HERIOT WATT UNIVERSITY

Heriot-Watt University
International Centre for Island Technology (ICIT):
Integration of Tidal Energy into Island Energy Systems

November 2024

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LEADERS IN IDEAS AND SOLUTIONS

- ICIT
- Since 1989
- New campus 2019
- *ORIC* - Orkney Research & Innovation Campus

LEADERS IN IDEAS AND SOLUTIONS

Island Economy

Farming

Fishing

Oil terminal

Tourism

Renewable Energy

OREF
ORKNEY RENEWABLE ENERGY FORUM

Teaching

Masters Level only

- MSc International Marine Science
- MSc Renewable and Sustainable Energy Transition
- MSc Marine Renewable Energy

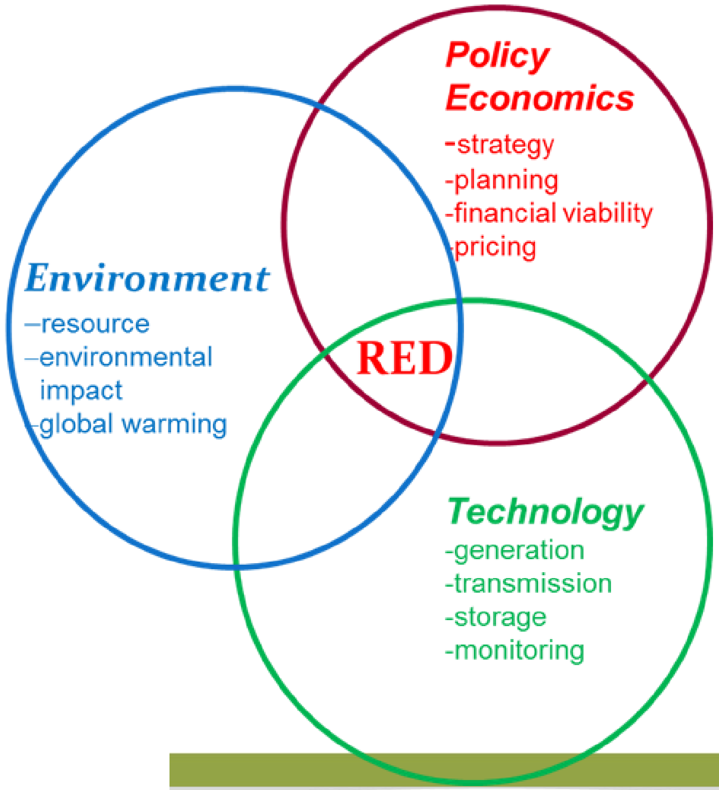
Host Field Courses including large gathering in October of each year and a Marine Survey course (A11VY)

Some IMS courses taught from Edinburgh and Tropical Coral Reefs (A11CR) taught in the field in Malaysia

“Go Global”

Postgraduate Teaching in Energy

- MSc Renewable and Sustainable Energy Transition
- MSc Marine Renewable Energy



HERIOT WATT UNIVERSITY

School of Energy, Geoscience, Infrastructure and Society

Orkney: an Energy Evolution

Generation

Large Scale

Household

Testing R&D

Constraint

Energy Systems

ReFLEX ORKNEY

ICNZ Islands Centre for Net Zero

The Project www.icnz.org

ICNZ
Islands Centre for Net Zero

The Islands Centre for Net Zero is a ten-year project working to support Orkney, Shetland and the Outer Hebrides on their path to net zero emissions.

The project is led by EMEC and works across the three island groups through its partners who cover multiple sectors Aquatera, Community Energy Scotland, Heriot-Watt University and the three Islands' Councils.

EMEC
THE EUROPEAN MARINE ENERGY CENTRE LTD

aquatera
environmental services and products

Community Energy Scotland
Cumhachd Coimhearsnachd na h-Alba
Empowering Communities

ORKNEY
ISLANDS COUNCIL

SHETLAND
ISLANDS COUNCIL

Comhairle nan Eilean Siar

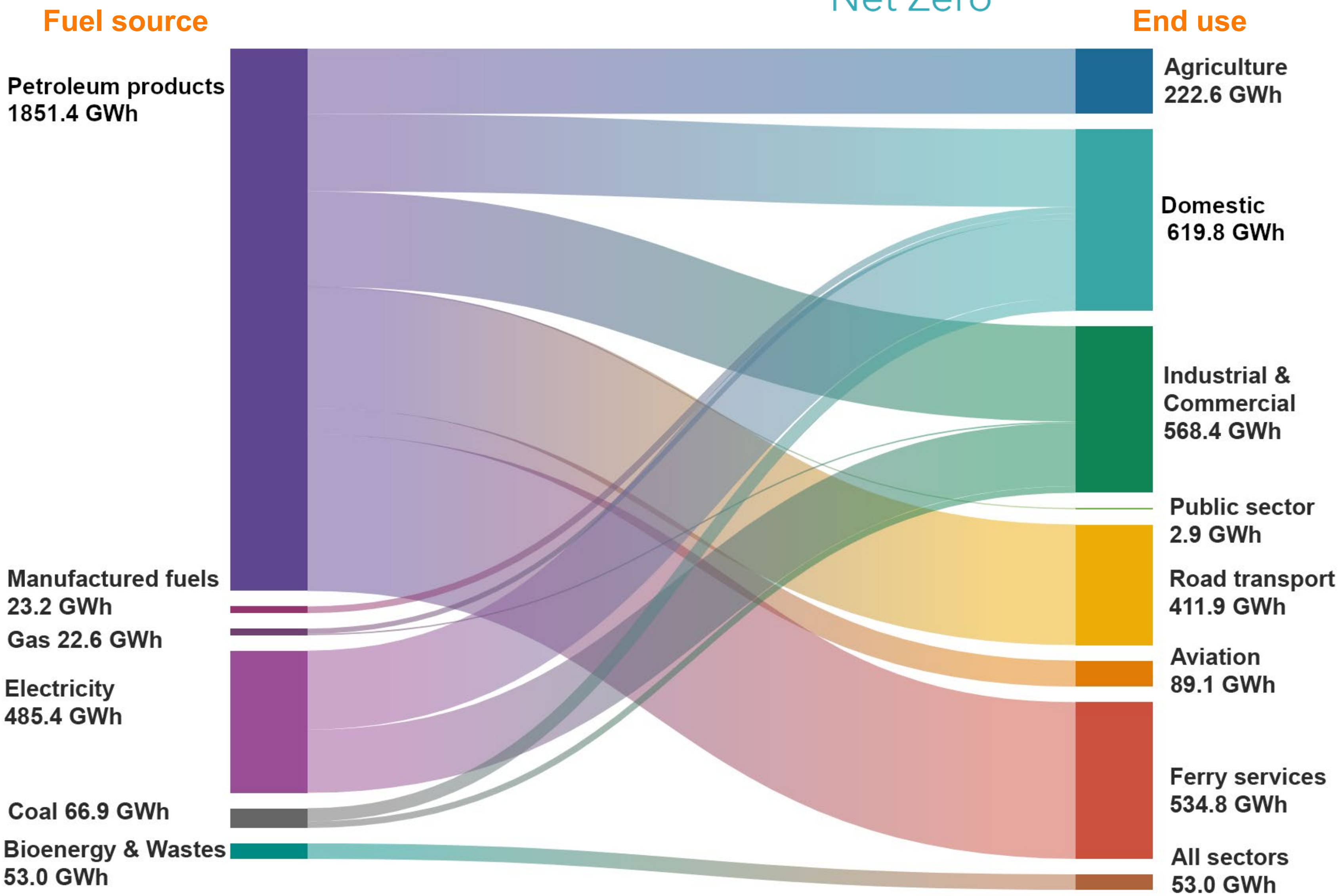
HERIOT WATT
UNIVERSITY

UK Government

Scottish Government
Riaghaltas na h-Alba
gov.scot

The challenge

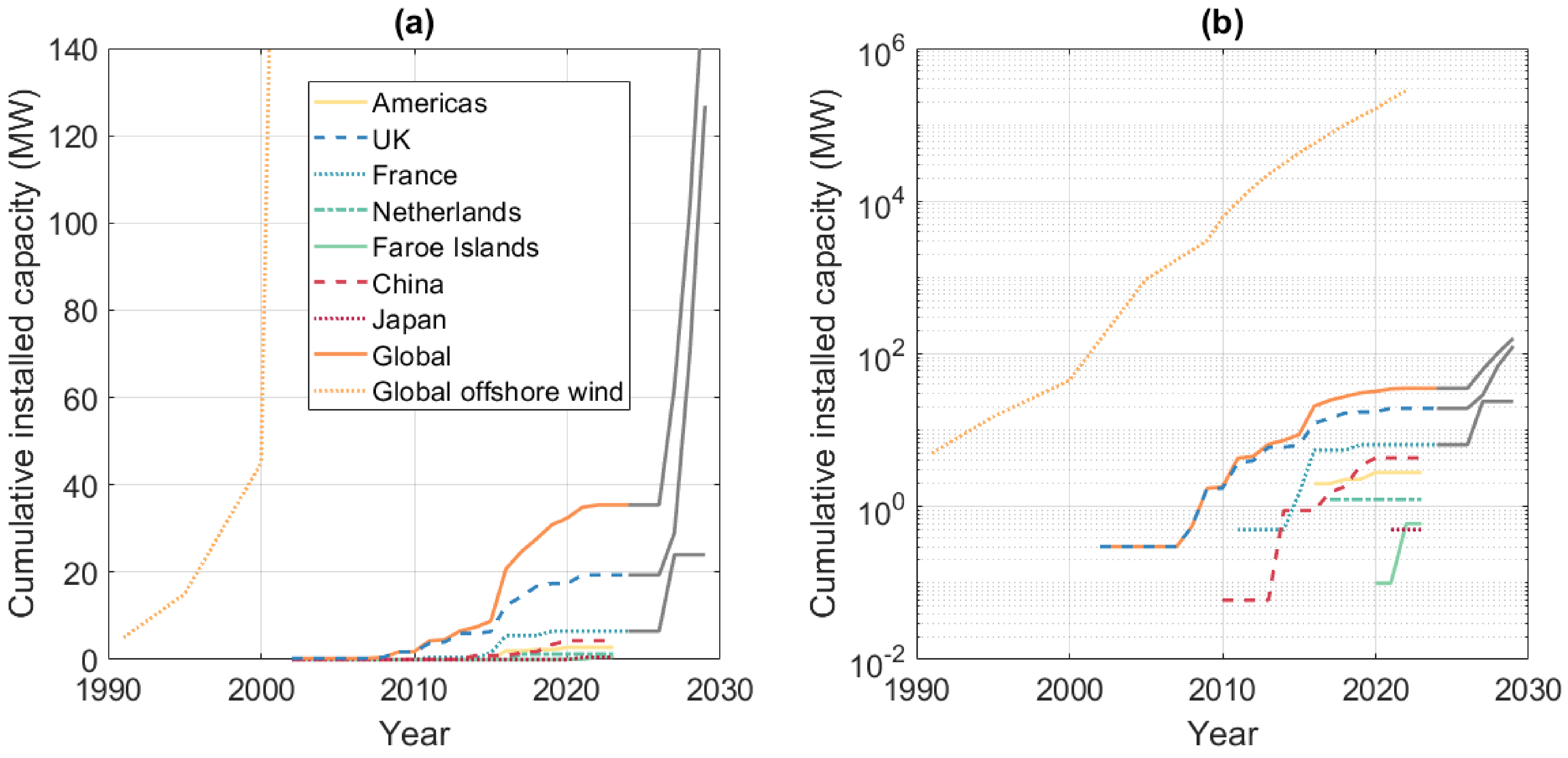
- Lifeline transport links account for 41% of total demand
- Largely off-gas grid; main heating solutions expensive, inefficient and carbon-intensive
- **Fossil fuels account for at least 78% of the islands' energy consumption.**



Sources:

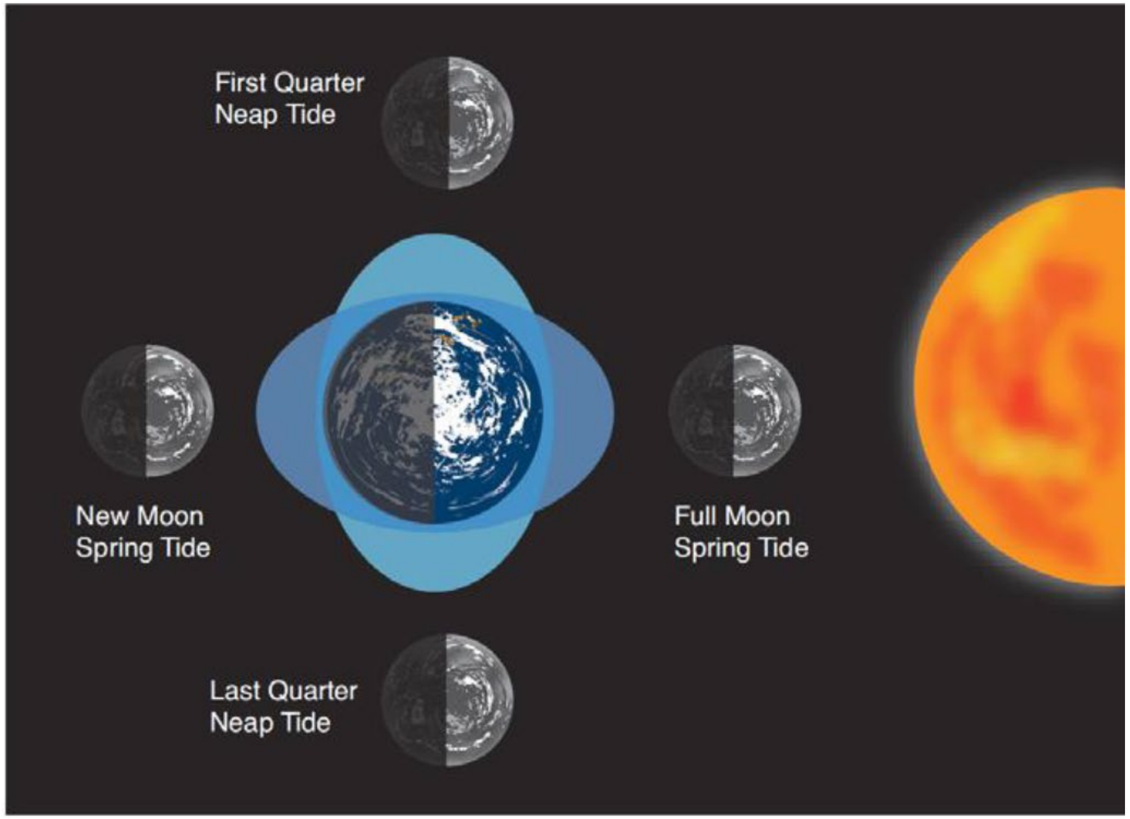
- Estimates of total final energy consumption for 2017 across Orkney, Shetland and Outer Hebrides , supplemented by marine and aviation data drawn from individual council surveys, and public databases (e.g. CAA) https://engrxiv.org/preprint/view/4078/7150

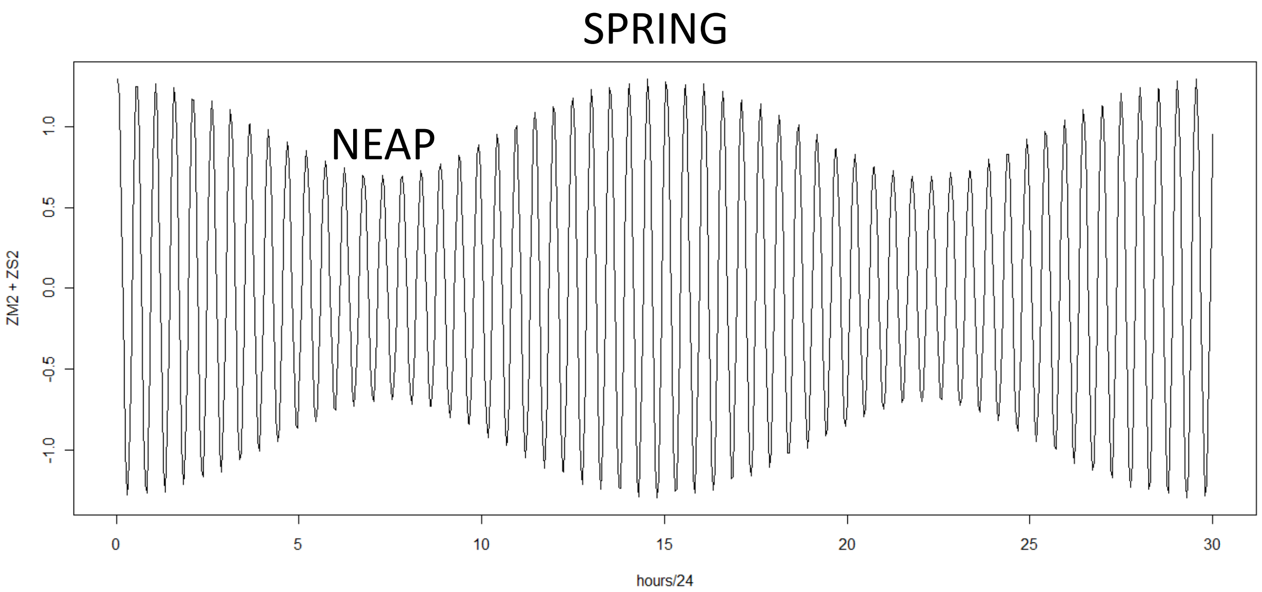
"A review of global tidal stream energy resources"



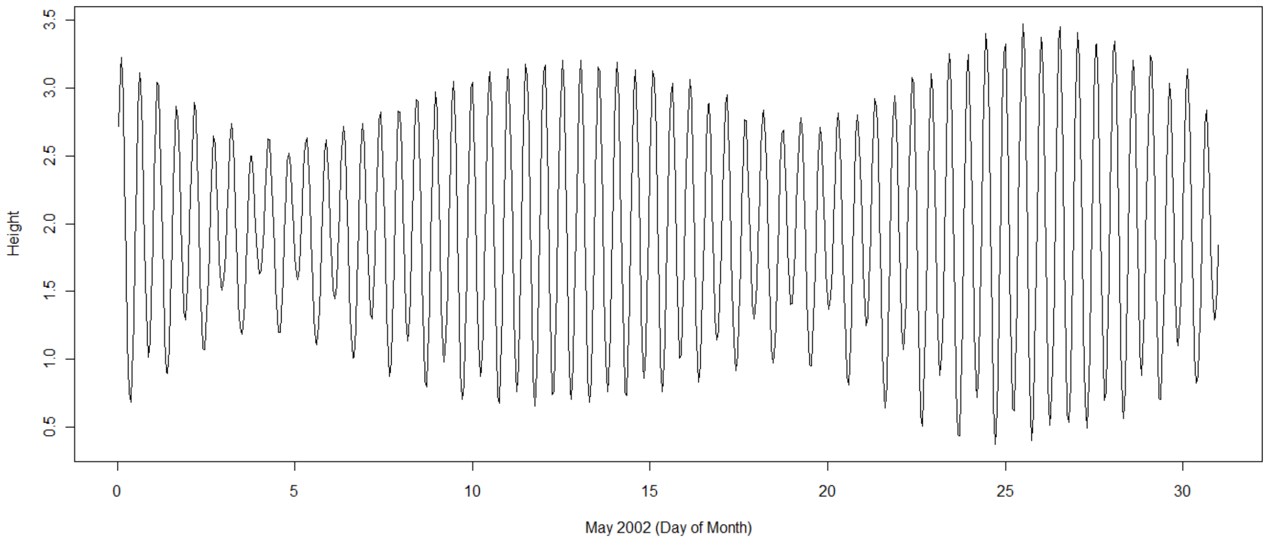
Cumulative installed capacity of tidal stream projects (and offshore wind)

Predictable and Cyclical Tides





Simulated tide using the M2 and S2 tidal constituents only



Data from Wick tidal gauge

A case for tidal (stream) energy

- Tidal energy is relatively predictable
- Tidal stream energy capture can be substantial and financially viable in the right locations

A proposition:

By making a substantial and predictable contribution to the total energy supply, tidal stream energy can add diversity and resilience to an electricity grid, with an appropriate design.

What would that design look like?

“Contribution Of Tidal Energy To An Integrated Island Energy System”

Almoghayer, Mohammed Alaa

A PhD Project sponsored by Energy Technology Partnership, Aquatera and Heriot-Watt University

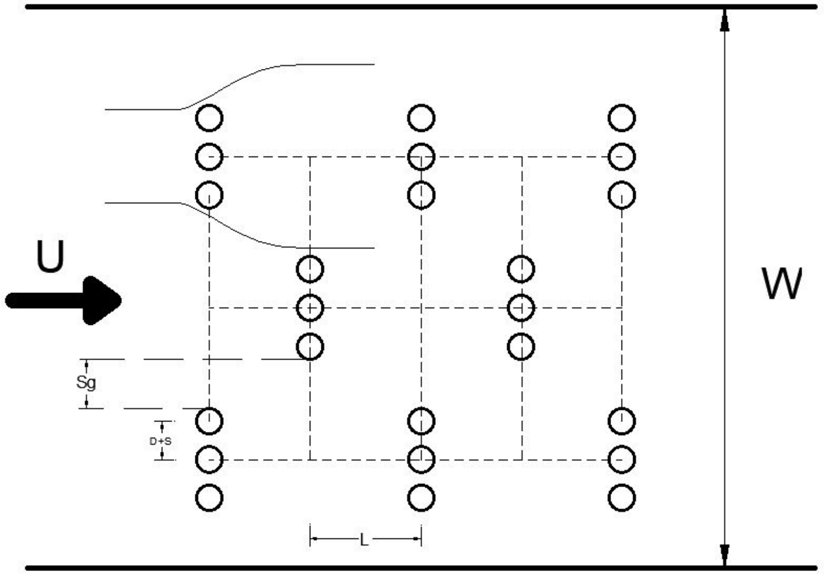
“The study will design a tidal array for Orkney waters, testing it against a wide range of constraints from engineering efficiency to market suitability”

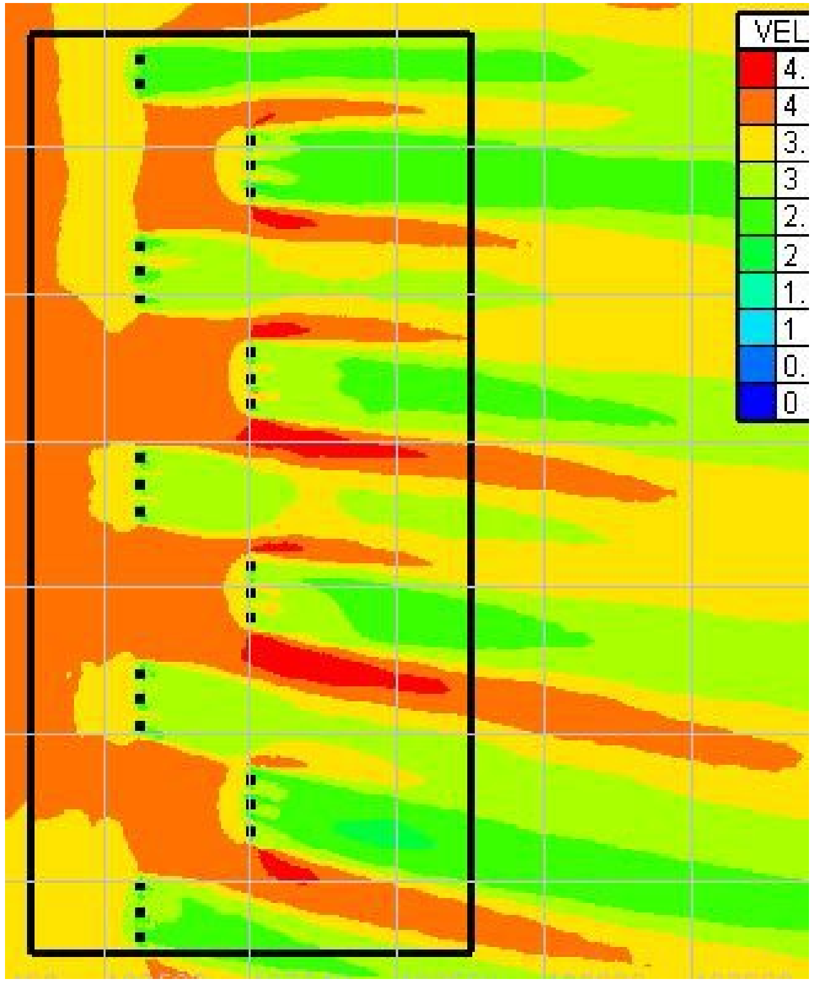
https://www.sciencedirect.com/science/article/pii/S0360544221027961

Tidal Stream Energy & Arrays.

Novel Design: Staggered Sub-Arrays efficiently capture power

Almoghayer and Woolf, 2019

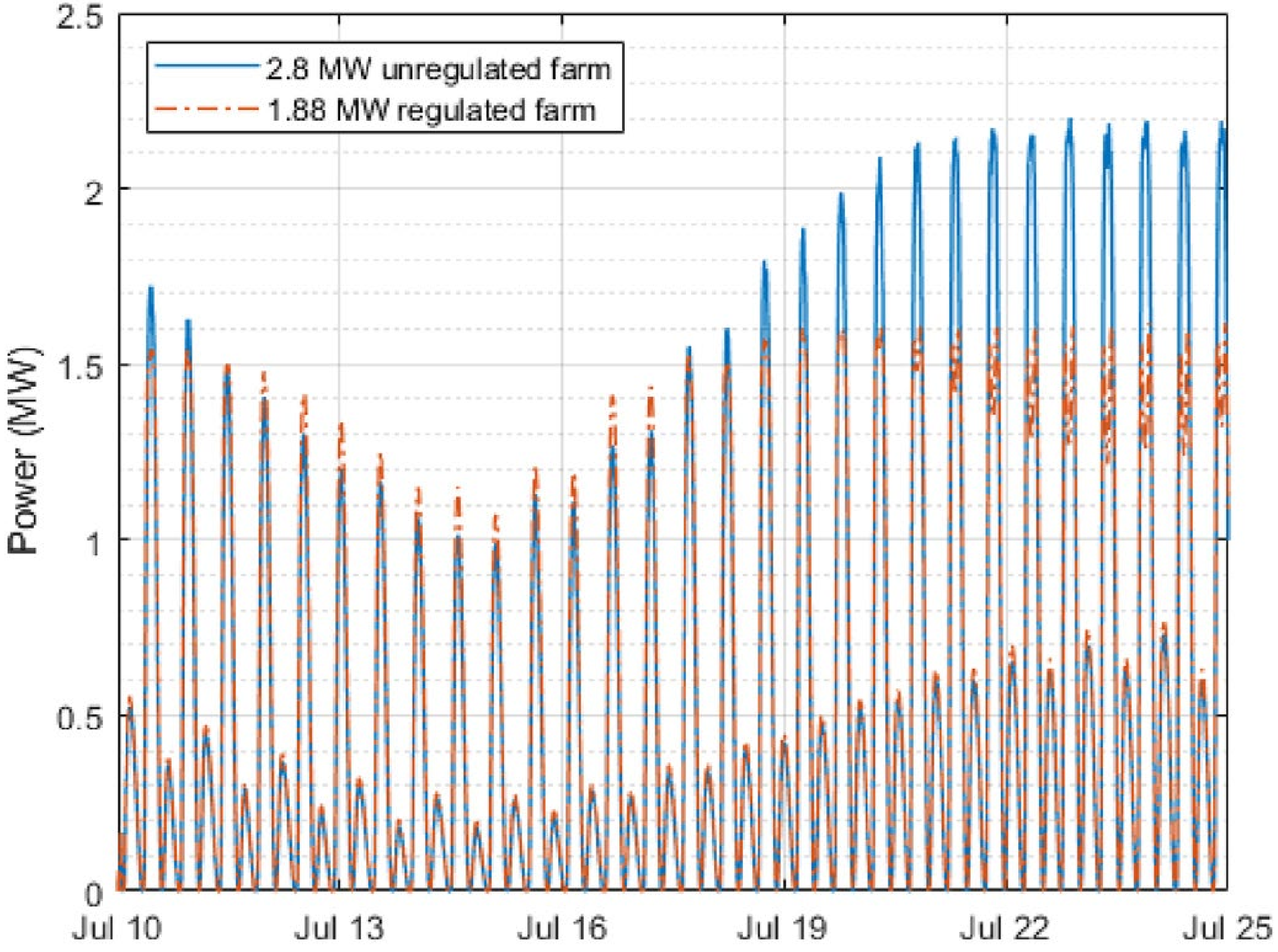




What are the main costs and how do they scale?

Item	Share	Sub-group	Unit
Device	41%	Rotor	£/m
		PTO	£/kW
		Electrical System	£/kW
		Mechanical System	£/kg
		Structure	£/kg
Foundation	26%		£/kg
Cable	13%		£/m
Installation	15%		£ (site-specific)
Grid connection	5%		£/kW

Vazquez A, Iglesias G. Capital costs in tidal stream energy projects - a spatial approach. Energy 2016;107:215e26. https://doi.org/10.1016/j.energy.2016.03.123.
Segura E, Morales R, Somolinos JA. Cost assessment methodology and economic viability of tidal energy projects. Energies nov 2017;10(11). https://doi.org/10.3390/en10111806.



Tidal Stream Energy in an Energy System. Strategy

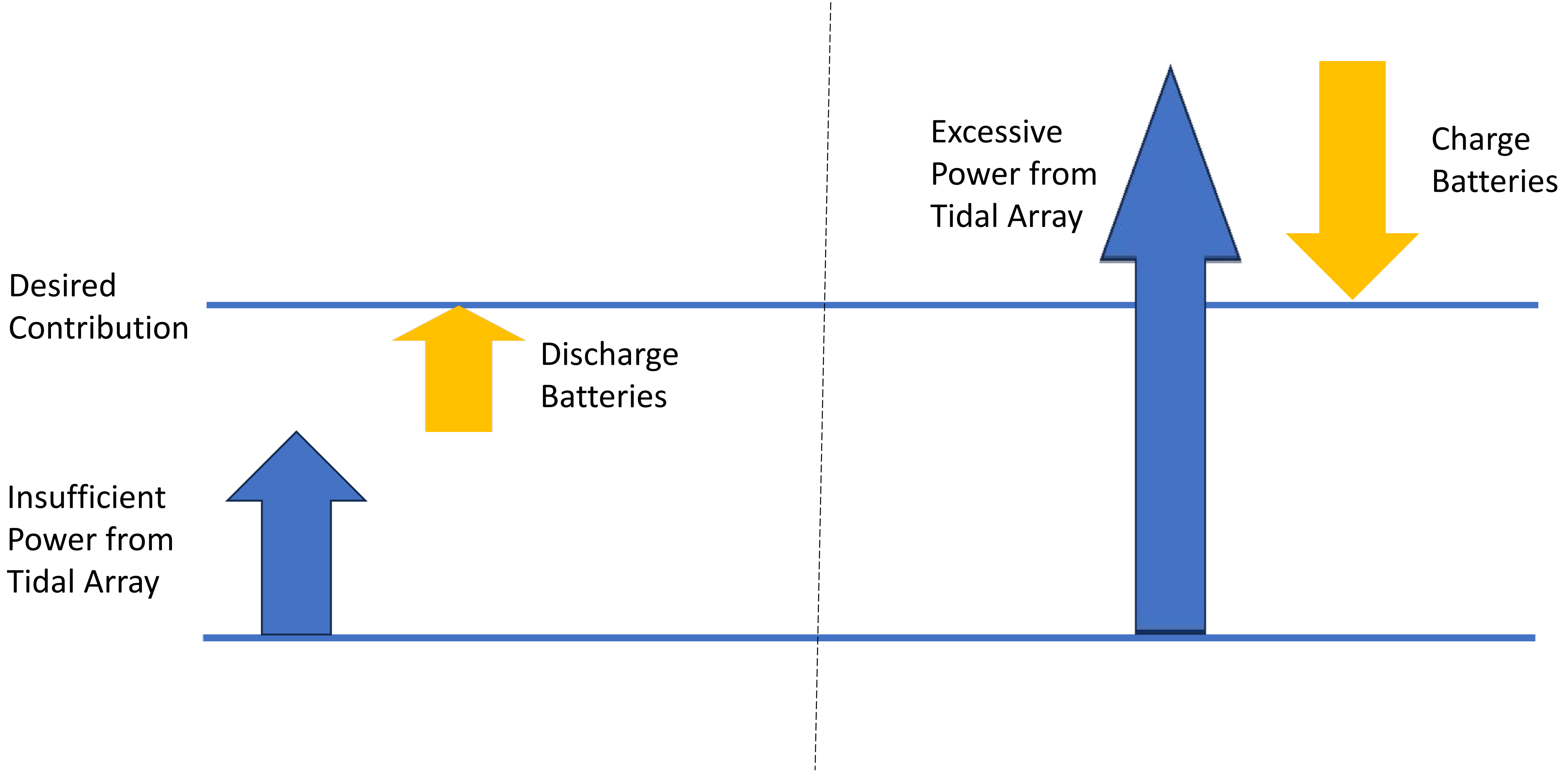
Stage 1. Regulation in the context of stabilising energy systems

Less is more?

Item	Unit	Reference cost	Saving(+)/Loss(-)
Annual Energy	MWh		-4.29%
Pre-deployment	£/kW	130	+33%
Construction	£/kW	4,200	+33%
Infrastructure	£	7,400,000	Unknown
Fixed O&M	£/MW/y	91,400	+33%
Variable O&M	£/MWh	7	+4.29%
Insurance	£/MWh/y	2,500	+4.29%
Connection charges	£/MW/y	60,400	+33%

Table 9 from Almoghayer, Woolf, Kerr and Davies (2022)
https://www.sciencedirect.com/science/article/pii/S0360544221027961

Tidal Stream Energy in an Energy System. Strategy Stage 2. Integration



Summary

- Tidal Stream Energy will not compete on scale with PV or Wind
- It can be a useful element of diversity and resilience
- Within an energy system, targeting maximum yield is probably a mistake
- Lower costs, better array efficiency and system efficiencies are practical by
  - (1) Regulation
  - (2) Integration

Questions?

Major themes

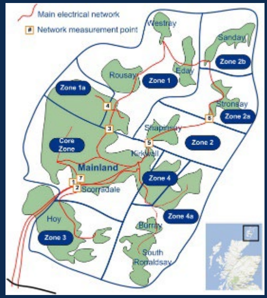
ICNZ
Islands Centre for Net Zero

Residential heating & homes

Hydrogen use cases

Personal transport

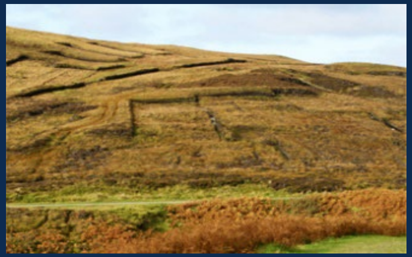
Tourism transport



Electricity systems & locational pricing

Industrial heating

Oil & gas transition



Carbon sequestration

The ‘Toolbox’

ICNZ
Islands Centre for Net Zero

Applied research

Identify realistic ways to shift from or reduce fossil fuels through the **Transition Labs**

Community resources

Supporting community-led projects through the **Islands Community Action Network**

Funding streams

Resource to find and secure grants and investment for projects through the **Accelerator**

Local data capabilities

Data hosting, mapping and visualising through the **Data Exchange**

Testing and demonstration

Overcoming technical, behavioural, regulatory challenges through **Demonstration**

Challenges Presented by Offshore Wind

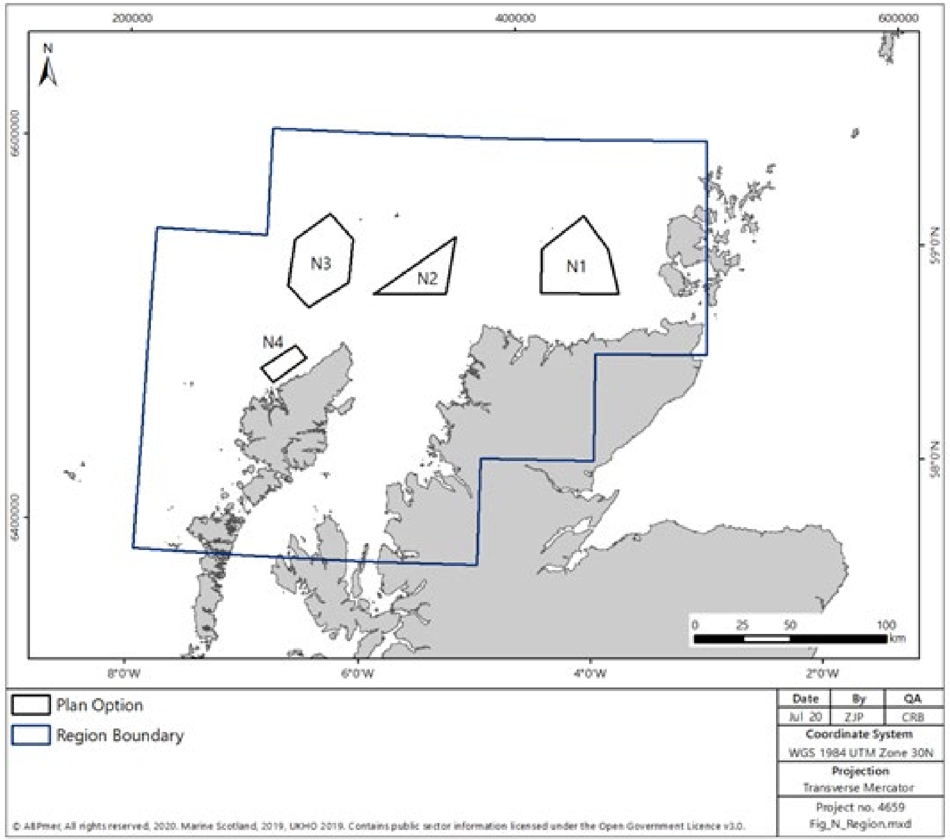
Crown Estate Scotland awarded rights to areas of the seabed for 4 windfarm projects in the NW Scottish waters (“ScotWind”), in conditions dictated by exposure to Atlantic storms and waves.

The climatological parameters in the area represent opportunities to harness the wind resources, pushing for the growth of decarbonized electricity generation in this mature sector.

Plan Option	Area (sq km)	Capacity (MW)	Foundation
N1	657	2000	Fixed
N2	390	1500	Floating
N3	103	495	Mixed
N4	161	840	Fixed

The harsh climate conditions have an impact on the complexity of infrastructure, on the turbine design, performance and deterioration, and on the operation and maintenance (O&M) of the developments, resulting in higher CAPEX and OPEX

ScotWind plan options off NW Scotland



Source: Scottish Government, 2020. Offshore Wind in Scottish Waters.

Through a critical review of the existing literature and the analysis of the metocean data, this study aims to assist developers to make informed decision on the O&M practices, considering the weather-related risk parameters.

SITE ACCESSIBILITY FOR MARINE OPERATIONS