BENEFITS OF TIDAL POWER AND ELECTROLYSIS

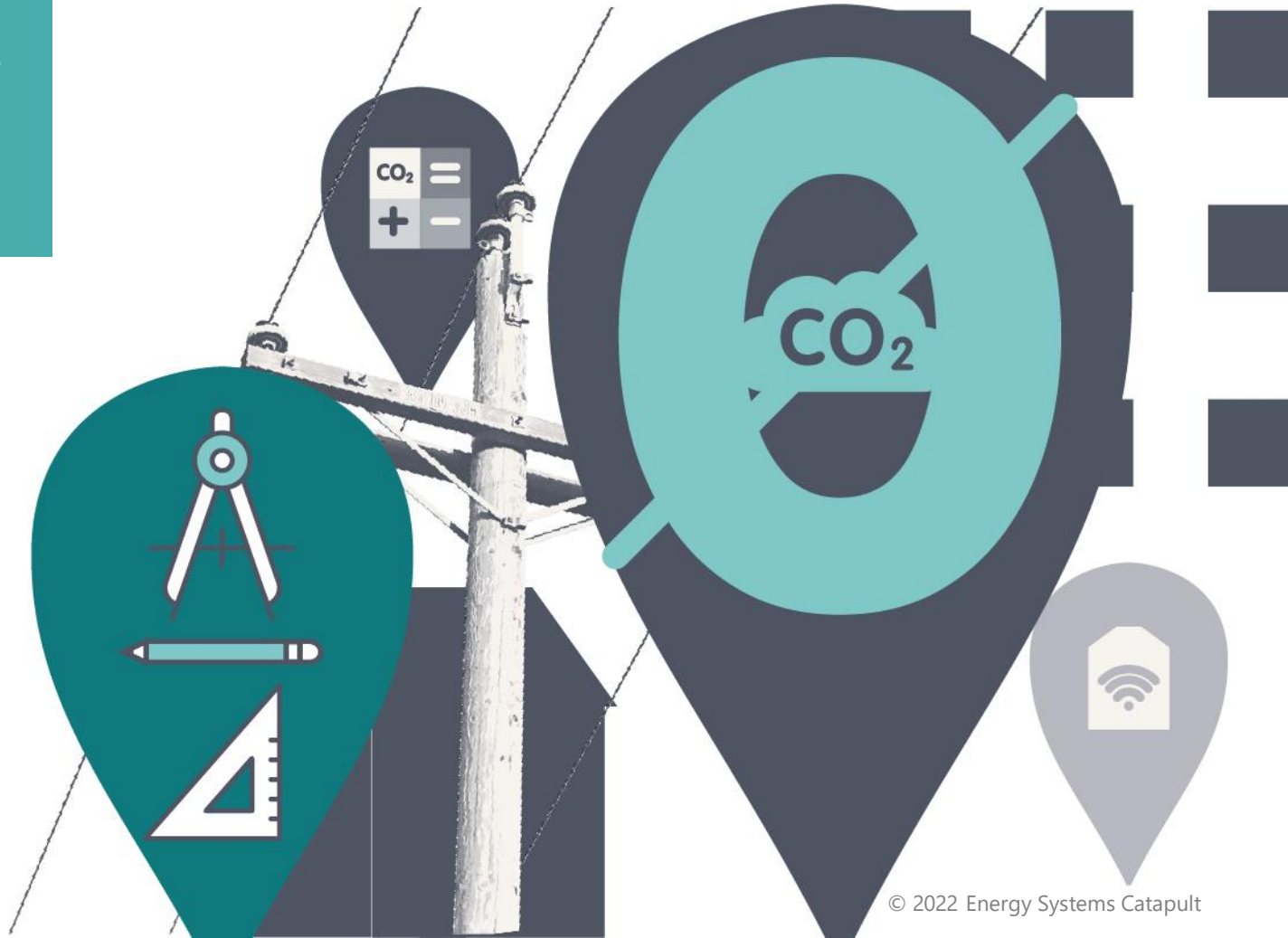
IN SUPPORTING ISLAND AND REMOTE COASTAL COMMUNITIES

TO ACHIEVE NET ZERO AT OPTIMUM COST

NICK ERAUT

PROJECT MANAGER

ALL ENERGY, MAY 2022

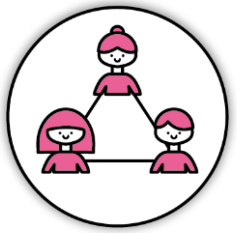


ABOUT US

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

WHO?

INNOVATION EXPERTS



DRIVING COLLABORATION

WHAT?

SUPPORTING INNOVATORS TO COMMERCIALISE

HELPING TO DESIGN THE FUTURE ENERGY SYSTEM TO UNLOCK INNOVATION

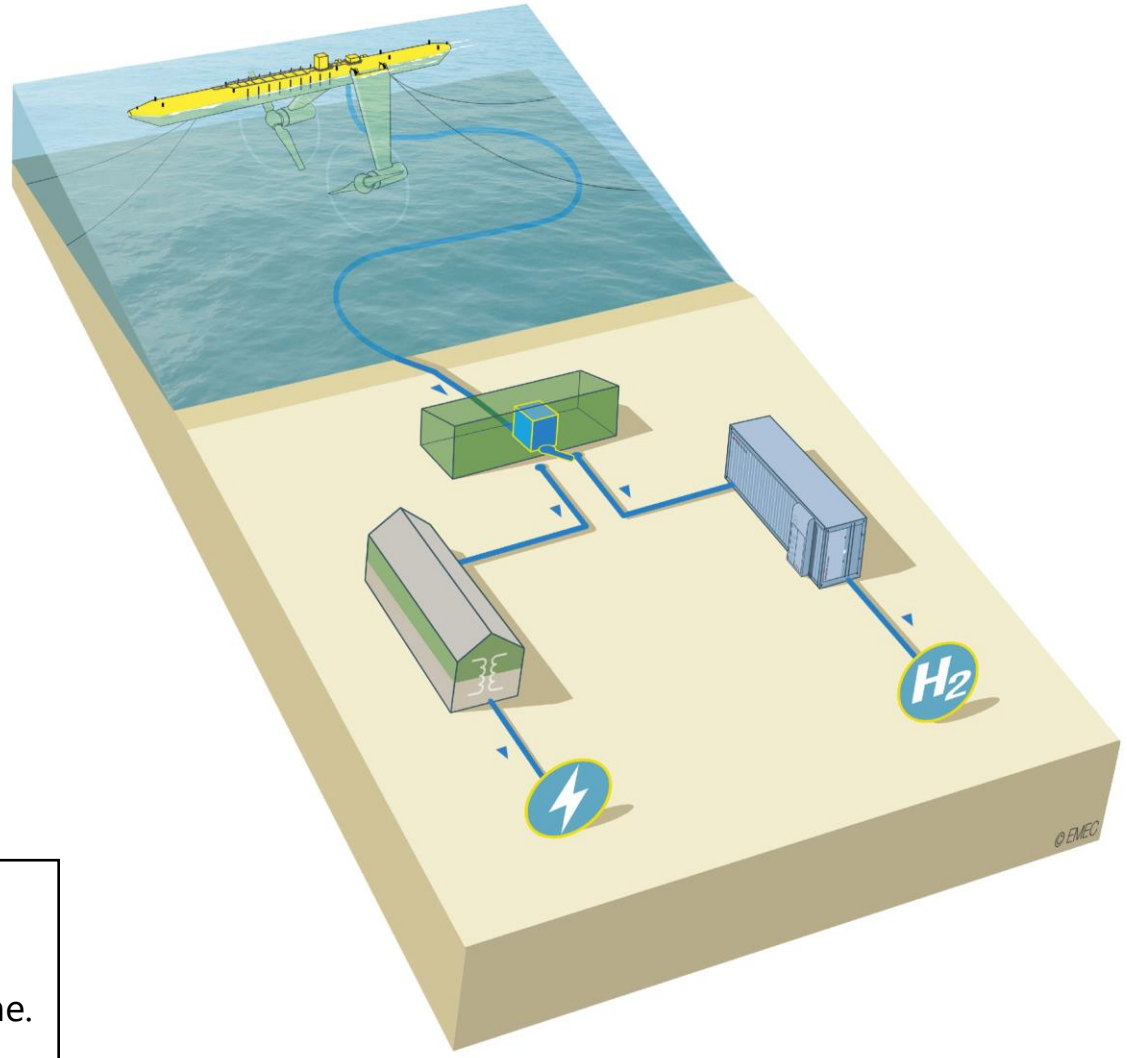
- Consumer Insight and Proposition Design
- Business Model Innovation
- Harnessing Digital and Data
- Test and Demonstration
- Delivering Large Scale Innovation Trials
- Whole System Modelling
- Clean Tech Engineering
- Systems Engineering
- Integrating the Transport and Energy Systems
- Markets, Policy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

We work with Innovate UK

"Integrating Tidal energy into the European Grid (ITEG)" project

Objectives:

- to develop a 2MW **tidal stream energy generation device** and demonstrate it at the EMEC test site in Orkney
- to develop and demonstrate a novel **electrolyser** to generate hydrogen at the EMEC test site, to be used in particular during periods of **grid constraint** limiting electricity export from the site, and to use the hydrogen to fuel local transport and other applications
- to understand the **whole-system impact and value** of the **combined solution** (tidal electricity generation with hydrogen generation, storage and use), and the resultant business case and roadmap for potential widespread deployment



Interreg North-West Europe ITEG
European Regional Development Fund

This project has received funding from the European Regional Development Fund (ERDF) through the Interreg North West Europe programme.

PROJECT INTRODUCTION

WHY?

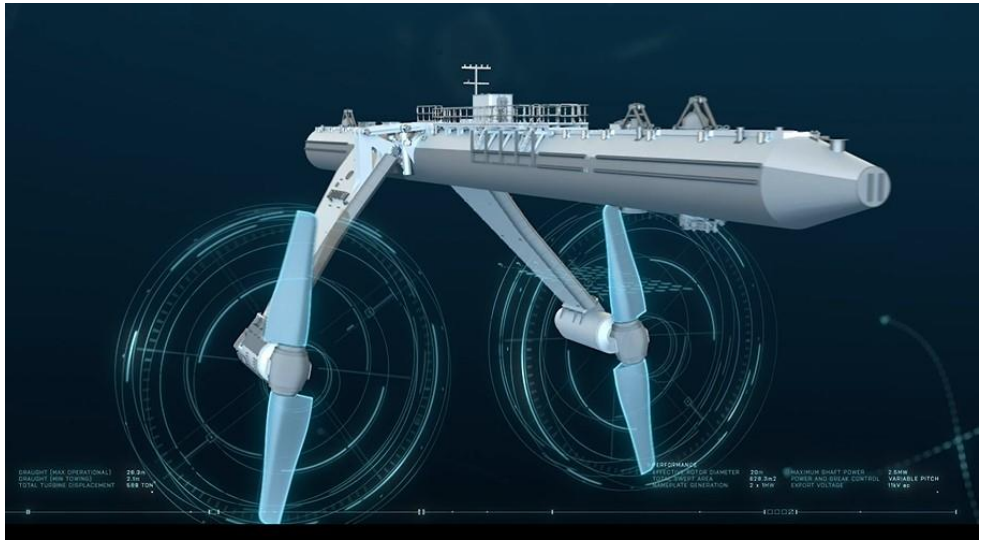
- Understand how best to **overcome network constraints** typical in island and remote communities
- Support roll-out of **proven marine energy solutions**, particularly scale-up of tidal energy
- Support the expansion of **green hydrogen**
- Develop a flexible **Energy Management System** for future commercialisation options
- Gain **risk reduction** experience for future projects
- Use hydrogen production and energy storage to demonstrate options for **future ocean energy markets**
- Build a roadmap for future implementation of **integrated systems** in remote areas

ORBITAL O2 TURBINE

ORBITAL MARINE POWER

CATAPULT Energy Systems

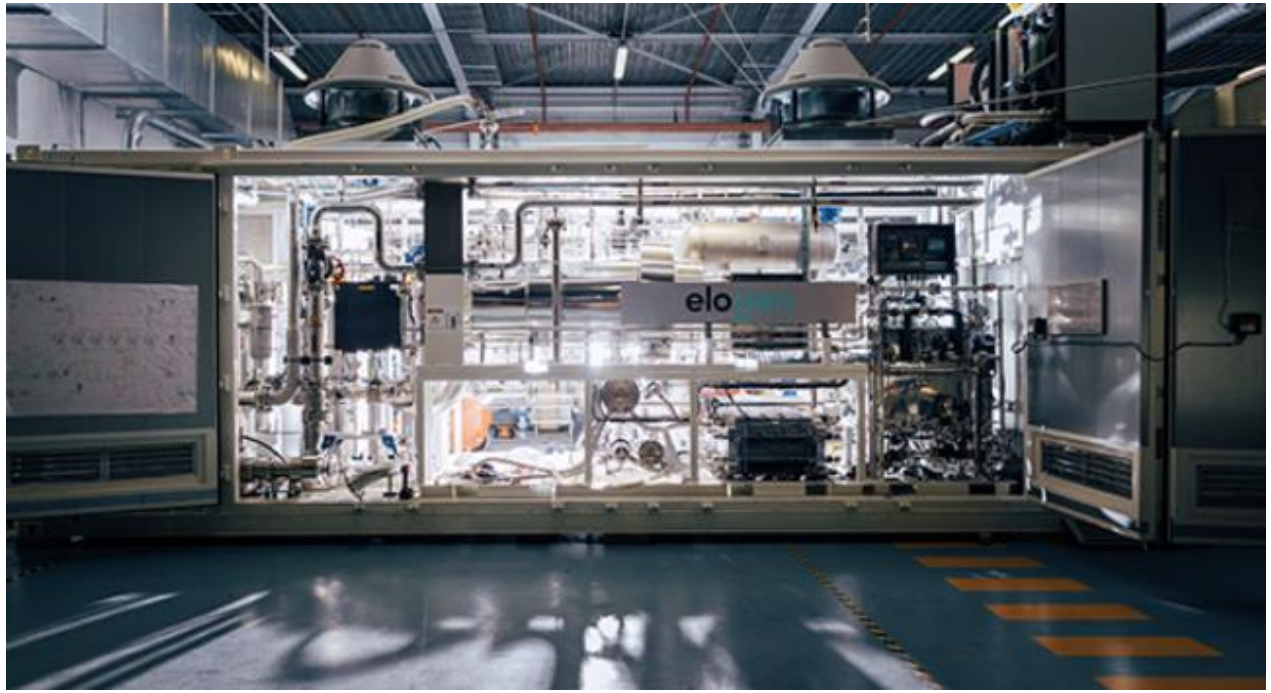
- At 2MW, the **world's most powerful operational tidal turbine**
- 2 x 1MW nacelles, 20m rotor diameter
- Innovative design and engineering
- First pitching blade for floating tidal stream energy
- 'Gullwing' legs allow access for maintenance
- Installation of turbine and moorings by low-cost work vessels
- Servicing by RIBs
- Clean, predictable electricity to meet demand of ~ 2,000 homes
- Operational, **supplying power to grid since summer 2021**



All images courtesy of Orbital Marine Power

ELOGEN ELYTE PEM ELECTROLYSERS

- Produce low-cost hydrogen
- **Flexible hydrogen production**
- **Ramping to match variable power input**
- Nominal Power 0.5 MW
- Maximum Power for short periods 1 MW
- Tested in marine environments
- Unit scheduled for deployment in Orkney, Autumn 2022



All images courtesy of Elogen

EMEC DEMONSTRATION SITE

- Tidal test site at the Fall of Warness in Orkney
- Ideal tidal velocities between islands
- Grid-connected substation and hydrogen production facility at Caldale, on adjacent island of Eday

Image courtesy of EMEC

WHOLE SYSTEM MODELLING

- Energy Systems Catapult has conducted a **detailed modelling study** of the **whole multi-vector energy system** across the Orkney archipelago, to analyse potential routes by which Orkney could **achieve net zero targets at minimum system cost** under a number of scenarios.
- Orkney has many similarities with **island and coastal communities** across north western Europe, and elsewhere.
- The findings are highly informative for such areas, which are often characterised by large tidal and/or wind energy resource potential but **constrained electricity grids**. We have identified potential high-impact targets for European roll-out where this may coincide with significant hydrogen demand.

Orkney archipelago showing analysis areas in ESC study

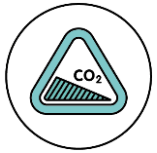
WHAT ROLE CAN TIDAL POWER AND HYDROGEN PLAY IN SYSTEMS SUCH AS ORKNEY?

- Primary energy has the potential to be a **mixture of wind and tidal generation alongside some solar PV,** with the potential to export electricity from Orkney

- **Tidal generation** alongside wind is valuable due to **predictability, diversity, complementary generation profiles, increased resilience and security of supply**

- **Hydrogen** could be used – in varying proportions – in fuel cells, non-domestic buildings and domestic buildings, as well as for maritime purposes, and could potentially be exported if market prices were high enough for Orkney-produced hydrogen to compete

- For non-domestic buildings, **hydrogen** can be important to decarbonise uses that are **hard to switch to electric heat**, such as some industrial processes

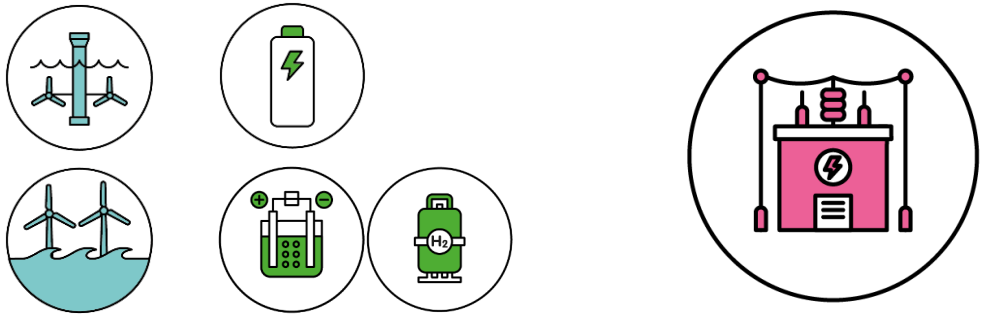


- **Carbon emissions** from the local area can be further reduced using tidal power and hydrogen; it is unlikely that net zero can be achieved except by using hydrogen.

SOLUTIONS TO NETWORK CONSTRAINTS

Problem viewed as Supply-Side only

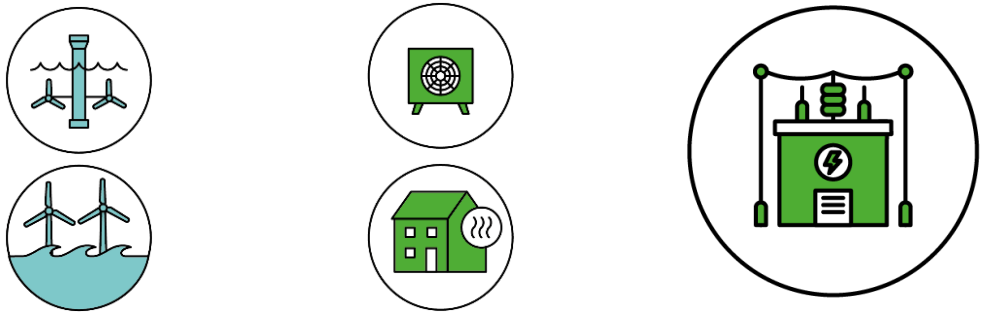
Problem Formulation:
Variable renewables into constrained grid curtails generation.



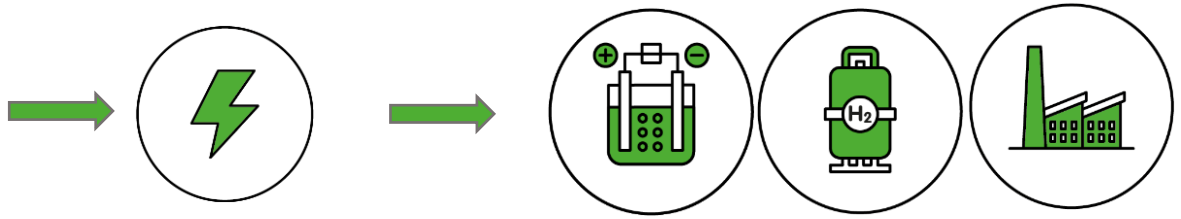
Supply-Side Solution:
- Add electrolysis & storage (elec & H_2) at renewable generation sites.
- Create H_2 demand to use the H_2.
- Need to transport H_2 to the H_2 demand (by road & ferry, or pipeline).

Problem viewed as Whole System

Problem Formulation:
Optimise whole energy system.



Whole-System Solution:
- Increased local elec demand (heat pumps) enables more variable renewables to be used with much less impact of constrained grid.
- H_2 use targeted to achieve optimum system benefit, to decarbonise difficult demands in particular (e.g. industry and some buildings).
- Locate larger-scale electrolysis close to H_2 demand, using released network headroom to transmit elec instead.



HYDROGEN HANDLING AND LOGISTICS IN ARCHIPELAGOS

Key Conclusions of Brief Review:

- Onshore hydrogen distribution systems are relatively straightforward
- Maritime transport of hydrogen between islands much more complex – safety and legislative issues to be considered during system design
- Pipelines can be cost-effective where volumes are larger
- Significant regulatory burden

Recommendations:

- Standardisation of system design and key components
- Strategic planning across the archipelago
- Explore appetite for a joint regulatory body (or approach) across the multiple legislative & regulatory domains involved
- Identification of an 'archipelago hydrogen distribution standards lead'

Orkney ferries, Images courtesy of EMEC

THE CASE FOR UPGRADING THE ORKNEY TRANSMISSION INTERCONNECTOR

SSEN proposed **additional 220MW capacity** connection to Caithness.

- Ofgem has **conditionally approved** it, but **subject to a further 135MW of generation** being commissioned first.
- Research commissioned by Orkney Islands Council (published May 2021[1]) estimated the **benefits to the Orkney economy to be ~£800m** if the wave and tidal industry made us of the interconnector

ESC study shows that, even with solutions outlined, building the electricity **interconnector upgrade unlocks significant potential**, allowing:

- a significant increase in **cost-effective wind and tidal generation** to a level that makes Orkney almost self-sufficient in a decarbonised future, only needing to import energy on limited occasions through the year
- **export** of significant quantities of both **wind and tidal generation** with possibilities for **hydrogen** export if markets can be accessed at a competitive price

Investment in the electricity interconnector upgrade, regardless of other factors, would therefore be a **"no-regrets" decision** which could be implemented immediately without pre-conditions, and there is a **clear case for change** in the present regulatory constraints.

Proposed interconnector, SSEN Sept 2018

1 https://www.pressandjournal.co.uk/fp/news/highlands-islands/3174442/power-link-between-orkney-and-the-mainland-could-be-worth-800-a-year-to-every-islander/

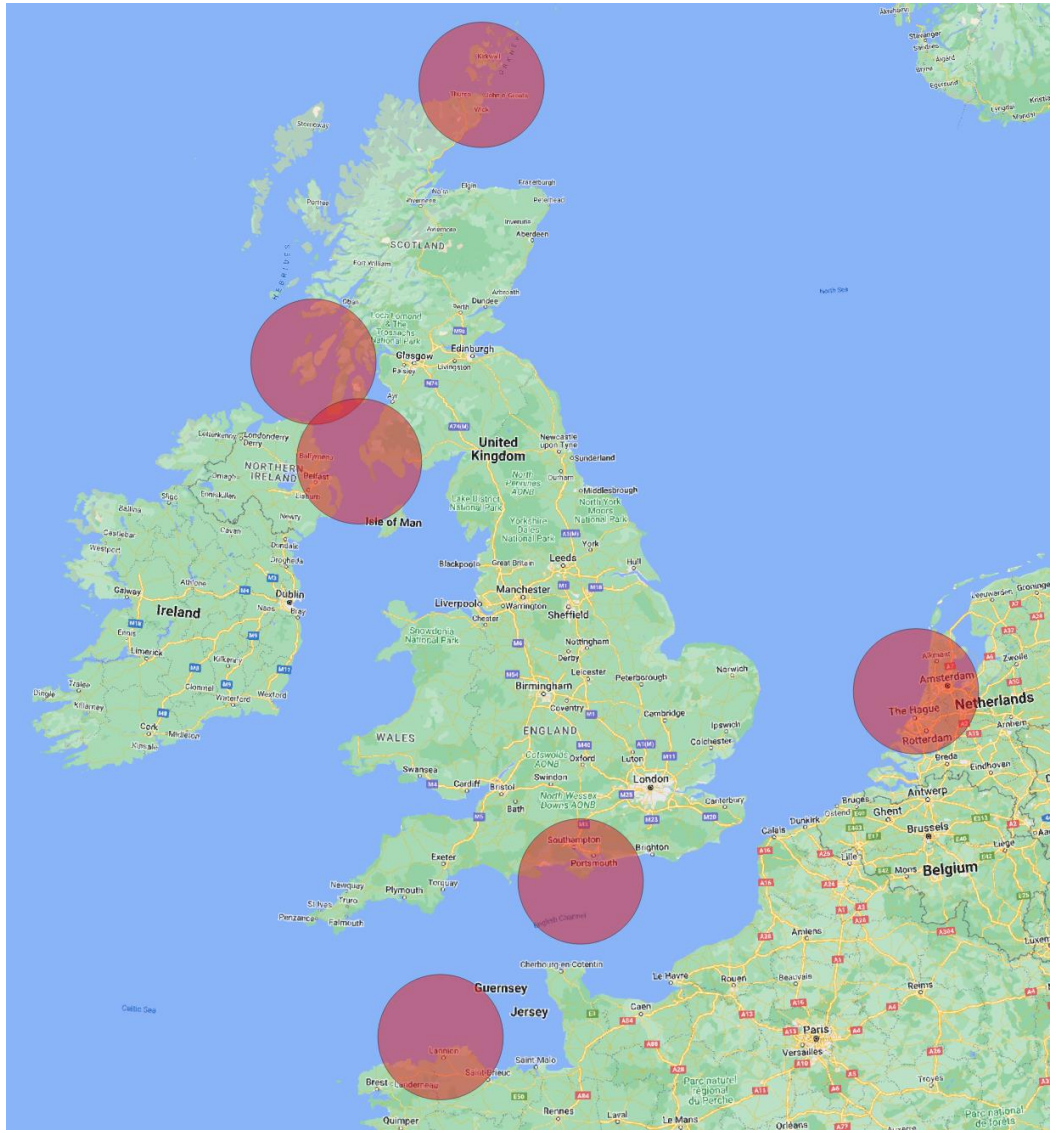
SWEET SPOTS FOR WIDER DEPLOYMENT OF COMBINED SOLUTION

Tidal Stream Capacity (UK):

- Tidal stream generation and hydrogen can each be rolled out in considerable quantity across Europe.
- Potential tidal stream capacity in UK alone estimated (by others) to be **10-15GW**.

Potential Sweet Spots (North West Europe):

- Potential to gain **maximum advantage** from combining these technologies, where **three factors coincide**:
  1. practically accessible **tidal stream resources**
  2. **constraints on exporting power** from the site
  3. potential **demand for the hydrogen** produced
- These sweet-spots represent **approx 6GW** of tidal stream capacity.
- They represent potential **early deployment targets**.



Sweet-spots for maximum benefit from tidal & hydrogen roll-out across North West Europe (with likely hydrogen demand and grid constraints)

OUR MISSION

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

Visit Energy Systems Catapult at STAND M66 in the INNOVATION ZONE along with ORE and CSA CATAPULTS

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ITEG PRESENTATIONS:

- **Thur 12th May, 11:30am**
  Offshore Wind / Marine Energy Theatre
  (location ORK55 in the Highlands & Islands Enterprise Zone)

- **Thur 12th May, 12:45pm**
  Hydrogen & Energy Storage Theatre
  (location Q20 next to the Hydrogen Tech Showcase)

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