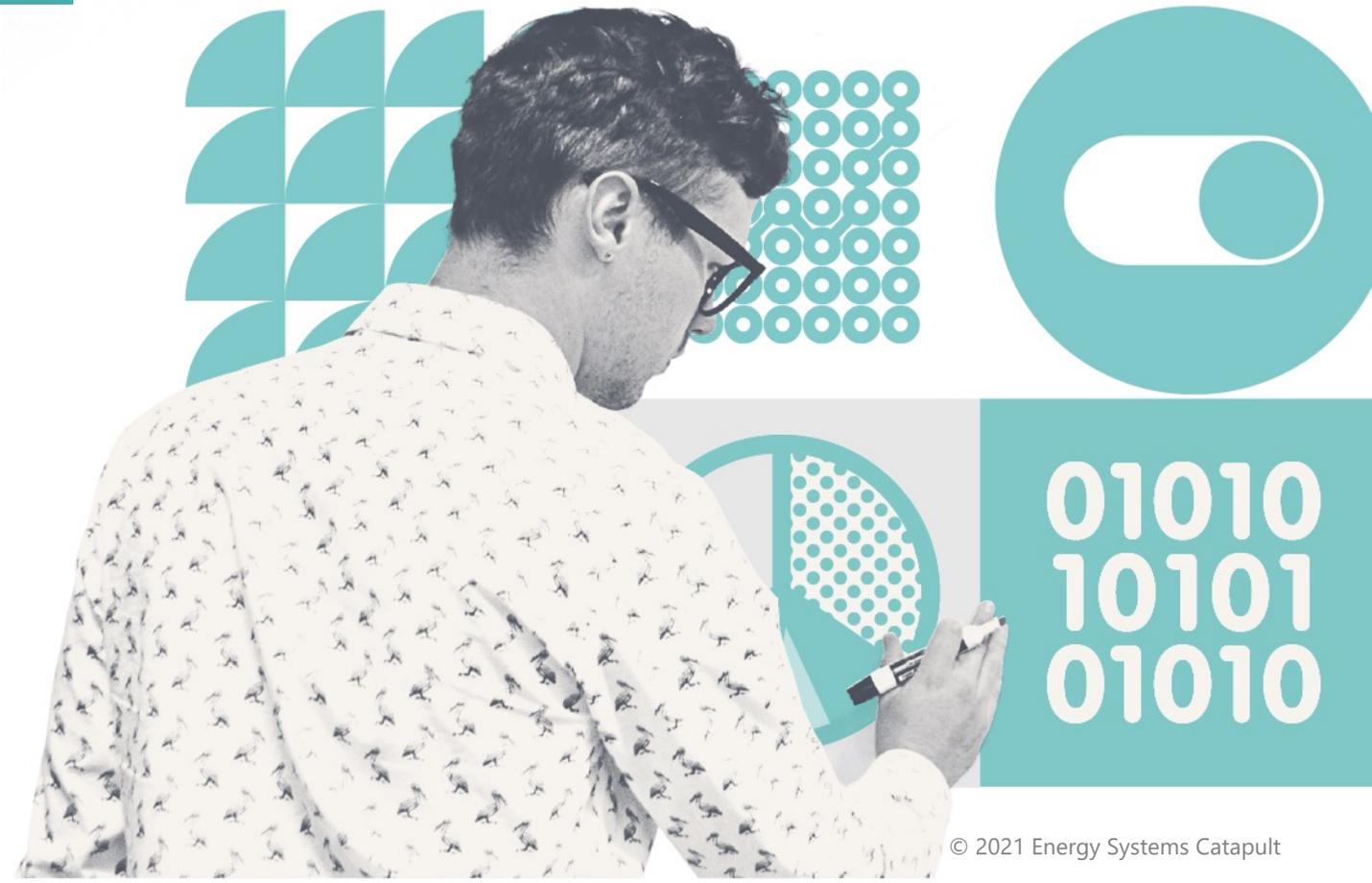


HIGH PRESSURE PIPELINES AS PART OF WHOLE ENERGY SYSTEM DESIGN

RICHARD WAINE CEng

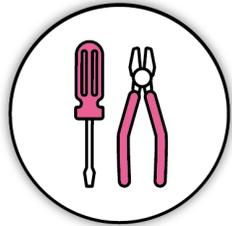
**HYDROGEN NETWORKS
CONSULTANT**

WEDNESDAY 25th MAY 2022



CATAPULT NETWORK.

SUPPORTING BUSINESS IN TRANSFORMING GREAT IDEAS INTO VALUABLE PRODUCTS AND SERVICES.



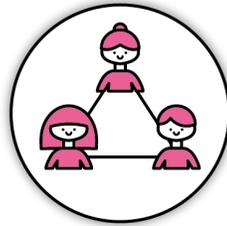
TECHNICAL CAPABILITIES, EQUIPMENT, AND OTHER RESOURCES



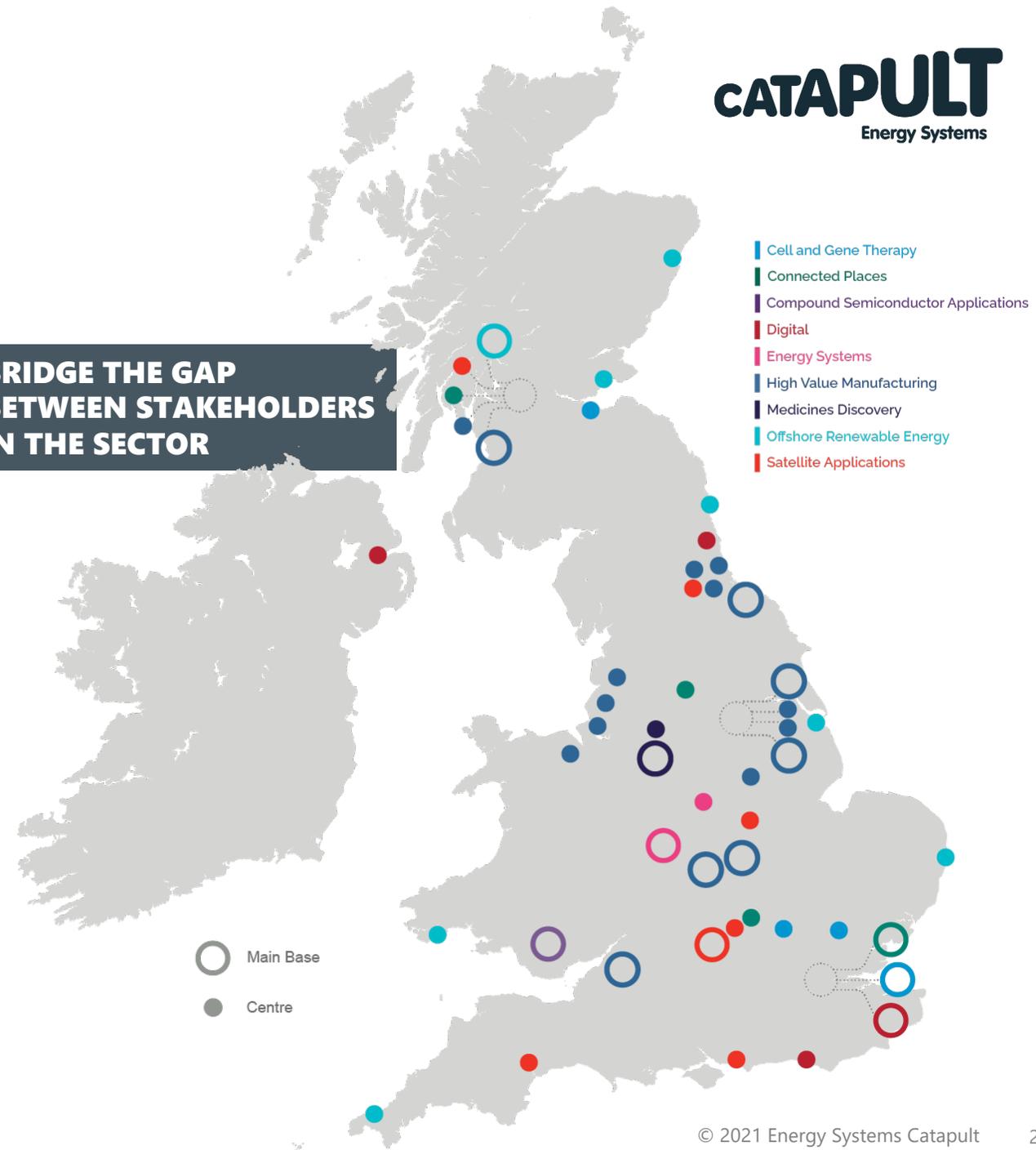
OPEN UP OPPORTUNITIES FOR INNOVATORS, IN THE UK AND GLOBALLY



SOLVE KEY PROBLEMS AND DEVELOP NEW PRODUCTS AND SERVICES



BRIDGE THE GAP BETWEEN STAKEHOLDERS IN THE SECTOR



We work with
Innovate UK

ABOUT US.

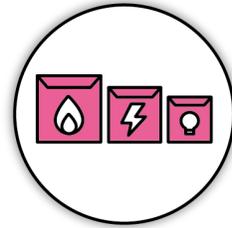
MISSION: UNLEASHING INNOVATION AND OPEN NEW MARKETS TO CAPTURE THE CLEAN GROWTH OPPORTUNITY.

WHO?

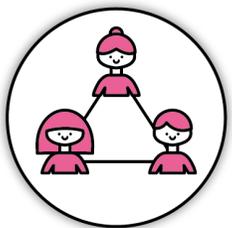


INNOVATION EXPERTS

WHAT?



SUPPORTING INNOVATORS TO COMMERCIALISE



PARTNERS & COLLABORATORS



HELPING TO DESIGN THE FUTURE ENERGY SYSTEM TO UNLOCK INNOVATION

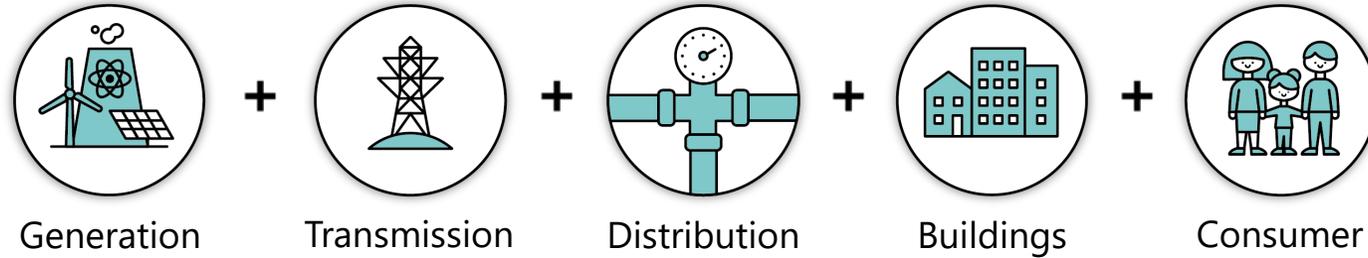
- Consumer Insight and Proposition Design
- Business Model Innovation
- Harnessing Digital and Data
- Test and Demonstration
- Delivering Large Scale Innovation Trials
- **Whole System Modelling**
- **Clean Tech Engineering**
- **Systems Engineering**
- Integrating the Transport and Energy Systems
- Markets, Policy and Regulation
- Decarbonising Local Places
- Decarbonising the Public Sector Estate
- Decarbonising Campuses, Business Parks and Industrial Estates

We work with
Innovate UK

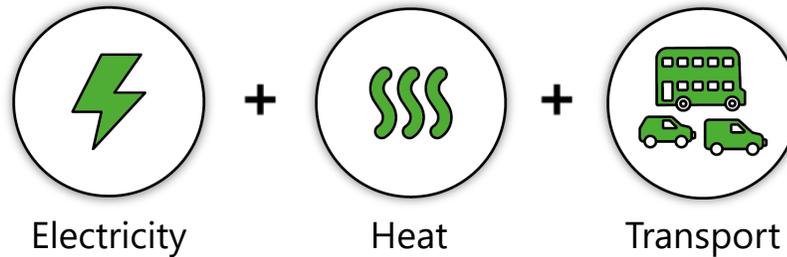
OUR EXPERTISE.

WHOLE SYSTEMS THINKING.

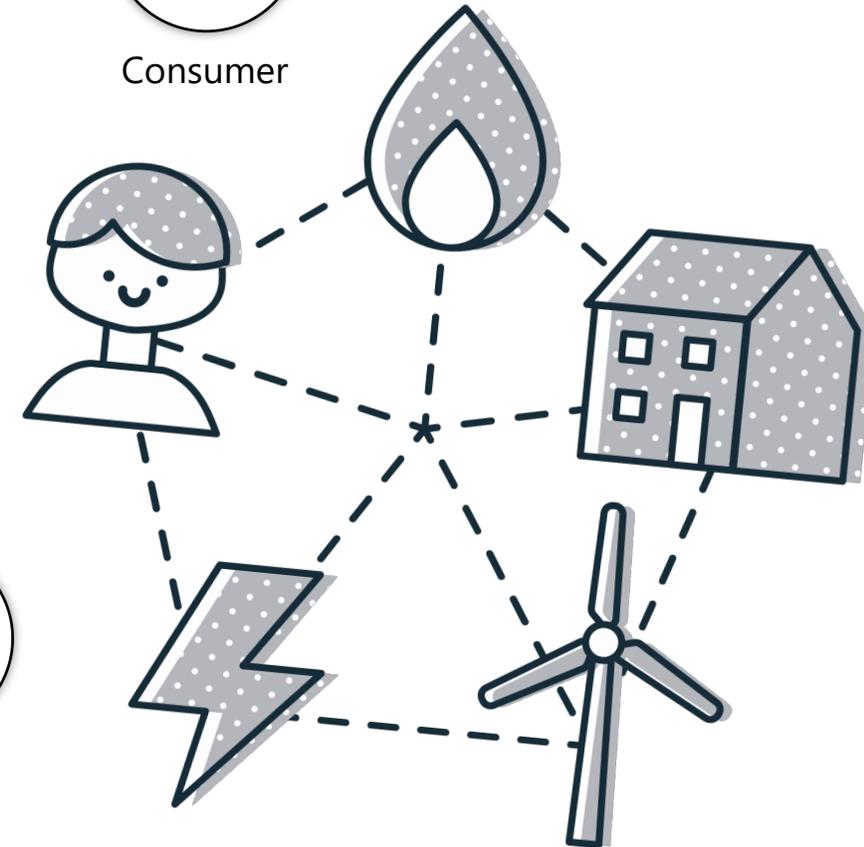
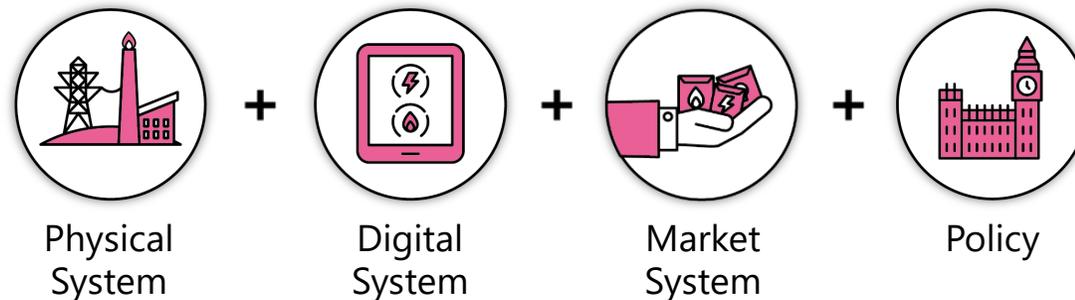
JOINING UP THE SYSTEM FROM SOURCES OF ENERGY TO THE CONSUMER



BREAKING DOWN SILOS BETWEEN DIFFERENT PARTS OF THE ENERGY SYSTEM



JOINING UP PHYSICAL REQUIREMENTS OF THE SYSTEM, WITH POLICY, MARKET AND DIGITAL ARRANGEMENTS



WHAT WE DO.

HELPING TO DESIGN THE FUTURE ENERGY SYSTEM TO UNLOCK INNOVATION.



**SYSTEM
ENGINEERING**



**CLEAN TECH
ENGINEERING**



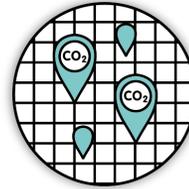
**WHOLE SYSTEM
MODELLING**



**MARKETS, POLICY
AND REGULATION**



**INTEGRATING THE TRANSPORT
AND ENERGY SYSTEMS**



**DECARBONISING
LOCAL PLACES**



**DECARBONISING THE
PUBLIC SECTOR ESTATE**



**DECARBONISING CAMPUSES, BUSINESS
PARKS AND INDUSTRIAL ESTATES**



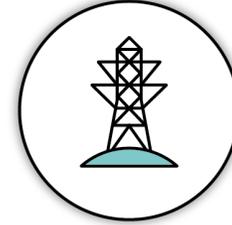
**Climate
change**



**Security
of supply**



**New
technologies**



**Ageing
infrastructure**



**Consumer
needs**

Change is coming from multiple directions.
Local, Regional, National and International Perspectives
Transformational, not incremental in nature.
Characterised by unprecedented complexity and uncertainty.
Unfolding at increasing pace.

DECENTRALISATION

DECARBONISATION

DEMOCRATISATION

DIGITALISATION

ESC PROJECTS WITH HP PIPELINES

Natural Gas, Hydrogen and CCS.



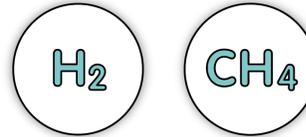
MILFORD HAVEN: ENERGY KINGDOM SYSTEM ARCHITECTURE

The project focused on developing diverse, local markets to support the transition, to hydrogen and renewables, of the cluster of major energy infrastructure along the Milford Haven Waterway.



Scottish Net Zero Roadmap

Aim of the project is to develop a roadmap that sets out how Scottish industry can move towards Net Zero by 2045, based on exploring a number of decarbonisation scenarios.



WWU: REGIONAL DECARBONISATION PATHWAYS

Build a strategic plan and roadmap for the entire WWU network. Developed in partnership with Costain



Welsh Future Energy Grid for Net Zero

Develop scenarios of the various paths Wales could take to decarbonise the energy system. Ensuring the investment is coherent, efficient, and timely.



Department for
Business, Energy
& Industrial Strategy

BEIS SYSTEM TRANSFORMATION TECHNICAL SUPPORT

MILFORD HAVEN: ENERGY KINGDOM



MILFORD HAVEN: ENERGY KINGDOM

MH:EK is exploring the potential of zero carbon hydrogen alongside renewable electricity to meet all of our future energy needs for buildings, power generation and fuelling transport.

MH:EK is one of the chosen “detailed design” projects within the Prospering from the Energy Revolution (Pfer) programme of works funded by UKRI as part of their Industrial Strategy Challenge Fund (ISCF).

MH:EK is gathering detailed insight into the whole energy system around the Milford Haven Waterway, to identify and design a future Smart Local Energy System. We are exploring how to make using and distributing green hydrogen financially viable within the different energy sectors of buildings, industry, power and transport all backed by comprehensive energy systems architecture.



MILFORD HAVEN: ENERGY KINGDOM
READ MORE: www.pembrokeshire.gov.uk/mh2-energy-kingdom



Project partners



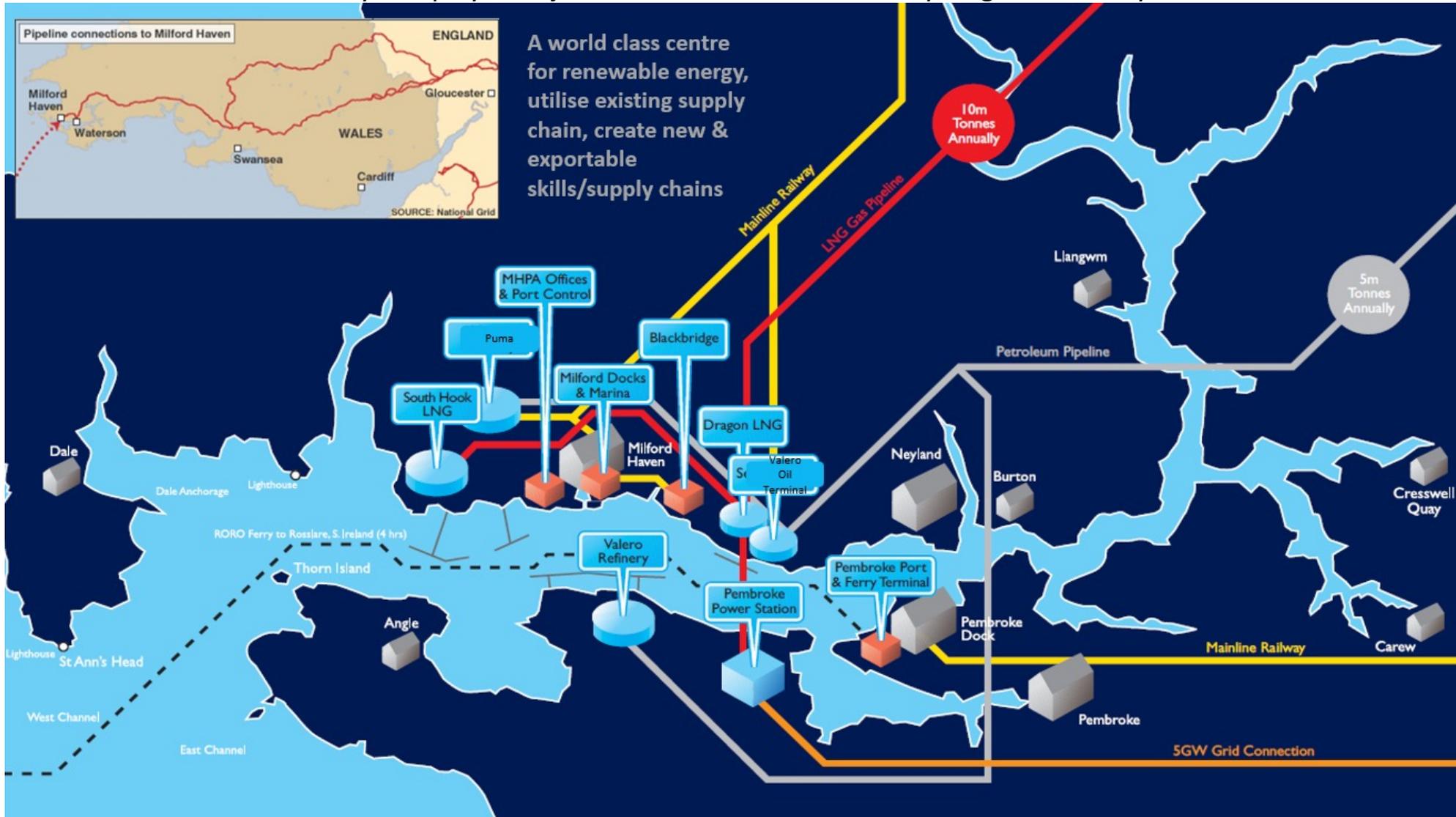
Electrolyser and refueller providers



MILFORD HAVEN: ENERGY KINGDOM

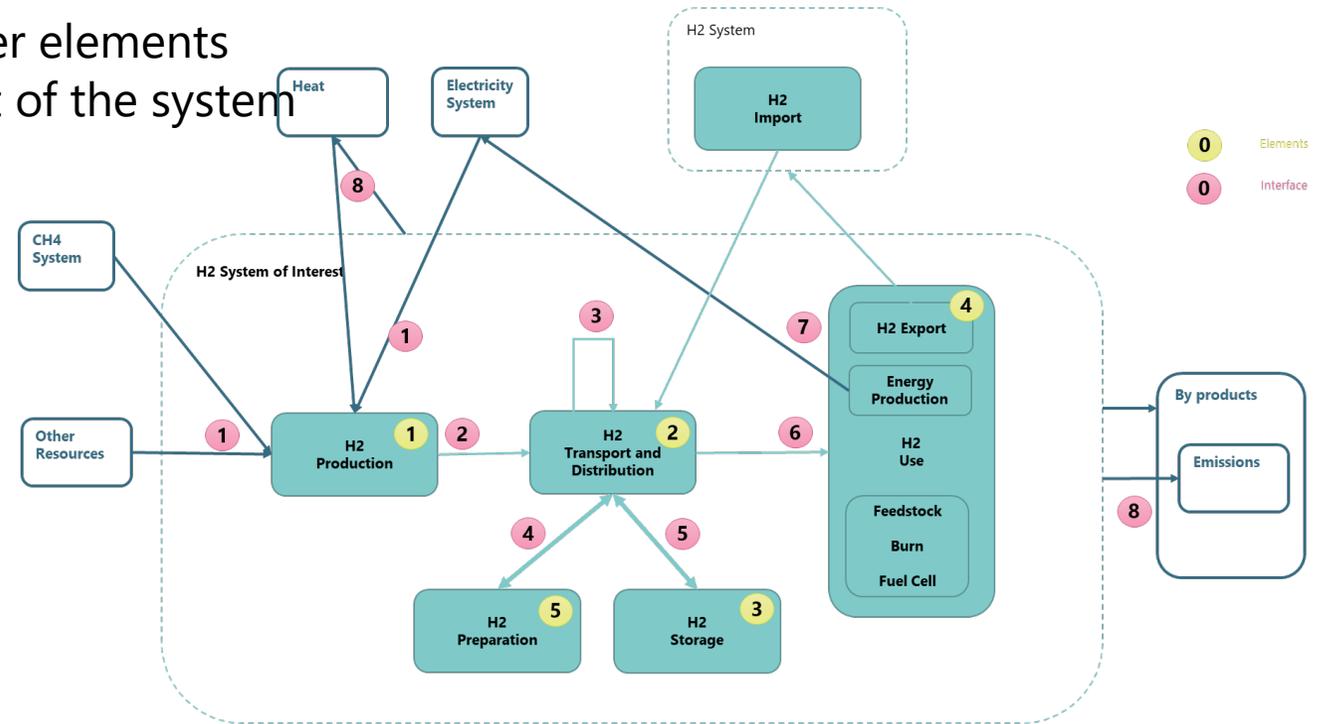
Milford Haven Waterway – Connected into the UK energy system

The Milford Haven Waterway can play a major role in a commercialised hydrogen economy for the benefit of UK Plc.

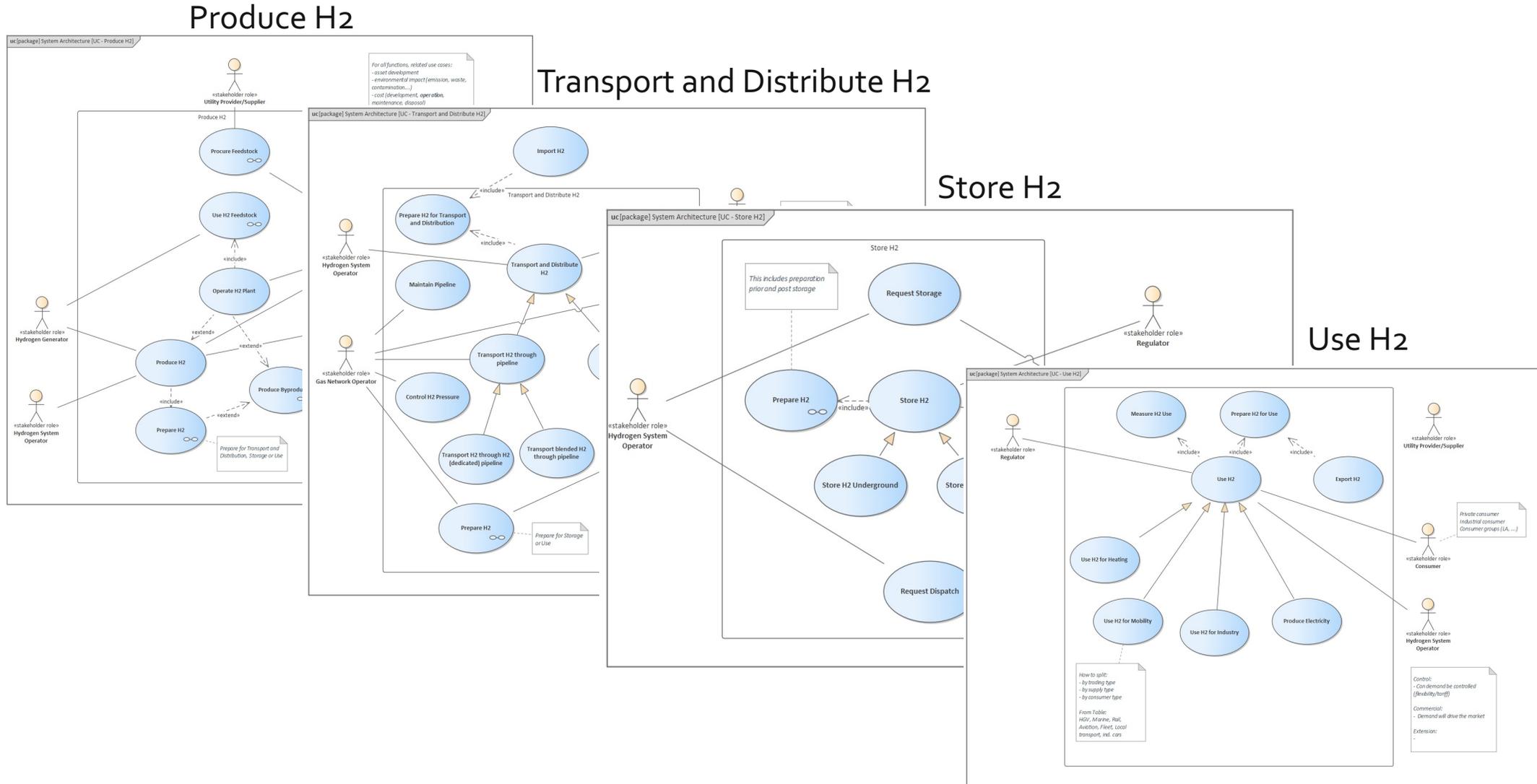


Physical Architecture Report

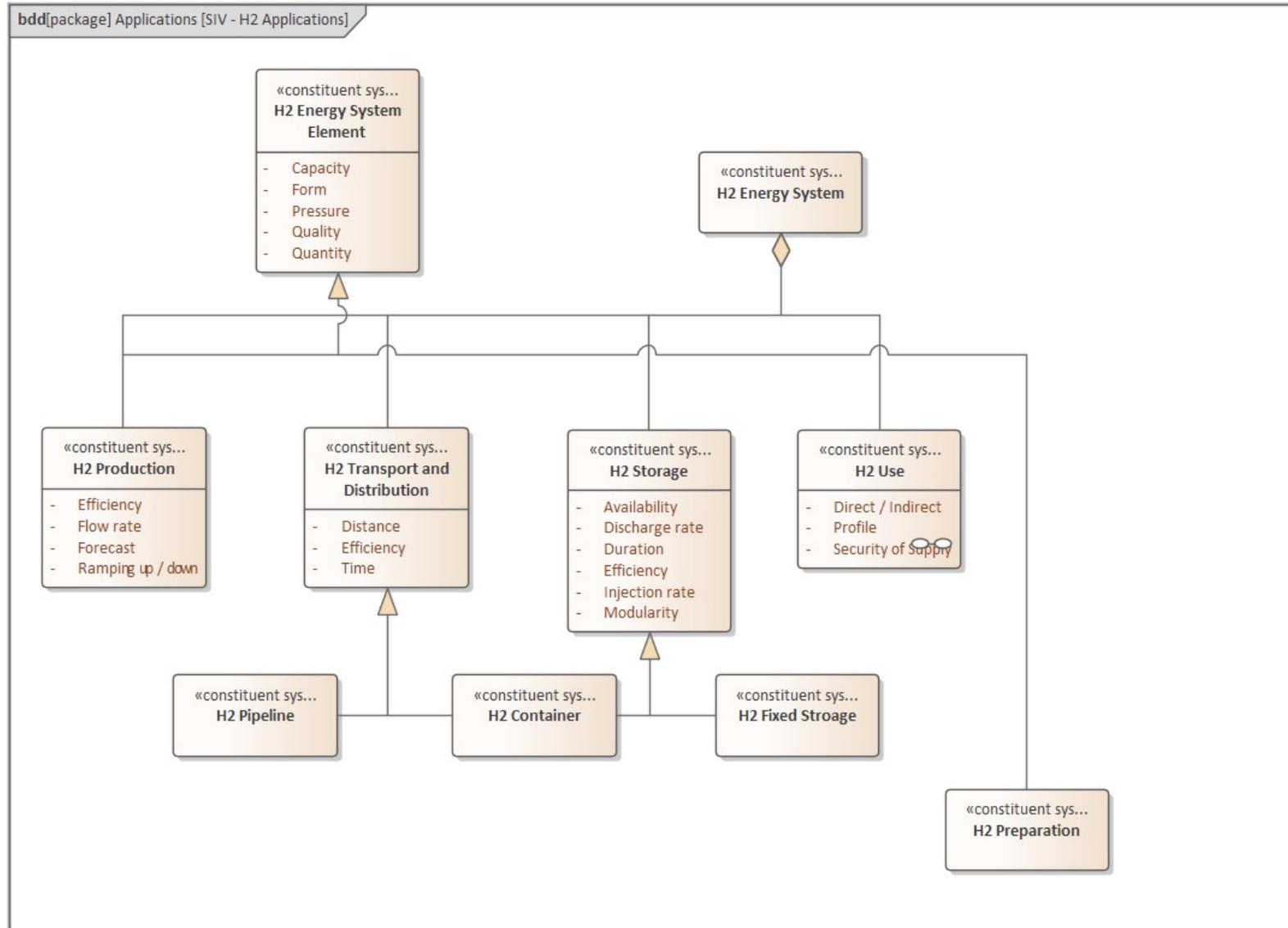
- System Architecture development process within the MH:EK project
- Hydrogen elements (Production, Preparation, Distribution, Storage, Use)
 - Background information
 - Interaction and interoperability with other elements
 - Integration of each element with the rest of the system
 - Control
- Blended Hydrogen Network
- Import / Export
- Interoperability
- Control
- Standards
- Outcome
 - Implications for MH Waterways
 - 14 Discussion / Decision / Action Points
 - Development of Potential System Arrangements (PSA)



Use Cases

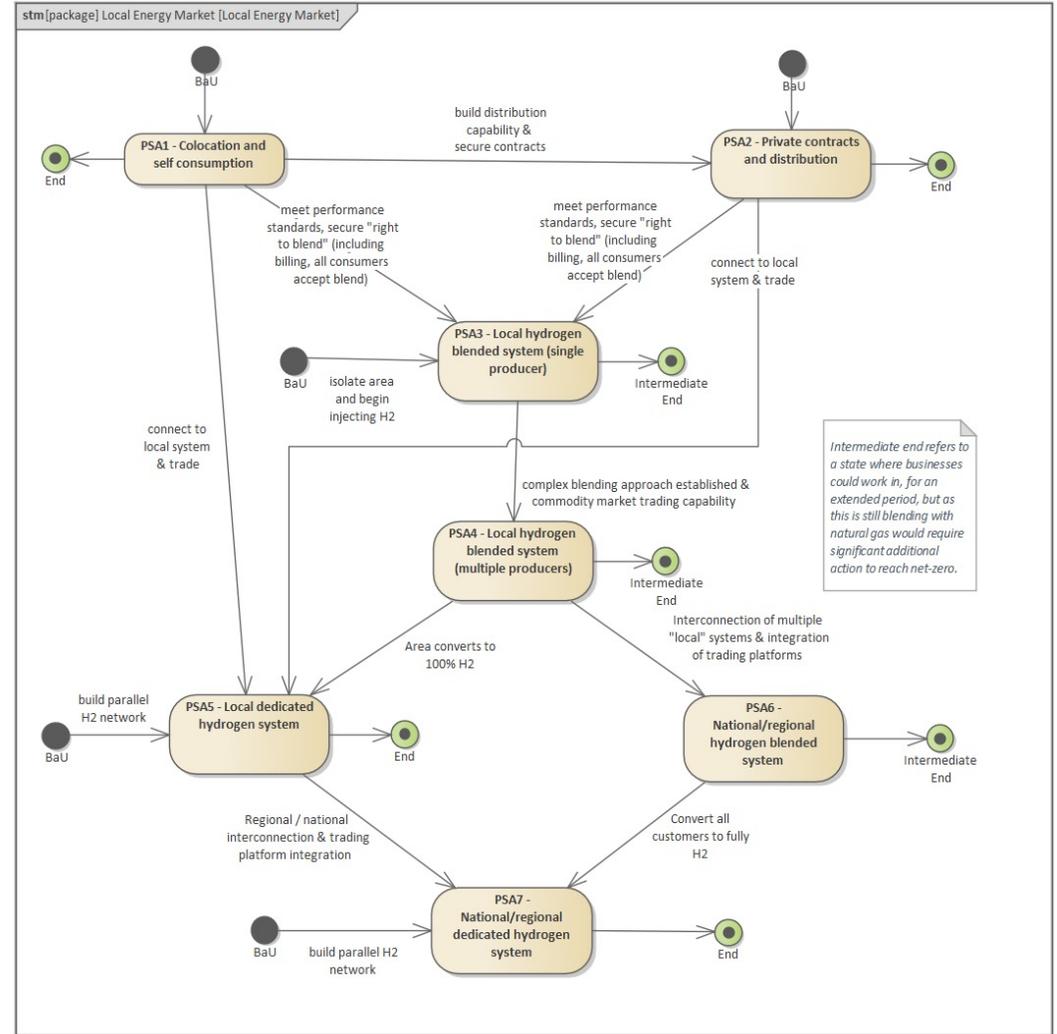


Physical Properties



Key learnings from the PSA work

- PSA1 Self Consumption
- PSA2 Private contracts
- PSA3 Local blended hydrogen (single producer)
- PSA4 Local blended hydrogen (multiple producers)
- PSA5 Local dedicated hydrogen
- PSA6 National blended hydrogen
- PSA7 Regional / National dedicated hydrogen



NATURAL GAS, HYDROGEN AND CO2 PIPELINES

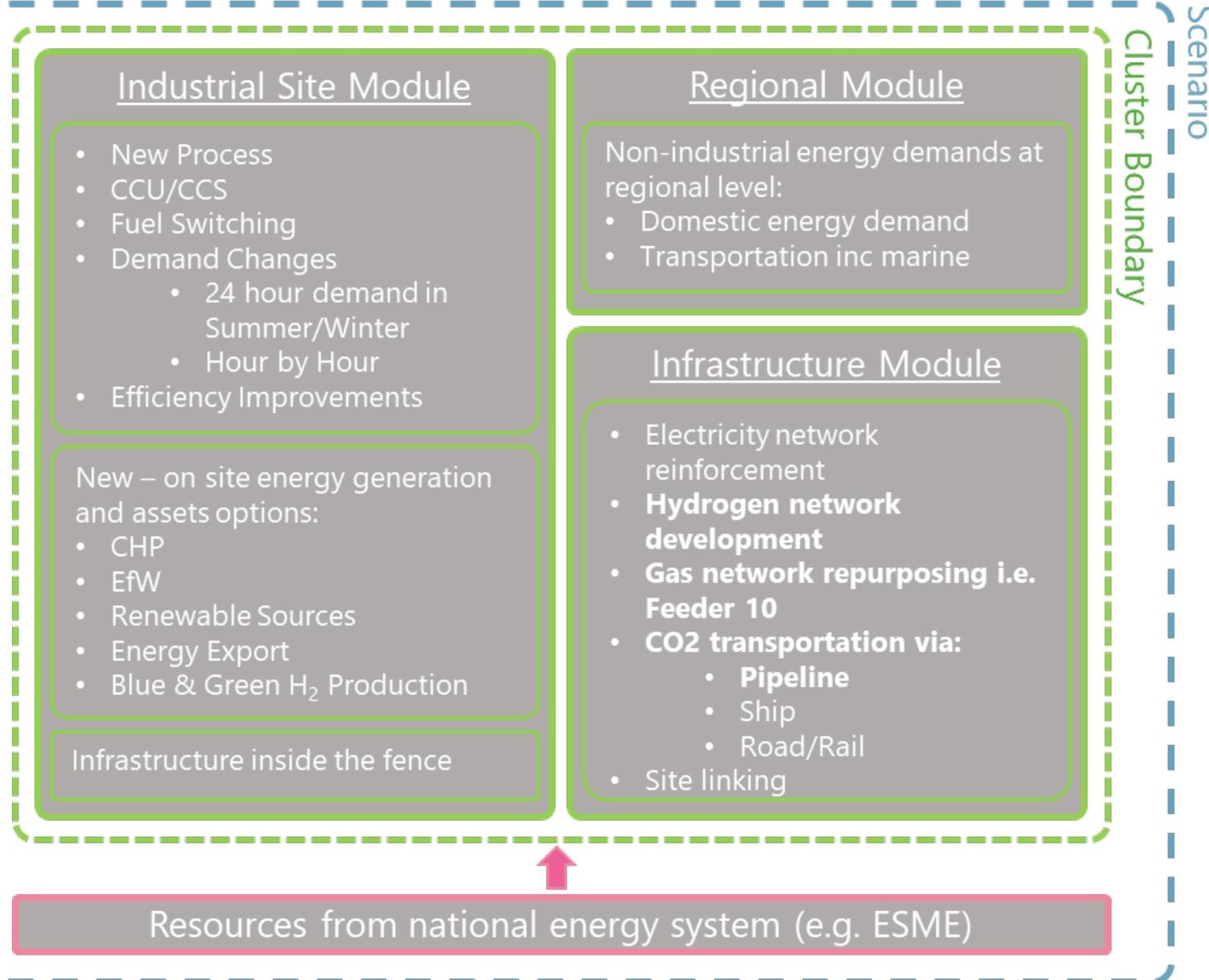
The aim of the project:

develop a roadmap that sets out how Scottish industry can move towards Net Zero by 2045, based on exploring a number of decarbonisation scenarios.

The project focuses on a cluster of industrial activity on the East Coast of Scotland which covers many of the largest industrial sites across a range of sectors and 80% of Scotland's industrial CO2 emissions.

SNZR is led by NECCUS and other project partners are Costain Limited, Doosan Babcock Limited, Halliburton Manufacturing and Services Limited, Aker Solutions Limited, Wood Limited, Energy System Catapult Limited, NZTC, Pale Blue Dot Energy Limited, Optimat Limited, The University of Edinburgh and The University of Strathclyde

SCOTLAND NET ZERO ROADMAP - MODEL OVERVIEW



The main objective of the cluster energy system modelling exercise is to assess the plausible role of industrial decarbonisation within the Scottish industrial cluster.

The model is suitable for answering several related questions, including:

- How do major infrastructure projects influence the viable options at the major emitters?

SCOTLAND NET ZERO ROADMAP INFRASTRUCTURE MODULE

An example of network map input, viewed in QGIS. This layout is purely to demonstrate key features of the input. It is not intended to represent a realistic scenario.

- inputs
 - cluster_sites
 - ◊ shipping_terminals
 - rail
 - road
 - - - shipping_routes
- hydrogen
 - h2_ooc_source
- h2_pipeline_routes
 - new
 - h2_ooc_demand
- co2
 - co2_ooc_source
- co2_pipeline_routes
 - new
 - repurpose
- electricity
 - electrical_connection_routes
- OpenStreetMap



Background layer is ©
OpenStreetMap
contributors.

- With deeper system complexity and integration, e.g. blue hydrogen production (H₂, CO₂, and potentially CH₄), are there opportunities for high pressure pipelines operators to further develop their value proposition to the energy system? (Both through transition and into Net Zero).
- The system value of high pressure pipeline assets could change as their role in the wider system changes e.g. resilience, reliability. Is it clear how and when this change is happening? Is this visible to decision makers?
- Evolution of systems of high pressure pipelines are important for physical, data, market and organisational system design (and vice versa). Are the supporting systems around high pressure pipelines ready to support this change for Net Zero?
- For hydrogen networks the practicalities of consumer switch over to hydrogen will impact options for high pressure natural gas pipeline repurposing. Are the feasible options known and visible?
- For hydrogen networks potentially changing supply/storage profiles from the likes of hydrogen generated from offshore wind. Is there clarity on the technical implications on the high pressure pipeline assets and any constraints for pipelines and the wider energy system?

QUESTIONS?

OUR MISSION

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

RICHARD WAINE

RICHARD.WAINE@ES.CATAPULT.ORG.UK

ES.CATAPULT.ORG.UK

@ENERGYSYSCAT



CATAPULT

Energy Systems



Welsh Future
Energy Grid for
Net Zero ([Link](#))

For the latest insights in energy
innovation

Keep up to date with our monthly
newsletter

[Sign up](#)

ADDITIONAL SLIDES



Milford Haven Waterway – The UK’s Largest Energy Port

Circa 25% of the UK’s energy imports with a huge opportunity to lead the transition from a fossil fuel to renewables based economy.



**Marine Renewables
A Major Future
Contributor**

**RWE Pembroke
Power Station
2200MW Combined
Cycle Gas Turbine**

**Valero Pembroke Refinery
270,000 bpd, 10.5m
barrels storage**

**Valero Pembrookeshire
Oil Terminal
8.7mb petroleum products
storage facility**

**Dragon LNG
Liquefied Natural
Gas terminal**

**South Hook LNG
Liquefied Natural
Gas Terminal**

**Puma
1.4m m3
storage facility**

4,000 jobs (40% of total local employment around the Port)

HELPING TO DESIGN THE FUTURE ENERGY SYSTEM TO UNLOCK INNOVATION.

CLEAN TECH ENGINEERING.

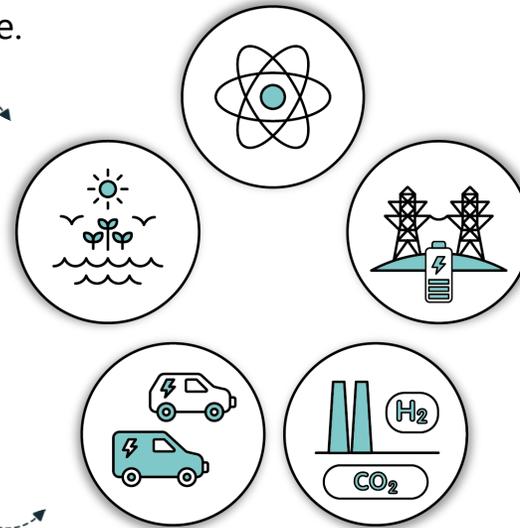
RENEWABLES

Expertise in solar, wind, marine generation and bioenergy, including: technology, systems and infrastructure. Informing decision making on investment to accelerate technology adoption.

TRANSPORT

Modelling, analysis and insight into the role of transport in future energy networks, optimising vehicle propulsion systems, consumer insight, market and policy frameworks, value chains, and new generation technologies.

Offering technical expertise and practical experience in development and deployment, considering implications for innovations and investment decisions.



NUCLEAR

Assessing nuclear potential of contemporary designs and new technologies including risk and cost reduction, coupled with unique modelling on infrastructure costs, integration with district heating or hydrogen, and flexible power generation.

NETWORKS AND ENERGY STORAGE

Assessing networks and energy storage within the context of whole energy systems, including new technologies, energy storage and system flexibility, and adapting infrastructure strategies.

HYDROGEN, INDUSTRY AND CARBON CAPTURE

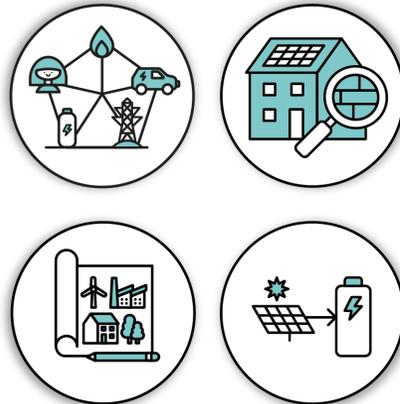
Building evidence for decision making on infrastructure needs for hydrogen and carbon capture, including innovation assessments, industrial deployment and storage risks.

HELPING TO DESIGN THE FUTURE ENERGY SYSTEM TO UNLOCK INNOVATION.

WHOLE SYSTEM MODELLING.

NATIONAL ENERGY SYSTEM MODELLING

Internationally peer reviewed Energy System Modelling Environment to provide evidence and insight on Net Zero strategy and policy.



LOCAL ENERGY SYSTEM MODELLING

Local Area Energy Planning and Local Energy Area Representation are key to our Placed-based Net Zero Toolkit.

BUILDING ENERGY SYSTEM MODELLING

Home Energy Dynamics model to understand the interactions between different domestic heating systems, controls, building fabric, weather and consumer needs.

STORAGE AND FLEXIBILITY MODELLING

Complementary to ESME, assess the value of storage technologies and identifies system service requirements of future energy systems.

Independent and technology-agnostic modelling of the physical, digital and market systems to help design and deliver the future energy system and target effective innovation investment.

We work with:

UTILITIES AND ENERGY SECTOR

Modelling the physical, digital and market systems to support the energy sector in targeting effective innovation investment

SMES AND INNOVATORS

Modelling the current and future energy system to identify barriers and opportunities for new products, services and business models.

GOVERNMENT AND LOCAL AUTHORITIES

Whole system modelling and analysis to support policymaking by government and investment decision making by local authorities.