

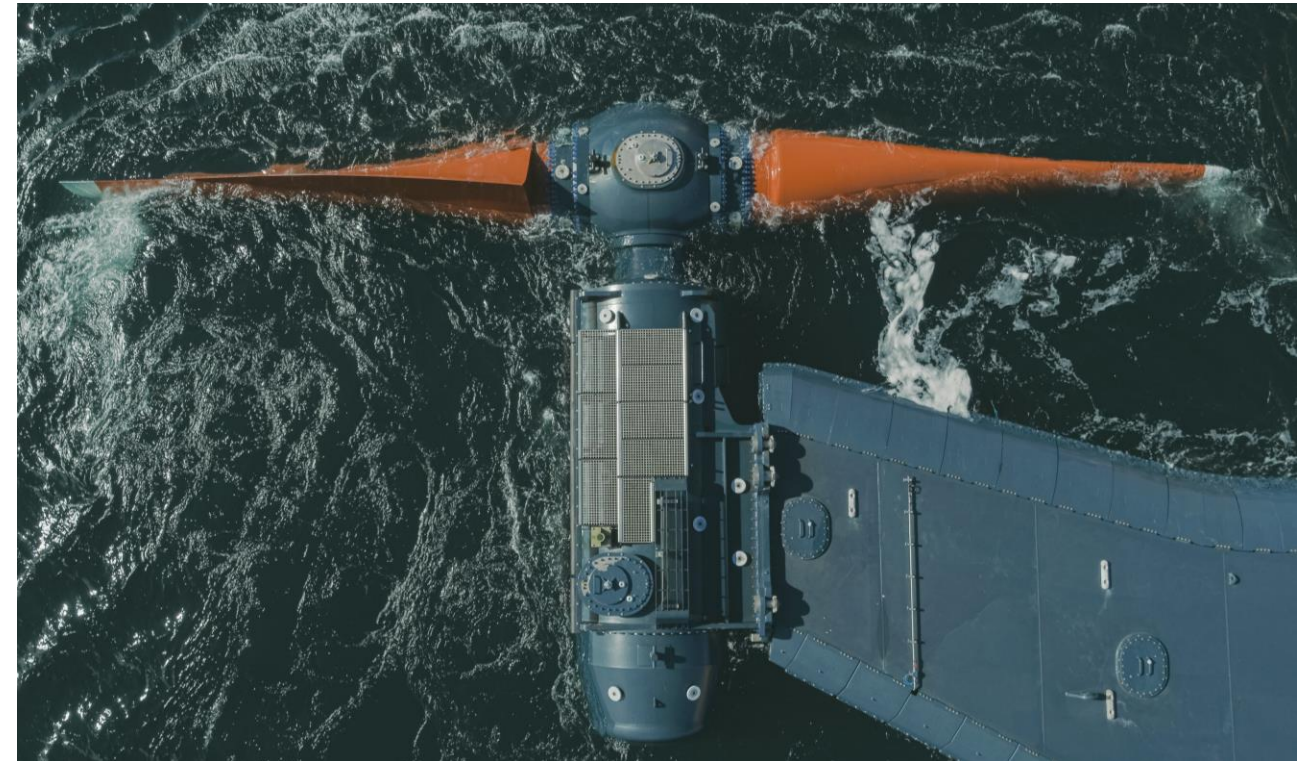
Alternative offtake routes for tidal stream energy

Tidal potential

The potential of tidal stream energy

The UK has the opportunity to build on world leadership in tidal stream energy, enhancing net zero efforts, improving energy security and generating jobs across the country.

- Tidal stream energy is a significant, **predictable renewable resource** > [*The UK has over 11 gigawatts \(GW\) of potential tidal stream capacity.*](#)
- Tidal stream can support **energy security** by reducing the requirement for gas to meet peak demand> [*Deployment of 6 GW of tidal stream, alongside 6 GW of wave energy, could reduce energy system costs by £1bn per annum.*](#)
- Through economies of scale and volume, learning by doing, and technology innovation, tidal stream will follow a similar **cost-reduction pathway** to solar and wind > [*The cost is forecast to fall to £50 per Megawatt hour \(MWh\) by 2050.*](#)
- Support for tidal stream energy will create **green growth** in coastal communities and across the UK > [*Tidal stream projects are being delivered with over 80% UK supply chain spend, compared to ~50% in offshore wind.*](#)
- **UK supply chain** content can be embedded not only in UK but **global** tidal stream deployments, with over 100 GW of deployment potential > [*By securing the export market tidal stream could add £17bn gross value added \(GVA\) to the UK economy.*](#)



For further information see: [Marine Energy Council - tidal stream energy](#)

Background

Crown Estate Scotland, Scottish Enterprise and Highlands and Islands Enterprise commissioned the European Marine Energy Centre (EMEC) and Offshore Renewable Energy Catapult to undertake a study looking at alternative offtake routes for tidal stream energy across Scotland and to begin considering the timelines and challenges associated with these.

Marine energy ambitions

- The UK Marine Energy Council is proposing a 1 GW by 2035 tidal stream deployment target. Recommended ambitions for Scotland are: 200 MW by 2030 and 700 MW by 2035.
- Over 130 MW of tidal stream projects are due to become operational by 2029 in the UK; 82 MW of which are planned to be deployed in Scotland.



The challenge

- **Market support:** while the Contracts for Difference (CfD) scheme has provided ringfenced revenue support for tidal stream energy creating a pipeline of projects, the capacity being unlocked on an annual basis will be insufficient to reach 1 GW by 2035.
- **Consenting:** even small projects require significant time and resource commitments, with tidal projects less than 50 MW requiring similar consenting to multi-GW offshore wind projects.
- **Grid:** the majority of UKs renewable resources are in Scotland; the majority of energy demand is further south. Recent offshore wind projects are facing >10-year connection delays. Ofgem network charging arrangements (1992) favour South Coast developments.

Project scope

Alternative offtake

- Due to grid constraints, and as part of the ongoing review of leasing arrangements for tidal energy, there is a need to consider alternative uses for electricity generated (alternative offtake).
- An offtake agreement enables a buyer to purchase a specified quantity of energy, at predetermined prices over a set period.
- There are several offtake routes being considered by the tidal sector including: electrolytic hydrogen production, community embedded generation, and power for local small-scale industrial demands such as whisky distilleries.
- This report will be used to inform future leasing design, evidence deliverability of industry-set targets and identify potential approaches to resolving deliverability constraints.

Approach

1. Assessment of tidal locations, potential offtake industries, and current grid connectivity
2. Stakeholder engagement via interviews and focus groups
3. Business model identification and evaluation
4. Roadmap

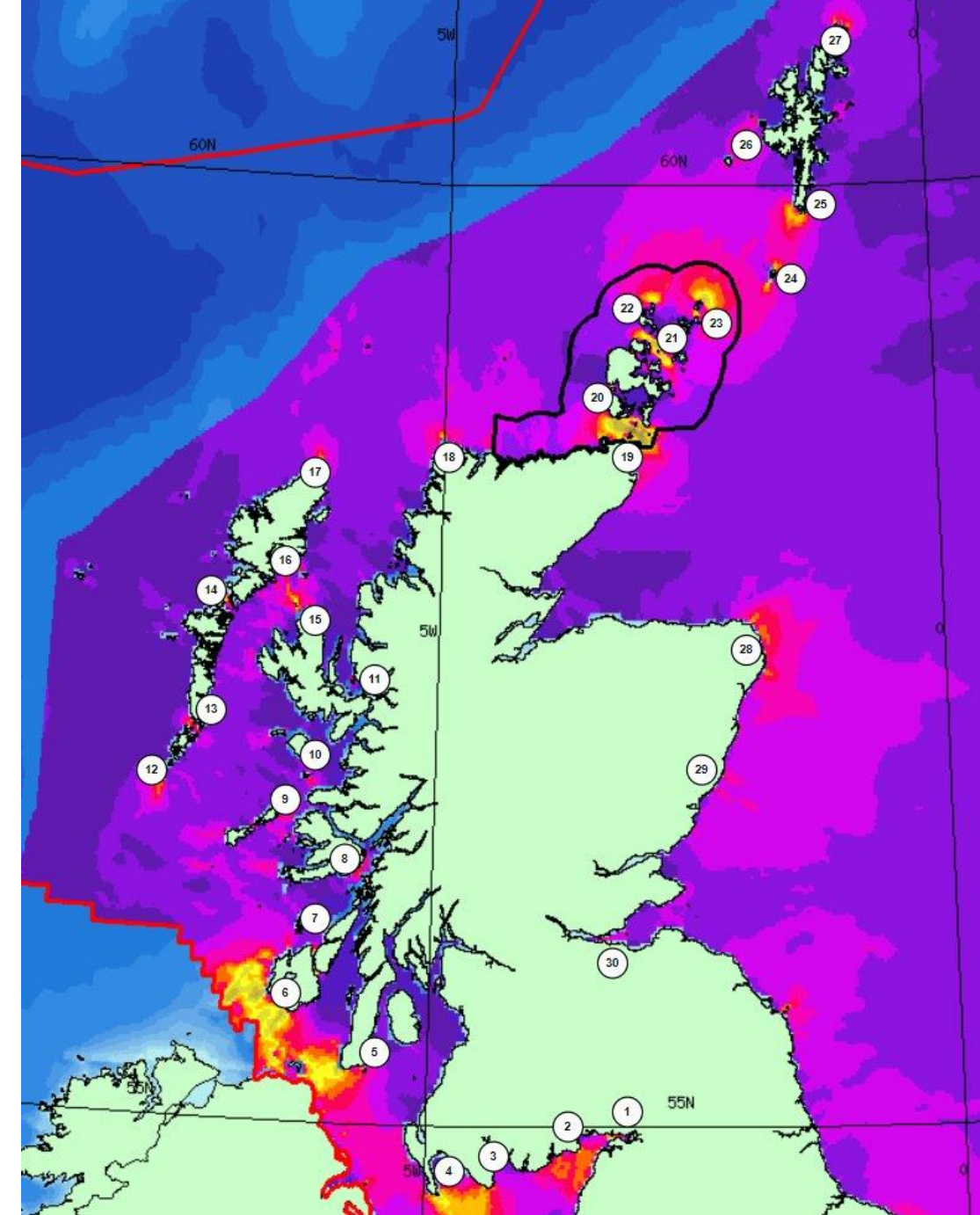


1. Assessment: tidal locations and potential offtake industries

30 locations of tidal stream resource were identified:

#	Name	#	Name
1	Annan	16	Sound of Shiant
2	Southernness / Solway Firth	17	Butt of Lewis
3	Burrow Head	18	Cape Wrath
4	Mull of Galloway	19	Pentland Firth
5	Mull of Kintyre	20	Sound of Hoy
6	Islay	21	Fall of Warness
7	Jura / Colonsay	22	Papa Westray
8	Firth of Lorn	23	North Ronaldsay
9	Coll / Tiree	24	Fair Isle
10	Small Isles	25	Sumburgh Head / South Shetland
11	Inner Sound	26	Foula / West Shetland
12	Barra Head	27	Unst / North Shetland
13	Eriskay / South Uist	28	Fraserburgh / Rattray Head
14	North Uist	29	Inverbervie
15	North Skye & Fladda Chuain	30	Firth of Forth

20 offtake industries were identified close enough to be potential end users.



2. Stakeholder engagement

Methodology

A stakeholder engagement exercise was conducted with geographical representation across **key tidal regions** (shown in green on the adjacent map) to understand the opportunities and barriers currently perceived with tidal stream generation and the alternative offtake model.

Main opportunities:

- Tidal stream predictability - a more secure and lower carbon grid.
- Reduced reliance on grid availability and subsea cables.
- Local employment and community benefits in coastal communities.

Main barriers:

- Upfront project development costs and lengthy consenting timescales.
- Current cost of technology and cables combined with the risk of new technology reliability.
- Financial exposure of being reliant on a single customer for the generator and a single supplier as the offtake party.

Interviews:

- Tidal developers
- Hydrogen and industry users

Sectoral focus groups:

- Community groups
- Local authorities
- Ports and harbours




3a. Business model evaluation

Potential offtake business models

- Across the 30 locations of tidal stream resource around Scotland, 20 offtake industries were identified close enough to be potential end users.
- The most common industries were maritime, crofting and farming, tourism, aquaculture, aviation and distilleries.
- Following stakeholder feedback, the six most promising offtake opportunities were then further evaluated based on:
 - the ability for energy supply to match demand;
 - economic viability;
 - impact on deployment ambitions (the scale of the opportunity).

Scenarios chosen for detailed evaluation

- Replacement of fossil fuel generators** is considered to be financially viable now (LCOE of diesel generation is £250 - £600/MWh), though detailed analysis of local tidal resources is needed to confirm suitability for tidal stream generation.
- Potential hydrogen offtake** applications for local industry offer a greater impact on deployment targets, and the largest opportunity identified for the alternative offtake model is the **production of synthetic fuels from green hydrogen**.
- There is considerable interest in **Community projects**, but the unproven nature of tidal technology is a key barrier to adoption.



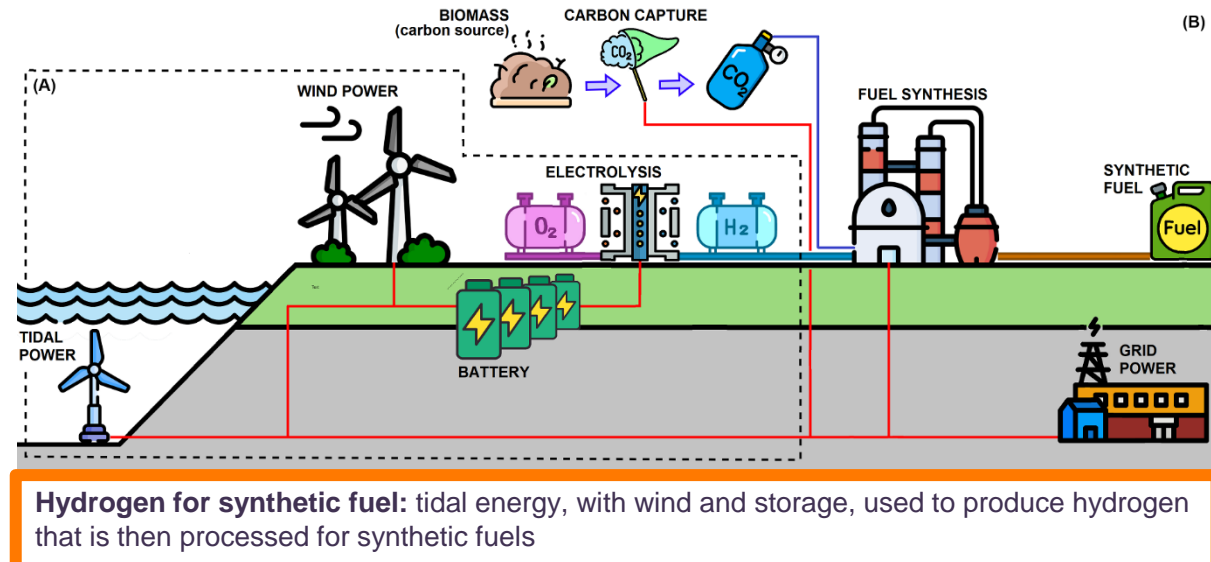
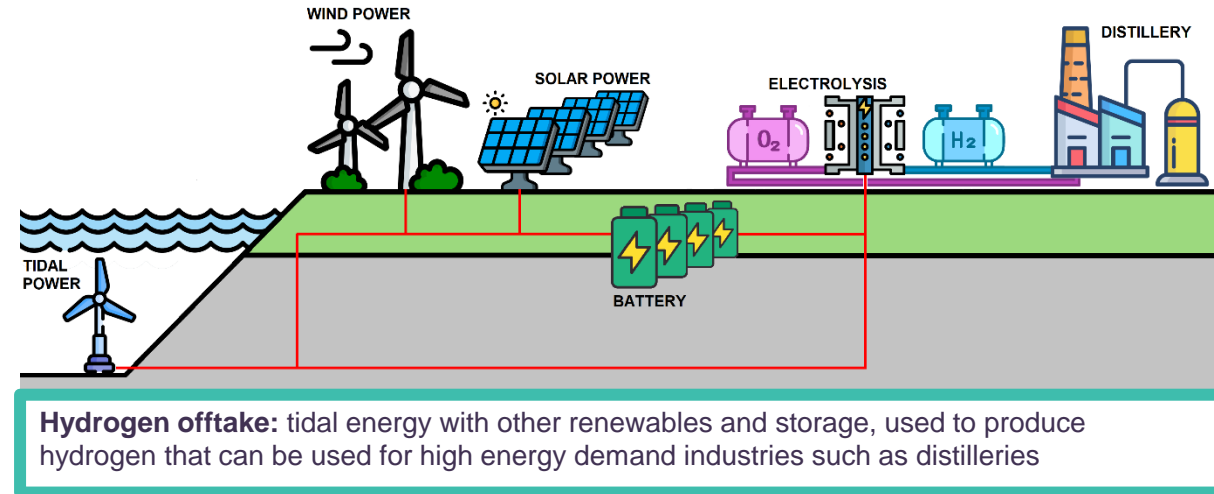
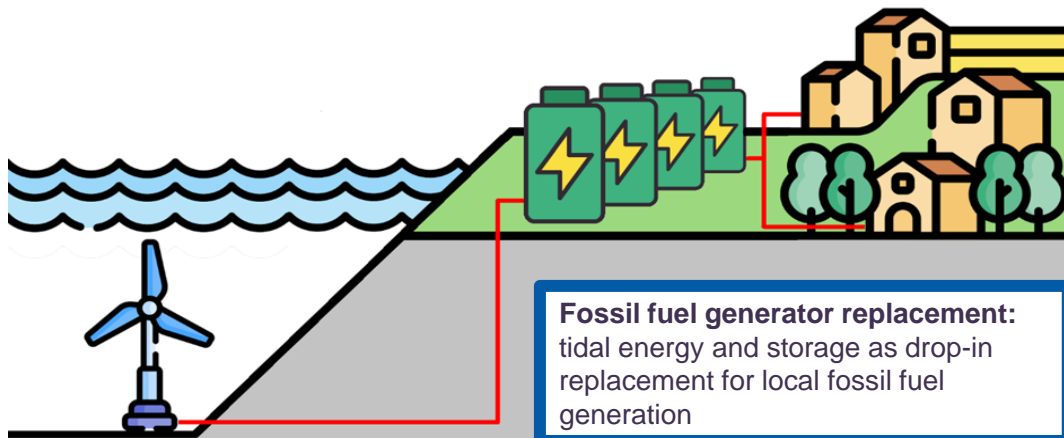
Business model	1. Matching supply and demand	2. Economic viability	3. Impact on deployment ambitions
Hydrogen offtake	High	High	High
Fossil fuel generation replacement	High	High	Medium
Community projects	Medium	High	Medium
Hydrogen co-location	Medium	Medium	High
Small scale deployment	High	Medium	Low
Ports and Harbours	Low	Low	High

Key: High ■ Medium ■ Low ■

3b. Offtake opportunities for key resource areas

Evaluation for key resource areas:

- **Fossil fuel generator replacement:** the diesel generator at **Barra and Vatersay** was modelled to understand the scale of tidal deployment required and factors that need to be considered when undertaking site selection.
- **Hydrogen offtake:** hydrogen can be considered for industrial applications; distilling is an early adopter in Scotland, such as the Protium project on **Islay** which was chosen to look at how the offtake model might be applied to this important Scottish industry.
- **Hydrogen for synthetic fuel:** with potential to contribute significantly to the decarbonisation landscape; this final model looks at how the **Pentland Firth** tidal resource could be connected to the Flotta oil terminal in **Orkney**, utilising the skillset of the local workforce to transition to this new green industry.



3c. Case studies



Hydrogen offtake case study

Protium HyLaddie project:
Green hydrogen heat
decarbonising Bruichladdich
Distillery

*Dynamic Combustion Chamber
(Courtesy of Protium)*



Fossil fuel generator replacement case study

Flex Marine Power:
Community-Embedded-
Tidal energy

*Flex Marine's 50 kW SwimmerTurbine
(Courtesy of Flex Marine Power)*



Hydrogen for synthetic fuel case study

Flotta Hydrogen Hub:
Repurposing current oil
terminal for green hydrogen
production

*Proposed development
(Courtesy of Flotta Hydrogen Hub)*



4a. Roadmapping

Roadmapping alternative offtake opportunities

Steps required to address market barriers were explored combining the findings from the stakeholder engagement, business model evaluation and review of offtake opportunities in key tidal resource areas.

Recommendations focus on **financial support**, **resource management**, and **reduced deployment time and risk** for both community scale and larger industrial projects.

- Key financial recommendations include development of a tidal specific feed-in tariff for smaller projects and a review of the Contracts for Difference mechanism, including a larger ring fence and non-price factors, e.g. local socioeconomic benefits.
- Resource potential could be maximised through detailed mapping of tidal resource suitable for projects less than 30 MW, to allow identification of smaller industry and community offtake opportunities that could be actively pursued.
- Resource mapping could be used alongside an increase in thresholds relevant to consents and leasing, to better support projects at different scales.
- Publicly underwritten warranties and insurance can reduce the cost burden associated with risk that is restricting the magnitude of tidal deployment.



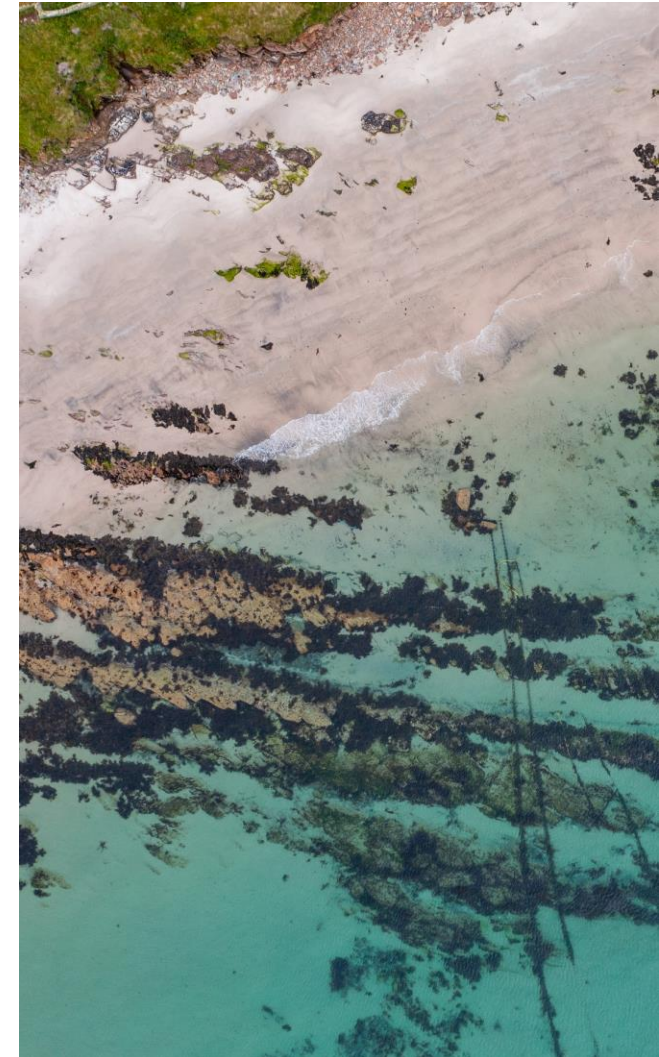
4b. Roadmapping

Proposed steps required to address market barriers

	Action	Outcome	Responsibility
Financial support	<ul style="list-style-type: none"> • Increase tidal CfD ringfence budget to £30m 	<ul style="list-style-type: none"> • Accelerate rate of tidal deployment, which alternative offtakes can benefit from via private network CfD 	UK Government
	<ul style="list-style-type: none"> • Incorporate non-price factors into tidal CfD evaluation process 	<ul style="list-style-type: none"> • Supports projects that place high value on local socioeconomic benefits, rather than just cost 	UK Government
	<ul style="list-style-type: none"> • Establish an enhanced Feed-in Tariff for small-scale tidal projects <5 MW 	<ul style="list-style-type: none"> • Provides a route to market for small-scale projects 	UK Government / Ofgem
	<ul style="list-style-type: none"> • Create funding calls with longer / rolling application periods 	<ul style="list-style-type: none"> • Enables community groups sufficient time to prepare proposals 	Scottish Government
Resource management	<ul style="list-style-type: none"> • Undertake feasibility studies to assess potential role of tidal energy in hydrogen offtake projects 	<ul style="list-style-type: none"> • Allows for detailed assessment of project viability at new / less developed tidal sites 	Crown Estate Scotland
	<ul style="list-style-type: none"> • Support battery installation in community settings 	<ul style="list-style-type: none"> • Increases energy security and reduces reliance on fossil fuel backup generation 	Scottish Government
	<ul style="list-style-type: none"> • Support 'final mile' cabling to connect smaller projects 	<ul style="list-style-type: none"> • Removes a prohibitive cost in small-scale tidal 	Scottish Government
	<ul style="list-style-type: none"> • R&D funding for 'low-flow' tidal technology 	<ul style="list-style-type: none"> • Helps identify solutions for communities with low tidal resources 	UK Government / UKRI
Deployment risks	<ul style="list-style-type: none"> • Establish an entity in which a Public Guarantor underwrites the low probability but high value risks in project warranties / insurance 	<ul style="list-style-type: none"> • Reduces cost of capital in tidal projects, increasing bankability and enhancing investment in sector 	UK Government / Scottish Government
	<ul style="list-style-type: none"> • Increase Section 36 project size trigger threshold to at least 5 MW 	<ul style="list-style-type: none"> • Reduces consenting costs and timeframe for small-scale projects, ensuring process is proportionate 	Scottish Government / Marine Directorate
	<ul style="list-style-type: none"> • Increase 30 MW upper leasing cap under the current ad-hoc leasing process 	<ul style="list-style-type: none"> • Enables bigger tidal projects to be built for large offtake opportunities 	Crown Estate Scotland
	<ul style="list-style-type: none"> • Set a date for phasing out fossil fuel generators 	<ul style="list-style-type: none"> • Removes dependency on fossil fuel generation in remote / island communities 	Scottish Government

Conclusions

1. **Displacement of fossil fuel generation** may now be becoming economically viable, however the local tidal resource needs to be accurately characterised to ensure that it is available at sufficient speeds in the necessary locations.
2. **Small-scale generation** offers opportunities for coastal communities to establish energy resilience whilst providing much needed revenue streams if they are community-funded.
3. **Processing of hydrogen to e-fuels** is best co-located with hydrogen production to maximise efficiency and minimise the cost and challenge of transporting hydrogen. E-fuels offer the least disruptive route to decarbonisation for risk averse industries such as maritime, farming and crofting.
4. **Conversion of oil terminals** (such as Flotta and Sullom Voe) to industrial hydrogen production sites offer ideal infrastructure and transition of workforce skills, whilst being ideally located to take advantage of tidal and surplus wind resources.
5. **Offtake is not a substitute for grid connection**, but an additional enabler offering opportunities for increasing tidal deployment.
6. **Barriers to alternative offtake** are particularly focused on cost and risk, which need to be addressed to enable both developers and offtake industries to pursue opportunities.
7. **Proactive identification of potential offtake opportunities** through an accurate modelling exercise should be conducted for all tidal resource locations and this information then used to identify suitable local offtake opportunities.
8. **Distribution connections** should be optimised by looking at how best to utilise tidal predictability to both: increase energy resilience on a local level for remote communities; and harness Scotland's vast offshore resources and legacy oil assets to deliver transportation decarbonisation and fuel security during the transition to net zero.



Recommendations

1. Future leasing

- 1.1 Detailed modelling of Scottish coastline to identify **best tidal locations** that can be used for strategic planning of **best use of resources**.
- 1.2 Modelling should acknowledge the opportunities **small-scale generation** offers coastal communities to establish **energy resilience** and **community benefit**.
- 1.3 A similar alternative offtake exercise should be conducted for **wave energy** and for **other UK regions**.

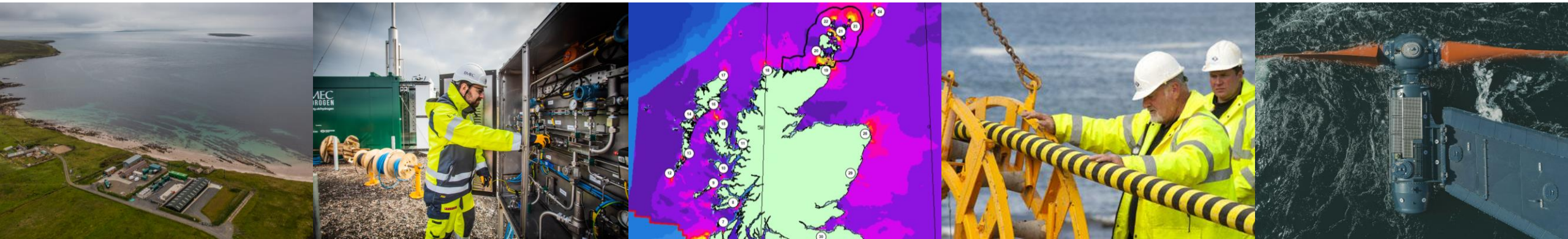
2. Deliverability of tidal

- 2.1 Detailed and proactive engagement with **likely industrial hydrogen users** within reasonable distance to tidal resource.
- 2.2 In-depth energy modelling for high-resource areas to understand how **multiple alternative offtake model** would work.

3. Tackling constraints

- 3.1 Market: Detailed modelling to understand **full project lifetime cost implications** of **private network versus grid connection** for CfD.
- 3.2 Market: The addition of **non-price factors**, including **community value** in revenue support schemes.
- 3.3 Consenting: Increase **thresholds and proportionality** for leasing and consenting requirements to better support projects at different scales.
- 3.4 Grid: Maximise the **advantages tidal predictability** to link offshore resources with decarbonising industrial assets





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