Baltic States Offshore Wind

Funding, Future Deployment and Transmission

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Agenda

- ESC Overview
- Net Zero Priorities
- Future Scenarios and case studies
- Conclusions

- Annex: ESC assets

Energy Systems Catapult (ESC): Overview

ESC drives innovation & open new markets to capture the clean growth opportunities…

200 Innovation experts

Hubs in Birmingham and Derby

We work with Innovate UK

Established, overseen and part-funded by Innovate UK. Independent from Government. Not for profit

Bridge the gap between stakeholders in the sector

Supporting innovators

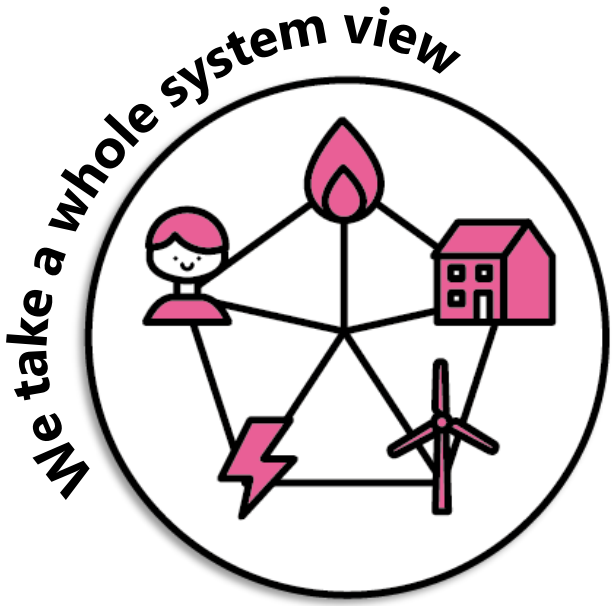
Research

Trials

Systems engineering

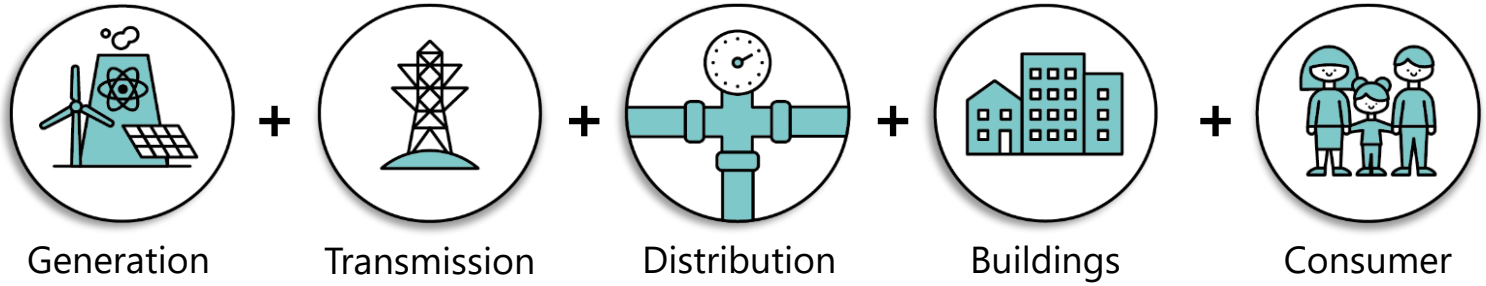
Digital

Modelling and simulation

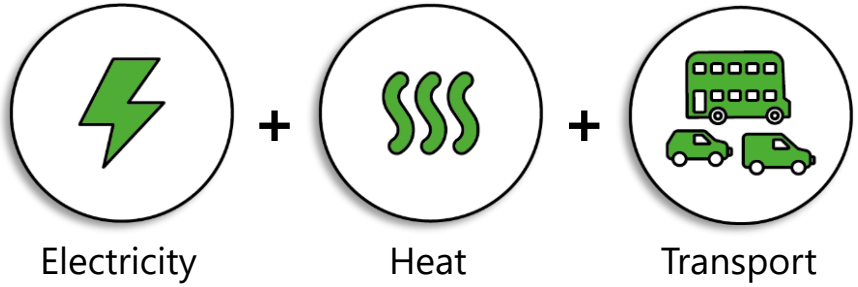


We take a whole systems approach, bringing together disciplines, tools & analysis from all vectors, sectors & stages of the system…

Joining up the system from **sources** of energy to the **consumer**



Breaking down silos between different **parts of the energy system**



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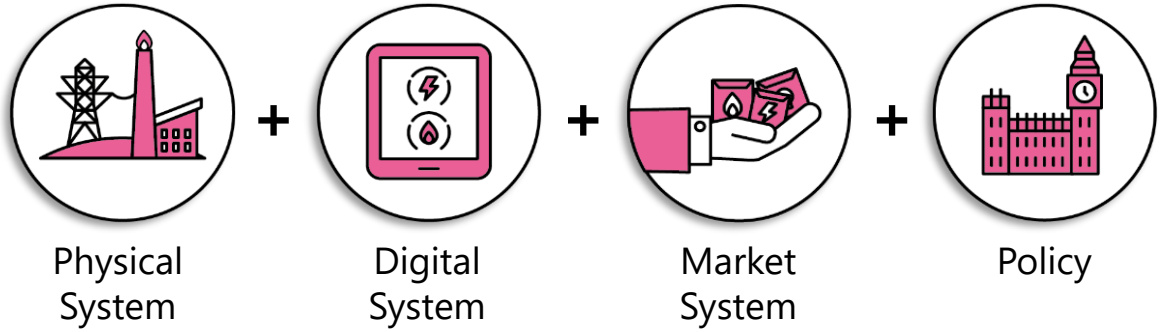
Joining up physical requirements of the system, with **policy, market** and **digital arrangements**



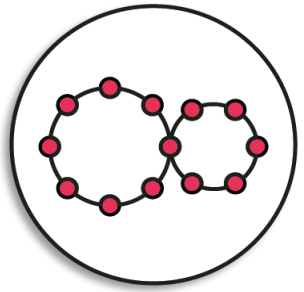
We can deliver a whole systems perspective by combining a range of inhouse capabilities…

Modelling

Digital and data

Consumer Insight

Markets, Policy and Regulation



Systems Integration

Infrastructure and Engineering

Within each capability are a number of distinct assets

CATAPULT Energy Systems

Modelling

National Energy System Modelling
Local Area Energy Planning and Modelling
Building Energy System Modelling

Energy System Modelling Environment™
Infrastructure Transitions Analysis Model
EnergyPath Networks™
Home Energy Dynamics
Storage and Flexibility Model

Digital and Data

Data Science
Data Systems

Living Lab
Energy Knowledge eXchange™

Consumer Insight

Research
Design
Trials

People Lab
Home Truths®

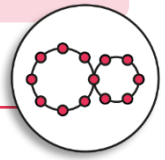
Markets, Policy and Regulation

Policy and Regulatory Knowledge
Economic Appraisal

Systems Integration

Systems Engineering and Integration
Dynamic Energy System Simulation
Dynamic Energy System Architecting
Business Model Innovation
Energy System Integration Guides

EnergyPath Operations™

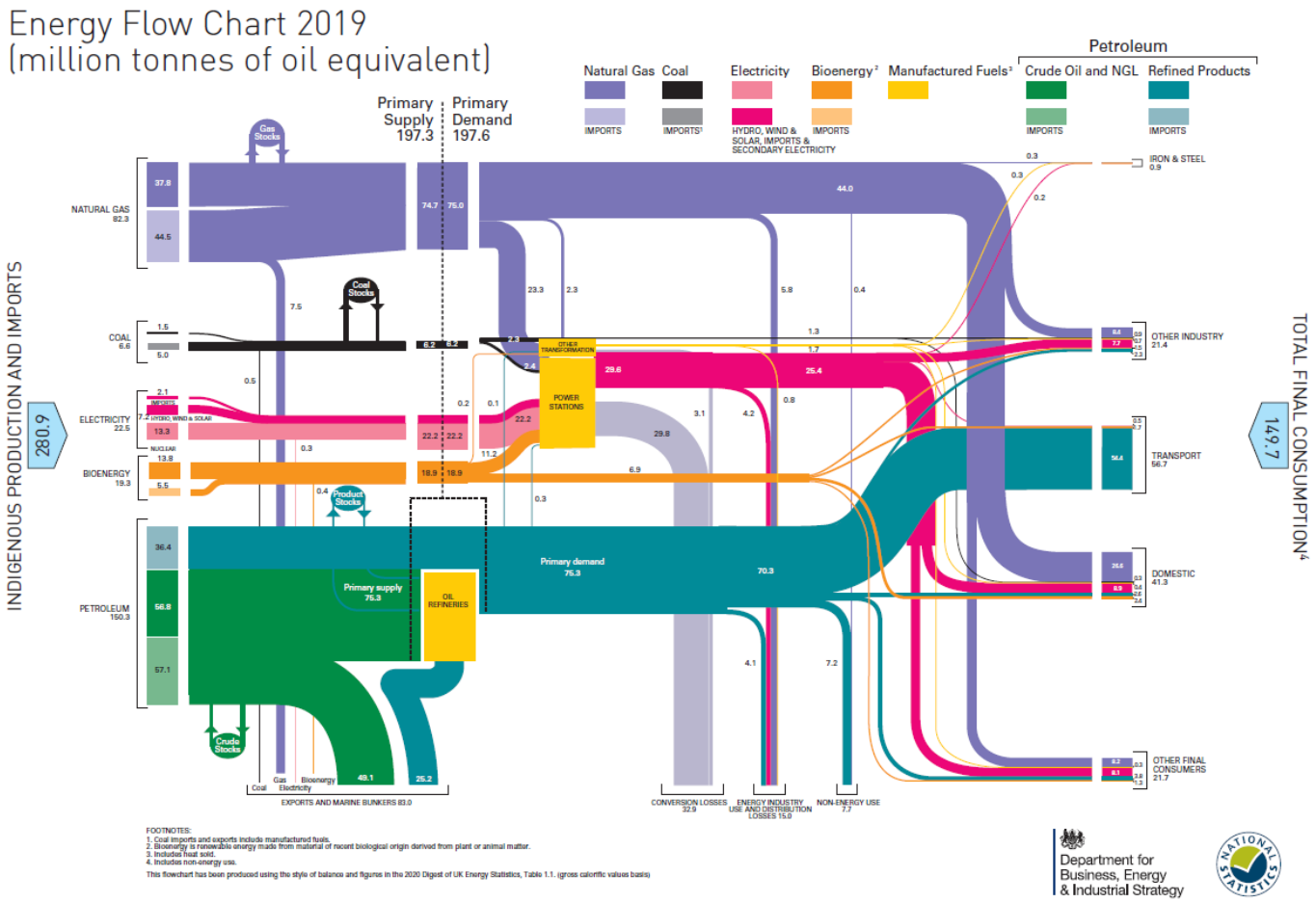


Infrastructure and Engineering

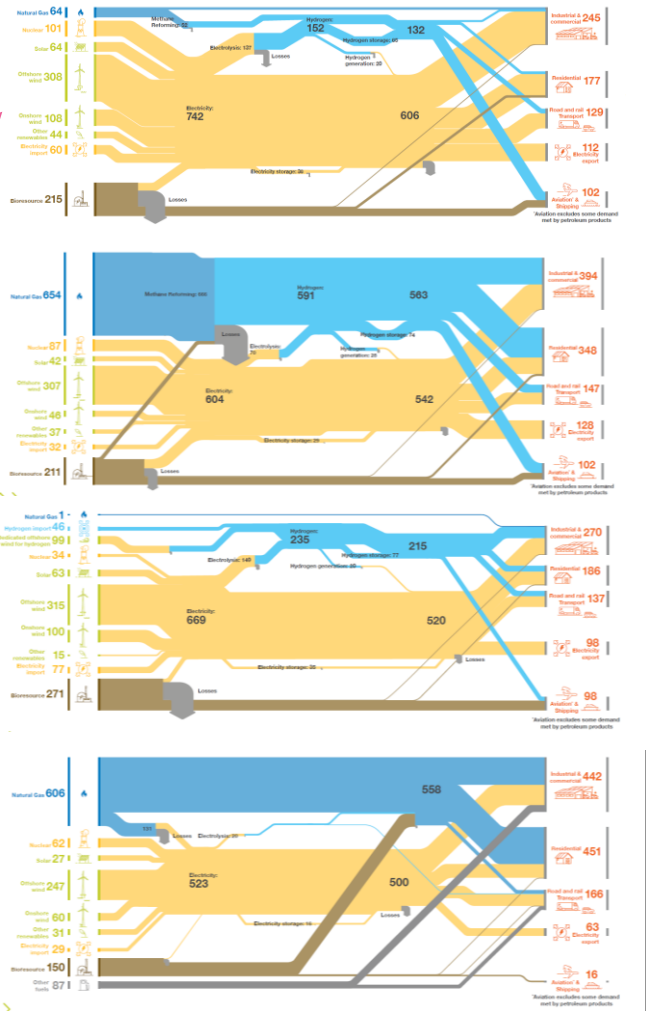
Networks and Energy Storage
Renewables
Transport
Nuclear
Carbon Capture and Storage, Industry and Hydrogen
Bioenergy

ESC Net Zero Priorities

There are many ways the future energy system could be configured



Energy Flow Chart 2019 (BEIS, 2019)



Future Energy Scenarios (National Grid ESO, 2020)

We work across spatial scales to provide evidence for least cost energy system designs that will work

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National policies support delivery of a whole system design, supply chain development and provide certainty to investors

Regional Frameworks can align local plans with national strategies, minimising infrastructure costs

Local Area Energy Plans create actionable and effective infrastructure plans in collaboration with local stakeholders

National Net Zero and Energy Policy

Region and Network Investment Plans

Local Policy and Local Area Energy Plans

ESME, Storage and Flexibility Model, CVEI

ITAM

EnergyPath Networks, LEAR

We explore pathways to 2050

Further Ambition

Endpoint similar to the CCC's 'Further Ambition' snapshot

Technologies in which there is relatively high confidence deliver net GHG emissions of 29 $MtCO_2e$ by 2050.

This is a 96% GHG reduction but is not net zero.

Without 'speculative' measures there is no 'slack' in the system. Therefore, even though this pathway does not fully achieve net zero, **the energy system is more highly 'carbon stressed'**.

Alternative Net Zero

Includes certain 'Speculative' measures proposed by CCC to reach net zero

'Speculative' measures include:

- dietary change
- afforestation
- aviation adjustments
- increased capture rates on hydrogen and power production plant

Delivers a feasible Net Zero energy system (100% net GHG reduction).

Measures provide some 'slack' in the system, which **reduces 'stress'** throughout the energy system.

Lifestyles, land use and low carbon energy: the Net Zero mixing desk

Emissions: 2015, Centralised 2050, Decentralised 2050

Three zero carbon vectors require unprecedented scale-up to displace fossil fuels for final energy

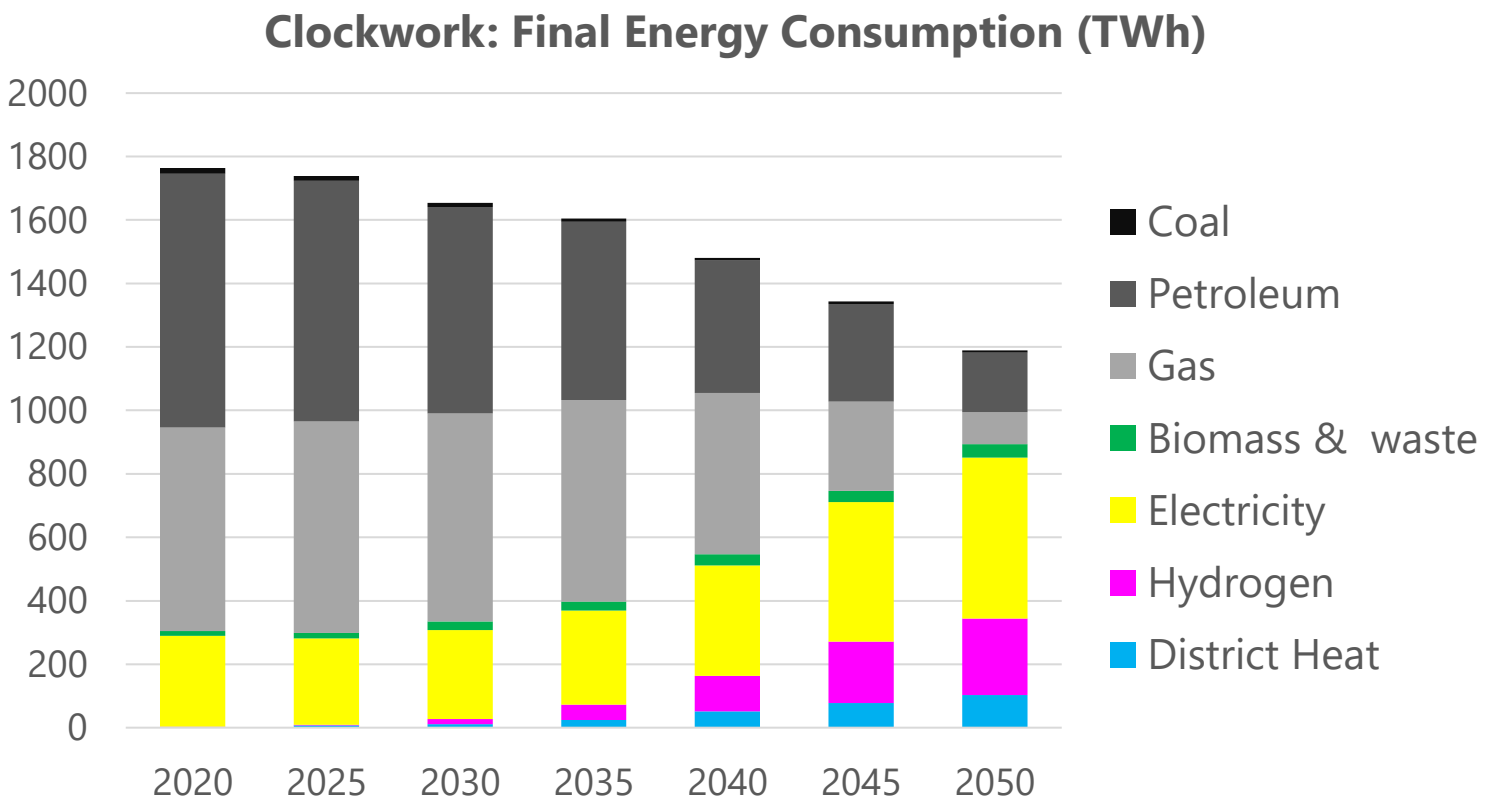
Could mean:

Unabated Fossil Fuel consumption down from **~1500TWh to <300TWh**

Electricity **600-800TWh**

Hydrogen **200-300TWh**

District Heat **Up to 150TWh**



Offshore wind- Future Scenarios

We consider Whole systems insights into technical elements

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Offshore transmission

- Interconnection has a lot to offer – operability and synergies with markets with different characteristics
- Offshore grid could be even more effective – directly selling wind to where it's valued highest

Smart Grid solutions

- A range of technologies already exists – the obstacle is finding the right governance arrangements to apply them, and comparing them fairly against conventional system services
- Operational paradigms – a grid made of many cells that self control, for example, may provide more reliability but less economy of scale

Wind farms and ancillary services

- With innovative control applications, wind farms could potentially contribute – but may not be most economic solution
- Industry can support the System Operator in design of products and services

Storage and Flexibility provisions

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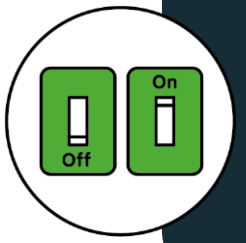
High Generation

- High generation of offshore wind requires significant back-up capacity
- Storage and flexibility is needed including demand-side management.

Storage Solutions

- Energy storage requirement will be significant by 2050, mainly to balance supply and demand daily.
- Hydrogen storage , seasonal variation in hydrogen demand considerations for various scenarios (e.g., daily hydrogen storage).



Curtailment

- Grid congestions issues and Interconnections for future energy systems
- Cost-effective solutions to curtailment issues

Markets, Policy and Regulatory elements:

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Market Design Reform

- Development of market models reflecting system values
- Balancing investment in assets
- Unlock flexibility in supply & demand

Policy Framework

- Evolved CfD design for future auctions (Innovation, changes…)
- Interventions/ investment for subsidy free projects

Network Designs & Charges

- Adapting to network challenges (e.g., locational values)
- Adapting to changes- Repurposing platforms, Supergrid, etc.

More info- ESC(2019), Towards a new framework for electricity markets

Offshore wind- Case Studies

Championing our collective Net Zero activities

As a Network, we sought to identify our ***strategic priorities*** for innovation, and kick start activities to ***enable*** us to accelerate impact

ESC - "Champion for Net Zero"

System Developer / Engineer: Identifying the key strategic innovation challenges and Roadmap to Net Zero

Working with industry and academia to tackle some of the hardest Net Zero problems

Coordinating the Catapult Network to deliver/tackle specific priority Net Zero challenges especially where cross-sector

Influencing *industry, Government and academia* on wider approach to Net Zero to accelerate and maximise clean growth

Collaborating with local Government and other institutions on place-based innovation

Outcomes:

- Assessment of UK Strengths & Institutional Activity
- The Production of a 'road map to Net Zero'
- Assessment of the potential impact of Embodied Carbon within Net Zero targets
- Whole System view & econometric evidence

ARPA-E –OREC-ESC

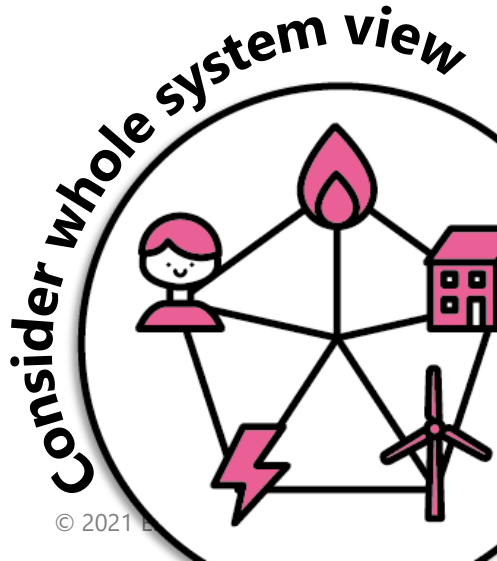
‘Advanced Grid Connection, Networks & Wider Program’

- **Aim:**
  - Efficient and reliable integration of floating offshore wind farms in power systems and investigation of the behaviour of offshore wind farms in the case of network faults.
  - Grid integration, network solutions (including hydrogen), market / business models and additional advanced turbine innovation.
- **Objectives:**
  - Analysis of fault scenarios for different DC floating network topologies and grid side faults.
  - Assessment of the performance of different DC network topology under fault
  - Techno-economic assessment of different fault scenarios and potential protection strategies
  - Comprehensive O&M systems development
  - Digital and data solutions
  - Energy storage integration
  - Whole system integration and analysis – markets for offshore, optimised grid integration

Take away message

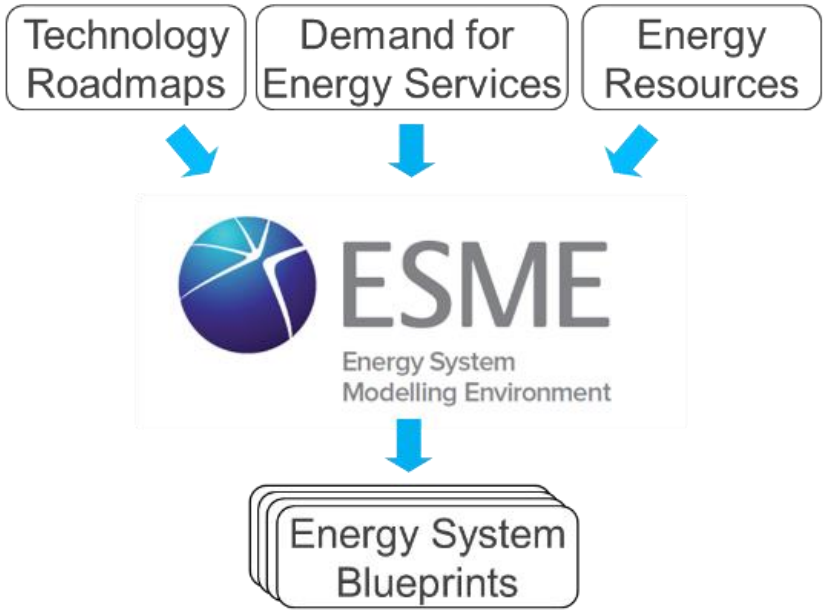
To continue to examine priorities for wind energy in the UK, and developing its role in the wider energy sector

- Priorities for the UK's long-term system approach to wind sector policy and development
- Preparing critical infrastructure & supply chain for increased wind power capacity
- Understand critical elements & barriers to address e.g. innovation, business models, data/digitisation,…
- Priorities for an approach that enables regional economies to lead sector development



Annex: ESC assets

ESC's Energy Systems Modelling Environment (ESME) allows pathways to Net Zero in 2050 to be explored



How does ESME work?

- **Whole-system** approach (power, heat, transport, industry & energy infrastructure);
- Least cost **optimisation** & **policy neutral**
- **Data-driven** deployment & utilisation of 400+ technologies
- **Probabilistic** treatment of key uncertainties
- Pathway and supply chain **constraints** to 2050
- **Spatial & temporal resolution** sufficient for system engineering

What types of discussion can ESME inform?

- What might be **'no regret' technology** choices and pathways to 2050?
- What is the **total system cost** of meeting defined energy targets?
- How "**valuable**" are **individual technologies** at the system level?
- What are the **key constraints**? (e.g. resources, supply chains etc.)
- How does **uncertainty** influence system design choices?

SFM & ITAM flow from ESME, but have been developed to offer additional insights

CATAPULT Energy Systems

Our Living Lab

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

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

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

ESME
Energy System Modelling Environment

Our Net Zero Place Tools

A suite of place based modelling tools, methods and guidance

Storage & Flexibility Model (SFM) builds upon **ESME** to deliver more value to stakeholders interested in **storage & flexibility**

Infrastructure Transitions Analysis Model (ITAM) uses **ESME** outputs and our place-based tools to understand national-local **infrastructure requirements**

SFM: Focused on storage & flexibility

CVEI: Focussed on Transport

ITAM: Focused on Infrastructure

Local Area Energy Planning is a method for developing detailed plans with stakeholders…

Local Area Energy Planning (LAEP) is a concept developed by the ESC to enable data-driven, spatial and collaborative planning, to help unlock investment and delivery of smart local energy systems – summarised by these 7 steps.

Each local area is different - its people, geography, building stock, energy networks and ambitions and priorities

Local Area Energy Planning provides a data driven, spatial and collaborative means, involving local government & network operators, of exploring a range of possible future local energy scenarios to cost-effectively decarbonise

Resulting in the identification of energy network and system choices to support carbon neutral aspirations - informing what local action is needed and where

Our Living Lab (>200 homes) allows real world testing of a range of consumer products & services

Supports testing of low carbon products and services with consumers

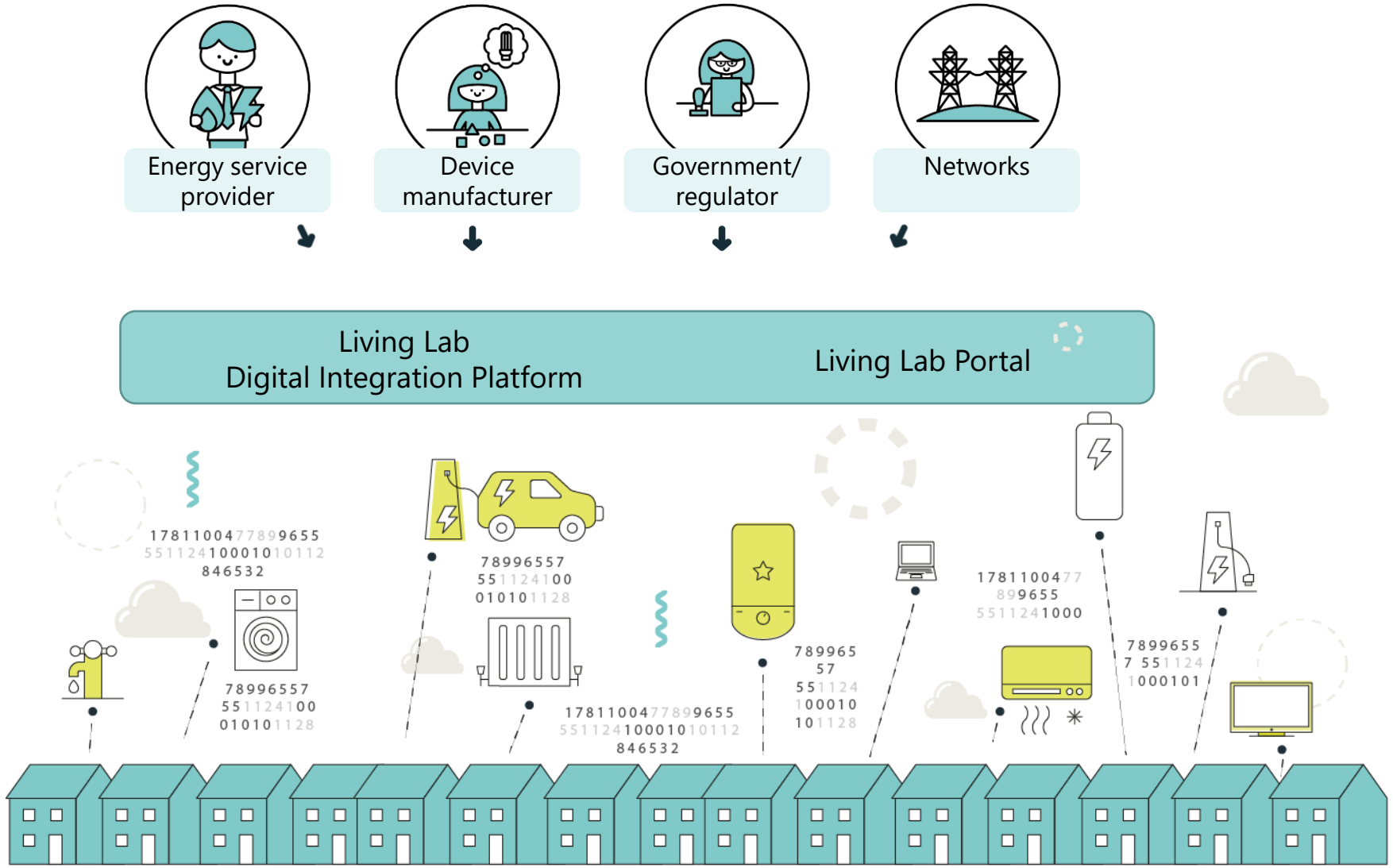
Provides rich consumer insight and data

Supports multiple trials

Broader range of consumers, homes and technologies

’00s of homes

Interoperable with other cloud platforms



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