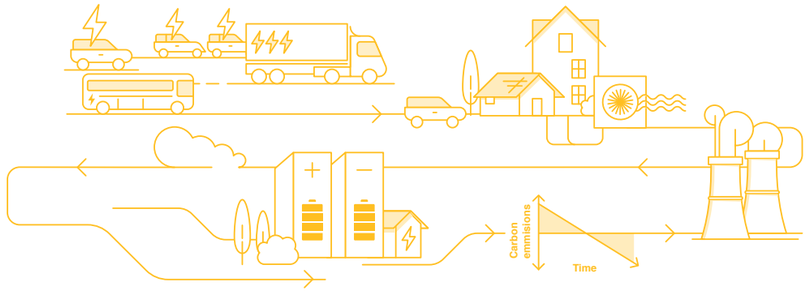
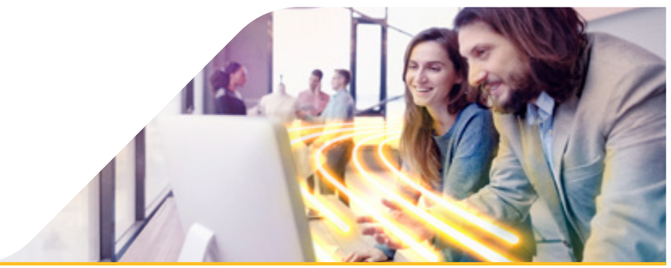


# Welcome

**This year is the second year of our FES Bridging the Gap to Net Zero project. With our stakeholders, we've been looking at some of the key messages from FES in detail and considering what they mean for the whole energy system in the coming decade.**

The focus for this year's project related to the impact of increasing renewable electricity generation on the operation of the system between now and 2030. The ESO already has an ambition to be able to operate a net zero carbon system by 2025, and by 2030 there will be even more renewable electricity connected.

**Laura Sandys**
Independent Chair of Bridging the Gap 2021

**Fintan Slye**
Executive Director, Electricity System Operator

Thank you!

**Bridging the Gap uses our Future Energy Scenarios' (FES) results to inform decisions now about what steps to take to progress towards net zero. FES tells us that by 2030, in addition to much more renewable electricity generation, there will also be changes to how and when electricity is being used (for example more electric demand for heating and transport).**

Renewable generation can provide cheap and plentiful electricity, but it doesn't follow the demand profiles which have dictated the way we operate the system in recent years. It has its own peaks and troughs of supply based on weather patterns, which are different to the peaks and troughs of demand. In order to maximise this source of low carbon electricity, we will need to adapt, so that **more flexible demand is being dispatched to match this less flexible, but decarbonised, electricity generation.** Bridging the Gap discussed this new, more complex, landscape and how to manage these challenges, including how data and digitalisation, technology and markets can help.

The main message we heard from our stakeholders is that more coordination across data and digitalisation, technology and markets is required. They cannot continue to be addressed in isolation. Unsurprisingly there was also consensus that we need more data and more digitalisation to enable the deployment of smart technologies and make markets better able to offer the range of flexibility the system will need. These three areas are interlinked and are all dependent on a robust communications infrastructure.

This final report contains recommendations to maximise the benefits from data and digitalisation, technology and markets when it comes to managing peaks and troughs. It also importantly includes recommendations on how to get these components to coherently interact. By bringing all these elements together in a coordinated approach, we can set in motion now the changes needed to make sure that by 2030, we are on a path to achieve net zero by 2050.

# Executive summary

## Stakeholder engagement

Bridging the Gap is a stakeholder-led project, promoting co-creation and collaboration, with the final conclusions representing the views of our stakeholders as well as the ESO. To do this, we've virtually engaged in the following ways:

- Roundtables with senior stakeholders
- Working groups with industry and government volunteers
- Industry wide webinars with online polls and Q&A sessions.

## Based on the feedback and insight from our stakeholder engagement, we've formulated some key messages and recommendations about how to best deal with the peaks and troughs.

The specific next steps and recommendations for each of the three pillars can be found here: data and digitalisation, technology, markets

### Data and digitalisation

**Key message:**

Increased data availability and digitalisation of systems is fundamental to enable markets and technology to manage peaks and troughs.

### Technology

**Key message:**

Technology is available now to help manage peaks and troughs but it needs to be smart, deployed at scale and in combination to be effective.

### Markets

**Key message:**

Electricity markets need reforming, whether they are for short term trading or longer-term contracts, to provide the flexibility needed to more effectively balance the system.

There are also **overarching recommendations** to integrate the approach to the pillars and help deliver a coherent approach to managing peaks and troughs

- **Integrate the three pillars** in innovation projects and business models.
- **Improve skills and literacy** in decarbonisation and digitalisation. The interconnection of these two areas is fundamental as is a deeper understanding of both energy and communications challenges. This requires new skills and capabilities across industry and government.
- **Learn from other sectors** already combining markets and technology using digitalised solutions.
- **Develop demand-side solutions** to accelerate end-consumers' ability to participate in delivering system stability.
- **Iterative policy and regulation** able to adapt and learn from experience quickly. This applies to both energy and communications policy and regulation as they are interdependent.
- **Unlock investment** to enable widespread adoption of technologies to provide flexibility.


Bridging the gap / Executive summary 05

# Bridging the Gap to Net Zero project

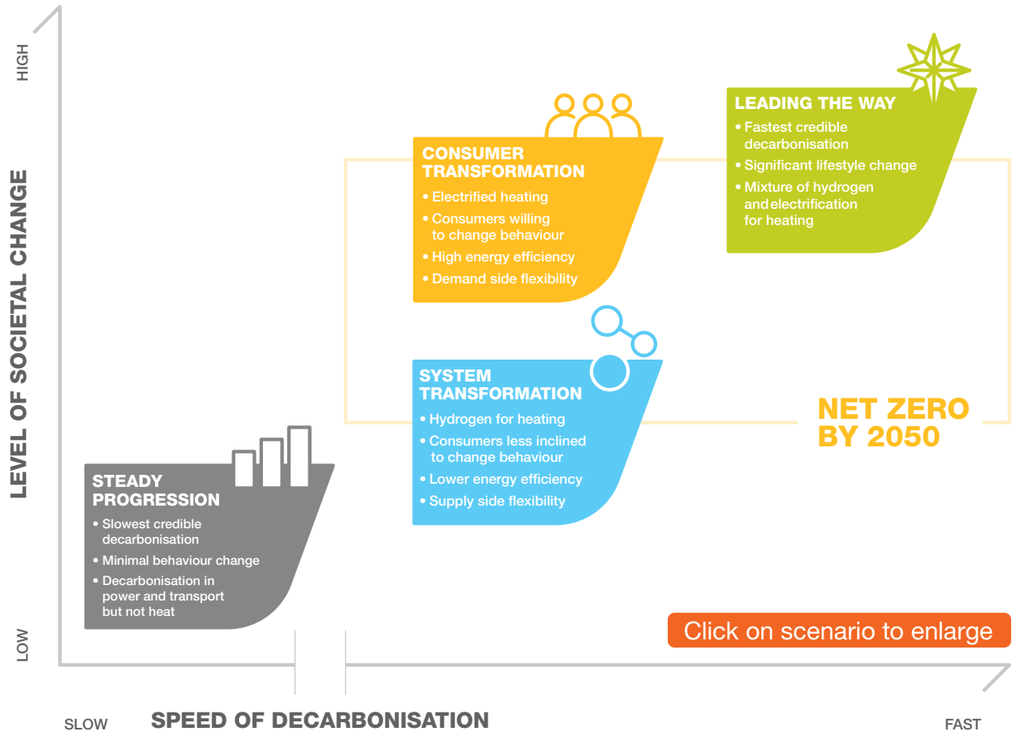


This year, the Bridging the Gap to Net Zero project has looked in more depth at the key messages from FES 2020 about data and digitalisation, technology and markets. Under the title of 'Peaks and troughs: how data and digitalisation, technology and markets can help meet the new challenges of a decarbonised electricity system', we've collaborated with over 200 stakeholders from across and beyond the energy industry to consider how the electricity system needs to change. During this project, we've chosen to concentrate on what needs to be done between now and 2030, identifying the next steps and recommendations that are required to get all of us on the path to net zero.

## What is Bridging the Gap to Net Zero?

As the Electricity System Operator (ESO), we produce annually a set of four credible Future Energy Scenarios (FES), which map what could happen between now and 2050. Our most recent FES publication features three scenarios that meet the 2050 net zero emissions target. These show the level and scale of change (and subsequent range of uncertainty) that we could see as the energy system continues to decarbonise.

The Bridging the Gap to Net Zero project aims to extend the FES cycle by drilling down deeper into the scenarios to explore specific areas of greatest uncertainty and ambiguity. The final output is a set of collaboratively sourced recommendations - for the ESO and wider industry - on the immediate next steps that should happen to progress the UK towards its next zero target.



# Bridging the Gap to Net Zero project

## By stakeholders, for stakeholders

The Bridging the Gap project has adopted a stakeholder-led approach, promoting co-creation with a wide range of stakeholders, resulting in recommendations agreed with and supported by industry. The project has been divided into two phases:

1

What are the new peaks and troughs that we could start to see in a decarbonising electricity system from now to 2030?
See page 16

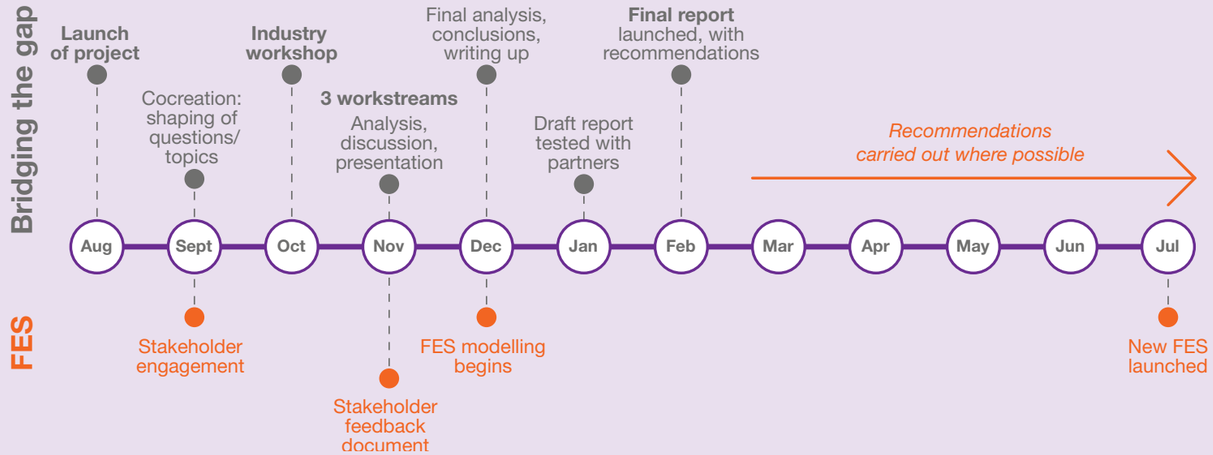
2

How can data and digitalisation, technology and markets help to manage the challenges associated with these peaks and troughs?
See page 19

We used various virtual methods of stakeholder engagement during this period, including:

- Roundtables with a small number of senior stakeholders (our 'core' stakeholder group) from across the energy industry.
- Working groups with up to nine external industry volunteers, using online workshops and whiteboards to gather ideas.
- Industry wide webinars utilising interactive audience polls and Q&A.

The timeline shown below provides a high-level overview of the stakeholder activity in the project since August 2020, along with its links with FES.




Click to enlarge timeline

# Context: the changing electricity system

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# Context: the changing electricity system

## The energy transition has already started

There has already been significant progress in the decarbonisation of electricity generation, with the sector responsible for a 55% reduction in carbon intensity between 2008 and 2018[1]. This is due to the near phase out of coal-fired generation, which has been accompanied by a 70% increase in renewable generation capacity since 2014[2]. Alongside this, there have been large numbers of new market participants connecting to the system – with a 60% increase in new market participants in 2019 alone.

At the ESO, we've worked hard over the previous decade to make sure that the rapidly decarbonising electricity system continues to be operated securely. The ESO has led numerous projects to facilitate the increase in renewable energy capacity. For example, in 2010, we implemented the Connect and Manage regime, to allow wind farms to more easily connect to the grid following a government policy decision.

Last year, in response to high renewable generation and low demand as a result of COVID-19 lockdown restrictions, we introduced a new frequency response product known as Dynamic Containment (DC).
As noted in our Operability Strategy report, DC was one of the ESO's key projects in 2020. This super-fast acting response product helps us to manage frequency on a system experiencing low inertia levels due to lack of traditional electricity generation.

1 Committee on Climate Change Sixth Carbon Budget 2020. Electricity Generation Report. Pg. 7 theccc.org.uk/publication/sixth-carbon-budget
2 Digest of UK Energy Statistics 2019. table 5.1 gov.uk/government/collections/digest-of-uk-energy-statistics-dukes

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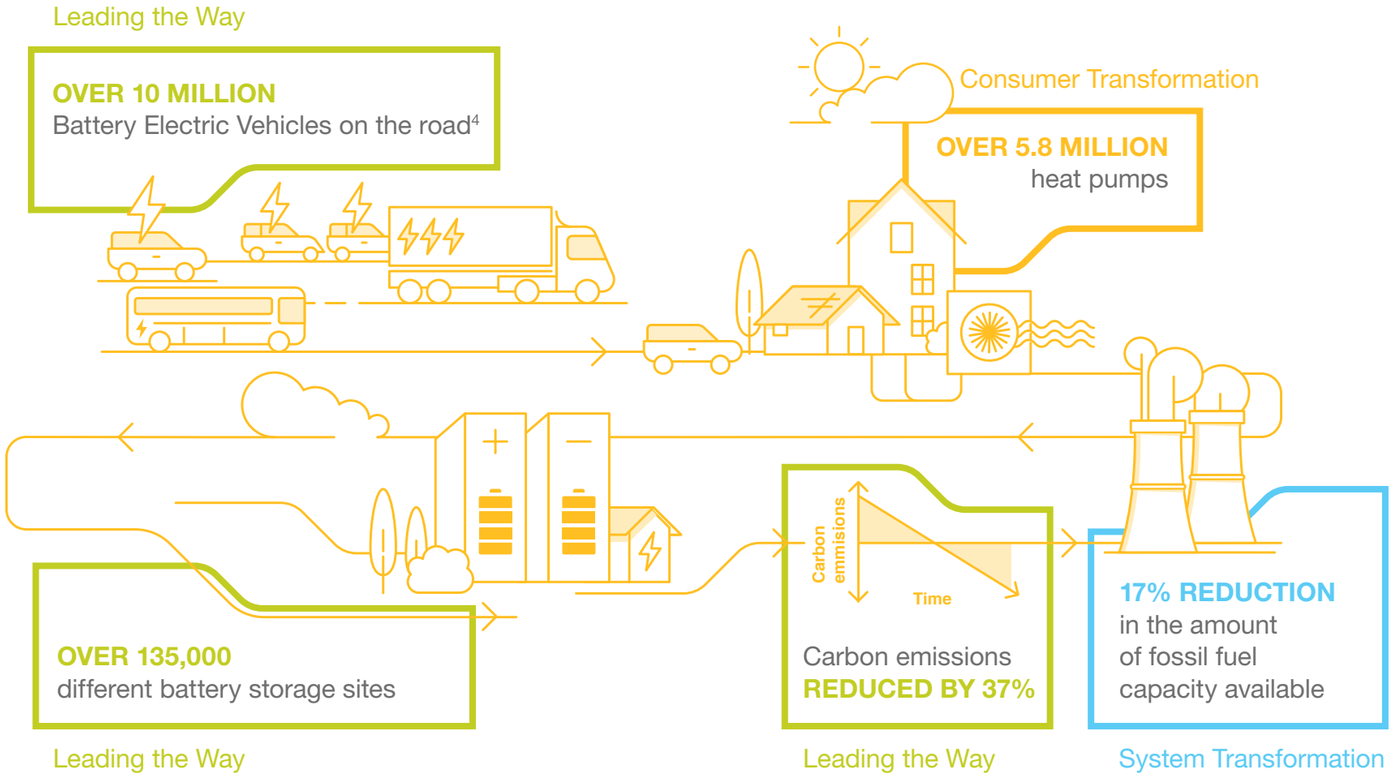
# Context: the changing electricity system

## There will be more change in the next 10 years

To make sure that the UK is on track to meet its net zero emissions target by 2050, the energy transition will have to continue. Our FES suggest that the power sector could contribute to this by becoming net zero, or even have 'net negative' emissions because of carbon capture and storage technology.

In FES, we also see millions of electric vehicles (EVs) connecting to the network (representing up to 100 TWh of demand by 2050). Additionally, electric heating will increase as we see 600,000 heat pumps installed per year by 2028 (as part of the Government's Ten Point Plan)[3].

The diagram provides some examples of what 2030 could look like, with statistics taken from all three of the FES net zero scenarios.




3 Ten Point Plan for a Green Revolution 2020. Point 1: Advancing Offshore Wind. Pg. 8. assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/936567/10_POINT_PLAN_BOOKLET.pdf

4 This was based on an Internal Combustion Engine ban date of 2032 in accordance with the most up to date government policy at the time of FES 2020 analysis.

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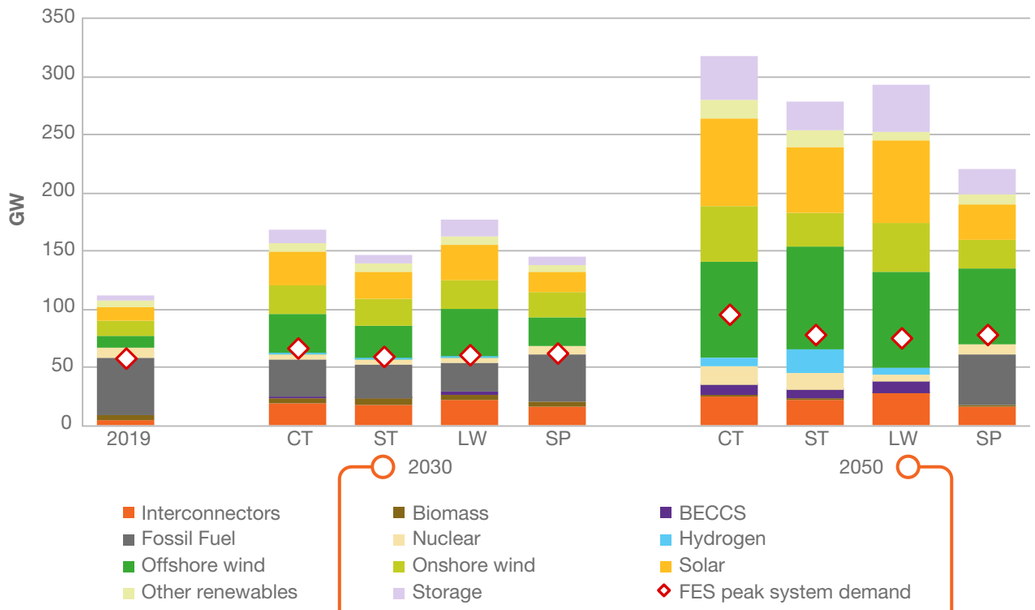
# Context: the changing electricity system

## Decarbonisation presents us with new peaks and troughs

Our system has been designed, built and operated around winter peak demand[5]. But with increased levels of zero carbon, intermittent electricity sources on the system, peak demand becomes only one of the operational challenges we face. Instead, we will need to look at various ‘peaks’ and ‘troughs’: those critical points when we need to take action to keep the system safe and secure. This will increase complexity of managing the electricity system.

The graph from FES 2020 (right) provides a view on what could happen, in terms of levels of installed capacity and peak demand, in the coming decades. It shows how much more renewable generation capacity we will have in the net zero scenarios and how much less fossil fuelled generation, which is able to respond easily to changes in demand.

Installed electricity generation capacity, plus storage and interconnection (no vehicle-to-grid or non-networked offshore wind)




By 2030, there could be more than 90 GW of renewable capacity, however peak demand remains similar to today, at around 70 GW, with as much as 40 GW from wind generation.

In 2050, the proportion of intermittent, renewable generation capacity increases significantly, which makes 2030 the practice run for 2050.

5 The ESO usually sees peak demand at between 5pm and 6pm on the electricity transmission system, whilst on the distribution network it’s between 6pm to 8pm

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# Context: the changing electricity system

Given the UK's commitment to net zero and looking at FES, there are some things we can say for certain about 2030. There will be:

1. **More intermittency in electricity supplies.**
2. **An increased need for flexible demand and supply.**
3. **Increased complexity due to millions of actions and many more participants in the energy system.**

By 2030, electricity system operation won't be driven by the need to match supply to demand, but by the opposite. The ESO control room will likely be dispatching demand (for example, from EVs and heat pumps) to manage the variability from low carbon supply generation. We are already preparing for this change at the ESO, with our strategic ambition to be able to operate the grid carbon free by 2025.

We've had a glimpse of what future operating conditions could look like in 2020 – the greenest year on record for Great Britain's electricity system. On 23 May low national demand accompanied with high renewable generation (approaching nearly 100% zero carbon conditions) meant our control room had to take action to reduce the zero-carbon generation on the grid to 80%, in order to keep the system secure and safe (read more about this case study in our Operability Strategy report here).



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# Peaks and troughs

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# Peaks and troughs

As part of our discussions with our stakeholders, we identified a variety of different potential peaks and troughs to be dealt with over the coming decade. The interaction between these is another challenge in itself.

## PEAKS

- Maximum requirement for dispatchable power
- Maximum flow on the network
- Maximum requirement for dispatchable demand

## TROUGHS

- Minimum supply of renewable electricity
- Minimum flow on the network
- No interconnector supply available

By 2030, we know there will be millions more potential participants in the market and millions more possible actions in the energy system

These peaks and troughs will become increasingly dynamic, variable and unpredictable, with changing characteristics in terms of:

| | |
|---|---|
| **Quantity** | and intensity of actions throughout the system |
| **Diversity** | of assets and actions throughout the system |
| **Interaction** | cumulative impacts of each action |
| **Different** | nature of products and services |
| **Devolution** | new partners and participants in the system, requiring a supportive, complementary environment |


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# Peaks and troughs

## Stakeholder feedback

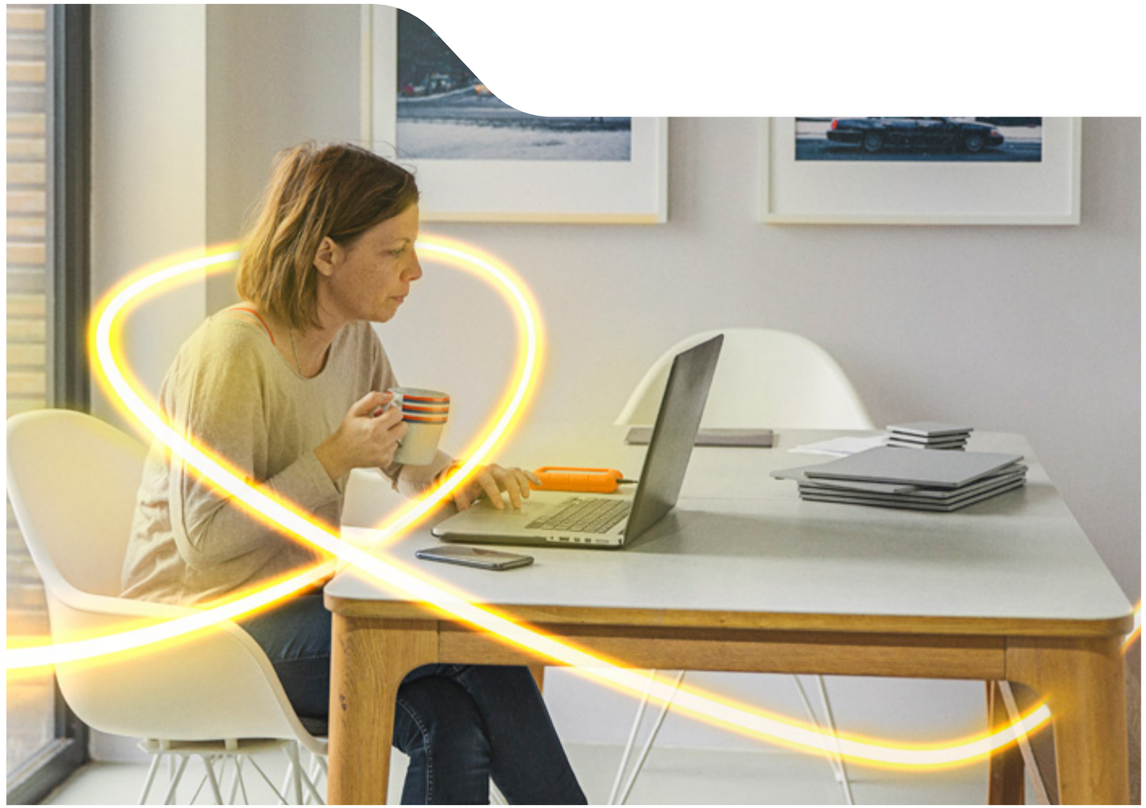
The list of peaks and troughs was presented and agreed at our industry wide webinar in October, attended by over 130 stakeholders.

Their feedback included some key themes to consider when thinking about how to address these challenges:

- Roles and responsibilities
- Whole system
- Consumer behaviour
- Visibility and transparency
- Decentralisation
- System standards and resilience
- Cost and value
- Policy and regulatory changes

### Who is responsible for managing these?

Meeting these challenges is not just the responsibility of the ESO; there will be roles and responsibilities for all parts of the energy industry. Greater levels of flexibility will need to be employed and the use of more data and digitalisation, technology and market solutions will help manage these.





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# Focus on data and digitalisation, technology and markets

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## The three pillars

**FES tells us that progress against the three pillars of data and digitalisation, technology and markets will be integral to the continued decarbonisation of the electricity system between now and 2030. In three working groups, we discussed each area in detail, how it can help and importantly, what needs to be done now.**

### Data and digitalisation

As the energy system continues to decarbonise and decentralise, we will start to see increasing numbers of actions and assets on the system - with potentially millions by 2030. From the ESO's perspective, this will mean that there will be a lot more transactions required to keep the system stable, particularly when we're dealing with the dynamic and variable peaks and troughs. This is recognised in the Energy White Paper, which states that the system will need 'a new digital infrastructure, which will complement the system's physical infrastructure to liberate the potential of smart, flexible technologies'[6].

**Key message:**
Increased data availability and digitalisation of systems is fundamental to enable markets and technology to manage peaks and troughs.

### Technology

We took the term technology to mean anything from domestic appliances to grid level battery storage. Technology can help in many ways to provide flexibility to manage peaks and troughs – and we're already starting to see this on both supply and demand side. As the Energy White Paper notes, 'Smart technology is unlocking new opportunities to give consumers more control, choice and flexibility over their energy use'[7].

**Key message:**
Technology is available now to help manage peaks and troughs but it needs to be smart, deployed at scale and in combination to be effective.

### Markets

Markets is a broad term which can imply either short term responses to a need, like the balancing mechanism as well as market mechanisms to encourage the development of products and services, such as Contracts for Difference (CFDs). The importance of designing future electricity markets for flexible demand and supply is noted in the Committee on Climate Change's sixth carbon budget, which says that a whole market approach is required, to 'reflect the importance of both flexible demand and supply of low-carbon electricity, so that both are rewarded in competitive markets to deliver the lowest-cost overall system'[8].

**Key message:**
Electricity markets need reforming, whether they are for short term trading or longer-term contracts, to provide the flexibility needed to more effectively balance the system.

6 Energy White Paper 2020. Quotation taken from pg. 69. assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/945899/201216_BEIS_EWP_Command_Paper_Accessible.pdf
7 Energy White Paper 2020. Quotation taken from pg. 21. assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/945899/201216_BEIS_EWP_Command_Paper_Accessible.pdf
8 Committee on Climate Change Sixth Carbon Budget 2020. Electricity Generation. Pg. 64. theccc.org.uk/publication/sixth-carbon-budget/

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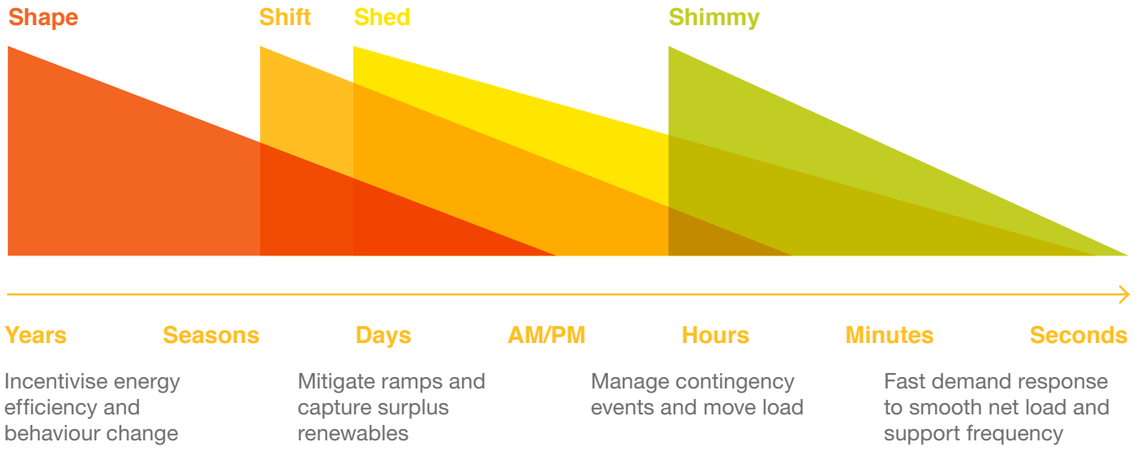
# Focus on data and digitalisation, technology and markets

## Planning from the future

By thinking about what needs to happen in our energy system in 2030, we can make plans now to set us in the right direction. When looking at peaks and troughs, this means considering how flexibility[9] will help keep the electricity system stable, safe and low-carbon.

We've used the diagram to the right (taken from an American study), as a way of helping us think about the different types of flexibility needed in 2030. In order to balance an increasingly dynamic and complex system, what do data and digitalisation, technology and markets need to provide the system? Hover each of the four triangles to find out.




### Shape

**Data and digitalisation:**
Greater availability of data provides a much clearer picture of what the trends are with new assets and locational vulnerabilities.

**Technology:**
Long duration storage is available to maximise use of renewable electricity generation on a seasonal basis (e.g. electrolysis and hydrogen).

**Markets:**
Market signals and network pricing help shape demand profiles and drive investment in long term assets.

9 The importance of flexibility is reflected in Ofgem's 2021/22 Forward Work Programme's priorities 'to deliver full chain flexibility in how we generate, use and store energy.' ofgem.gov.uk/publications-and-updates/forward-work-programme-202122-consultation

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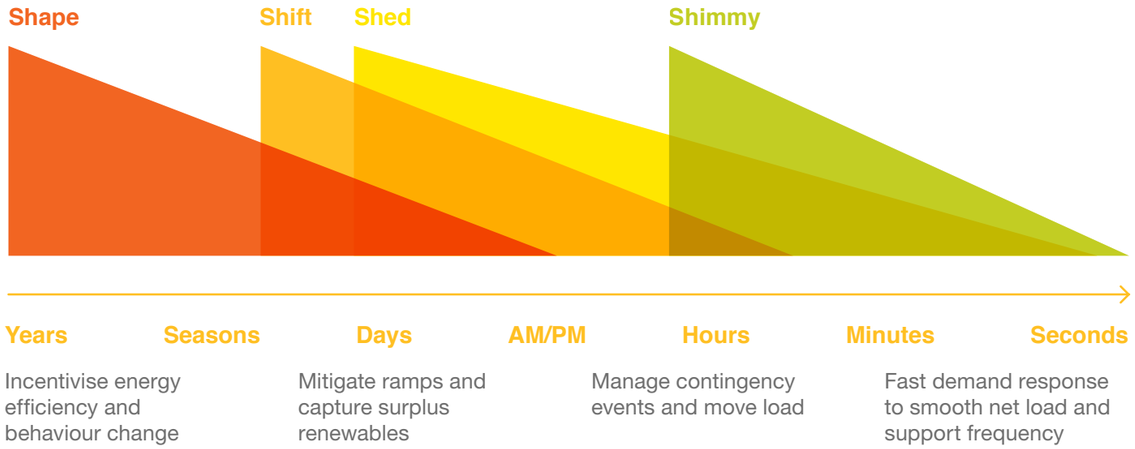
# Focus on data and digitalisation, technology and markets

## Planning from the future




### Shed

**Data and digitalisation:**
Digital tools provide access, visibility and enable market signals to drive automated shedding.

**Technology:**
At community level, flows of energy are managed by technologies including the use of local storage, like vehicle to grid.

**Markets:**
Intra-day flexibility and wider participation is possible in the balancing mechanism.

### Shift

**Data and digitalisation:**
Data and digital tools throughout the system are embedded in technologies, including in homes, and provide visibility of the potential to shift demand.

**Technology:**
Enabled smart technologies are able to store and discharge energy responding to grid signals. Thermal storage in 4th/5th generation district heat networks can store energy over days.

**Markets:**
Day ahead flexibility markets send signals for appropriate forms of flexibility to respond to surpluses or deficits in supply or demand.

### Shimmy

**Data and digitalisation:**
Highly sensitive system tools are in place to communicate need, assess capability and resilience, providing clear market signals.

**Technology:**
Smart appliances in homes and businesses are remotely turned on/off, up/down.

**Markets:**
ESO balancing and frequency response services are giving market signals up to the final moment.

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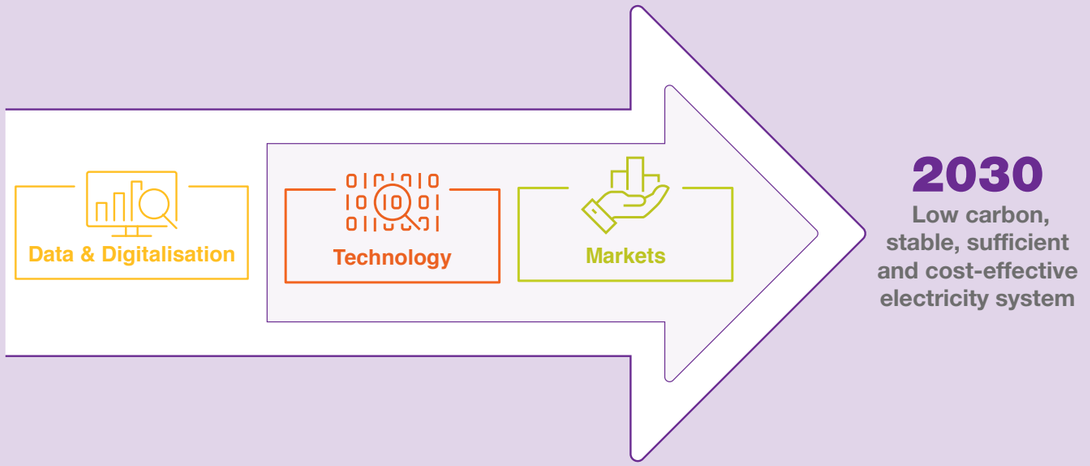
# Focus on data and digitalisation, technology and markets

## Stakeholder feedback

Stakeholders who attended the October webinar on the theme of peaks and troughs were invited to take part in one of the three workstreams looking into data and digitalisation, technology and markets. Volunteers then worked with the ESO in a set of short workshops over a four-week period, scoping the problem and recommending initial findings. The questions the workstreams addressed were informed by stakeholder input (voting on virtual polls) during the October webinar. **Slides from the event can be found here**.

A key element of stakeholder feedback during this process was the importance of the clear interaction of the three pillars of data and digitalisation, technology and markets. For example, we cannot have a future energy system that doesn't have the right markets to enable supply and demand side technologies. And these need sufficient levels of data and digitalisation to operate well. All solutions will need an integrated approach, bringing digitalisation, technology and markets together, with the aim of stable and low carbon electricity system operation at its heart.

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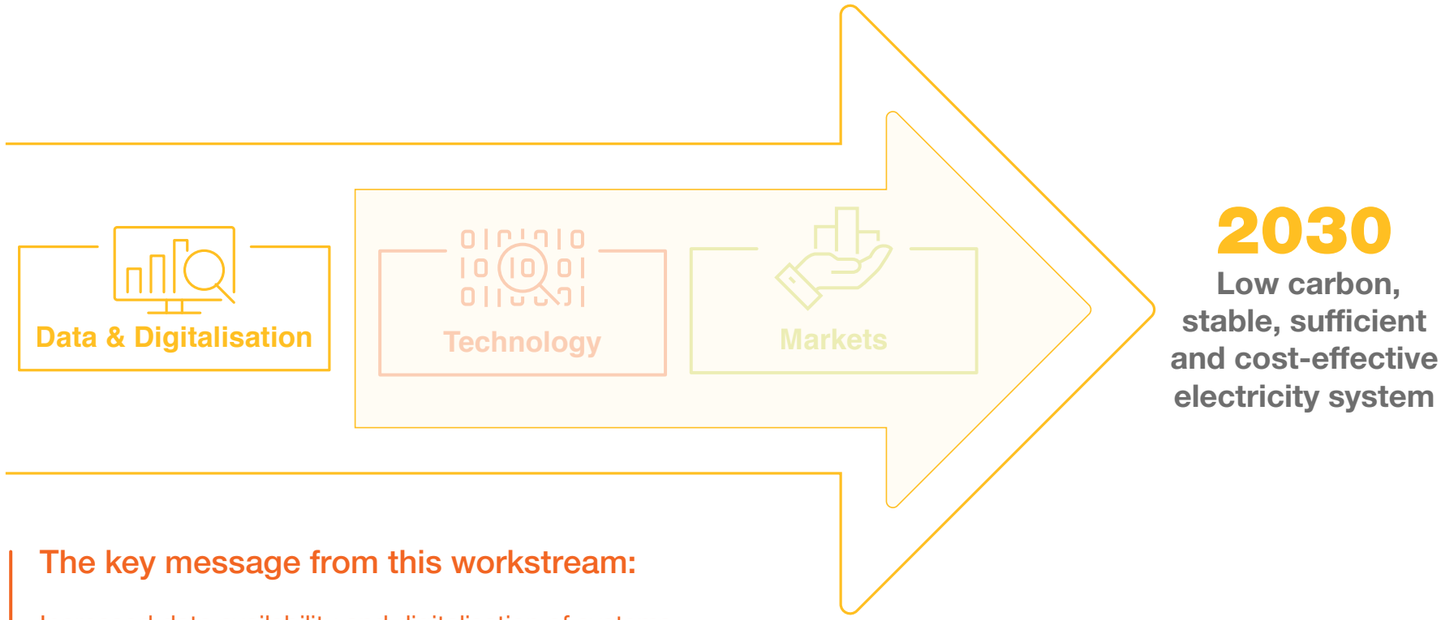
# Data and digitalisation workstream findings

## About the workstream

The workstream had a total of seven external volunteers from the likes of Energy Systems Catapult, Electron and Ofcom. As well as looking at what data and digitalisation can do to help operate a decarbonised system, the working group also examined other sectors' and countries' use of data and digitalisation to help manage rapidly changing peaks and troughs in supply and demand, and the barriers to implementing these in the energy system. More about the workstream's activities can be found here.




### The key message from this workstream:

Increased data availability and digitalisation of systems is fundamental to enable markets and technology to manage peaks and troughs.

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# Data and digitalisation workstream findings

## Key areas of action for data and digitalisation:

1. Review regulatory incentive regimes to make sure that they encourage effective collaboration and data sharing.
2. Develop an industry wide interoperability standard for data. This will ensure the effective sharing of information between all participants to keep the system stable.
3. Encourage a joined-up approach with communications infrastructure planning.
4. Endorse initiatives to enhance and develop the workforce, relating to upskilling of data and digitalisation expertise in the energy sector.
5. Promote a systems approach to conducting pilot projects at different scales involving machine learning and/or Artificial Intelligence (AI) to forecast the rapidly changing peaks and troughs.
6. Identify least regrets actions to speed up the rollout of data and digitalisation processes to manage peaks and troughs. This should be focused on making progress in areas where there is already existing clarity on the use case, cost and benefit.
7. Consider the creation of a Digital Twin, replicating the electricity system, by cross-industry organisations.

## Stakeholder feedback

**Having greater control and understanding of what's going on in the [communications] network is absolutely key. Often… there's an assumption that communications will always be there and is very easy to get."**

*- Workstream volunteer*

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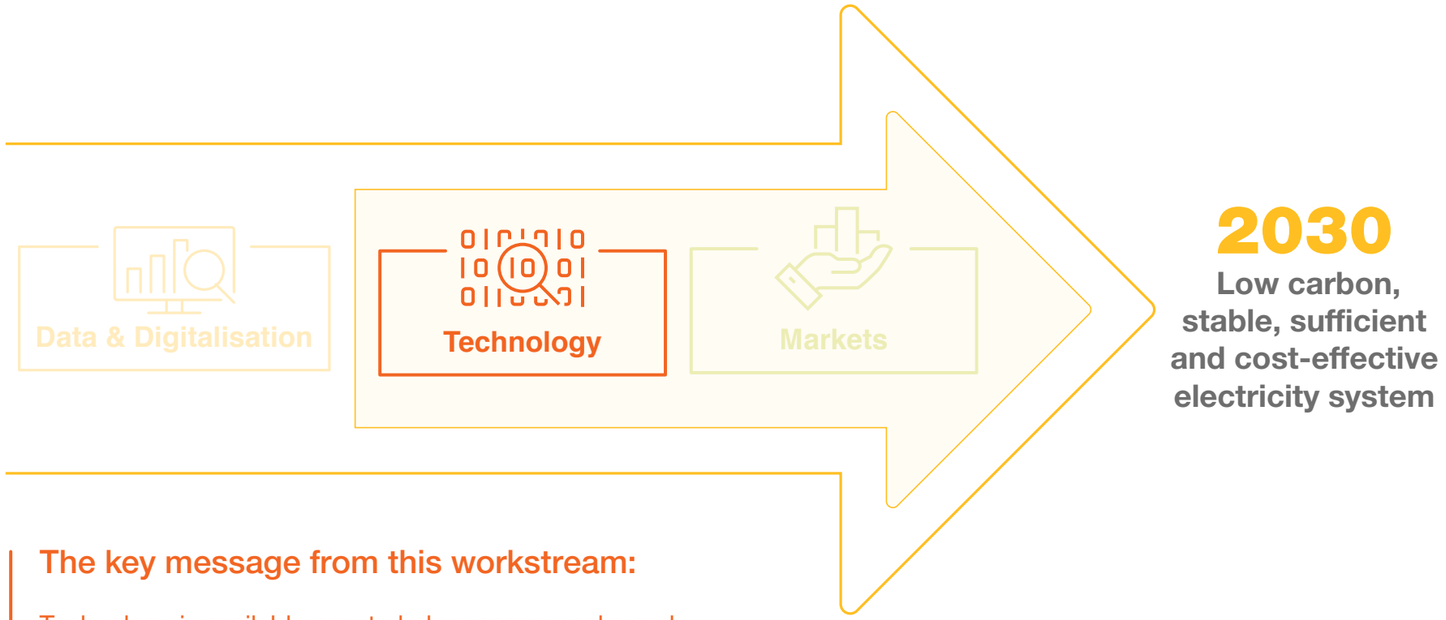
# Focus on data and digitalisation, technology and markets

## Technology workstream findings

### About the workstream

The technology workstream – which included volunteers from TechUK, BEAMA[10] and the Association for Decentralised Energy (ADE) - looked at how technology could help to manage peaks and troughs and which technologies have the potential to make the biggest positive impact between now and 2030. Using the categories of Shape, Shift, Shed and Shimmy, existing technologies were assessed as to how they can help manage peaks and troughs and at which level (transmission, distribution or behind the meter). More about the workstream's activities can be found here.




**The key message from this workstream:**

Technology is available now to help manage peaks and troughs but it needs to be smart, deployed at scale and in combination to be effective.

10 BEAMA is a member association that represents manufacturers of electrical infrastructure products and systems.

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# Technology workstream findings

## Key areas of action for technology:

1. Develop interoperability standards for existing technology types to be able to interact.
2. Promote greater use of Internet of Things (IOT) sensors and control systems at sub-stations, to get better, near real-time network data from low voltage networks.
3. Further the deployment of demand side response (DSR) technologies to enable Distributed Energy Resources (DER) flexibility to be aggregated.
4. Adopt a whole system approach when planning new DER, with sufficient visibility of potential interactions and impacts, so that assets are designed to help manage local flexibility.
6. Improve the effectiveness of metering solutions. BEAMA, as a part of the working group, agreed to take this challenge to its members, to see what they could do to improve their products.

## Stakeholder feedback

**Interoperability between existing technology types needs to be fast tracked to manage network power flows more flexibly."**

*- Workstream volunteer*

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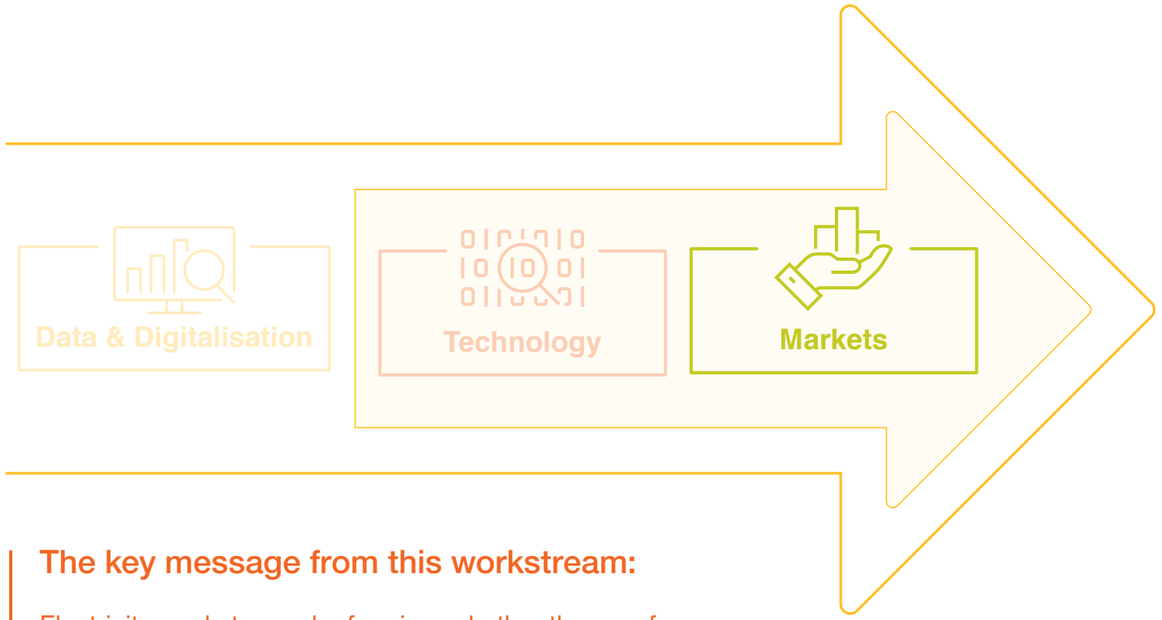
# Markets workstream findings

## About the workstream

This workstream had a wide range of volunteers, from Arenko to Reactive Technologies and Envision. The volunteers looked at both short term responses and market mechanisms to see how they can help manage peaks and troughs. Additionally, they examined the question of: how can markets unlock the value of flexibility and enable wider consumer participation? More about the workstream's activities can be found here.




### The key message from this workstream:

Electricity markets need reforming, whether they are for short term trading or longer-term contracts, to provide the flexibility needed to more effectively balance the system.

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# Markets workstream findings

## Key areas of action for markets:

1. Simplify flexibility markets through effective design, to make it easier to participate and improve market signals.
2. Review contract lengths for balancing services, with the intention to support greater revenue certainty for flexibility providers. These contracts also must be cost effective for the consumer in the long run.
3. Create a liquid forward market, by consolidating all services that do not take part in the Balancing Mechanism or stability ancillary services.
4. Design the market to be more 'stackable' so that flexibility providers can gain revenue from multiple streams.
5. Consider direct flexibility support or subsidies, akin to wind investment being de-risked through CfDs. An equivalent for flexibility providers could be Power Purchase Agreements (PPAs).
6. Put in place a minimum purchase of flexibility from smaller players, to boost decentralised flexibility efforts.
7. Attach a greater premium to demand flexibility over similar flexibility from supply.
8. Factor in the carbon emissions of different technologies when pricing flexibility.[11]

## Stakeholder feedback

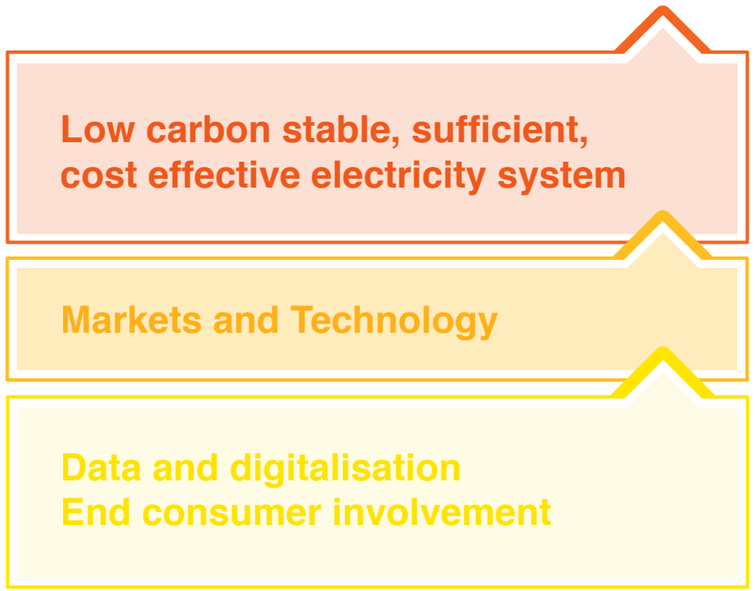
**"CFDs bring forward generation, while the Capacity Market keeps generation on the system that would naturally get retired, so volatility [in wholesale prices] is dampened which means there's no market signal to bring forward more modern solutions for peaks and troughs."**

*- Workstream volunteer*

11 Within the ESO's licensed remit to incentivise this we have committed to calculate the approximate amount of gCO2e/kWh of actions taken by the ESO, conserving the proportion of the total CO2 emissions running on the system which is a result of the ESO's actions. Find out more here: ofgem.gov.uk/system/files/docs/2020/12/final_determinations_-_eso_annex_.pdf

# Focus on data and digitalisation, technology and markets

## Integration of the three pillars




**We considered the core pillars of data and digitalisation, technology and markets separately because of our timescales. However, the importance of their integration when addressing peaks and troughs was clear in the workstream discussions, as well as in the feedback from our core stakeholders.**

We also agreed on two **fundamental requirements**, which are the basis for a whole system approach to managing more renewable generation:

- More data and digitalisation is needed consistently across all sectors.
- End consumers need to be able to play their part in a simple and equitable way.

There are also **barriers**, which need to be addressed in order to start making progress on our net zero path:

- There are currently siloed policy and regulatory approaches to these three areas, but they are interlinked and underpinned by data and digitalisation.
- The existing legal and regulatory frameworks for markets are no longer fit for purpose in an electricity system with a high level of renewable generation capacity and many more, smaller, market participants.
- The speed of deployment of the technologies is not adequate for the rate of change of electricity supply sources.
- There are not enough skilled professionals, able to advise end consumers on low carbon choices and fit low carbon technology. There is a lack of literacy regarding all aspects of decarbonisation across the spectrum, from end consumers to policy makers, from businesses to tradespeople.
- There is a lack of whole system thinking and insufficient levels of collaboration and coordination.

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# Key messages and recommendations

# Key messages and recommendations



**Within our workstreams, we identified key messages from each topic as well as areas of consensus and barriers. Using these as a basis, our internal ESO experts have worked with our co-chair Laura Sandys to devise a list of overarching recommendations for the barriers as well as more detailed next steps and recommendations for each pillar.**

There are some actions which the ESO can commit to now. There are also recommendations for the wider energy industry: a call to action for industry, government and regulators to work together to bridge the gap to net zero. We've highlighted where there are links to other policies, plans and projects, which will be able to support and possibly address some of our recommendations.

## Overarching recommendations

**Integrate the three pillars** in innovation projects and business models.

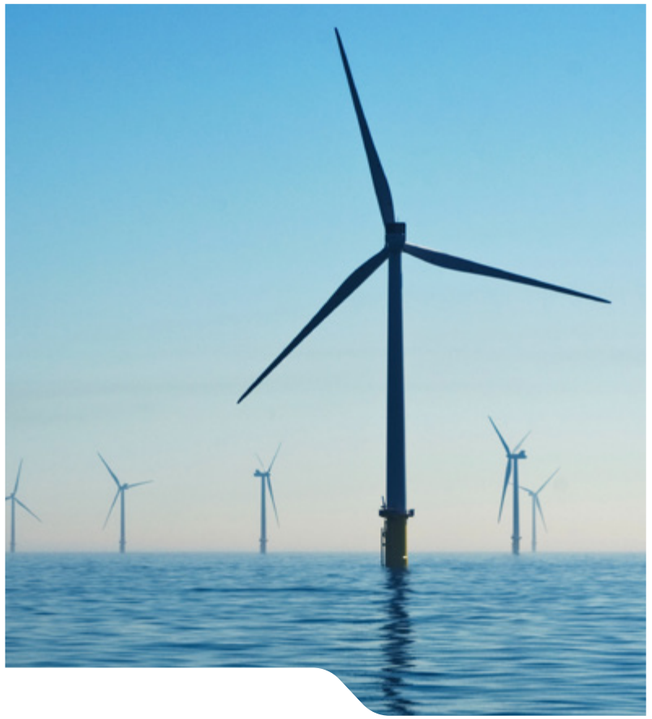
**Improve skills and literacy** in decarbonisation and digitalisation. The interconnection of these two areas is fundamental as is a deeper understanding of both energy and communications challenges. This requires new skills and capabilities across industry and government.

**Learn from other sectors** already combining markets and technology using digitalised solutions.

**Develop demand-side solutions** to accelerate end-consumers' ability to participate in delivering system stability.

**Iterative policy and regulation** able to adapt and learn from experience quickly. This applies to both energy and communications policy and regulation as they are interdependent.

**Unlock investment** to enable widespread adoption of technologies to provide flexibility.



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## Data and digitalisation

Increased data availability and digitalisation of systems is fundamental to enable markets and technology to manage peaks and troughs.

**For 2030, we need:**

- Increased data from all participants in the system.
- Interoperability standards to enable active data flows throughout the system.
- Deep digitalisation of all energy assets.

### Next steps for the ESO:

**Drive greater data availability and digitalisation throughout the energy system.**

The ESO will need more, and better-quality data, to be able to get the full potential from digitalised systems.

- We will operate on an open data basis, sharing as much information as we can to allow others to innovate and help find solutions.
- Data quality will need to improve. As new sources of flexibility come online, we will need their operational data.
- As part of our Digitalisation Strategy for 2021[12], we are committed to improving our internal policies and assurance to demonstrate good data stewardship.

**For the longer term, the ESO will collaborate to develop a digital twin** of the GB electricity system. Working with other organisations, such as the DNOs, we will combine resources to develop a model which can help assess how to improve the performance of markets.

**Use machine learning and AI computing to model the interaction between digital platforms, technologies and markets signals.** This will build our understanding and help identify risks and opportunities.

12 ESO Digitalisation Strategy link

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# Key messages and recommendations

## Data and digitalisation

### Recommendations for the wider energy industry:

**Agree roles and responsibilities** for the development of the digital twin operation and ownership.

**Introduce interoperability standards.** Standards are needed to ensure that different systems and products can work together and allow interoperability across data, services and technologies.

**Standardise new terms and conditions.** Regulation and policy should encourage all system terms and conditions to be consistent, requiring a presumed open data standard clause and the adherence to interoperability standards for all infrastructure.

### These recommendations link to:

**Energy White Paper:** Building ‘world leading’ digital infrastructure for our energy system (based on Energy Data Taskforce vision, first Energy Data Strategy due in spring 2021)

**Ofgem’s Forward Work Programme:** partly dedicated to unlocking benefits of data and digitalisation, including:

- Developing data and digitalisation standards for more open data, data quality and transparency.
- Embedding standards to ensure that data is interoperable across the energy sector, markets and government.

**MEDA Innovation:** Innovate UK is developing interoperability standards through its innovation programmes.

**BEIS Smart systems and flexibility plan** (due spring 2021)

**BEIS Engineering Standards review**

Bridging the gap / Key messages and recommendations 31

# Key messages and recommendations

## Technology

Technology is available now to help manage peaks and troughs but it needs to be smart, deployed at scale and in combination to be effective.

**For 2030, we need:**

- Smart technologies, all digitally enabled.
- Deployed at scale and throughout the energy system.
- Combined technologies, delivering multiple services.

### Next steps for the ESO:

**Focussed research:** Use our internal research and trials on new technologies to help us understand better what can assist with managing peaks and troughs.

- For example, we've started a project into how we can improve our modelling techniques, so that we can properly assess future energy network requirements during periods of low renewable electricity supply.

**Improve how we communicate our needs to customers.** We will work with our customers to ensure that the information we already publish clearly shows where the system needs are and where there are opportunities for investment.

- Publish data on the procurement and utilisation of different services provided by technologies to the ESO.
- Continue to enable new technologies, by publishing new capability and system needs to provide a pathway to innovation.

- For example, we do this already with our stability pathfinder and innovation projects. The recent 4D heat project[13] is a good example of how to enable technology to help manage peak electricity supply.

13 4D heat project

Bridging the gap / Key messages and recommendations 32

# Key messages and recommendations

## Technology

### Recommendations for the wider energy industry:

**Change regulatory barriers to support demand-side first responses:** Unlock more investment in the wide range of decarbonisation assets on the supply and demand side and enable safe and economic system operation using all available services and tools.

**Use policy to enable widespread deployment of existing technologies and new ones.** The impact of technology will be limited if policy doesn't support new technologies' adoption and create a pull for innovation.

**Collaborate with a much wider range of manufacturers,** service providers from other sectors, and technology experts to identify how non-energy assets can help the energy sector.

Ensure all new products and infrastructure are digitally enabled. Government needs to set strong standards to ensure that all products and services are "energy ready", so able to assist in energy markets.

### These recommendations link to:

**Energy White Paper:**

- Smart appliances' regulation will be based on principles of interoperability, data privacy, cyber security.
- Long duration storage to be targeted through the net zero innovation portfolio.

**Ofgem's Forward Work Programme:**

- Removing barriers to storage.
- Working with industry to enable flex and remove barriers to storage.

Bridging the gap / Key messages and recommendations 33

# Markets

Electricity markets need reforming, whether they are for short term trading or longer-term contracts, to provide the flexibility needed to more effectively balance the system.

**For 2030, we need:**

- Simplified and accessible markets.
- Market arrangements that unlock investment.
- Markets that reflect the different timescales of system stability.

## Next steps for the ESO:

**Accelerate the simplification of markets.** With simpler access arrangements across the whole system, more participants will be able to provide the range of flexibility required. The ESO will do this for those markets for which it is accountable.

- **We will share our expectations for market change over the next 5 years.** To support our operability strategy, we will set out how we see markets changing between now and 2025. We will also outline how we intend to deliver transformational change across the market areas, for which we are accountable.
- For example, we are already looking into removing barriers and enabling wider access to the Balancing Mechanism as well as how to facilitate more real-time trading. We will also review Code Governance to see how this could be improved and simplified.

**Ensure market platforms are fit for an increasingly dynamic future by learning from other sectors.**

- For example, we will be introducing a Single Markets Platform over the next two years, which will significantly reduce the amount of time and effort required to participate in markets.



Bridging the gap / Key messages and recommendations 34

# Key messages and recommendations

## Markets

### Recommendations for the wider energy industry:

**Focus as much on demand markets as well as supply markets.** Policy and regulation need to give as much focus to demand side markets as it does to supply side markets.

**Encourage the development of a variety of flexibility products and aggregator services,** which enable fair rewards to flow to providers and the widest access to flexibility markets and actions.

**Policy and regulation for markets need to be consistent, coherent and provide confidence.** This helps investment decisions and sets the framework for safe and simple propositions to end consumers. It should also set a hierarchy of action to help determine how national and local markets will interact and support each other.

### These recommendations link to:

**Energy White Paper:**

- Assess market framework changes to facilitate the development and uptake of innovative tariffs.

- Smart Systems Plan due in Spring 2021.

**Ofgem's Forward Work Programme,** within the work on full chain flexibility:

- Evaluate what mechanisms are available to unlock demand side flex.

- Reviewing Access Charging Reforms.

**ENA Open Networks plans** to develop consistent frameworks for different markets operating at different levels.

Bridging the gap / Key messages and recommendations 35

# Continuing the conversation

Email us with your views on FES or any of our future of energy documents at: FES@nationalgrideso.com and one of our team members will get in touch.

Access our current and past Bridging the Gap documents here: nationalgrideso.com/future-energy/future-energy-scenarios/bridging-the-gap-to-net-zero

Get involved in the debate on the future of energy and join our LinkedIn group Future of Energy by National Grid ESO

Write to us at:

**Energy Insights & Analysis**
**Electricity System Operator**
**Faraday House**
**Warwick Technology Park**
**Gallows Hill Warwick**
**CV34 6DA**


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# Appendices



Bridging the gap / Appendices 37

# Example peaks and troughs

**We produced some examples of specific conditions that we could see in our future energy system, under various combinations of high and low supply and demand, and the challenges that these would pose to system operation.**

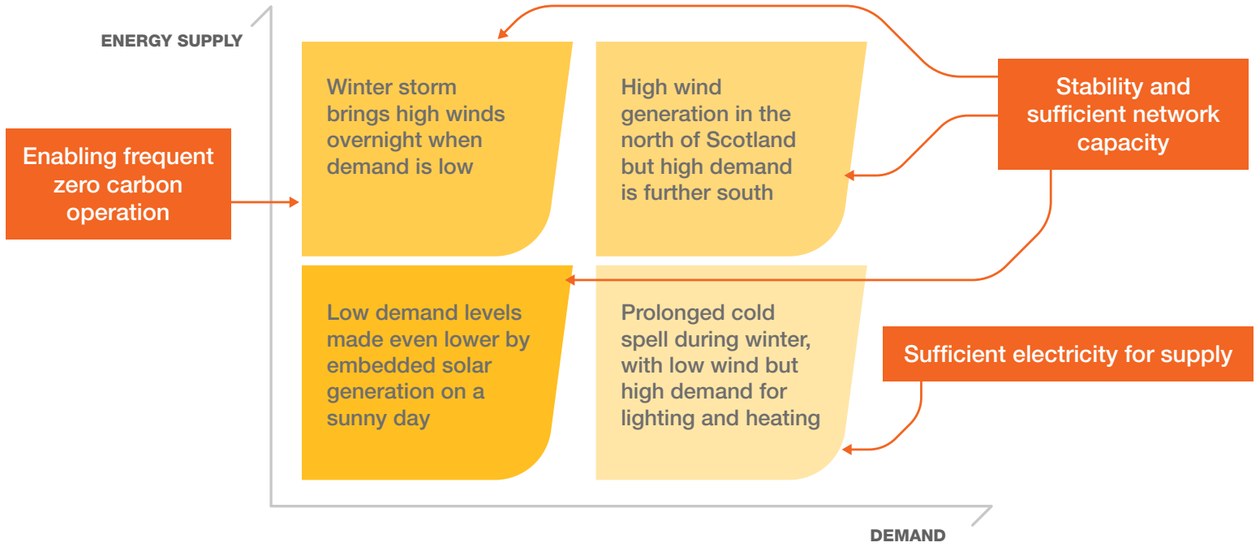
We looked at the events which represented challenges relating to:

1. Sufficient electricity for supply
2. System stability and capacity
3. Enabling frequent zero carbon operation (relating to the ESO's ambition to operate a zero-carbon grid by 2025).

The diagram below demonstrates the different supply and demand scenarios, and their implications for the above challenges.

These, predominantly driven by the weather and consumer behaviour, provide an insight into what the system will need to deal with, to keep the system stable, in future.

There are, of course, many other scenarios which can have an impact on these fundamental aims of operating the electricity system. The diagram below provides a useful insight into some of the most significant challenges we could see in the future with increased renewable generation.




Bridging the gap / Appendices 38

# Data and digitalisation workstream

## List of stakeholders

- Jake Verma, Energy Systems Catapult
- Rhiannon Calado, National Grid ESO
- Elena Theodorou, Energy Networks Association
- Jon Ferris, Electron
- Myriam Neaimeh, Turing Institute
- Sammy Blay, Reactive Technologies
- Vaughan John, Ofcom
- Mark Walton-Hayfield, Envision Digital

Additional thanks goes to Dinker Bhardwaj (BEIS) and Steven Steer (Ofgem) for their feedback throughout the data and digitalisation workstream.

## Further workstream detail

Included here is some additional material produced to answer the workstream's supplementary question of: what can we learn from other sectors' and countries' use of data and digitalisation to help manage rapidly changing peaks and troughs?

The slides with the interim recommendations presented at our webinar in November can be found here.

**Uber:**

- Consumers give data sharing permissions in return for accessibility of drivers, so they have the needed visibility.

**Netflix streaming service:**

- Owns and rents localised caches depending on demand.

**HMRC tax platform:**

- Multiuse platform that allows millions of people to cooperate and take part in the system.

**Estonia:**

- Built an e-government, converting public services into flexible e-solutions. Every citizen has a digital identity which they use across public services.

**Supermarkets/logistics:**

- Storage management to deal with ebbs and flows in supply and demand, including the data that sits behind this.

**Communications infrastructure:**

- Where there are compatibility standards throughout the sector to ensure interoperability between different systems.

**Denmark:**

- The Danish TSO Energinet have their own data hub, where every piece of information about the electricity consumption of consumers is stored.

**This review led us to identify the following barriers to implementation:**

- Lack of coherent planning with Telecoms.
- Uncertainty - we know we need more data but how much more do we need?
- Disparity between networks (including between gas and electricity).
- Interoperability standards are lacking so that we can see the millions of actions and assets on the system.
- Skillsets within industry and data maturity within organisation are vastly different.
- Need for granular, close to real time information that is in a standard format.
- Lack of incentives to share data between networks– uncertainty around competition and collaboration.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# Technology workstream

## List of stakeholders

- Jim Allen, Capula Limited
- Caroline Bragg, Association for Decentralised Energy
- Teodora Kaneva, Tech UK
- Tim Naylor, Envision Digital
- Rob Nickerson, National Grid ESO
- Aneesa Parkar, National Grid ESO
- Rebecca Sweeney, Energy Systems Catapult
- Jeremy Yapp, BEAMA

The slides with the interim recommendations presented at our webinar in November can be found here.

## Further workstream detail

The working group looked at examples of how increased use of technologies can help manage peaks and troughs. There were some key requirements highlighted:

- Assets need to be digitalised (as in smart-enabled) in order to provide flexibility.
- Data needs to be available to enable smart operation of these technologies.
- Smart technologies, combined with the right customer offering, can make it simple for end consumers to be involved.
- A cross sector approach is needed, which involves not only the energy industry, but also planners, car manufacturers, heating technicians, training providers, consumers and government policy makers and many more.

On the next page, there are some examples of how combined deployment of smart technologies can have a big impact.


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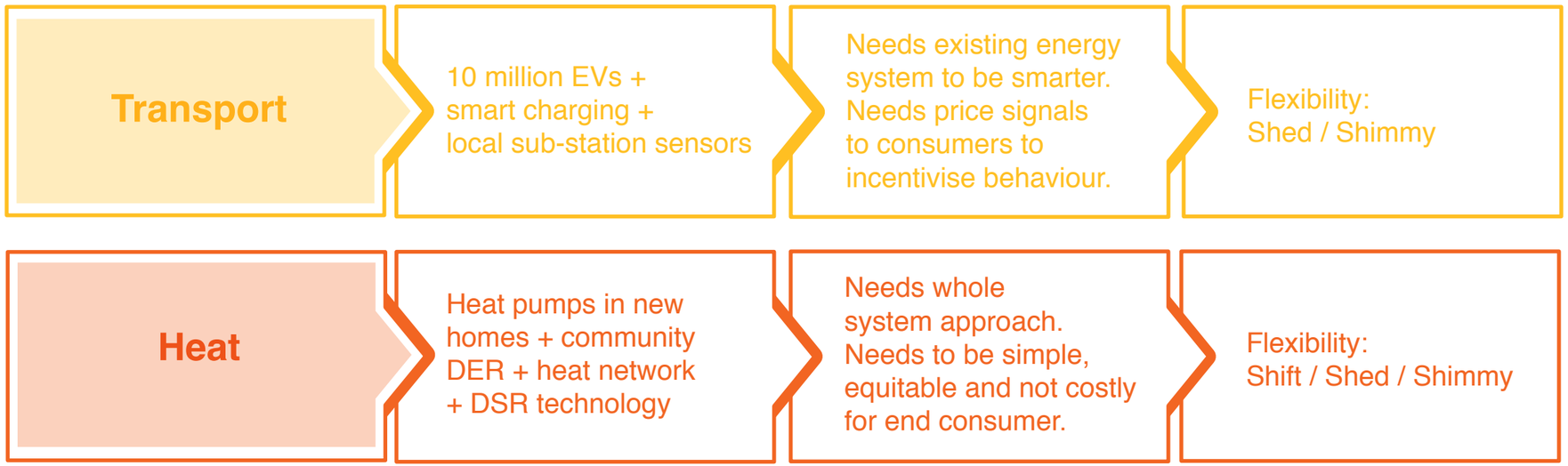
# Technology workstream

**Heat and transport are priority areas for action and where combinations of current technologies can make a big difference**





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# Markets workstream

## List of stakeholders

- Phil Lawton, Energy Systems Catapult
- Amir Alikhanzadeh, Energy Systems Catapult
- John Twomey, National Grid ESO
- Rend Nawari, National Grid ESO
- Andy Hadland, Arenko
- Luiz Avelar, Envision Digital
- Sammy Blay, Reactive Technologies
- Caroline Bragg, Association for Decentralised Energy
- Rick Parfett, Association for Decentralised Energy
- David Sykes, Octopus
- Matthew Deitz, BEIS (workstream observer)

The slides with the interim recommendations presented at our webinar in November can be found here.

## Further workstream detail

In order for markets to be able to deliver there are some key requirements relating to data and digitalisation and technology:

**Data and digitalisation:**

- The availability of data is a pre-requisite.
- Data monitoring and openness is needed to enable technologies at different levels to participate (noting smart meter data in particular).
- Energy infrastructure is digitalised, including across the full range of voltage levels.

**Technology:**

- Technology is available and in place to facilitate consumer propositions that are simple and automated.
- Flexible distributed technologies are widespread in the electricity system.
- Technology is adopted by consumers, and managed by third parties.

**What are the barriers to more flexibility on the market?**

Flexibility is already important and used today, but there are barriers to the development of more flexible assets, despite the fact that we know we will need more flexibility in future. The workstream identified key areas that represented barriers to market for flexibility solutions:

- New flexibility providers are unable to access all potential revenue streams.
- Lack of cost reflectivity in electricity pricing.
- Existing market interventions such as the capacity market and Contracts for Difference already distort the wholesale market and reduce price volatility. Our workstream volunteers suggested that volatility would actually improve business cases for flexibility.
- Lack of access to existing revenue streams, particularly for small scale flexibility.


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# Thank you!

## To everyone who contributed, our workstream volunteers and particularly to our core stakeholders:

- Aimee Betts, Caralambous – BEIS
- Andrew Lever, Carbon Trust
- Barnaby Wharton, Renewables UK
- Caroline Bragg, Association for Decentralised Energy
- Charles Wood, Energy UK
- Eric Brown, Energy Systems Catapult
- Goran Stbac, Imperial College London
- Johnny Gowdy, Regen
- Julie Finkler, BEIS
- Keith Bell, University of Strathclyde, UK Energy Research Centre and the Committee on Climate Change
- Louise van Rensburg, Ofgem
- Marta Krajewska, Energy UK
- Nina Skorupska, Renewable Energy Association
- Patrick Cassels, Ofgem
- Peter Bingham, Ofgem
- Randolph Brazier, Energy Networks Association
- Robert Hewitt, BEIS
- Simon Dawes, BEIS
- Sulaiman Ilyas-Jarrett, BEIS

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