CATAPULT
Energy Systems

# MARKETS ADVISORY COUNCIL: WHAT DO WE MEAN BY FLEXIBILITY AND WHAT FLEX WILL THE FUTURE SYSTEM NEED?


ENERGY SYSTEMS CATAPULT TEAM

# ESC HAS A RANGE OF NET ZERO MODELLING/SIMULATION TOOLS WHICH CAN HELP ANSWER QUESTIONS ABOUT FUTURE ENERGY SYSTEM

Energy Systems

## Our Living Lab

A world leading Test Environment of 00's of connected homes

LIVING LAB

## Our Consumer Panel

A panel of 000's of consumers to test new ideas and inform product and service design

## Our Data

Access to data collected from a wide range of research and innovation projects

01010
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## Our Net Zero Nation Tools

A suite of national energy system modelling and simulation tools and methods

**Create whole system evidence**

**Inform policy and Research**

**Test system value of innovations**

## Our Net Zero Place Tools

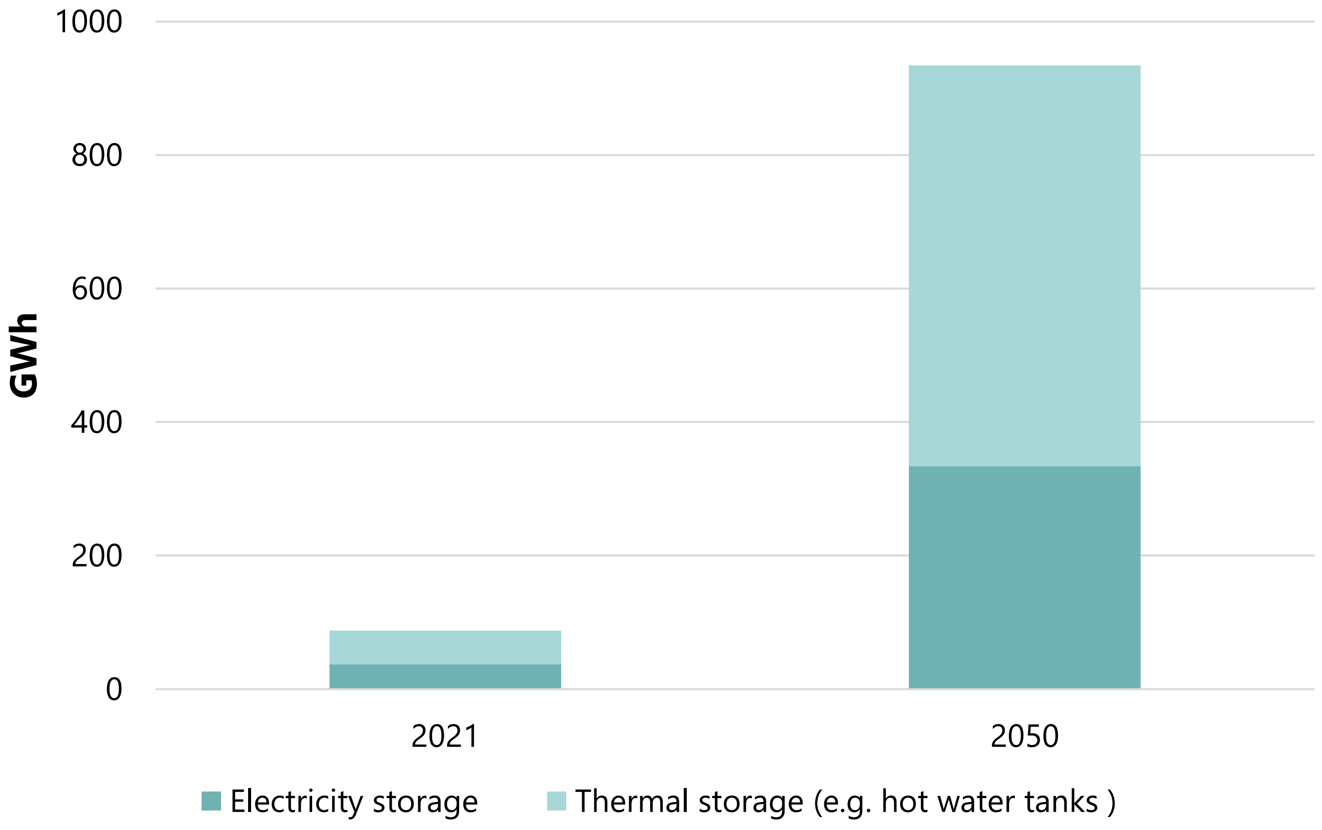
A suite of place based modelling tools, methods and guidance

*The internationally peer-reviewed Energy System Modelling Environment (ESME) is the UK's leading techno-economic whole system model – providing in-depth evidence for industry, academia, the Climate Change Committee (CCC) and the UK Government.*

ESME
Energy System Modelling Environment

- **ESME | Flex** – *Focussed on storage and flexibility*
- **ESME | Transport** – *Focussed on transport*
- **ESME | Networks** – *Focussed on infrastructure*
- **ESME | Road Freight** – *Focussed on road freight*
- **ESME | Bioenergy** – *Focussed on bioenergy*
- **ESME | Industry** – *Focussed on industry*

# THE FUTURE ENERGY SYSTEM WILL REQUIRE AN ENORMOUS INCREASE IN NON-GASEOUS STORAGE AND FLEXIBILITY




*Illustrative Results only - from ESC's ESME modeling suite*

*Note*: Non-gaseous energy storage in current system is mainly made up of electricity storage (pumped hydro storage (~26GWh) and batteries (~2GWh), and thermal storage (largely hot water tanks but in the future could include other technologies such as phase change materials.) By 2050 we expect an increase in all these technologies with additional electricity storage from **compressed air energy storage** and **liquid air energy storage.**

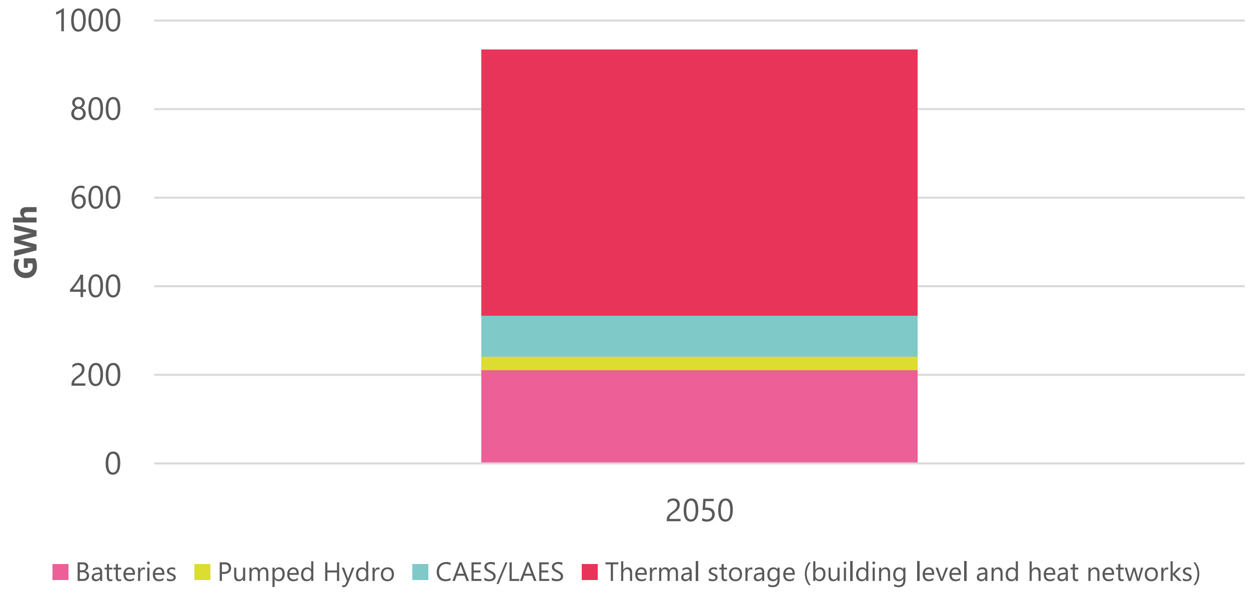
The transition from a fossil fuel-based energy system to one where the power systems is:

a. much bigger (electrification of heat, transport etc)
b. based largely on wind

This will result in a significant increase in non-gaseous energy storage (and other flexibility options such as demand side response)

Today, the vast majority of flexibility in the UK energy system is provided by gas with ~17TWh of natural gas storage (ie the gas grid) supporting providers of 'flexibility', such as gas-fired turbines and gas boilers (not shown on this chart).

# FUTURE STORAGE TECHNOLOGY MIX AND SCALE IS HUGELY UNCERTAIN, BUT IT WILL INCLUDE A RANGE OF DIFFERENT TECHNOLOGIES




*Illustrative Results only - from ESC's ESME modeling suite*

*Note*: By 2050 we expect an increase in all these technologies with additional electricity storage from **batteries** (~200GWh) **compressed air energy storage** and **liquid air energy storage** (combined at ~90GWh) **and pumped hydro storage** (~30GWh). Thermal storage through a mix of **hot water tanks** and more innovative solutions such as **phase change materials** provide a large amount of storage by 2050 (~600GWh).

A range of storage technologies will be required by 2050 to meet different system needs (see next slide). Although there is uncertainty around the future storage mix, for the scenario shown **here short duration electrical storage is provided through batteries**, and **longer duration electrical storage through pumped hydro, compressed air energy storage and liquid air energy storage.**

A significant amount of **thermal storage (hot water tanks and more innovative solutions like phase change materials)** is also needed to spread heat demand over several hours.

# MULTIPLE FLEXIBILITY SOLUTIONS OVER MULTIPLE VECTORS WILL BE NEEDED TO MEET THE NEEDS OF THE FUTURE SYSTEM

| Typical Duration | Role | Vectors | Example technologies |
|---|---|---|---|
| Up to 4 hrs | Within day balancing of renewables, peak reduction, fast demand response, reserve (managing contingency events) | Electricity | Batteries, flywheels, supercapacitors, gravitational storage |
| Up to 4 hrs | Peak shifting | Heat | Thermal storage including: sensible thermal storage (i.e. hot water tanks), phase change materials and thermochemical storage. |
| Hours/ within day | Peak shifting | Electricity/DSR | EV smart charging |
| Up to 24 hrs | Within day balancing of renewables, inter day balancing of renewables, peak reduction reserve | Electricity | Pumped hydro storage, Compressed air energy storage, Liquid air energy storage, redox flow batteries |
| Seasonal | Meeting seasonal peak demands, energy security | Gas | Hydrogen (*storage facility + H2 turbine/ fuel cell, boiler)* |

Many technologies can provide a combination of these roles but **no single solution can efficiently meet them all**. This means there is no “one-size fits all” solution to flexibility in the energy system....

# FLEXIBILITY CAN PROVIDE SIGNIFICANT SYSTEM VALUE EXAMPLE#1, DEMAND SIDE RESPONSE - INTRODUCING EV SMART CHARGING COULD REDUCE PEAK DEMAND SIGNIFICANTLY


When smart charging is introduced to the system a mix of Home charging tariffs are available, including:

- Flat Rate
- Time of Use
- Delegated Control

**Introduction of smart charging sees a 7% decrease in whole system peak demand in 2035.**

*Results from ESC's ESME Transport analytical framework.*

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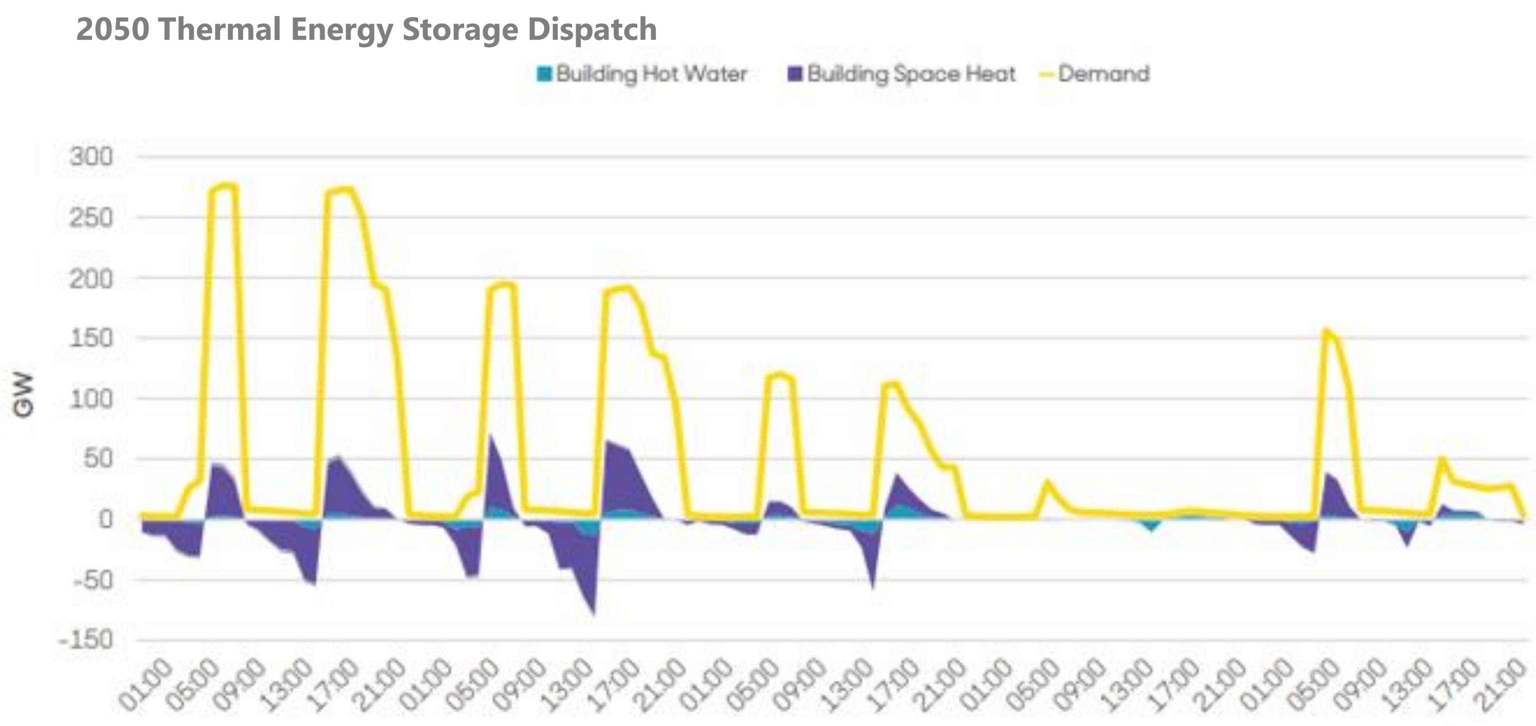
# FLEXIBILITY CAN PROVIDE SIGNIFICANT SYSTEM VALUE
# EXAMPLE#2, DEMAND SIDE RESPONSE – SMART HEATING

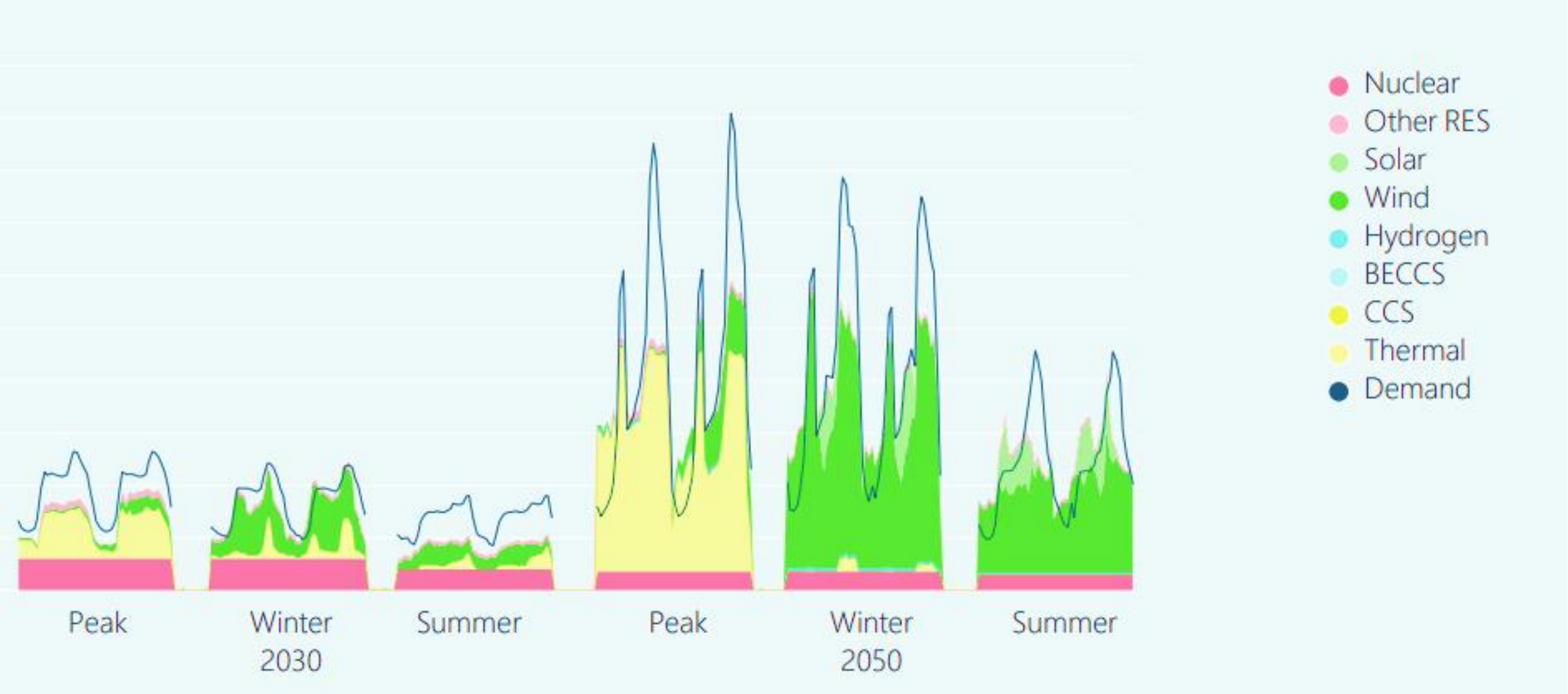



By 2050, modelling suggests thermal storage is used extensively when demand is high, and charged when demand is much lower.

This helps to reduce generation capacity needed to meet total system demand.

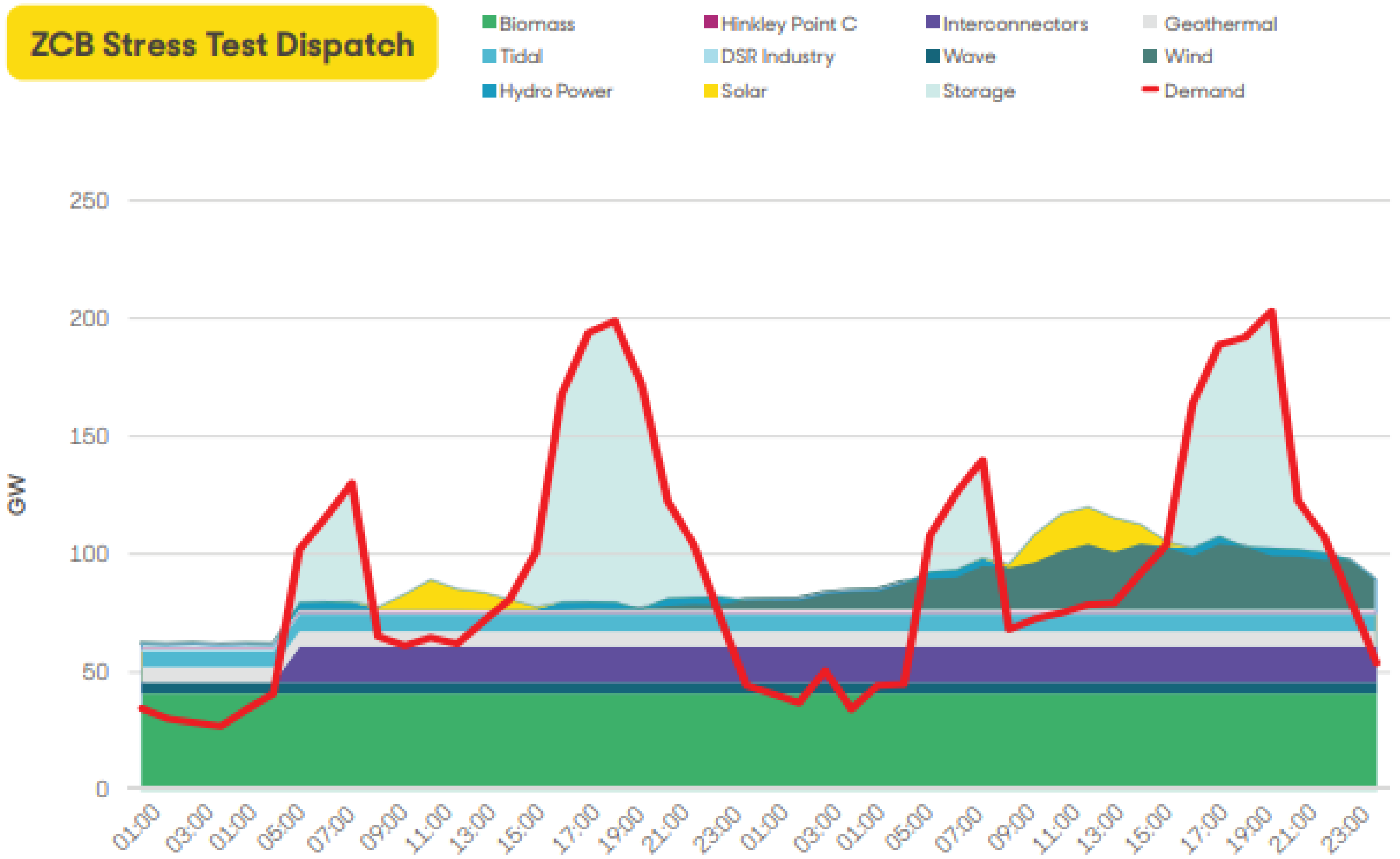
*Illustrative Results only - from ESC's ESME Flex modelling, published in: Good Energy, Renewable Nation report*

# THE TOUGHEST CHALLENGE TO SOLVE FOR IN THE FUTURE SYSTEM IS SUSTAINED LOW-WIND PERIODS…




*Illustrative Results only - from ESC's ESME Flex modelling*, published in: *https://es.catapult.org.uk/report/solving-the-offshore-wind-integration-challenge/*

# … EVEN OUR MOST PRO-RENEWABLES SCENARIOS UNDERLINE THE NEED FOR DISPATCHABLE 'FIRM' TECHNOLOGIES




The stress test case represents a period in 2050 of very low wind and solar combined with high demand (e.g. a cold, windless series of days).

Here, even with a range of other renewable technologies (biomass, wave, tidal, hydropower and geothermal), **significant additional dispatchable generation, in this case storage, is needed to meet peak demands**

*Illustrative Results only - from ESC's ESME Flex modelling, published in: Good Energy, Renewable Nation report*

# HOW DO WE DESIGN A FUTURE MARKET THAT INCENTIVISES THAT WIND RANGE OF FLEX? CURRENT ARRANGEMENTS WON'T DELIVER THE RANGE OF FLEXIBILITY WE NEED

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**Barriers to flexibility under the current market arrangements…**

- Lack of sufficiently granular time / location-based operational signals to incentivise flex operation of assets
- Limited investment signals / limited signals for flexible assets to hold back energy for periods of system stress (e.g. long duration storage)
- Demand customers "locked-out" of flexibility opportunities (settlement periods; policy costs; limited retail propositions; barriers to small-scale access to flexibility services)

**… we need an ambitious package of reform and modernisation of the electricity system, ESC analysis suggests:**

1. **Planning reform** and strategic network planning are top priorities to unlock necessary grid investments
2. **Locational pricing** to better reflect the realities of the physical infrastructure and enhance opportunities for cheaper (flexibility) solutions
3. **Outcome based investment drivers** (e.g. a Clean Electricity Standard on suppliers) to create a level playing field and reduce policy distortion
4. **Retail market reform** to ensure consumers have access to flexibility opportunities and are protected from harm
5. **Digitalisation** to optimise millions of flexibility assets across the system
6. **Operability / ancillary service reform** to enhance ability of non-traditional assets to contribute.

BEIS' REMA consultation concludes: "Current arrangements will not deliver a fully decarbonised power system by 2035… the Capacity Mechanism is unlikely to bring forward low carbon flexibility at the pace required".

OUR MISSION

TO UNLEASH INNOVATION AND OPEN NEW MARKETS TO CAPTURE THE CLEAN GROWTH OPPORTUNITY.

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