March 2023

Future Energy Scenarios

# Bridging the Gap to Net Zero

ESO

# Navigation

This version of the Bridging the Gap to Net Zero document has been optimised for printing out or viewing on a tablet.

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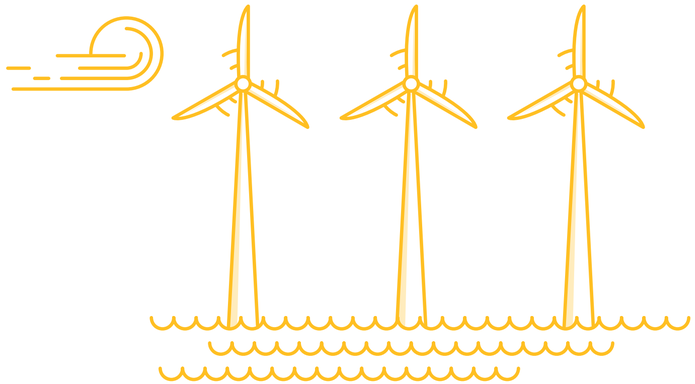


# Foreword

**Bridging the Gap this year continues to highlight key areas for action to achieve Net Zero. We have built on last year's flexibility timeline, which outlined a series of actions needed to be able to operate a decarbonised electricity system in 2035. Two key components of how we can do this, according to our Future Energy Scenarios, are domestic demand flexibility (including from EVs) and the production and availability of hydrogen.**

**Fintan Slye**
Executive Director,
Electricity System Operator (ESO)

Talking to our stakeholders, it is clear they also see these two aspects as vital pieces of the puzzle to decarbonise our electricity supplies. They also rightly highlighted some of the big challenges with their use. Firstly, as we've stated in previous years' reports, clarity and certainty of direction for Net Zero is needed. This was also clearly stated in the recent Net Zero Review along with the importance of taking action urgently. We fully support this message and believe the FSO will be able to provide the strategic direction desired by much of industry through its Net Zero Advisory role.

Domestic demand flexibility relies on achieving the requisite levels of engagement and awareness amongst households, so it can support system operation. We have started tapping into this over the recent winter with our Demand Flexibility Service (DFS), which will help inform how we can make this commonplace in the near future. To complement this, our stakeholders agreed that a greater level of public awareness of Net Zero is still needed, so that we all understand our role in decarbonisation. This should be alongside a greater understanding by industry of the differences of consumers' needs, abilities, and motivations when it comes to energy.

For hydrogen, there was consensus amongst our stakeholders about how hydrogen can help with flexibility. Green hydrogen from electrolysis maximises the use of renewable electricity by producing hydrogen at times of peak supply. This can then be either used immediately in industrial settings or stored for the generation of electricity at times of peak demand. However, government support will be needed to kick start this process and financial incentives need to be revealed to provide a clear strategic direction.

We are making progress towards to Net Zero. We have already operated the electricity network with 87% zero carbon electricity in January 2023. However, there is still much to do to adapt and transition to a decarbonised system. This report highlights what is needed for consumers to be engaged and for hydrogen to materialise. It also highlights again that industry is ready for the challenge, there is consensus about the urgency and appetite to take some risks to get on the path to Net Zero.

# Introductions from our partners

**Rachel Mills,** Citizens Advice
**Abigail Ward,** Energy Savings Trust

The current affordability and energy security challenges present us with urgent priorities, which in the past may have conflicted with the need to continue decarbonising at the pace and scale needed to reach Net Zero by 2050. But circumstances have shifted so that these priorities are now well aligned. Addressing the climate crisis, extricating ourselves from volatile global fossil fuel supply chains by investing in renewable energy generation and reducing our overall demand for energy are the surest ways to improve energy security while bringing down consumer bills.

Demand flexibility will be a crucial piece of the energy security and decarbonisation puzzle. While the benefits of demand flexibility are well-recognised, we were concerned that many of the benefits may be felt primarily by early adopters, as has been the case with previous technological transitions. There is a strong equity and social justice argument for taking mitigating action to minimise this disparity as the reality is that all consumers have a role to play.

For these reasons, we were eager to participate in National Grid ESO's Bridging the Gap work, which has taken a deep dive into understanding the barriers to consumer awareness of and engagement in flexibility and will help the operation of a fully decarbonised electricity system by 2035. The current energy crisis has accelerated the delivery of these kinds of services and the transition to a more flexible energy system to an extent no one could have predicted, even 18 months ago. The coming years will see even greater change and it will be crucial that as many households as possible understand and are able to benefit from a more agile and flexible energy system. This Bridging the Gap report helps to start a critical and timely conversation about consumer engagement and the equity of this transition.

**Danielle Stewart, Hydrogen Programme Director**
National Gas Transmission

**Delivering a decarbonised power system by 2035 will require coordination and collaboration across the full value chain.**

It has been an exciting opportunity to partner with the Electricity System Operator to explore the role that hydrogen can play as a source of flexibility. A smart combination of low-carbon gases and renewable electricity in an integrated energy system will help to achieve a resilient and affordable path to Net Zero for all consumers.

Through this partnership, we have collectively been able to bring together a wide range of stakeholders to understand what some of the barriers and opportunities are and build a consensus of key recommendations to industry. Thank you to everyone who has worked with us to share thoughts, insights, and evidence.

We look forward to receiving your feedback on this report.

# Executive summary

## Welcome to the fourth iteration of FES Bridging the Gap to Net Zero.

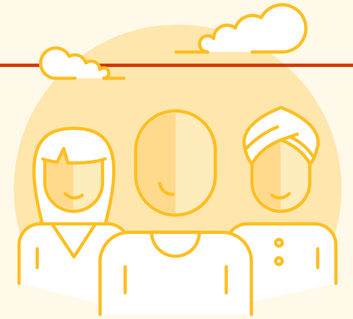
Continuing with the theme of flexibility and taking a whole system view, we have this year delved into more detail on two important providers of flexibility in our Future Energy Scenarios (FES): domestic **end consumers** and **hydrogen**. Both are assumed to be available at scale to assist with operating the system in all the Net Zero scenarios in FES. However, both are currently at negligible levels.

So, what is needed to ensure that end-consumers' demand side response will be sufficient to reduce peak demand in winter 2035? And what are the key barriers to be resolved so that hydrogen can play an important role in both demand and supply flexibility?

**To address these two challenges, we convened two in-person workshops, where we posed the following questions:**

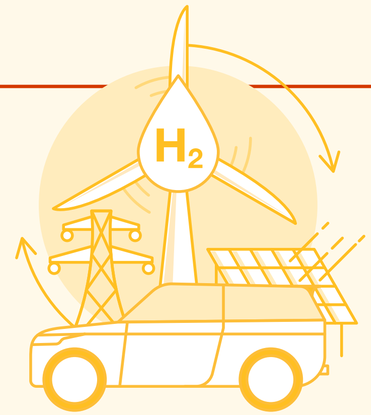
1

How do we increase end-consumer awareness of, and engagement in, energy, which will help the operation of a fully decarbonised electricity system?



2

How do we deploy hydrogen as a source of flexibility to help the operation of a fully decarbonised electricity system?



# Executive summary

## What is flexibility? Why is it important?

Flexibility is the ability to shift in time or location the consumption or generation of energy (according to DESNZ' Smart Systems and Flexibility plan). The need for greater levels of zero carbon flexibility stems from the fact that our electricity system is changing and so the way that the ESO operates the system needs to change too. Historically, supply was adjusted to meet demand by using gas-fired power stations. In future, our system will be supply-led and demand will need to be more flexible to keep the system operating safely, reliably and cost-effectively.

The assumption that flexible demand will be available is made in all our Future Energy Scenarios and this in turn informs our other work too, for example network planning (Network Options Assessment) and market reform (Net Zero Market Reform). Flexible demand and supply options are therefore a fundamental part of how we see zero carbon operation actually functioning in 2035. Without flexibility, from end-consumers and hydrogen amongst many other sources, it will be much harder and more expensive to meet the 2035 target.

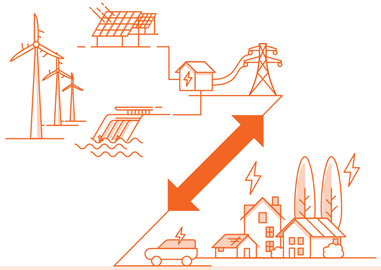
## The system is changing

Increased decarbonisation of the electricity system has resulted in changes in four key areas.

Less flexible generation, like gas power stations, means it is harder to make supply match demand.

New electricity generation methods require new ways to maintain the grid's stability and reliability.

More variable, weather-dependent sources of generation, sometimes generate too much electricity and sometimes too little.



Renewable generation, particularly wind, is often far from areas of high demand, which can cause problems when it comes to electricity transmission.

# Executive summary

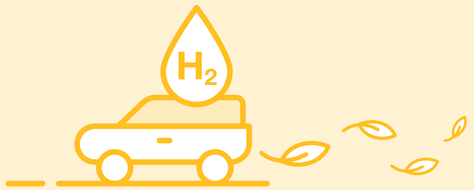
The following **Key Messages** are the key areas of consensus from stakeholders' discussions at the workshops.

## Consumer key messages:

- A better understanding of different consumers, their motivations and ability to provide flexibility is needed, so that the energy transition benefits everyone.
- Develop new tariffs and products to benefit all end-consumers, so that they can be part of the solution for operating a decarbonised electricity system. New market structures are needed to facilitate this and incentivise behavioural change.
- An effective information campaign about how households can contribute to Net Zero is needed, with consistent messaging about energy flexibility alongside energy efficiency. This should be supported by consistent, joined-up advice services across Great Britain offering action-orientated, tailored guidance.

## Hydrogen key messages:

- Hydrogen has a role to play to help operate a fully decarbonised electricity system. To make this happen, we need to urgently develop the commercial frameworks and market design, which will help business models develop and infrastructure to be built.
- Accelerate decision-making relating to the use of hydrogen and the networks needed to facilitate its production and transportation. Set strategic direction for hydrogen by establishing an independent body to make decisions and coordinate.
- Industry needs a flexibility roadmap, outlining in more detail what is likely to be needed between now and 2035, so that they can make the necessary investment.



# Executive summary

## Two different topics, one set of questions

**Working with our partners – National Gas Transmission, Citizens' Advice and the Energy Savings Trust – we were able to engage with a broad range of stakeholders from across the whole energy system. To help structure our approach at the in-person workshops, we used the same set of questions for both consumer engagement and hydrogen:**

- What does good look like in 2035?
- What is already underway?
- And what are the barriers to achieving the 2035 vision?

It was clear from both groups that stakeholders wanted more clarity around the energy system transition, what will be needed when and who is responsible for what. This chimes with one of the key messages from last year's Bridging the Gap's report: **Net Zero needs cross-sector coordination**. There has since been progress towards agreeing the scope of a Future System Operator (FSO), which could take on this responsibility but in the meantime, stakeholders are still looking for more clarity about the roles and responsibilities to deliver Net Zero. The recent Net Zero Review clearly makes this point as well arguing that more clarity, certainty and consistency is desperately needed and it recommends an Office for Net Zero Delivery to coordinate across multiple Government departments.

Additionally, **market reform** is high up on the agenda for both topics as it was last year as well. The planned wholesale market reforms will form the basis for the smart tariffs and flexibility services end-consumers will need to be able to provide flexibility. Having clear market signals will also help investors build their business cases for the development of hydrogen infrastructure, such as storage, electrolysers and hydrogen peaking plant. We will continue to engage with DESNZ on their Review of Electricity Market Arrangements (REMA) as well as developing our own ancillary markets, which can provide the right signals for flexibility in the short and longer term.

# Executive summary

The discussions at the workshops focussed on some of the biggest barriers, which produced a list of recommended actions with suggested owners. These recommended actions will be considered by the ESO, DESNZ, Ofgem and our partners in industry and beyond to inform plans and approaches over the next year.

## Consumer engagement

### Key barriers:

**Lack of awareness:**
How to ensure the public is informed?

**Lack of right incentives:**
How to incentivise different consumers to maximise flexibility?

**Lack of a clear plan about how we get from here to 2035:**
How do we achieve our consumer engagement vision?

## **What next?** Summary of actions

| Recommended action | Proposed owner | Barrier 1: Awareness | Barrier 2: Incentives | Barrier 3: Plan |
|---|---|---|---|---|
| Establish a campaign body for consumer awareness of Net Zero and Energy | **DESNZ** | ✓ | | |
| Run regular, consistent, campaigns about Net Zero and Energy | **DESNZ/ Campaign body** | ✓ | ✓ | ✓ |
| Set up national energy advice service to support and complement awareness campaign | **DESNZ** | ✓ | | |
| Improve market signals for flexibility to enable suppliers, energy service providers and innovators to develop a compelling customer value proposition | **ESO**<br><br>**Suppliers/ Aggregators/ others** | | ✓ | |
| Understand consumers better through archetypes, demand data, ability to flex | **ESO/ Suppliers/ Energy advice sector** | | ✓ | |
| Joined up strategy for consumer engagement across Government, regulator, local authorities, industry, ESO/FSO and consumer groups | **DESNZ** | ✓ | ✓ | ✓ |

# Executive summary

## Hydrogen

### Key barriers:

**A lack of plan, coordination or collaboration**

**Infrastructure is not ready to support introduction of hydrogen**

**Commercial uncertainty (for creating demand and for creating supply)**

## **What next?** Summary of actions

| Recommended action | Proposed owner | Barrier 1: Coordination | Barrier 2: Infrastructure | Barrier 3: Commercial Uncertainty |
|---|---|---|---|---|
| Establish co-ordinating body for hydrogen | **DESNZ** | ✓ | | |
| Clarity about what flexibility is needed when and where | **DESNZ/ESO** | ✓ | | ✓ |
| Improve connections and the network planning process for both gas electricity | **ESO** | | ✓ | |
| Allow hydrogen blending | **DESNZ** | | ✓ | ✓ |
| Expedite development of hydrogen storage | **DESNZ/Ofgem** | | ✓ | ✓ |
| Create the right market signals to produce hydrogen with excess renewable electricity to help balance the system and to encourage investment in hydrogen infrastructure | **ESO/DESNZ** | | | ✓ |
| Clear, certifiable hydrogen standard to prove provenance/quality | **DESNZ/Ofgem** | ✓ | | ✓ |
| Change to low regrets from no regrets approach | **DESNZ/Ofgem** | | ✓ | ✓ |

# Consumer engagement

ESO

# What’s the challenge?

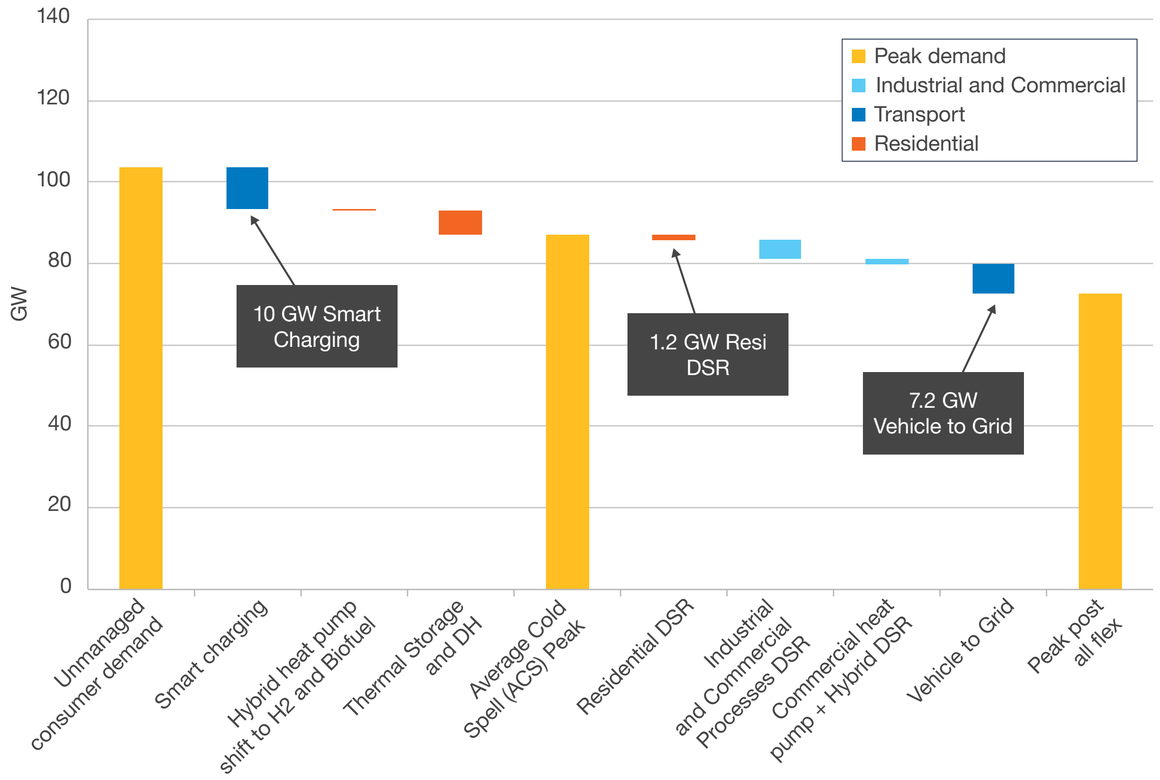
**Up until recently, end-consumer demand has defined how the electricity system operated. The supply of electricity would be shaped to fit the demand profile, which when aggregated across the whole of the country, was fairly predictable.**

The urgent need to decarbonise has changed, and will continue to change, how the electricity system and the wider energy system works. Renewable electricity will meet the majority of energy needs in future, but it can only generate when the conditions are right. This makes the supply profile as well as its location the defining elements in the electricity system. Demand will need to move in future to meet supply. End-consumers have an important part to play and this is a fundamental assumption in our Future Energy Scenarios, our Network Options Assessment and our Net Zero Market Reform.

Domestic end-consumers and their role were the focus of our discussions as the challenge to make millions of diverse households into active participants in the energy system is huge. In previous Bridging the Gap projects, we have discussed what needs to happen in terms of infrastructure (such as the roll out of smart meters and upgraded infrastructure to support more electrification) and there are many projects and activities underway to address this, for example the Smart Systems and Flexibility Plan and Energy Digitalisation Strategy by DESNZ and Ofgem. While the infrastructure to enable this change is vital, our work this year focussed on the need to influence behaviour at an individual household level to produce a cumulative, system-level result.

## FES 2022 Consumer Transformation – an electrified scenario

Peak ACS electricity demand in 2035 – Consumer Transformation




*For the analysis and assumptions behind these graphs, please look at our Future Energy Scenarios report and data workbook.*

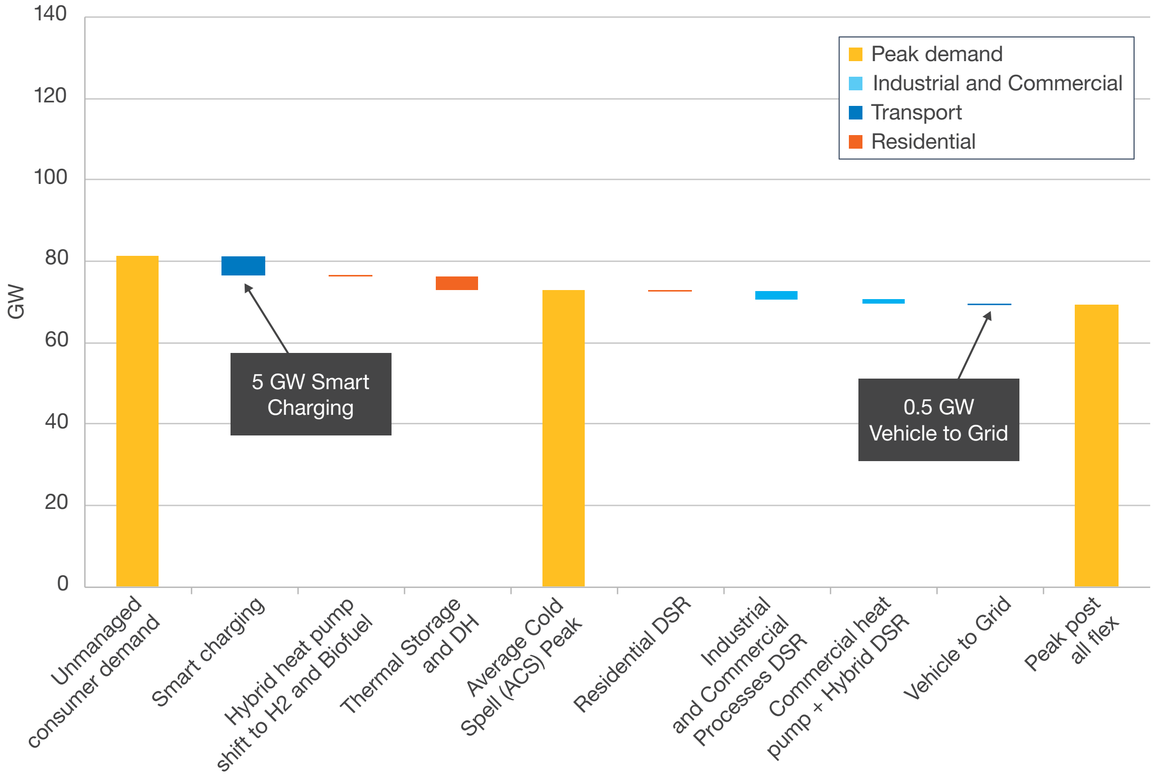
# What's the challenge?

By 2035, FES tells us that smart charging of electric vehicles as well as demand side response (DSR) in domestic households are required to lower overall peak demand. For this to happen, householders will need to have some or all of the following: an energy tariff or service to incentivise demand shifting, the right infrastructure connected to their homes, smart appliances, new heating systems and energy storage. The enabler to all of this is a higher level of consumer awareness and engagement in energy and Net Zero.

These charts from FES, give us a range of the levels of flexibility we might expect from across the energy system, including domestic end-consumers. What is important to note is that flexibility is reducing the overall peak demand by at least 15% in 2035 and that this final peak demand, post all flexibility, is what is being used to plan the network. Domestic demand side response is more than just another way of reducing carbon emissions, it is fundamental to being able to operate the network in 2035.

## FES 2022 System Transformation – a hydrogen scenario

**Peak ACS electricity demand in 2035 – System Transformation**




*For the analysis and assumptions behind these graphs, please look at our Future Energy Scenarios report and data workbook.*

# What’s the challenge?

Using the FES 22 figures, the following table gives an indication of the scale of change likely between now and 2035 and the challenge ahead of us.

**Domestic flexibility** includes smart charging, residential demand side response and vehicle to grid

| | 2022 | 2035 – Consumer Transformation | 2035 – System Transformation |
|---|---|---|---|
| **Flexibility available from domestic flexibility** | ~200 MW | 18.2 GW | 5.6 GW |
| **Domestic customers providing demand side response** | ~1 million signed up to Demand Flexibility Service | 3.7 million homes* | 1.2 million homes* |
| **Electric vehicles on the road** | ~1,050,000 | 27,270,000 | 19,600,000 |
| **EVs smart charging** | n/k | 22.8 million | 12.6 million |

*These FES figures are the numbers of homes providing flexibility at times of peak demand, however this is not the same as the number signed up. This will be a lot greater, as it’s assumed only a small proportion is able to provide flexibility at any particular time.

# What does consumer engagement in energy look like in 2035?

**Talking with our stakeholders, we agreed on what we thought good looked like for 2035; what the aspirational vision is of the future for domestic, energy consumers. From this starting point, the actions needed to enable this can be determined.**


Domestic end-consumers understand more about Net Zero and know there is a benefit to them, directly and indirectly, from flexing their energy use.

Those end-consumers, who participate directly in flexibility, can do so with minimum effort, via smart meters and technology combined with a range of smart tariffs and services available to them.

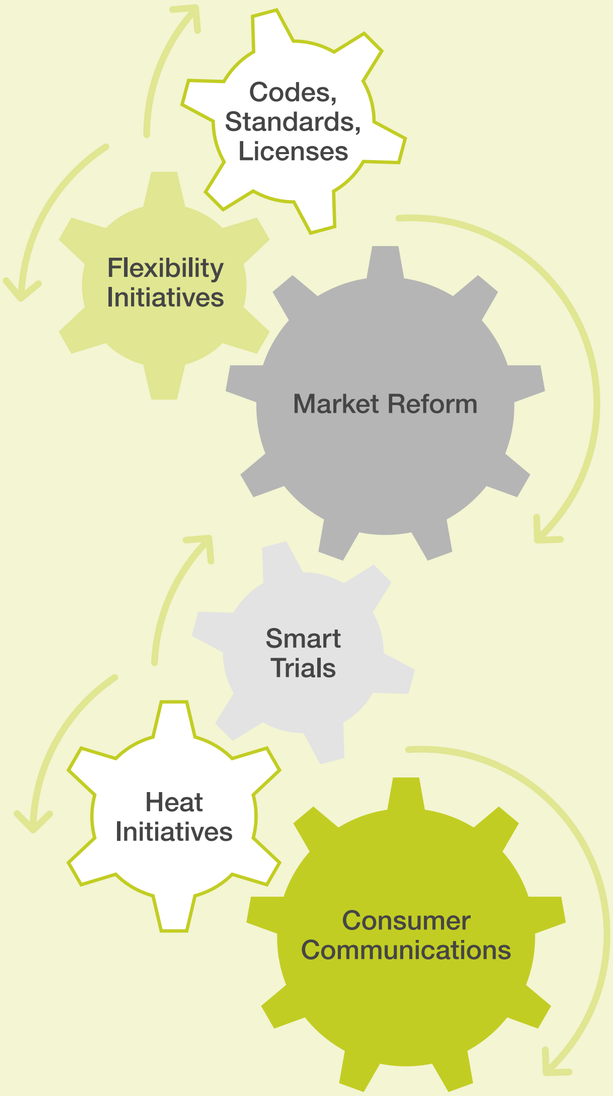
They are confident that their data is safe and know their consumer rights are protected. They have an independent source of advice for support should anything go wrong.

They know that they are doing the right thing to keep the lights on, keep carbon emissions down and keep costs down for everyone.

# What's already happening?

**Understanding where we are now is really important, so that we can identify gaps and think about how we can address them. The projects and activities listed here are from across different sectors and cover areas such as heating, codes, standards, smart tariffs, flexibility trials and digitalisation.**

Some of the gaps from this range of activities relate to understanding end-consumers better, knowing how to engage with them and how to bring about enduring and repeated behavioural change. It was also clear that whilst there is a lot going on, it is probably not being done in a coherent and coordinated way. These topics came up in the discussion about barriers.




## Codes, Standards, Licenses

- DESNZ Smart and Secure Electricity System – licencing and smart mandates
- Flex assure – code of conduct for flexibility providers
- P415 – access to wholesale markets for virtual lead parties

## Flexibility Initiatives

- ESO's Demand Flexibility Service
- DSO/DNO flexibility trials, e.g. Project Leo
- Crowdflex Innovation project

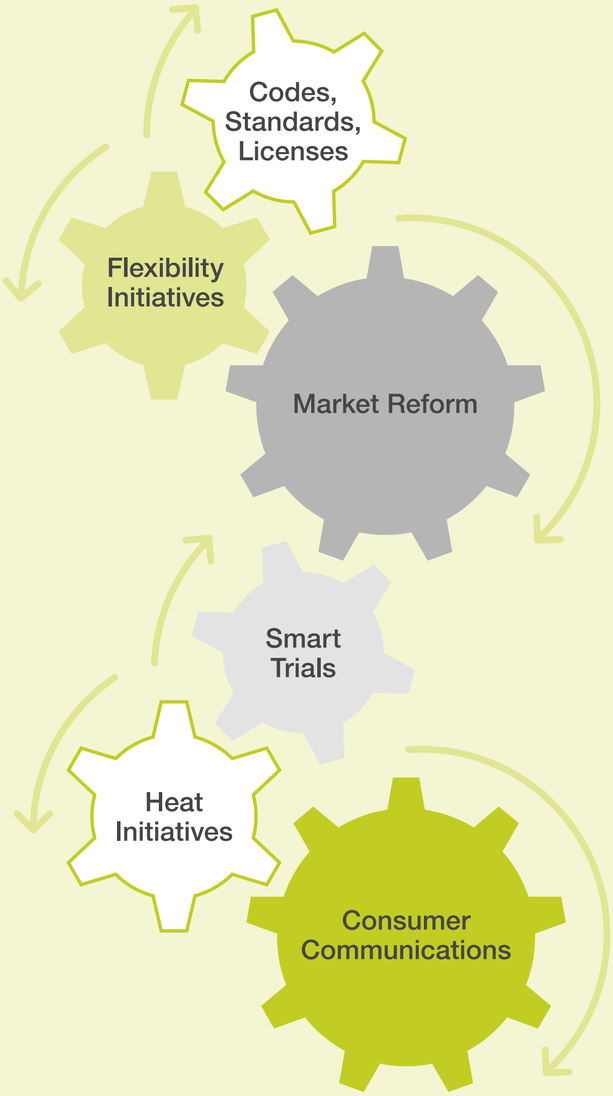
# What's already happening?

## Market Reform

- Review of Electricity Markets Arrangements
- Smart and fair consumer spatial analysis
- Energy Digitalisation Taskforce recommendations
- Ofgem local energy Government/ open letter on price controls

## Smart Trials

- DESNZ smart tariff comparison tool
- Right charge
- EV energy taskforce




## Heat Initiatives

- Social Housing Decarbonisation Fund
- NEAT HEAT – OVO and UKPN
- British Gas Heat pump service
- Prospering From the Energy Revolution – superhub Oxford

## Consumer Communications

- Smart meter campaign by Smart Energy GB
- Ofgem's Open letter: Reforming our rules related to domestic supplier-customer communications

# What’s already happening?

## Demand Flexibility Service – first step toward direct end-consumer engagement.

In autumn ’22, there were risks and uncertainties for the coming winter as a direct result of possible shortfalls in Europe’s gas supply. As a prudent system operator, we took steps to ensure that we were well prepared to maintain safe and secure operation of the electricity system.

The new Demand Flexibility Service is one of those steps. It allowed us to access additional flexibility when the national demand was at its highest over winter. Domestic consumers and businesses are rewarded by an approved DFS provider to reduce their electricity consumption at peak times by using less or shifting consumption to a different time of day. It has been available from November 2022 until the end of March 2023, with more than one million households and businesses signed up to participate through 30 approved providers. Some of these providers participated at our workshops alongside Energy UK and the Association for Decentralised Energy.

During the first three months, the Demand Flexibility Service participants have achieved a demand reduction of over 2 GWh. With the backdrop of the cost of living crisis, mainstream media coverage of the Demand Flexibility Service has created consumer awareness and engagement in consumer demand flexibility, and we have seen an increased interest from consumers in participating. This supports one of the key messages from this year’s Bridging the Gap that a broader campaign to empower households to contribute to Net Zero is vital and will have impact.

We recognise that in this initial service, consumer participation has been typically driven by manual action and a change in behaviour to adjust their electricity demand. In future, a flexible energy system will require greater automation. However, the Demand Flexibility Service has provided an opportunity to engage consumers and accelerate the transition to a smart, flexible energy system this winter through a nationwide demonstration of a demand reduction service.

# What are the barriers?

At the workshops we gave our stakeholders the chance to say what they felt some of the biggest, most difficult barriers to making progress were. There were many noted, but after some analysis there were some key themes which came out of the discussions.

**Awareness**

Lack of awareness from consumers and lack of clear narrative about Net Zero and what we expect from consumers.

**Cost of retrofit**

Homes are still energy inefficient and retrofits and new appliances are expensive. Householders may also perceive taking action as intrusive and additional hassle.

**Markets**

Energy market design currently doesn't provide the right signals to develop smart tariffs and a value proposition for consumers.

**Low Consumer Engagement**

Lack of a clear plan about how to get from here to 2035.

**Clarity**

Lack of data and understanding about consumers, their motivations and ability to provide flexibility.

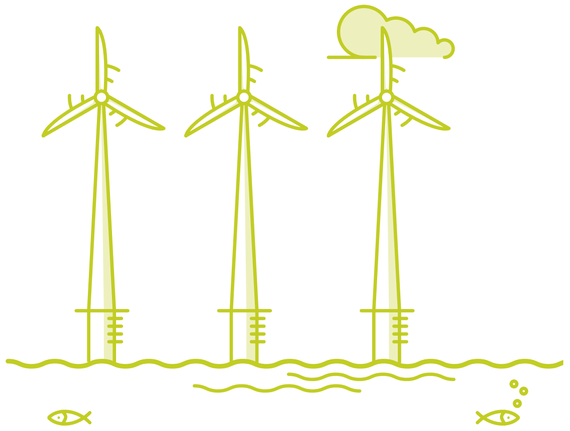
**Understanding**

Lack of trust of energy suppliers and big business, particularly with regard to use of individuals' data.

**Trust**

# Overview of barriers and milestones

To realise our vision for 2035, there are barriers to address now and milestones to achieve along the way. The three key barriers shown here were the ones our stakeholders agreed were the most important to address now.



**Key barriers**

**2025 Milestones**

**2030 Milestones**

**2035 VISION**

## Key barriers

**Lack of awareness:**
How to ensure the public is informed?

**Lack of right incentives:**
How to incentivise different consumers to maximise flexibility?

**Lack of a clear plan about how we get from here to 2035:**
How do we achieve our consumer engagement vision?

Existing milestones  Aspirational milestones

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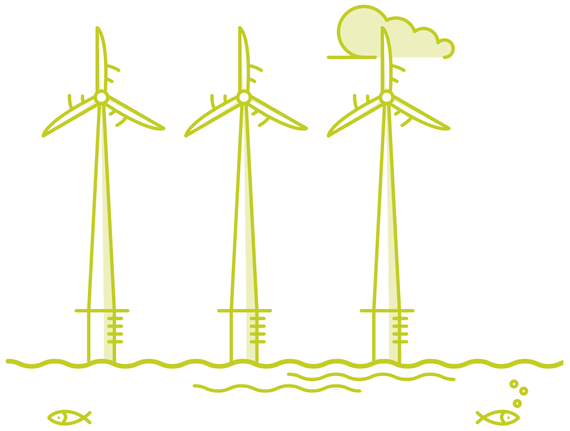

**Key barriers**

**2025 Milestones**

**2030 Milestones**

**2035 VISION**

## 2025 Milestones

| | | |
|---|---|---|
| Half-hourly settlement and smart meters have been rolled out across the country | Advisory service for all things energy set up | Market signals are available for energy suppliers and service providers |
| Affordable, smart by default appliances are available | Clarity of roles and responsibilities | Annual coordinated energy awareness campaign |
| Successful wide scale trials with a range of different consumers | Renewable electricity policy costs have been removed from electricity bills | Building regulations are Net Zero compliant and enforced |

Existing milestones  Aspirational milestones

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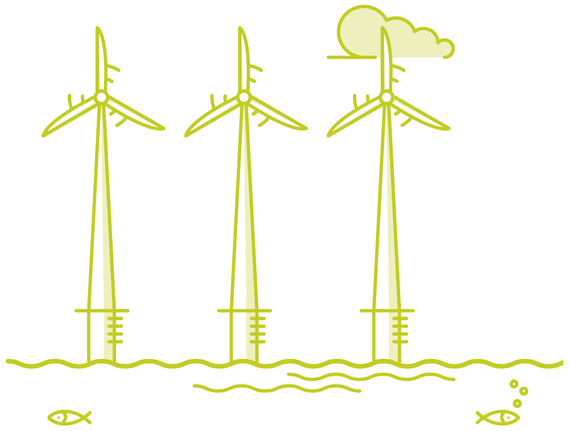

**Key barriers**

**2025 Milestones**

**2030 Milestones**

**2035 VISION**

## 2030 Milestones

| | | |
|---|---|---|
| Minimum energy standards for all homes (EPC C or equivalent) | Sales of new petrol and diesel cars to end in the UK | Local area energy plans are an established part of local network planning process |
| Energy markets are aligned to enable and give value to flexibility | Smart tariffs are available to all, based on type of use, not time of use | The enabling infrastructure for domestic flexibility is in place, including an internet of buildings |

Existing milestones  Aspirational milestones

# Overview of barriers and milestones

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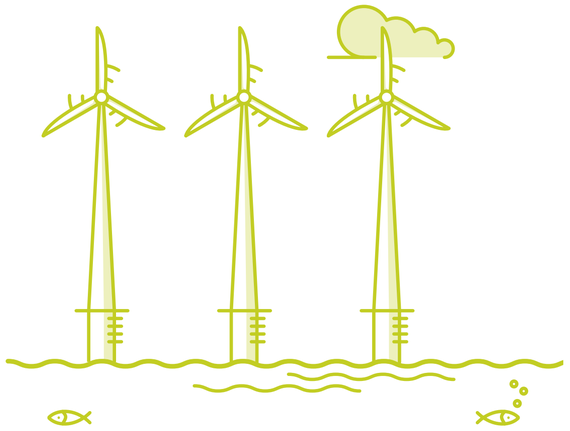


**Key barriers**

**2025 Milestones**

**2030 Milestones**

**2035 VISION**

## 2035 VISION

Domestic end-consumers understand more about Net Zero and know there is a benefit to them, directly and indirectly, from flexing their energy use.

Those end-consumers, who participate directly in flexibility, can do so with minimum effort, via smart meters and technology combined with a range of smart tariffs and services available to them.

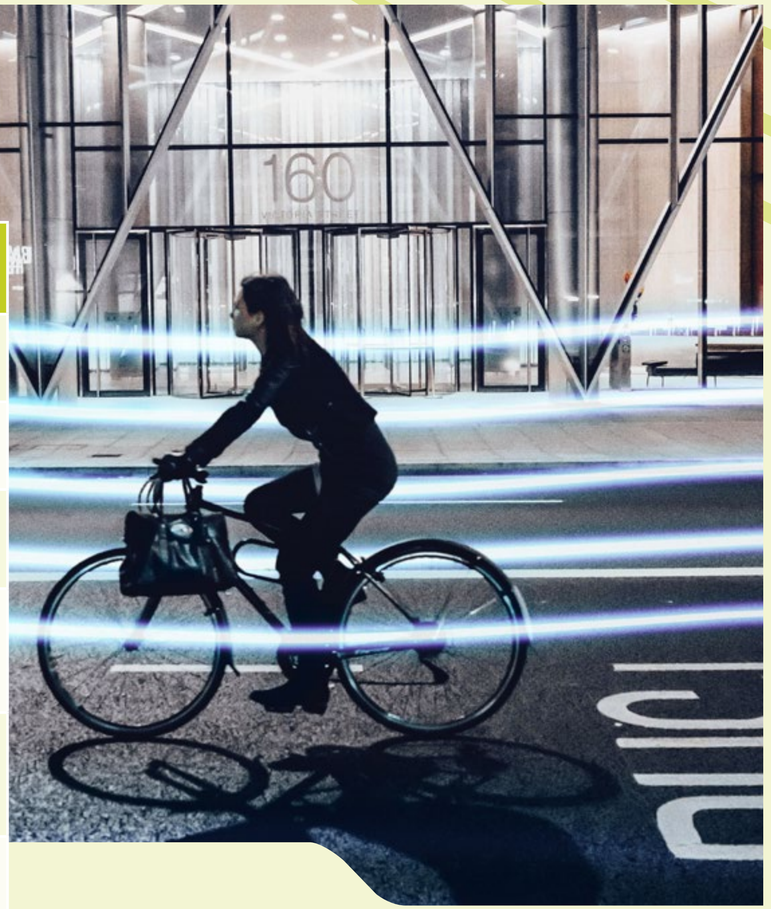
They are confident that their data is safe and know their consumer rights are protected. They have an independent source of advice for support should anything go wrong.

They know that they are doing the right thing to keep the lights on, keep carbon emissions down and keep costs down for everyone.

# Summary of recommended actions

**Three different groups discussed what actions are needed to address each of the key barriers (see Appendix 1 for the details). From these discussions, the key recommended actions, with suggested owners, can be consolidated as shown here.**

| Recommended action | Proposed owner | Barrier 1: Awareness | Barrier 2: Incentives | Barrier 3: Plan |
|---|---|---|---|---|
| Establish a campaign body for consumer awareness of Net Zero and Energy | **DESNZ** | ✓ | | |
| Run regular, consistent, campaigns about Net Zero and Energy | **DESNZ/ Campaign body** | ✓ | ✓ | ✓ |
| Ensure every household has access to a national, independent advice service that offers action-orientated and tailored advice | **DESNZ/Advice services** | ✓ | | |
| Improve market signals for flexibility to enable suppliers, energy service providers and innovators to develop a compelling customer value proposition | **ESO/ Suppliers/ Aggregators/ others** | | ✓ | |
| Understand consumers better through archetypes, demand data, ability to flex | **ESO/ Suppliers/ Energy advice sector** | | ✓ | |
| Joined up strategy for consumer engagement across Government, regulator, local authorities, industry, ESO/FSO and consumer groups | **DESNZ** | ✓ | ✓ | ✓ |



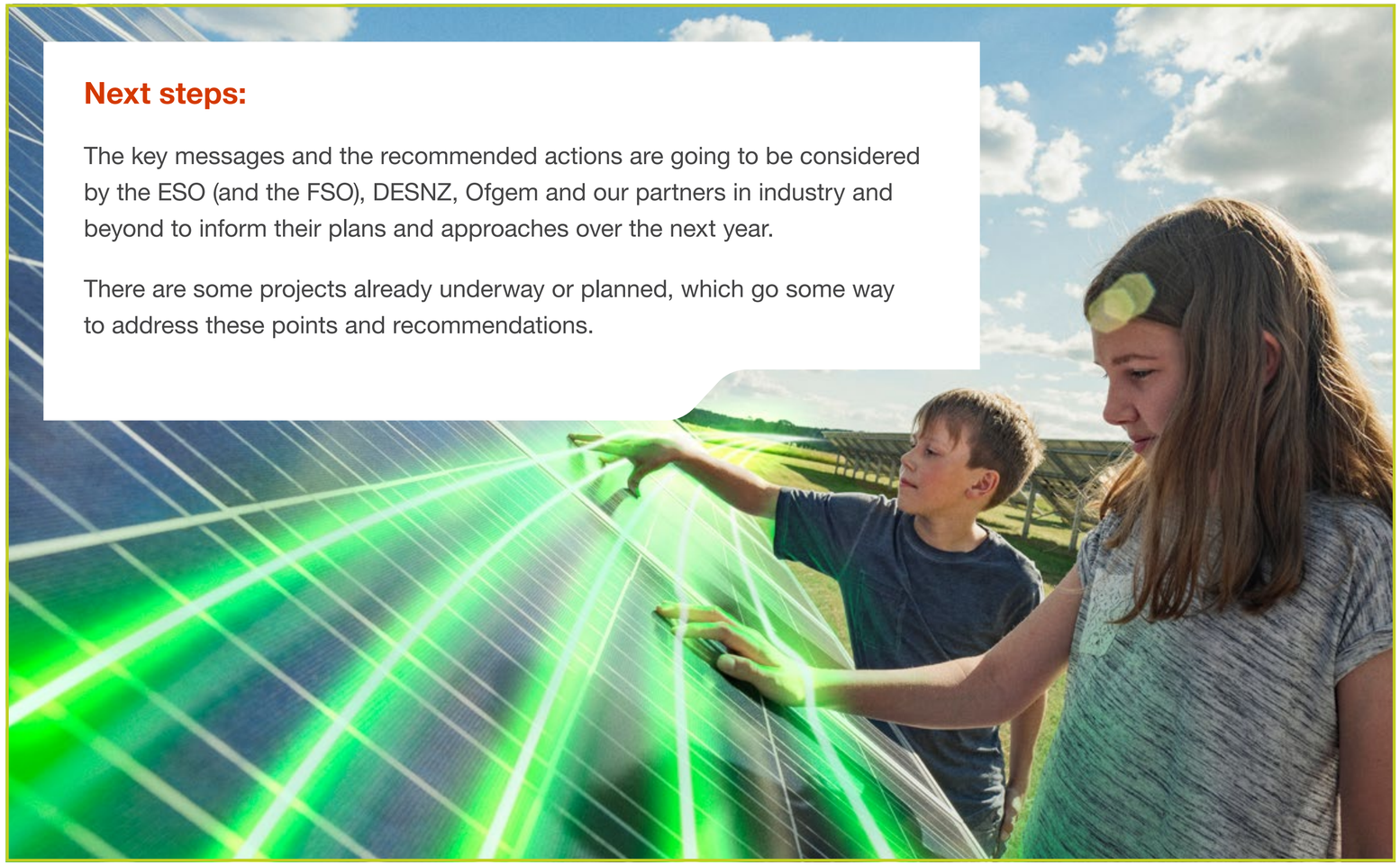
# Key message and next steps

**From the discussions with our stakeholders and the list of recommended actions, we can summarise the main areas of consensus in the following key messages:**

1 A better understanding of different consumers, their motivations and ability to provide flexibility is needed, so that the energy transition benefits everyone.

2 Develop new tariffs and products to benefit all end-consumers, so that they can be part of the solution for operating a decarbonised electricity system. New market structures are needed to facilitate this and incentivise behavioural change.

3 An effective information campaign about how households can contribute to Net Zero is needed, with consistent messaging about energy flexibility alongside energy efficiency. This should be supported by consistent, joined-up advice services across Great Britain offering action-orientated, tailored guidance.



## Next steps:

The key messages and the recommended actions are going to be considered by the ESO (and the FSO), DESNZ, Ofgem and our partners in industry and beyond to inform their plans and approaches over the next year.

There are some projects already underway or planned, which go some way to address these points and recommendations.

# Key message and next steps

1 **Consumer Archetypes:** We are working alongside the Centre for Sustainable Energy (CSE) and Element Energy to develop a set of industry standard consumer archetypes that can be used to model different types of consumers across the network and how they may behave with respect to Net Zero and their energy consumption in the coming years. This set of archetypes will cover both gas and electricity and is intended to benefit the further development of our future energy scenarios across the whole energy system; transmission and distribution. They will also be shared for all industry to use to help create a coherent approach to the energy transition.

**Service Provider Mapping Capability:** A project aiming to enhance the ESO's understanding of the technical capabilities and commercial decision-making (investment and operation) of existing and future flexibility providers across all voltage levels. This greater understanding will enable ESO to reform markets in ways that unlock the potential of future flex providers, enabling them to maximise their value to the whole electricity system.

**Next phase of Crowdflex:** This innovation project started prior to DFS and trialled the impact of price signals on domestic customer behaviour. Following completion of the initial phase, the ESO will lead the application for the next phase in March 2023. If successful, this will start in July 2023 with the aim to be carrying out large-scale domestic trials assessing demand turn up, turn down and automated response in Autumn/Winter 2023.

**Flexibility roadmap:** The ESO is looking at the requirements case for flexibility across the system and this will form the basis of a plan outlining what flexibility is needed when and where.

**Barriers to participating in Energy Flexibility:** Citizens Advice is conducting research exploring people's barriers to participating in energy flexibility services. In the first strand, they will be hearing from people with barriers to using the technology often required for such services and expect to publish findings in Spring 2023. In the second strand, they will hear from people with barriers to changing their energy usage behaviours away from peak times. Citizens Advice expect to publish findings from this in Summer 2023.

# Key message and next steps

2 **Building on Demand Flexibility Service:** After this winter is over, we will draw on research already underway to evaluate consumer experiences to the Demand Flexibility Service. This will help us gain a better understanding of different consumers, motivations and their ability to provide flexibility. DESNZ, Ofgem and Citizens Advice have contributed to the scoping of this work, and the findings will be published in the summer. The ESO is also engaging with stakeholders to review service options beyond winter 2022/2023. Longer term, we expect developments in the wholesale and retail markets will unlock the potential of demand side flexibility.

**Energy markets reform:** In our ongoing Net Zero Market Reform programme, feeding into DESNZ' Review of Electricity Market Arrangements, we are looking at how markets need to evolve to provide stronger incentives for flexibility across all end consumers, including domestic customers.

DESNZ is also working on energy retail market reform as Government is committed to reforming the energy retail market so that it works betters for consumers, is resilient and investable, and supports wider energy system transformation.

3 **DESNZ' Help for Households:** This initiative is a start to raise awareness across the country about energy efficiency and could be expanded to cover Net Zero themes as well.

**The Smart Energy campaign** to inform customers about smart meters is an example of what an awareness campaign could look like and potentially provides a basis from which to grow.

# Hydrogen

ESO

# What's the challenge?

**Hydrogen does not currently play a big part in the UK's energy mix, however hydrogen is a significant feature in all the FES Net Zero scenarios. Within these scenarios the role, volume, location and type of hydrogen needed varies greatly. This range reflects the ongoing debate around how hydrogen is most likely to support a Net Zero future. However, in all our Net Zero scenarios, hydrogen plays a role in helping to balance electricity supply and demand.**

For the purposes of this project, we are focussing on stakeholders' views of what action is required to develop green hydrogen as a tool to help balance a fully decarbonised electricity system. This role for hydrogen is common across the FES and outlines a clear need on which to build a proposed set of actions.

Green hydrogen has the potential to play a role in balancing the electricity system by providing flexibility. It can do this in three ways.

- First, electrolysers could act as a flexible source of demand by making use of excess renewable electricity as an alternative to constraining generation.
- Secondly, the hydrogen produced by electrolysis can then be stored for use when needed, including over long durations.
- Thirdly, hydrogen can be used for power generation at times of peak demand, replicating the flexible electricity generation we currently get from gas power stations.

Green hydrogen production also has the potential, if correctly located, to reduce network constraints, which arise because of the amount of electricity needing to be transported around the country from where it's generated to where it's consumed. These constraints, and the associated costs, are forecast to increase until the requisite network infrastructure is in place.

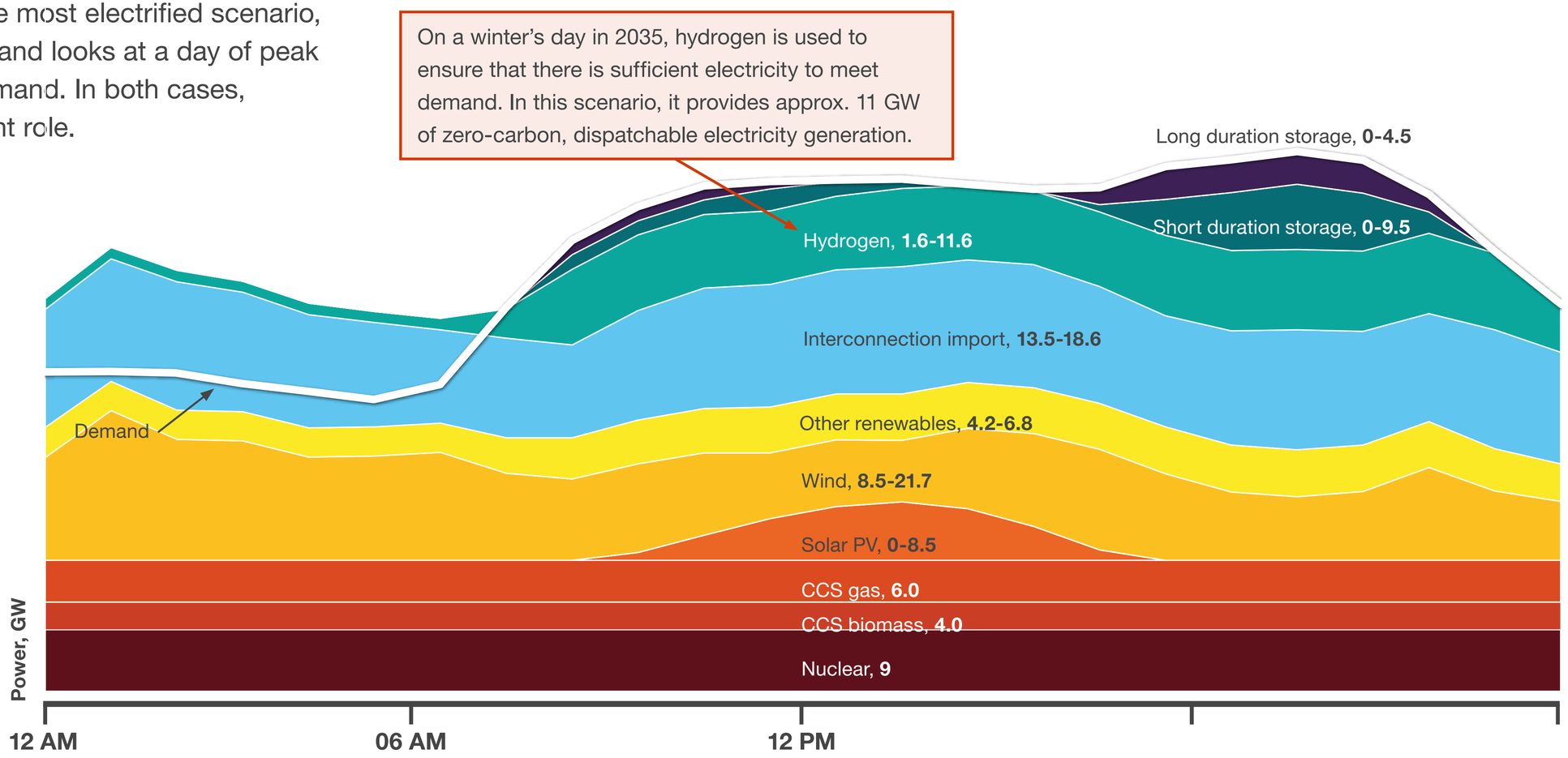
### Green Hydrogen

Hydrogen produced by electrolysis utilising renewable energy.

# What's the challenge?

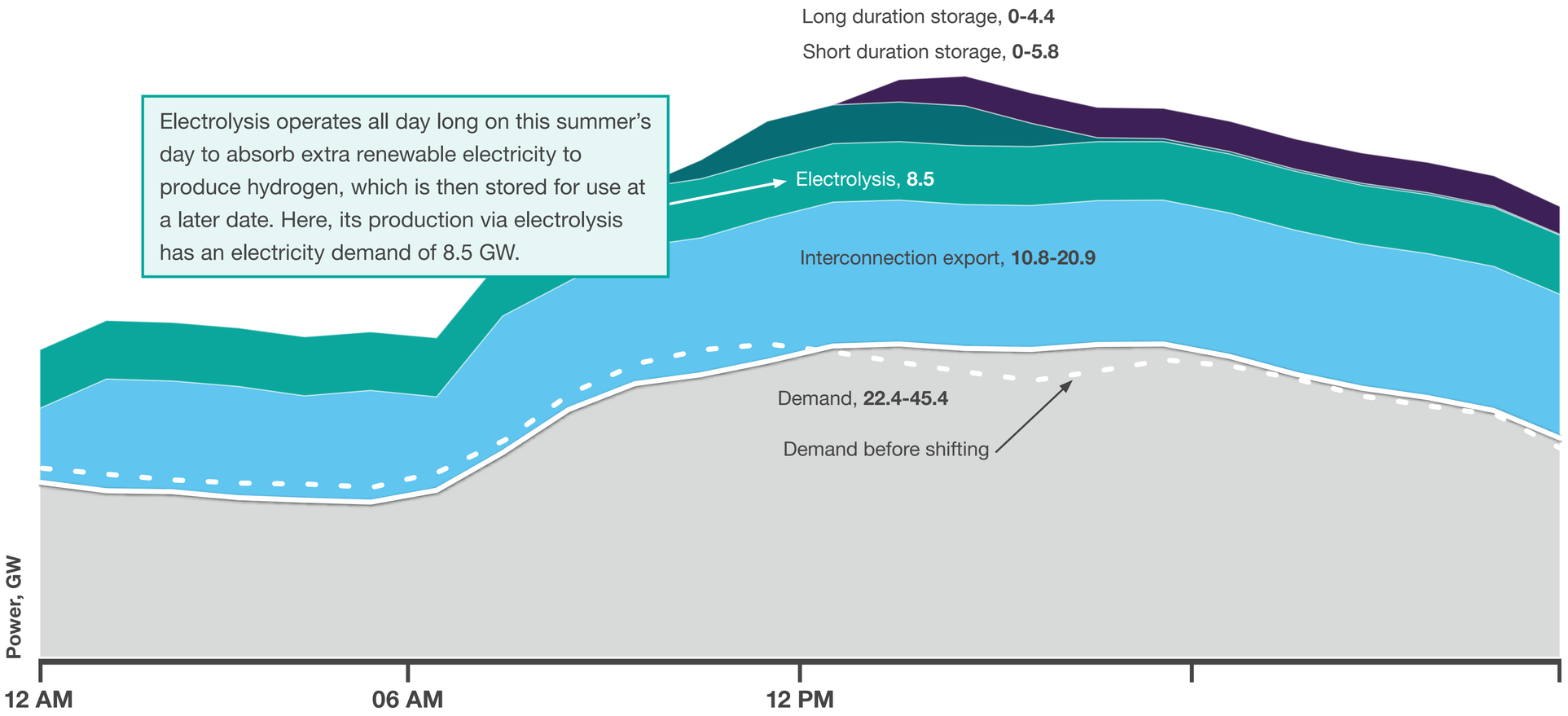
How hydrogen could help is illustrated here, with images taken from our Day in the Life of 2035 project. This work was based on the most electrified scenario, Consumer Transformation, and looks at a day of peak supply and day of peak demand. In both cases, hydrogen plays an important role.

## Winter's day in 2035: Electricity supply



# What’s the challenge?

## Summer’s day in 2035: Electricity demand



# What’s the challenge?

## This much we know

**There are still some very big decisions relating to hydrogen, which are yet to be made (namely around heating for homes). However, there is some certainty, which we used as a starting point for our discussions.**

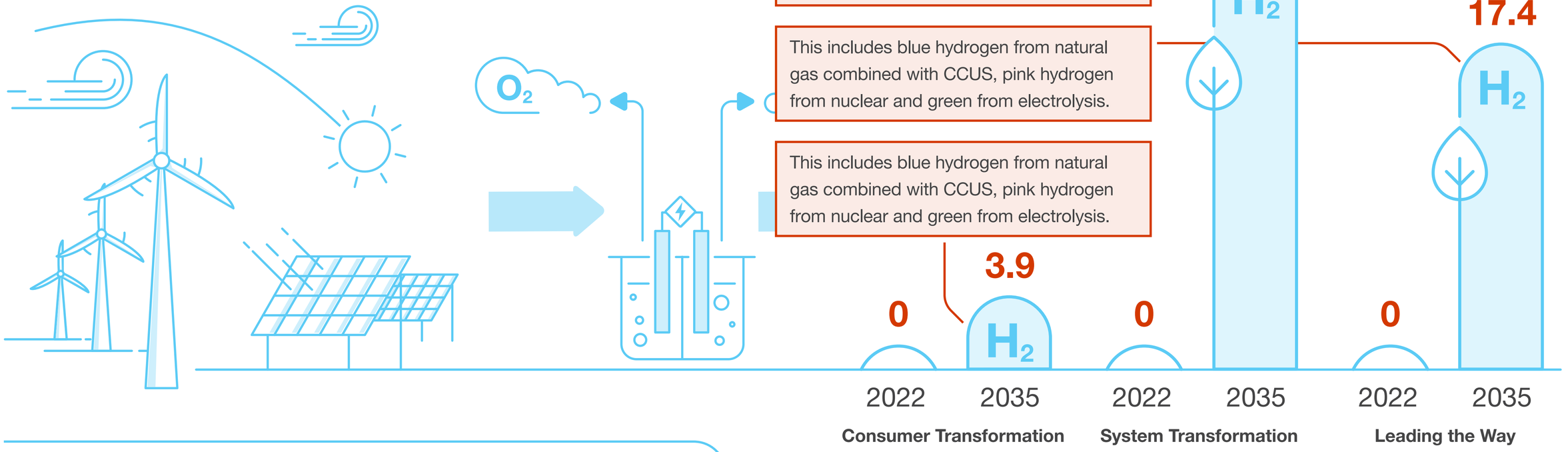
We know there is sometimes more renewable electricity generation than demand and this will happen more and more frequently in future as our renewable generation increases. We also know that we can use electrolysis to make hydrogen, which can be stored until needed. Distributed electrolysers can also help with electricity system constraints and reduce the need for new electricity infrastructure. Further, we know that hydrogen will be needed to decarbonise some industrial activities.

These are all certainties and this was an area of clear consensus across all stakeholders when discussed at the workshop. This certainty means that investment in hydrogen infrastructure to meet this need should not be delayed. This is reflected in the recommended actions at the end of this section.

# What's the challenge?

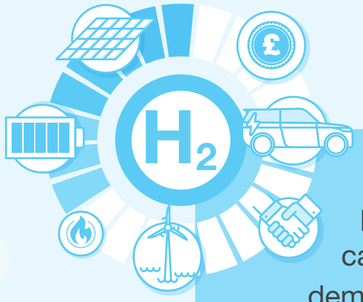
The graphic here shows the range for all hydrogen production in FES 22. It shows clearly the level of investment and change required between now and 2035 in hydrogen production capacity. The big range of production capacity between the scenarios is because System Transformation and Leading the Way assume hydrogen will be used for heating at scale, whilst Consumer Transformation doesn't. Both use hydrogen, however, to help balance the network.

## Total hydrogen production capacity (GW) 2035



# How could hydrogen help with flexibility in 2035?

**Our stakeholders agreed a view of what they thought good looked like for 2035 as an aspirational vision for how hydrogen could help with operating a fully decarbonised electricity system.**




Green hydrogen provides a low carbon source of demand and supply flexibility to the energy system through its production, storage, transportation and generation infrastructure.

Businesses in each part of the green hydrogen supply chain have access to energy markets and commercial arrangements that allow for predictable revenue streams, which in turn support investment and delivery of longer-term consumer benefit.

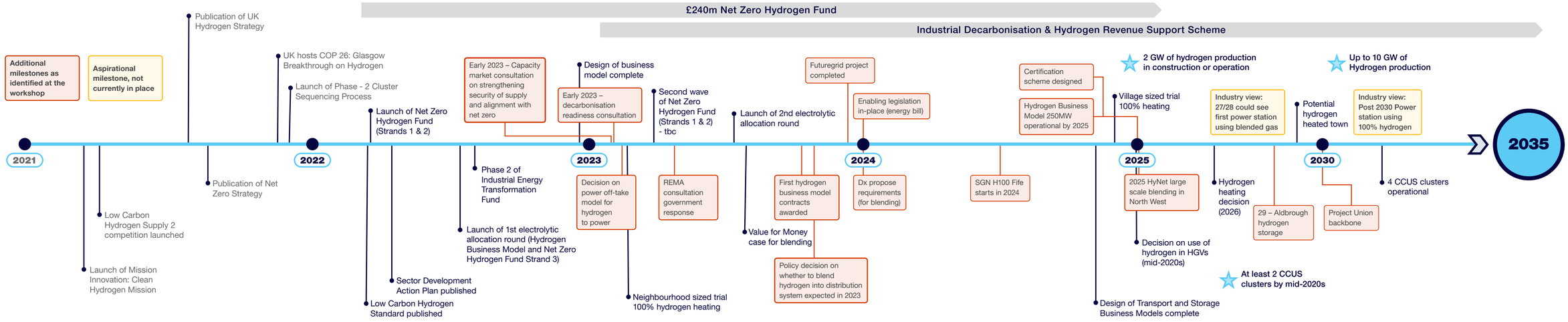
Both the equipment supply chain and connections process are set up to facilitate investment.



Green hydrogen is established as part of a whole energy system planning and regulatory process, which ensures a coherent approach to delivering Net Zero.

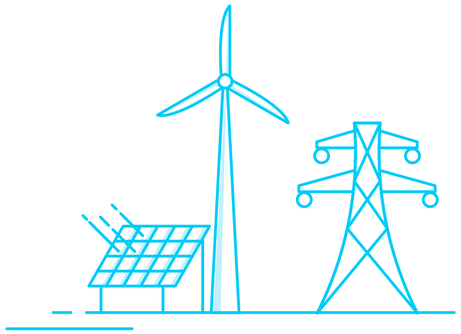
# Milestones along the way to 2035

We presented our stakeholders with the Government's hydrogen investors' roadmap as a starting point, published in April 22. We used this as a basis to ask them what they think needs to happen, in an ideal world, to make sure that the hydrogen infrastructure needed for our desired levels of flexibility is actually built. The image here is an annotated version of the timeline, with the additional, aspirational milestones highlighted.



# What are the barriers?

We asked our stakeholders which they thought were the biggest, most difficult barriers to making progress, meeting the milestones and achieving the vision. There were many noted, but a consensus on the key themes was developed.



**Infrastructure**

Decisions and investments are being delayed due to infrastructure not yet being ready. For example, storage of hydrogen is seen as a critical component and it is unclear how much is required, where it should be located and how it should be regulated.

**Planning**

There is no visibility of how much flexibility is required or which locations are optimal for green hydrogen production. Given the length of planning cycles, this ambiguity hampers investment.

**Connections**

The timescales are longer than necessary for connections to the electricity and gas systems, incurring additional expense.

**No Hydrogen for Flexibility**

Lack of certainty about markets and financial incentives makes hydrogen business models unclear.

**Markets**

The supply chain for the equipment needed for hydrogen development needs to be scaled up. The UK will be competing globally against markets that have already made clearer commitments and decisions on hydrogen.

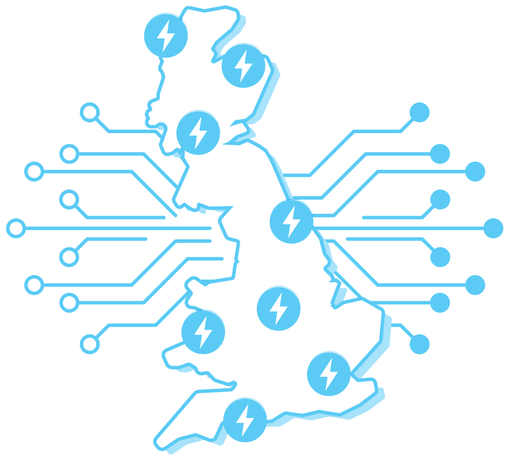
**Supply Chain**

This relates not only to the question of hydrogen for heating but also to the slow pace of decision making relative to ambitions for key topics such as blending, standards and regulations relating to all aspects of the hydrogen supply chain.

**Clarity on hydrogen**

# Overview of barriers and milestones

To realise our vision for 2035, there are barriers to address now and milestones to achieve along the way. The three barriers here on the right were agreed as the most important to address now.



Key barriers

2025 Milestones

2030 Milestones

2035 VISION

## Key barriers

A lack of plan, coordination or collaboration

Infrastructure needed for introduction of hydrogen not in place

Commercial uncertainty (for creating demand and for creating supply)

Existing milestones

Aspirational milestones

# Overview of barriers and milestones

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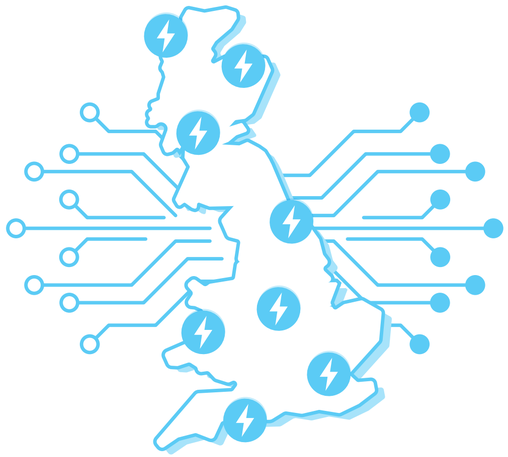


**Key barriers**

**2025 Milestones**

**2030 Milestones**

**2035 VISION**

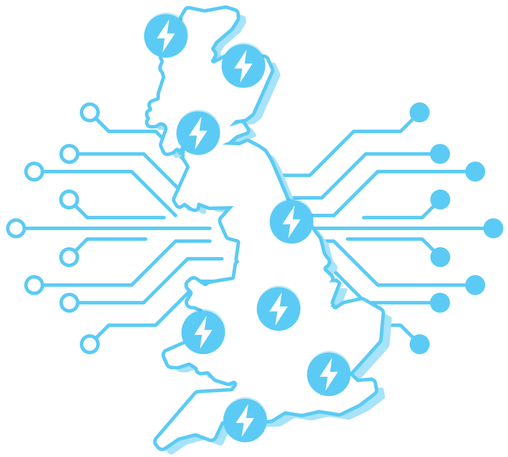
## By 2025 Milestones

- Up to 2 GW of hydrogen production in construction or operation
- FutureGrid project completed
- REMA consultation Government response
- At least 2 Carbon Capture Utilisation and Storage clusters by mid-2020s
- First hydrogen business model contracts awarded
- Neighbourhood sized trial 100% hydrogen heating
- HyNet project complete- large scale blending in North West
- Decision on blending hydrogen into distribution system

Existing milestones  Aspirational milestones

# Overview of barriers and milestones

To realise our vision for 2035, there are barriers to address now and milestones to achieve along the way. The three barriers here on the right were agreed as the most important to address now.



**Key barriers**

**2025 Milestones**

**2030 Milestones**

**2035 VISION**

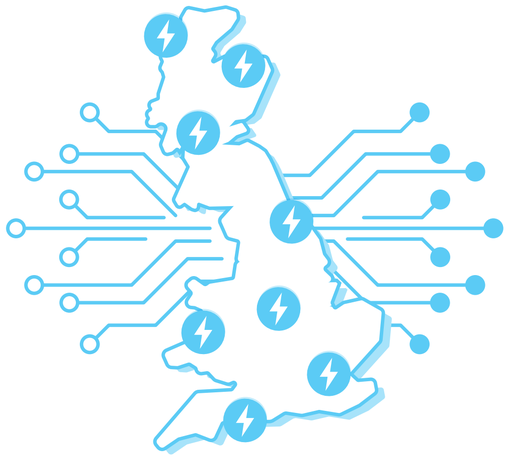
## By 2030 Milestones

- Up to 10 GW of hydrogen production
- Project Union hydrogen backbone
- Hydrogen heating decision (2026)
- Potential hydrogen heated town
- Before 2030- first power station using hydrogen and natural gas blends
- Power station using 100% hydrogen
- Aldeburgh hydrogen storage

Existing milestones  Aspirational milestones

# Overview of barriers and milestones

To realise our vision for 2035, there are barriers to address now and milestones to achieve along the way. The three barriers here on the right were agreed as the most important to address now.



**Key barriers**

**2025 Milestones**

**2030 Milestones**

**2035 VISION**

## 2035 VISION

Green hydrogen provides a low carbon source of demand and supply flexibility to the energy system through its production, storage, transportation and generation infrastructure.

Businesses in each part of the green hydrogen supply chain have access to energy markets and commercial arrangements that allow for predictable revenue streams, which in turn support investment and delivery of longer-term consumer benefit.

Both the equipment supply chain and connections process are set up to facilitate investment.

Green hydrogen is established as part of a whole energy system planning and regulatory process, which ensures a coherent approach to delivering Net Zero.

# Summary of recommended actions

**Three different groups discussed what actions are needed to address each of the key barriers (see Appendix 2 for the details). From these discussions, the key recommended actions, with suggested owners, can be consolidated as shown here.**

| Recommended action | Proposed owner | Barrier 1: Coordination | Barrier 2: Infrastructure | Barrier 3: Commercial Uncertainty |
|---|---|---|---|---|
| Establish co-ordinating body for hydrogen | **DESNZ** | ✓ | | |
| Clarity about what flexibility is needed when and where | **DESNZ/ESO** | ✓ | | ✓ |
| Improve connections and the network planning process for both gas and electricity | **ESO** | | ✓ | |
| Allow hydrogen blending | **DESNZ** | | ✓ | ✓ |
| Expedite development of hydrogen storage | **DESNZ/ Ofgem** | | ✓ | ✓ |
| Create the right market signals to produce hydrogen with excess renewable electricity to help balance the system and to encourage investment in hydrogen infrastructure | **ESO/DESNZ** | | | ✓ |
| Clear, certifiable hydrogen standard to prove provenance and quality | **DESNZ/ Ofgem** | ✓ | | ✓ |
| Change to low regrets from no regrets approach | **DESNZ/ Ofgem** | | ✓ | ✓ |

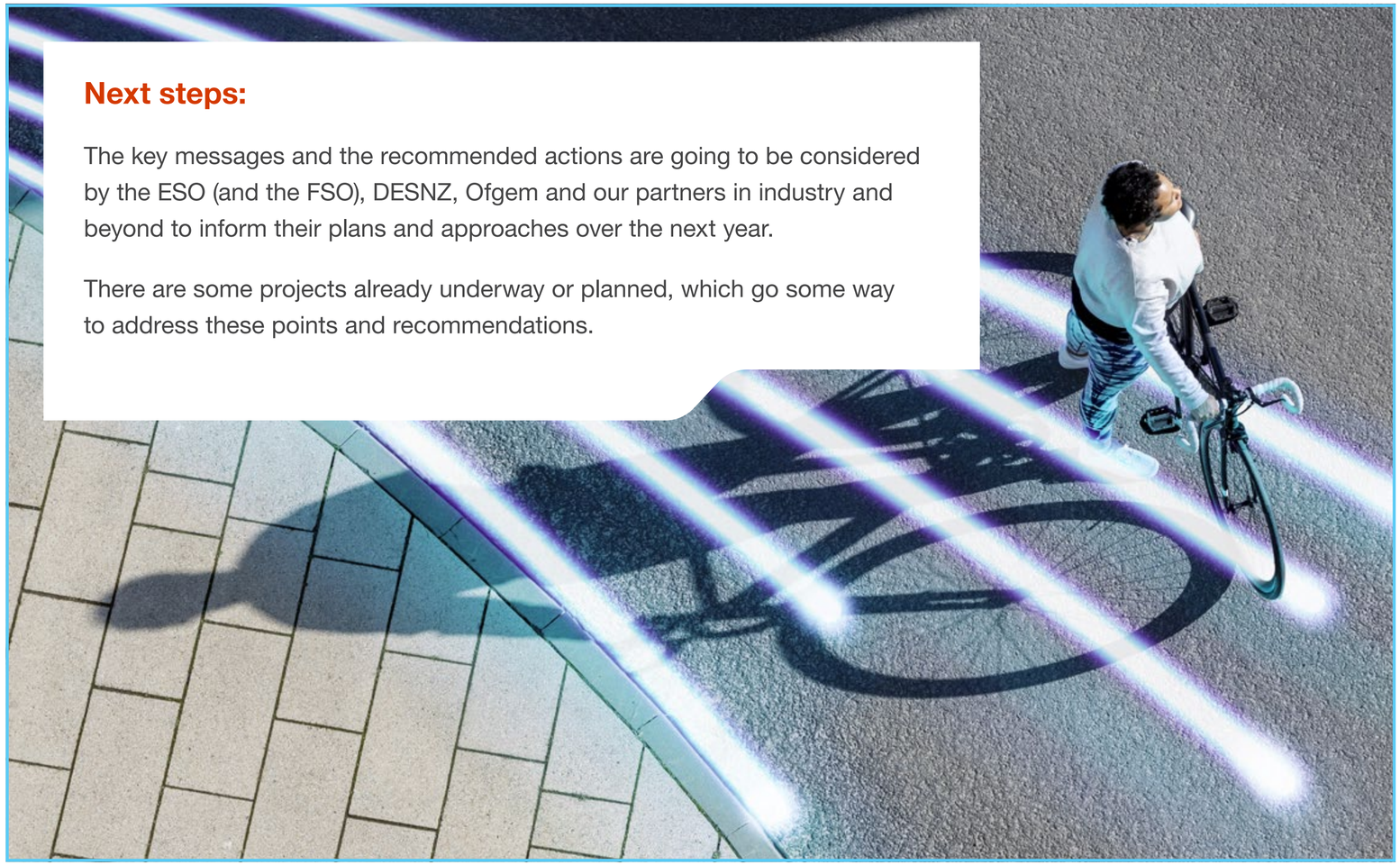
# Key messages and next steps

**From the discussions with our stakeholders and the list of recommended actions, we can summarise the main areas of consensus in the following key messages:**

1 Hydrogen has a role to play to help operate a fully decarbonised electricity system. To make this happen, we need to urgently develop the commercial frameworks and market design, which will help business models develop and infrastructure to be built.

2 Accelerate decision-making relating to the use of hydrogen and the networks needed to facilitate its production and transportation. Set strategic direction for hydrogen by establishing an independent body to make decisions and coordinate.

3 Industry needs a flexibility roadmap, outlining in more detail what is likely to be needed between now and 2035, so that they can make the necessary investment.



**Next steps:**

The key messages and the recommended actions are going to be considered by the ESO (and the FSO), DESNZ, Ofgem and our partners in industry and beyond to inform their plans and approaches over the next year.

There are some projects already underway or planned, which go some way to address these points and recommendations.

# Key messages and next steps

1 **Energy market reform:** In our ongoing Net Zero Market Reform programme, feeding into DESNZ' Review of Electricity Market Arrangements, we are looking at how markets need to evolve to provide stronger incentives for flexibility, including flexibility provided by hydrogen assets.

In the short term, we are considering how to develop cost-effective, market-based solutions to incentivise electrolysers and we would be interested to work with industry on analysing the benefits for consumers of potential models.

**Hydrogen production:** the first hydrogen production Contracts for Difference will be awarded later in 2023.

**Business model for storage:** DESNZ has committed to developing a business model for storage for 2025.

**Net Zero Hydrogen Fund:** provides CAPEX support to electrolysers

**Ofgem:** Ofgem (and other agencies) engaging closely with DESNZ on the next steps for the development of the various proposed hydrogen business models and schemes

2 **Establishing a co-ordinating body for hydrogen:** the FSO will be an independent body, which takes a whole system approach and will consider the interactions across electricity, gas and other markets such as hydrogen. We believe that the FSO will help provide the strategic direction needed for hydrogen to develop, as it will have whole systems network planning as part of its remit as well as being an advisor to Government about Net Zero.

DESNZ is also considering the role of strategic planning for hydrogen infrastructure and the recent hydrogen transportation and storage consultation included a chapter on strategic planning.

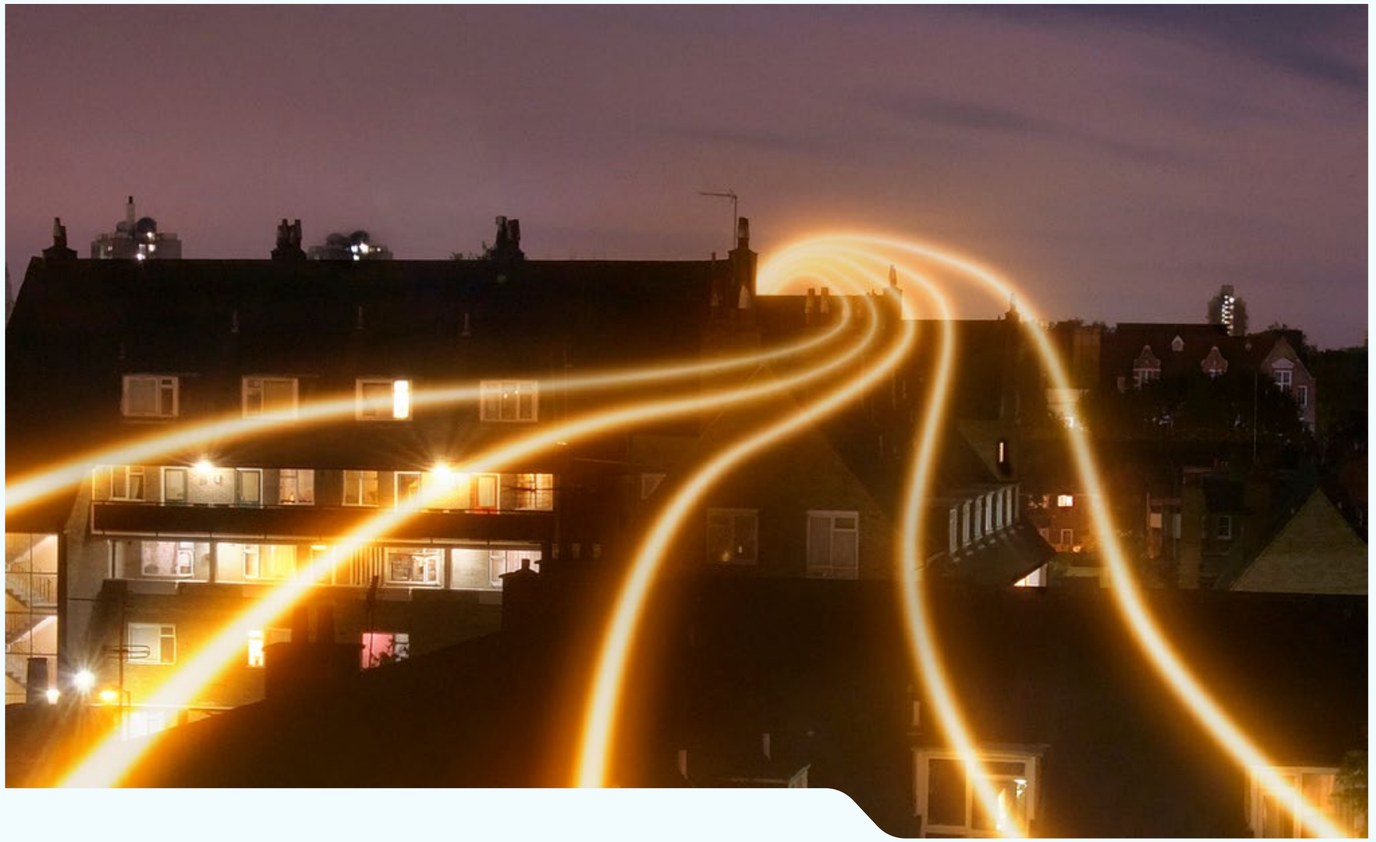
GB connections reform**:** The ESO is already aware of the challenges currently facing customers when it comes to connections and of the need to update the connections application process. As a result, we have launched the Connections Reform project to address these challenges, which should help more hydrogen-related projects to connect to the electricity network.

Project Union will connect hydrogen production, storage and demand to enable Net Zero and empower a UK hydrogen economy. Repurposing existing transmission pipelines will create a low-cost hydrogen 'backbone' for the UK by the early 2030s and connect to the proposed European Hydrogen Backbone.

# Key messages and next steps

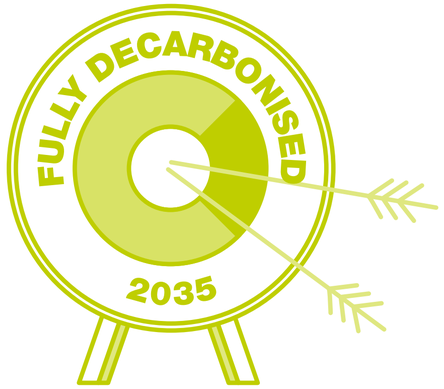
3 **Flexibility roadmap:** The ESO is looking at the requirements case for flexibility across the system and this will form the basis of a plan outlining what flexibility is needed when and where.

**Whole system network planning –** As part of Ofgem's Electricity Transmission Network Planning Review (ETNPR), the ESO has been tasked with reviewing the current network planning process and improve it to help reduce constraints. The ESO is developing the Centralised Strategic Network Plan (CSNP) which will initially look at providing an indication of the ESO's best view for where electrolysers should be located in future. In future iterations, the CSNP will take a more whole system approach by considering the electricity and gas networks to recommend a more robust and strategic network plan that can deliver a transmission system capable of meeting the net-zero hydrogen strategy.



# Appendix 1 – Consumer engagement: detailed actions

For the three key barriers identified, we asked stakeholder groups to identify actions to be taken now (shown in the tables here). As the groups were working in parallel, there is some repetition but this helped to prioritise the actions listed.




## 1. Barrier: Public Awareness: How to ensure the public is informed?

| Recommended action | Description | Timing | Proposed owner |
|---|---|---|---|
| **Campaign body** | **Establish an independent body – regulated and supported by an appropriate funding mechanism.** Take learnings from other campaign models on the design of the body as well as a long-term campaign. Draw on communications experts as well as industry participants, funded through licence obligations. | 2022-2025 | Government |
| **Campaign "process"** | **Use crisis as a trigger:** public awareness of the energy crisis provides an opportunity engage the public and share information. Message design principles: simple, consistent, tailored based on consumer types, positive. | 2022-2025 | New campaign body (see previous action) |
| **Energy "literacy"** | **Increase energy literacy:** provide information on the basics, for example FAQs, how to guides, smart meters, comparison sites, understanding bills, demand flexibility, energy efficiency, new technologies, etc. | 2022-2025 | |
| **Advice & Support** | **Advice services:** to support the awareness campaign, there needs to be consistent, joined-up national advice services across Great Britain offering impartial and tailored advice to all households about how to take action on choosing smart tariffs, energy efficiency measures, heating systems, etc. | 2022-2025 | Advice services |
| **Sponsorship & engagement** | **Use variety of means to raise awareness:** for example opinion leaders, gamification, corporate sponsorship, etc. | 2022-2025 | Campaign body |

# Appendix 1 – Consumer engagement: detailed actions

## 2. Barrier: Lack of right incentives: How to incentivise different consumers to maximise flexibility

| Recommended action | Description | Timing | Proposed owner |
|---|---|---|---|
| **Compelling Customer Value Proposition** | **Reform markets:** need to accelerate REMA process so that the right financial incentives are in place.<br><br>Suppliers, aggregators and companies to develop exciting, varied propositions that target consumers and meet their specific needs. | 2022-2025 | Government<br><br>Suppliers/Aggregators |
| **Simplicity & clarity where needed** | **Consistent, clear information** to help ease of comparison, visibility and certainty of costs. | 2022-2025 | Suppliers/Aggregators<br><br>Advice Services |
| **Consumer Segmentation** | **Develop better understanding of end-consumers:** set up consumer archetypes to drive deeper understanding of consumer "motivations"; use these archetypes across industry so that they are commonly understood. | 2022-2023 | ESO/ industry |
| **Campaign with Clear Ownership** | **Establish a centralised campaign:** Government owned campaign, which combines flexibility messaging with energy efficiency, delivered and coordinated through trusted channels; needs to be iterative to manage risks of misinformation. | 2023-2025 | Independent body |

# Appendix 1 – Consumer engagement: detailed actions

## 3. Barrier: Lack of a clear plan about how we get from here to 2035: How do we achieve our consumer engagement vision?

| Recommended action | Description | Timing | Proposed owner |
|---|---|---|---|
| **Joined up strategy for consumer engagement in Net Zero** across sectors /departments / businesses with a clear narrative /roadmap | **Overarching strategy on Net Zero engagement, including:**<br>• Operational and investment signal setting<br>• Consumer regulations<br>• Public awareness campaign | 2023 - 2025 | Government |
| | **Dynamic regulation:**<br>• Ensuring roll out of plans above with clear accountabilities<br>• Code governance & accessibility (code reform)<br>• Streamlining market entry | | Regulator |
| | **Local area energy planning includes:**<br>• Building public trust<br>• Coordination of activities (e.g. Heat zone/retrofit)<br>• Consumer advice services | | Local Authorities |
| | **Flexibility Roadmap:**<br>• For both transmission and distribution<br>• Helps to provide investment signals for infrastructure, including IT | | ESO<br>DSO |
| | **Build trust and engagement:**<br>• Between Government, local authorities, and end-consumers<br>• Ensure protections for consumers in vulnerable circumstances | | NGOs/Consumer Groups |

# **Appendix 2** – Hydrogen: detailed actions

For each barrier, a group of stakeholders was asked to recommend the key actions and owners to address the challenge. As the groups were working in parallel, there is some repetition in content but that does help to identify those actions which should be prioritised.

## 1. Lack of a plan or coordination: how to bring the industry together to make progress?

| Recommended action | Description | Timing | Proposed owner |
|---|---|---|---|
| **Establish a co-ordinating body for hydrogen** | A new body should be established to lead and accelerate decision making. It should be independent of industry and Government to make impartial and objective decisions. This could help shift mindset from “Just In Time” to strategic planning. | ASAP | DESNZ |
| **Define the problem** | Need to provide clarity about what level of flexibility we’re likely to need, including how much hydrogen is needed, when and where. | ASAP (months) | ESO/FSO |
| **Mechanism for sharing information** | This is vital to help the industry coordinate better and operate efficiently. Things to share include lessons learnt and look at other countries to scope the nature of learning that is needed. | ASAP | DESNZ/ co-ordinating body/ industry |

# Appendix 2 – Hydrogen: detailed actions

## 2. Infrastructure not ready: How to make sure that the right infrastructure is ready (e.g. storage, connections, equipment).

| Recommended action | Description | Timing | Proposed owner |
|---|---|---|---|
| **Improve connections process** | Lead times for connections are very long (years +), for assets that could otherwise be operational in a relatively short time. | ASAP | DNO's (gas and electricity)<br>TO's (gas and electricity)<br>ESO<br>OFGEM |
| **Enable movement of hydrogen** | Introduce a hybrid system that allows blending up to 20%, use learning from clusters and set up ability to export for producers of hydrogen on a regional basis. | 2023 | Parliamentary approval (DESNZ)<br>Upgrade to existing gas networks |
| **Expedite development of storage** | Need governance structures in place and necessary market signals. | 2025 | DESNZ<br>Private sector<br>System operators |

# **Appendix 2** – Hydrogen: detailed actions

## 3. Commercial uncertainty: How do we achieve certainty for both demand and supply?

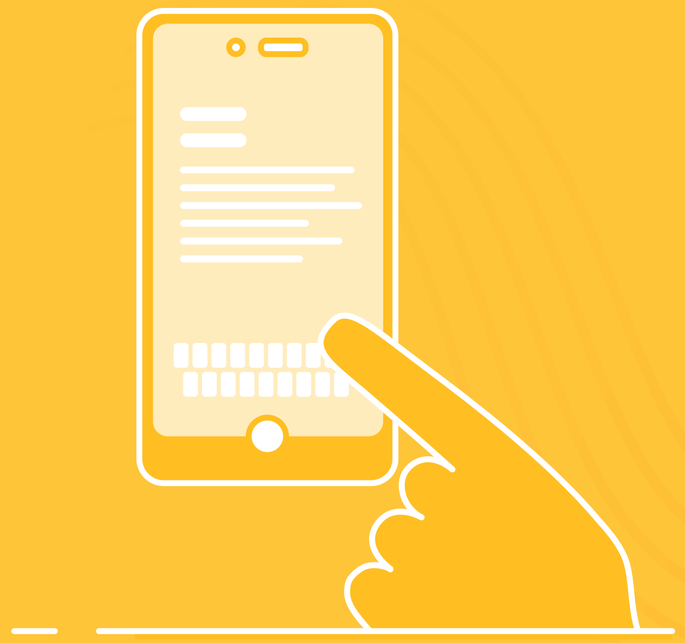
| Recommended action | Description | Timing | Proposed owner |
|---|---|---|---|
| Make a decision on **blending** into the gas grid | Blending would create a clear market for hydrogen, making it easier for investors to develop a business case. | ASAP | DESNZ |
| **Create incentives** to produce hydrogen with the excess renewable electricity | **Create the right market signals** to produce hydrogen with excess renewable electricity to help balance the system. | 2024 | DESNZ, Ofgem, ESO |
| Change to **low regrets** from no regrets approach | Increase risk appetite, as it is currently hindering and slowing the decision-making process. | ASAP | DESNZ |
| **Certifiable hydrogen standard** in industry | An internationally recognised standard for hydrogen being injected into the grid, including a revision of the low carbon hydrogen standard, to provide greater certainty of how/where hydrogen can be used. | 2025 | DESNZ/ industry |
| **Investment signals** for large scale hydrogen storage | Need signals from Government to invest in storage, then industry can respond. | 2025 | DESNZ |

# Get in touch

Email us with your views on this report or any of our future of energy documents at: box.FESbtg@nationalgrideso.com and one of our team will respond.

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



# Thank you!

**To everyone who contributed, particularly our partners at Citizens Advice, Energy Saving Trust and National Gas Transmission. The complete list of the stakeholders who have contributed to this report is below:**

Association for Decentralised Energy
BEAMA
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DESNZ
E.ON UK
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Energy Systems Catapult
Energy UK
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RWE Generation
SGN Energy Futures
Siemens Energy
Smart Energy GB
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