OFFSHORE EMERGING RENEWABLES IN WALES

THE OPPORTUNITY FOR THE SOUTH WALES INDUSTRIAL CLUSTER

CATAPULT Offshore Renewable Energy · Marine Energy Wales / Ynni Morol Cymru · Port of Milford Haven · ERM

INTRODUCTION

AUTHORS AND REPORT REMIT

Marine Energy Wales (MEW) brings together site and technology developers, the supply chain, academia and the public sector seeking to establish Wales as a global leader in sustainable emerging offshore renewable energy generation.

Our remit is to support and highlight what is required and what is underway to realise this opportunity as well as demonstrating the sector's progress. The UK leads the world in understanding how we can use the ocean's natural rhythms to produce clean, sustainable electricity from offshore emerging renewable energy. As a strategic gateway into the sector MEW is well placed to highlight Welsh capability, champion the Welsh opportunity and encourage strategic relationships in order to achieve Wales's decarbonisation targets.

Marine Energy Wales has been subcontracted by the Port of Milford Haven to provide input into the "Generation of Clean Energy" work package, providing the conduit to, and interface between, the offshore emerging renewable sector and the South Wales Industrial Cluster interests.

Offshore Renewable Energy (ORE) Catapult is a not-for-profit research organisation, established in 2013 by the UK Government as one of a network of Catapults in high growth industries. It is the UK's leading innovation centre for offshore renewable energy and helps to create UK economic benefit in the sector by helping to reduce the cost of offshore renewable energy and support the growth of the industry.

This report provides a summary of the marine and offshore renewable energy potential within and adjacent to Welsh Waters, with a focus on those in the South and West to ensure economic feasibility is maximised through proximity and direct adjacency to the demand associated with the South Wales Industrial Cluster.

"The UK leads the world in understanding how we can use the ocean's natural rhythms to produce clean, sustainable electricity from offshore emerging renewable energy."

THE FUTURE CLEAN ENERGY OPPORTUNITY

Marine and offshore renewable energy sources in Wales offer a currently untapped solution to help decarbonise businesses comprising the South Wales Industrial Cluster, and beyond, with a high abundance of resource availability off the South Wales coast. Additionally, the diversity of sources represented by wave, wind and tide can help to create a more resilient renewable energy supply if developed in conjunction with each other.

Both tidal range and tidal stream offer a 100% predictable and reliable form of renewable energy; and with tidal cycles operating at different times at different points along the South Wales coast there lies an opportunity to maximise balanced power generation through geographically distributing installations.

The close relationship between wave and wind resource makes wave energy a natural complement to wind energy. Generated by the same weather systems, waves persist after wind speeds decline, therefore when wave energy is deployed as part of the energy mix alongside wind energy it helps to smooth out power production curves and reduce the variability of energy output associated with wind energy generation.

As well as the potential to help provide clean power to industry, the process of large-scale deployment will have the added benefit of creating and maintaining jobs and economic opportunities for industry. For reference, ORE Catapult's 2020 report, Benefits of Floating Wind to Wales and the South West, estimates that a 500MW project could create up to 1500 direct jobs in the region throughout the project's lifetime. The manufacture and assembly of marine energy devices as well as the redevelopment of ports and grid infrastructure will require large amounts of materials and resources that can be produced and processed within the cluster itself should the right level of support be provided to the supply chain. Whilst investment into upskilling and expanding capabilities and capacities will be required across the supply chain in order to meet the demands of ambitious marine renewable deployment, this will work towards advancing the cluster's commercial offering alongside decarbonisation as the marine energy sector grows both nationally and internationally.

In order to fully decarbonise, the co-development of battery, hydrogen and other energy storage technologies can, and should, be integrated with marine renewable energy in order to provision consistent baseload power that matches demand. Whilst diversity of supply will lead to a greater stability of energy provisioning, storage technologies will be vital for ensuring that any gaps or shortfalls in renewable energy supply can be filled to meet demand. Early engagement with energy generators is therefore important to ensure full integration of these systems.

METHODOLOGY

This desk-based study compiles existing evidence and research in order to provide an indication of the in-development and future offshore renewable energy potential.

The reports and evidence referenced are provided as hyperlinked documents to expand the basis of the report and enhance the contextual information available.

Under each of the main offshore renewable energy types (tidal stream, tidal range, wave, fixed bottom wind (where depths in the search region allow) and floating offshore wind) a review of historic and planned projects and their relative capacities within the South Wales region has been undertaken, indicating status, reasons for projects having been abandoned and potential areas for future development.

> **"As a desk-based exercise this report is an initial assessment of the opportunities for green offshore energy provision."**

This report relies on GIS work undertaken as part of prior studies, which are referenced with the relevant figure excerpts included. MEW have collated the GIS data available and have engaged with the Offshore Renewable Energy Catapult and other stakeholders on the possibility of producing new GIS resources that can better inform site appraisals and associated decision-making. These can be pursued should there be deemed both a need and available resource allocation.

This report presents a high-level overview of some of the barriers and challenges associated with harnessing each offshore energy type. As a desk-based exercise this report is an initial assessment of the opportunities for green offshore energy provision and is subject to further refinement through engagement with project developers. During the engagement with developers following on from this initial report, more details will be sought via one-on-one engagement with developers to better understand regional aspirations and barriers to success. As part of this planned engagement, we will also be ascertaining opportunities for hydrogen integration within the pipeline of future projects.

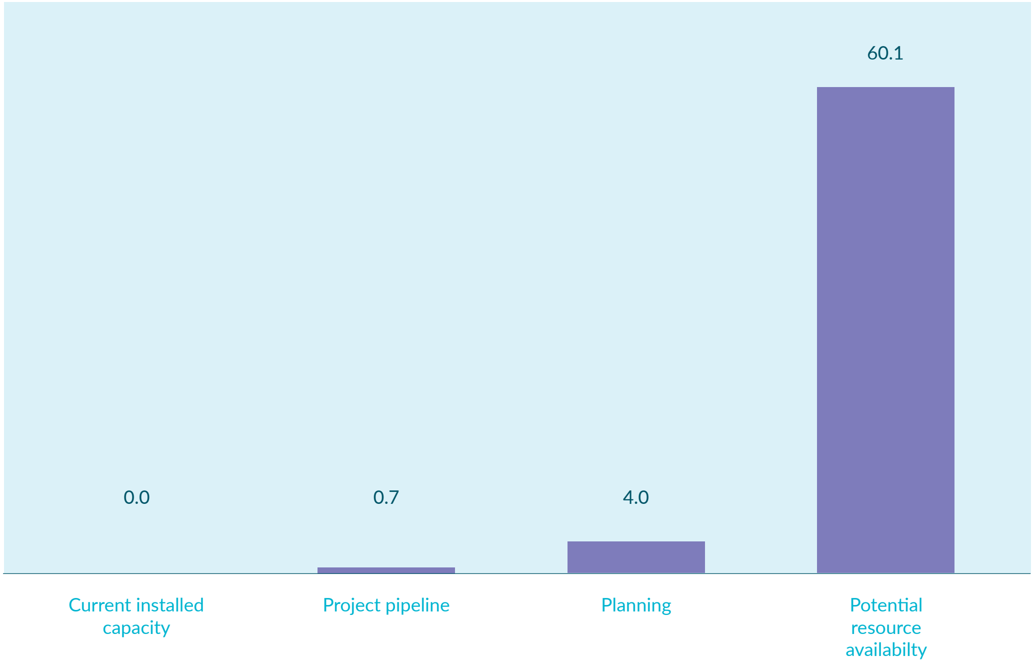
OFFSHORE RENEWABLE ENERGY OPPORTUNITIES IN WALES

The section below provides an overview of the potential and geographic location of the emerging offshore renewable resources, with a focus on South and West Wales.

Whilst we have interrogated the seabed lease allocations (awarded by the Crown Estate) for the resource types and identified the extent of the capacity that is associated with these leases, it is important to note that the generating capacity could increase significantly beyond these figures.

Total realised capacity will be a product of the power rating of the intended devices, the resource available and to which the technology is best suited, the ability to achieve consents and licensing and the developer appetite to pursue projects. This is provided with greater accuracy for wind energy generation projects given the mature nature of the wind turbine market and the attention currently afforded to Floating Offshore Wind in the Celtic Sea. For marine renewable technologies such as wave and tidal stream this is currently more challenging to estimate. In 2011 the Marine Renewable Energy Strategic Framework estimated that up to 6.4GW of installed capacity could be achieved from wave and tidal stream. However, the technological solutions for harnessing this potential have advanced significantly in the last decade and a further study is required to refine these capacity assessments. An estimate of 9GW was also provided for Tidal Range, however this was based across four projects, and it is anticipated that advances in technology and the identification of additional sites mean that this figure could be higher. Because of the limitations of the information available it is not currently possible to produce a definitive maximum and minimum value of energy extraction for each resource area as this is dependent on a diverse set of factors beyond simply technological capability. This includes, but is not limited to economics, policy, environmental constraints and competing uses of resource areas. Where possible, quantifiable values from prior studies have been presented.

FLOATING OFFSHORE WIND



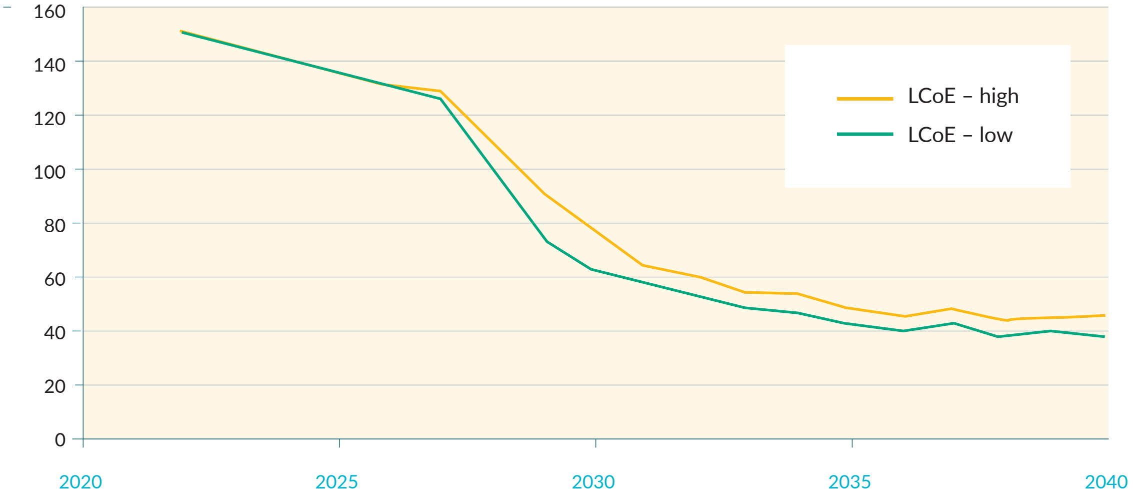


Figure 1 Celtic Sea floating offshore wind pipeline and LCOE trajectory (Source: ORE Catapult internal modelling).

Given the interest and the relative maturity of wind turbine technology it can be expected that the regional pipeline of floating offshore wind projects will grow the most of any form of offshore renewable energy in the near term.

Figure 2 shows the average offshore wind speeds in the waters around Wales, indicating an area of high resource in the Celtic Sea off the Southwest coast of Wales. Figure 3 shows the bathymetry of the region which is highly relevant as floating foundations are considered favourable to fixed bottom ones in water depths in excess of 60m. By comparing both Figure 2 and Figure 3 it can be seen that there are large regions with deep waters and high wind resource off the coast of Southwest Wales.

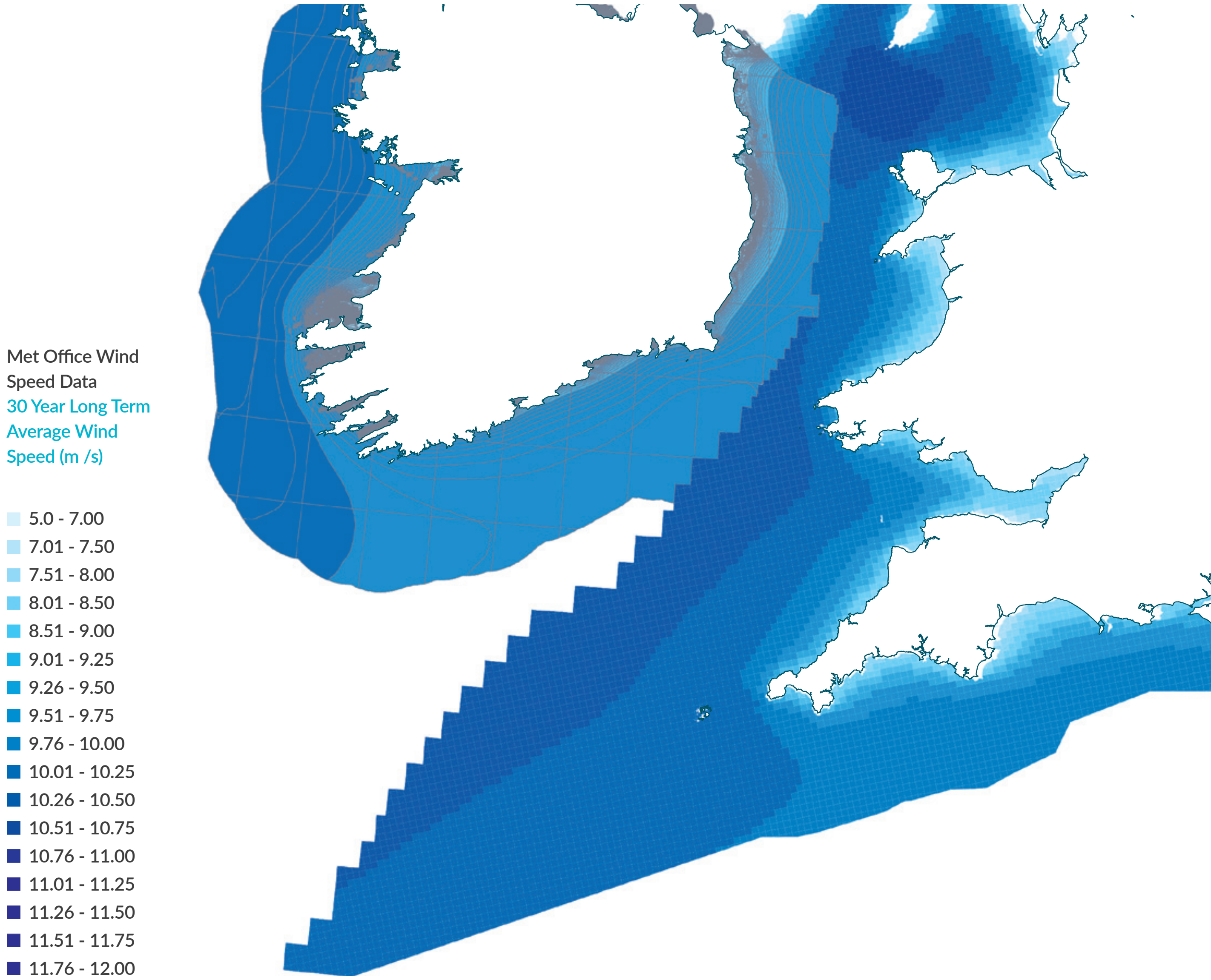


Figure 2 Offshore wind speed. (Source: Constraint Mapping in the Celtic Sea, Offshore Renewable Energy Catapult (2020).

Figure 3 Bathymetry of the Celtic Sea. (Source: Constraint Mapping in the Celtic Sea, ORE Catapult (2020).

Table 1 and Figure 4 show some of the projects that are being progressed in the Celtic Sea. The list is not exhaustive and is changing all the time. We expect to see GW scale projects being developed in the coming years.

Project Name	Capacity	Developer	Expected Completion
TwinHub	32MW	Hexicon	2025 (contracted)
Erebus	96MW	Blue Gem Wind (a joint venture between Total and Simply Blue Energy)	2026/2027
Valorous	300MW	Blue Gem Wind	2029
Llyr 1	100MW	Floventis (a joint venture between SBM Offshore and Cierco)	Unknown
Llyr 2	100MW	Floventis	Unknown
Whitecross	100MW	Offshore Wind Ltd. (a joint venture between Cobra and Flotation Energy)	Unknown
Pembrokeshire Demonstration Zone	180MW	Wave Hub	Unknown
Llywelyn	300MW	Falck Renewables & BlueFloat Energy	Unknown
Petroc	300MW	Falck Renewables & BlueFloat Energy	Unknown
Gwynt Glas	300MW – 1,000 MW	EDF Renewables UK & DP Energy	Unknown
Celtic Deep 1	98MW	AWC Technology Ltd.	Unknown
Celtic Deep 2	300MW	AWC Technology Ltd.	Unknown

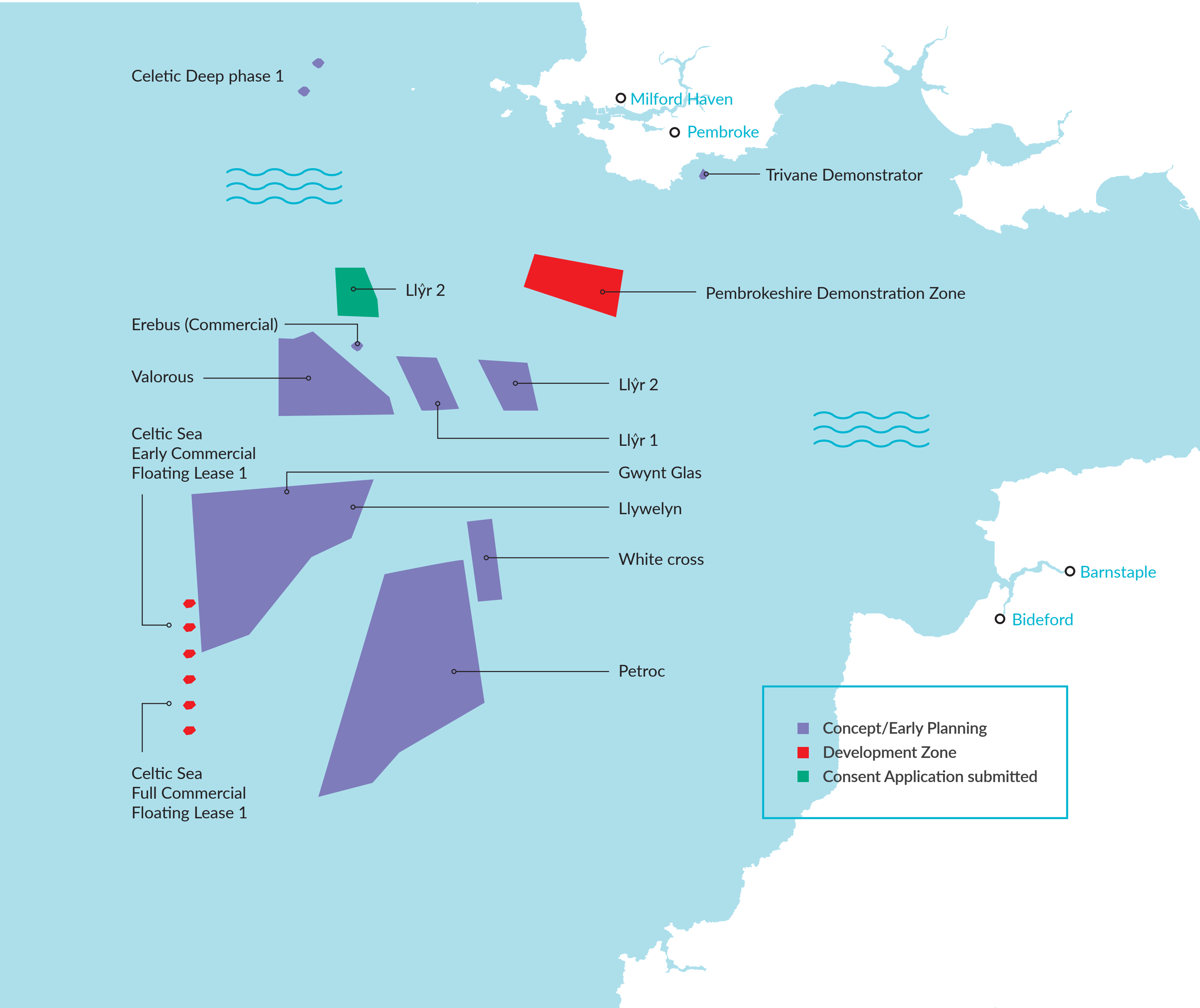
Table 1 Floating wind projects in planning in the Celtic Sea.

Some developers are currently working towards a steppingstone approach of incrementally larger projects in order to grow regional supply chain capacity and learning alongside the projects themselves. Other developers intend to enter the market at the larger commercial stage with projects at a scale of 1 GW or above.

In November 2021, The Crown Estate (TCE) published further detail on its leasing plans in the Celtic Sea, confirming its ambition to unlock up to 4GW of new floating offshore wind capacity by 2035. Following the announcement in July of "Areas of Search", they published "Refined Areas of Search" which are smaller areas of seabed within which projects may be located in the future, shown in Figure 5.

The original Areas 1 and 5 have been removed from current consideration, while five smaller areas have been identified within Areas 2, 3, and 4, after engagement with multiple stakeholders. The Crown Estate said it will further refine the areas over the coming months into potential Project Development Areas in order to ensure that developers have access to floating offshore wind locations that are expected to be deliverable in the near term. TCE will also conduct engineering and environmental surveys in advance of consenting in order to be able to supply data to successful bidders to accelerate the delivery of their projects. The project development areas will be offered to the market via competitive tender, to be launched in mid-2023. Work to identify the project development sites, which started last year, is being undertaken simultaneously with the plan-level Habitats Regulations Assessment, which assesses the potential impact of leasing on environmentally valuable habitats.

Figure 4 **Early commercial scale projects under development in the Celtic Sea.**



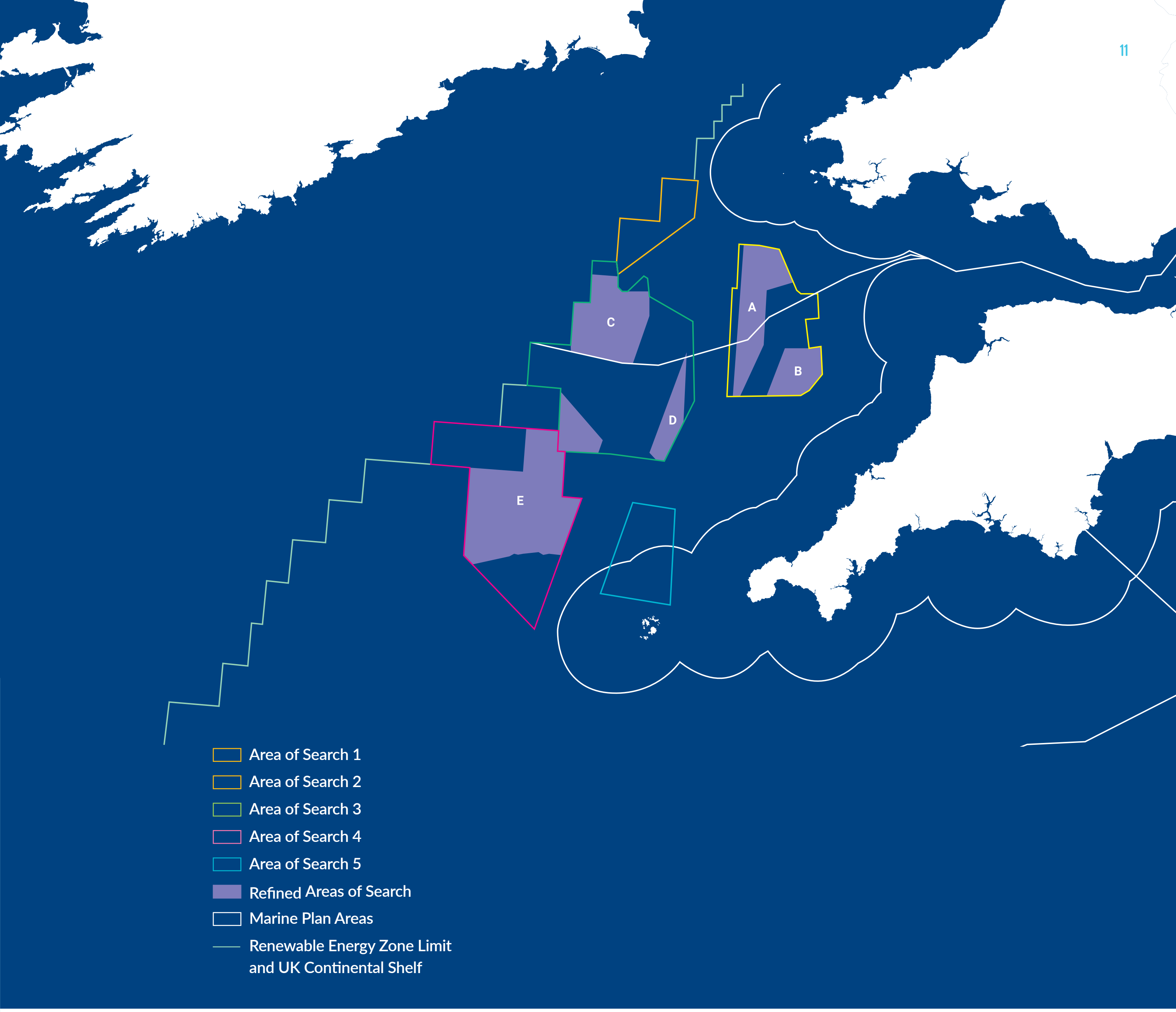


Figure 5 Refined Areas of Search for FLOW in the Celtic Sea.

TCE now plans to focus on full commercial scale projects (of up to 1GW in size) to give stronger signals to the supply chain on future demand and help projects become more cost competitive. The leasing process could see rights for commercial projects awarded by the end of 2023, with full commercial projects delivered from 2030-2035.

TCE will also collaborate with the Electricity System Operator and others to support a coordinated grid solution in line with ongoing work as part of the Offshore Transmission Network Review to accelerate grid development. TCE plan to assess the longer-term potential for further market growth in the Celtic Sea beyond 2035. They also indicate that the region has the economic potential to utilise as much as a further 20GW of floating offshore wind capacity by 2045. Future leasing rounds will be used to bring viable further capacity to the market.

In order to support a growing pipeline of projects in the region, significant infrastructure will need to be put in place to transport electricity to the grid. Pembrokeshire already has high voltage grid infrastructure that was put in place to export power from Pembroke power station. The PDZ and Blue Gem Wind's project both plan to utilise this infrastructure, however significant upgrades may be needed to support gigawatt scale power production from the Celtic Sea.

Both Figure 3 and Figure 6 have been taken from the Offshore Renewable Energy Catapult's report, Floating Offshore Wind Constraint Mapping in the Celtic Sea which attempts to highlight areas of least constraint for floating offshore wind development in the Celtic Sea. The study considers several hard and soft constraints that would likely impact upon site location for floating offshore wind farms including military danger zones, Ramsar sites, marine protection areas, sites of special scientific interest, special areas of conservation, special protection areas, existing lease sites, military exercise zones, shipping routes, fishing areas, wind resource, wave power, current, bathymetry, wrecks, visual impact and NATS radar. The zones identified are displayed in Error: Reference source not found and represent 25,000km² of seabed with calculated deployment potential ranging from of 49.9GW (low) to 120GW (high).

It should be noted that in highlighting areas of least constraint this does not mean that development cannot take place outside of these zones. As the report does not include economic considerations for site selection, it cannot be used to determine the most cost-effective sites for deployment. Likely due to lower project costs, all proposed projects to date are sited closer to shore than the zones identified.

Sites for cable landfall are also an important consideration when selecting sites, and this has not impacted on the zone designation in the report. At present, the substation at Pembroke Power Station

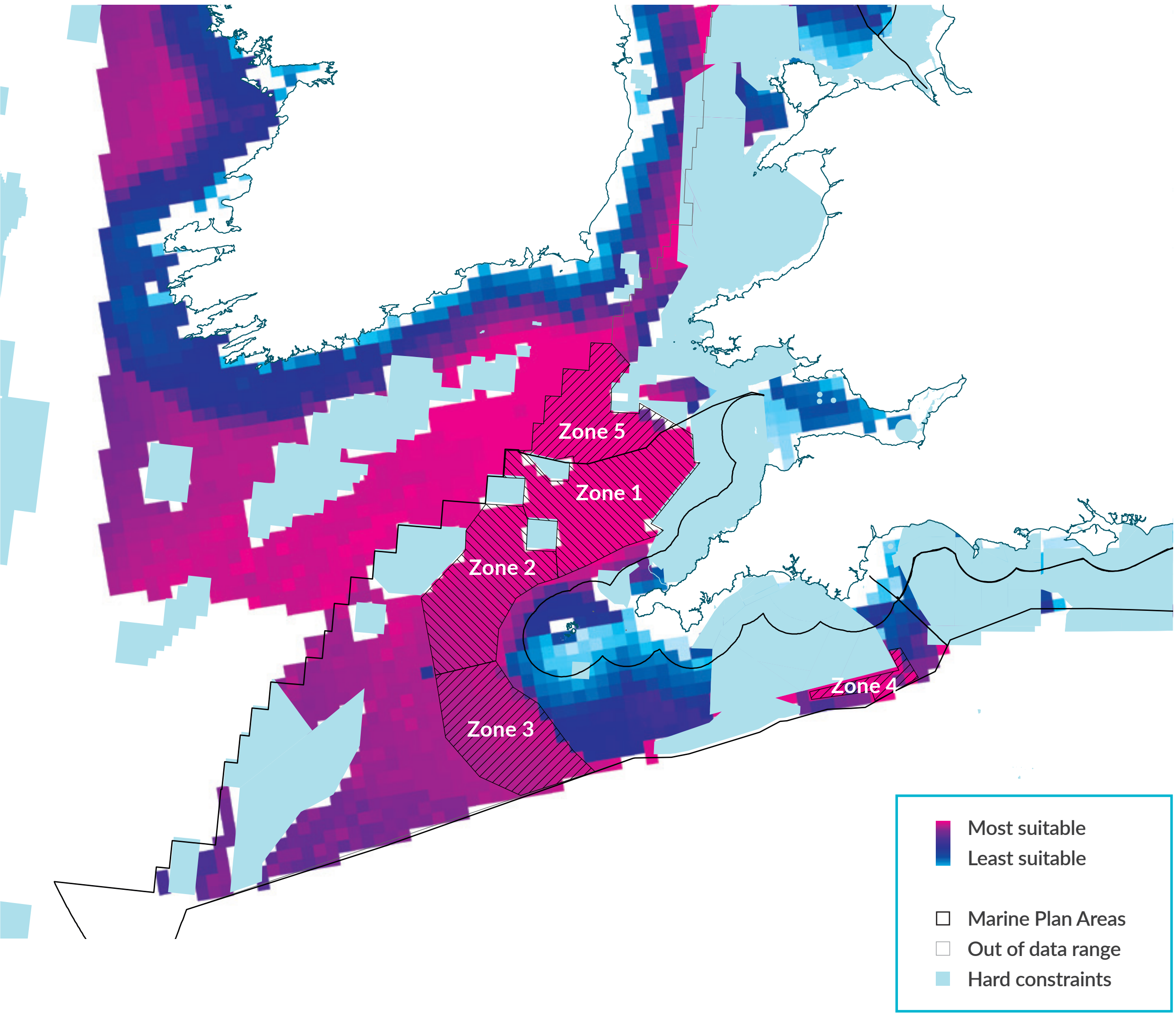


Figure 6 Zones of least constraint for floating offshore wind development. Source: Constraint Mapping in the Celtic Sea, Offshore Renewable Energy Catapult (2020).

is the most suitable location to connect to the grid for all developments in the region. Currently, there are no comparable grid connections available in Devon and Cornwall. It should also be noted that the existing connection at Pembroke is limited in capacity, and therefore new substations and grid connections will need to be created in Wales and Southwest England to accommodate the growing pipeline of projects. This was confirmed in the recent Welsh Government grid report, where it was shown that to accommodate 4GW of new capacity from the Celtic Sea, Pembroke substation would either need to be extended, or a new substation would need to be built locally. RWE is considering the development of a 'Celtic Sea substation' on its site in order to accept more electrons from FLOW into the national grid. Additionally, an extensive amount of reconductoring would be required on the South Wales transmission network, including the section from Pembroke to Swansea North, but this could be delivered without having to build new circuits. However, beyond 4GW, it is likely that new double overhead 400kV circuits out of Pembroke will need to be constructed.

Alternatively, additional capacity could be accommodated by constructing offshore HVDC links between Pembroke and the Southwest of England. Solutions like this in other parts of the UK are currently being evaluated as part of BEIS' Offshore Transmission Network Review, which aims to ensure that the future offshore transmission network is designed in such a way that it results in minimal disruption to local communities. Previous offshore wind developments have faced barriers from local communities opposing the construction of new onshore transmission network infrastructure, which could pose a challenge to net zero ambitions.

The follow-up study Strategic Infrastructure & Supply Chain Development – Deployment Scenarios has calculated feasible deployment of offshore wind within each DNO zone. Assuming deployment density and several additional constraints (including shipping lanes, Marine Protected Areas (MPAs), Fishing activity and clustering effect of existing and planned wind farms, it concluded that up to 60.1GW could be deployed in the Celtic Sea. As well as this, there are also several projects proposed in Irish waters.

Another development that took place in November 2022 was the Celtic Sea Cluster outlining their strategy for the wider Celtic Sea region with regards to FLOW development. The cluster is made up of Welsh Government, Cornwall & Isle of Scilly, Celtic Sea Power, Marine Energy Wales and ORE Catapult, with the cluster's five key strategic actions including:

1. Providing leadership to the region
2. Streamlining the development process for FLOW
3. Accelerating industrialisation in the region
4. Growing sustainable regional industries
5. Integrating regional business support.

On the whole, this strategic plan has been put together to maximise long-term economic opportunity for the Celtic Sea region that current and future FLOW project pipelines offer, and to enable a strong degree of local content in the process.

In addition to this strategic outline, the Celtic Sea Cluster is also responsible for R&D in the form of Pembroke Dock Marine, of which the Marine Energy Engineering Energy Centre of Excellence (MEECE) and the Pembrokeshire Demonstration Zone (PDZ).

FLOATING OFFSHORE WIND AND GREEN HYDROGEN PRODUCTION

Increasing volumes of floating offshore wind will be well suited to UK production of green hydrogen.

Co-location of hydrogen with offshore wind will enable an increase in usable energy from individual projects as well as providing long-term storage and an alternative fuel source for increased UK electrification. There is ongoing debate about the merits of green vs blue hydrogen in terms of environmental impact and project economics.

Over the last decade, record low gas prices have made the economics of blue hydrogen look attractive, though the environmental merits are not clear, with large uncertainty over the potential efficiency of carbon capture in the process. For the foreseeable future, with gas prices subject to huge uncertainty and climbing to record high levels, the economic argument no longer carries the same weight. The ORE Catapult estimates that the cost of supplying blue hydrogen is tied to gas prices, which is likely to remain around £145/MWh (£5.70/kg) in the short to medium term, based on an underlying gas price of £3.53/therm. This is due to geo-political factors linked to the Russian war in Ukraine, and Europe's historic dependence on Russian gas that will now be phased out, creating a pinch point in the global gas markets.

In Figure 7 ORE Catapult forecast the cost of producing green hydrogen from floating offshore wind to reduce from around £145/MWh for early commercial projects around 2025-2027 to around £75/MWh by 2030 and reducing below £50/MWh by 2040. This cost reduction is driven by the major cost reductions in FLOW as well as swift cost reductions in the cost of electrolysis – both driven by a combination of technology innovation and large-scale deployment.

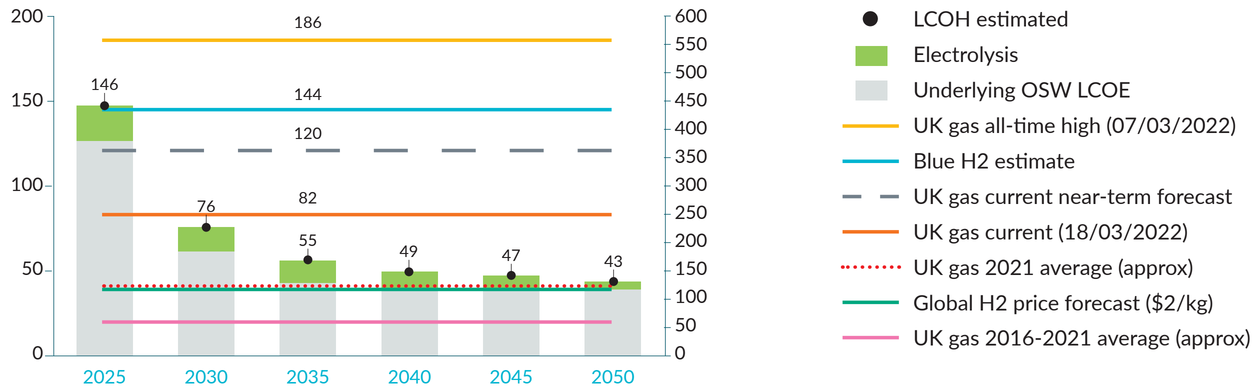


Figure 7 Forecast UK FLOW green hydrogen vs various UK gas price benchmarks (ORE Catapult, 2022).

Comparing the cost of UK FLOW-produced green hydrogen with the cost of green hydrogen imported from overseas, in the long-term, by 2050 (and potentially earlier), UK FLOW-produced hydrogen should be at cost parity with the cheapest global cost for green hydrogen, around the £40/MWh (£1.60/kg) mark. As markets and infrastructure mature, global hydrogen prices may become a valid comparison but, in the near-term, the comparison with hydrogen imported from Europe is more relevant. ORE Catapult forecasts that UK FLOW-produced hydrogen should reduce below the cost of green hydrogen imported from Europe around 2030 and continue to track below European prices for the foreseeable future.

As well as benefitting from low costs due to the best European wind resource, UK-produced hydrogen will also incur lower transportation costs. In addition to the benefits of using UK-produced green hydrogen domestically, the scale of the UK's offshore wind resource and ambition mean that there is huge potential to export UK green hydrogen to Europe and beyond. This opportunity was valued at £48bn per year in ORE Catapult's Solving the Integration Challenge (StIC) study (Solving-the-Integration-Challenge-ORE-Catapultr.pdf), with hydrogen forming 25% of Europe's energy needs by 2050. This opportunity will only accelerate and increase as demand grows even faster than previous predictions, given the imperative faced by an increasing number of countries to reduce reliance on Russian gas., with hydrogen forming 25% of Europe's energy needs by 2050. This opportunity will only accelerate and increase as demand grows even faster than previous predictions, given the imperative faced by an increasing number of countries to reduce reliance on Russian gas.

(European hydrogen price forecast from the International Council on Clean Transportation (ICCT)).

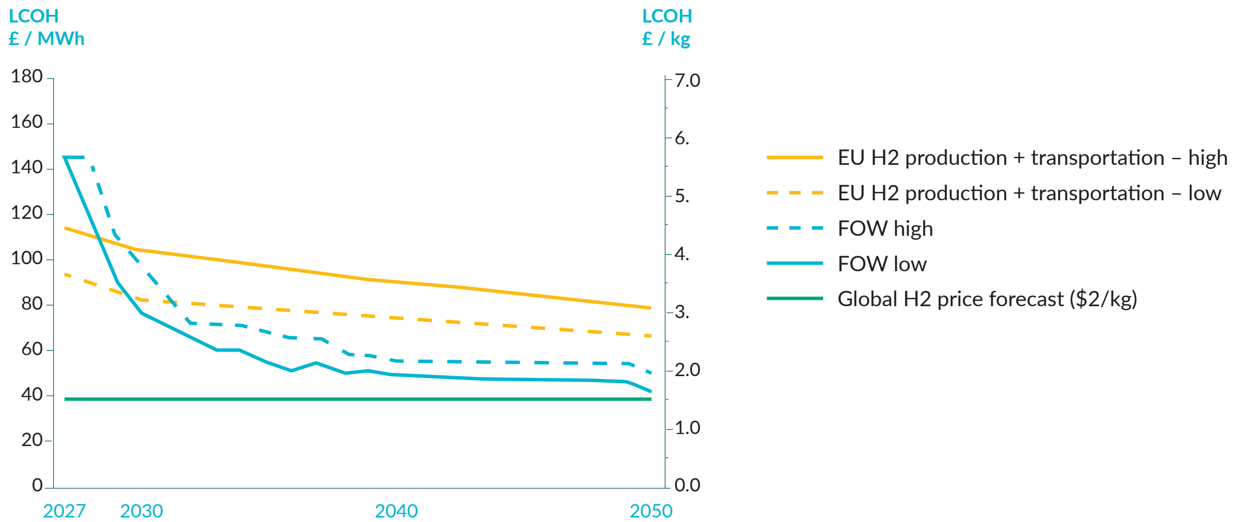


Figure 8 UK FLOW H2 vs European and global H2 imported into UK (ORE Catapult, 2022).

Table 2 illustrates offshore renewable projects with hydrogen production that are being progressed in Welsh waters:

Project Name	Capacity	Developer	Expected Completion
Project Dylan	300MW 1GW	ERM and Source Engie	Commercial windfarm by 2028 Expansion by 2030
Pembroke Net Zero Centre	100-250MW	RWE	2028

Table 2 Welsh offshore renewable projects with hydrogen production.

South Wales is increasingly becoming a hub for hydrogen-related activities, with several opportunities being explored using offshore floating wind. Supported by Welsh Government, ERM recently completed a feasibility study for rolling out the ERM Dolphyn technology in the Celtic Sea; ERM Dolphyn is a first of its kind technology, combining electrolysis, desalination, and hydrogen production on a floating wind platform. The green hydrogen produced by ERM Dolphyn is returned to shore via pipeline, where it can be used for power generation, transport, industrial use and heating. Working with Source Energie, several offshore sites with great potential have been identified, with an optimum site being selected to develop a 300MW field, named Dylan, with a pipeline back to Milford Haven, and a potential expansion to a GW phase c.2030. RWE is also developing a hydrogen project, likely to be a 100-300MW electrolyser producing green hydrogen, potentially from a combination of grid-connected and renewables (such as solar PV and offshore wind).

There are, however, several legislative gaps for hydrogen application. As offshore hydrogen production is an emerging area being explored and developed by different operators, there needs to be a clear stipulation on whether a Safety Case should be submitted and approved by the relevant authority prior to installation and/or operation of offshore hydrogen production facilities. The National Policy Statements for energy are currently being revised and updated by the Government to reflect the policies and broader strategic approach as set out in the Energy White Paper: Powering our Net Zero Future (Dec 2020.) Where there is no technology specific NPS (i.e., for hydrogen), the overarching NPS for Energy (EN-1) may be used as the primary policy for decision making.

Lastly, many developers are exploring offshore wind opportunities to produce electricity, as detailed in the previous section, and as the technology evolves and demand for hydrogen increases, many may explore the opportunities of dividing these wind farm sites and apply for hydrogen production as well as electricity.

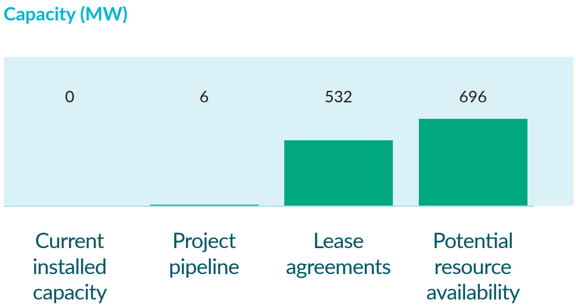
BOTTOM-FIXED OFFSHORE WIND

Figure 9 **Bottom-fixed offshore wind availability and LCOE in South Wales (ORE Catapult internal modelling).**

The Atlantic Array was a proposed 1.2 GW fixed bottom wind farm on the Western approaches to the Bristol Channel. The project was initially put forward by RWE but was cancelled in 2013 citing technical and financial challenges.

In close proximity to South Wales, the Bristol Channel is the largest area of suitably shallow water for fixed bottom offshore wind development as shown in Figure 3. However, the large tidal range and significant tidal streams found in this region make windfarm development more technically challenging and these are possible reasons why no projects have been progressed in this region to date.

TIDAL STREAM



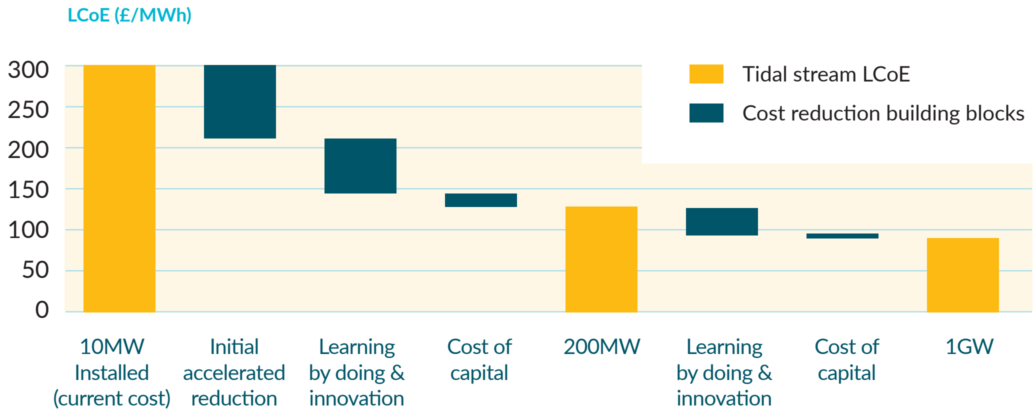


Figure 10 Tidal stream pipeline in Wales and LCOE trajectory vs total installed capacity (ORE Catapult internal modelling).

South Wales tidal stream activity has, to date, centred around the concentrated currents associated with the geological features at Ramsey Sound in Pembrokeshire. Ramsey Sound, the narrow stretch of sea between Ramsey Island and the Welsh mainland, is home to some of the fastest flowing tidal stream resources in the UK with peak flows of around 4 meters per second.

To date only one device has been deployed in this area; the Delta Stream 0.4 MW tidal turbine built and deployed by Tidal Energy Limited in 2014. As the first ever consented and deployed marine energy project in Wales, a sensor component designed to help detect marine life unfortunately malfunctioned, causing the device to cease power production after only 3 months. Due to the high costs associated with retrieval, the project, along with plans for a larger commercial array was abandoned. More detailed information about the Ramsey Sound site can be found via Tethys.

The site has since been taken over by Cambrian Offshore who plan to utilise the existing consents and infrastructure to repower the site after removing the original Delta Stream turbine which still sits on the seabed. Upon repowering, the site will have a capacity of up to 1 MW and will become the only tidal stream site actively contributing to the South Wales grid.

The existing consented area situated in Ramsey Sound makes up only a small portion of the tidal stream potential in the surrounding area. While the current site is in one of the highest resource areas close to shore, there exists a much larger area West of Ramsey Island and St David's Head. In 2011, Swansea University developed estimates from modelling that 1.3TWh could be extracted from this resource area annually after delineating areas as suitable or unsuitable for deployment from a mix of constraints.

In December 2021, the Morlais tidal energy scheme was granted an initial consent by the Welsh Government which will pave the way for a demonstration zone off the coast of Holyhead, Anglesey. Connected to the UK grid, Morlais is set to be the biggest tidal stream demonstration site in the world, with the potential to deliver up to 240MW of electricity. The site is due to come online in 2023/2024 and will be a step forward for tidal stream, helping to bridge the gap between R&D and full deployment.

In November 2021, UK Government announced that Allocation Round 4 (AR4) will include a ring-fenced budget of £20m for tidal stream. The government said it hopes this funding will give the marine energy sector a chance to develop its technology and lower costs in a similar way to the offshore wind industry. This could encourage deployment that will drive cost reduction towards £90MWh at 1GW deployed capacity. Further to this, in July 2022 several tidal stream projects totalling 40.82MW secured a Contract for Difference with an agreed strike price of £178.54/MWh. The one successful Welsh project is the 5.62MW Morlais Magallanes GR3 project which is expected to be completed by 2025/26. The tidal stream resource area around Wales is shown in Figure 11.

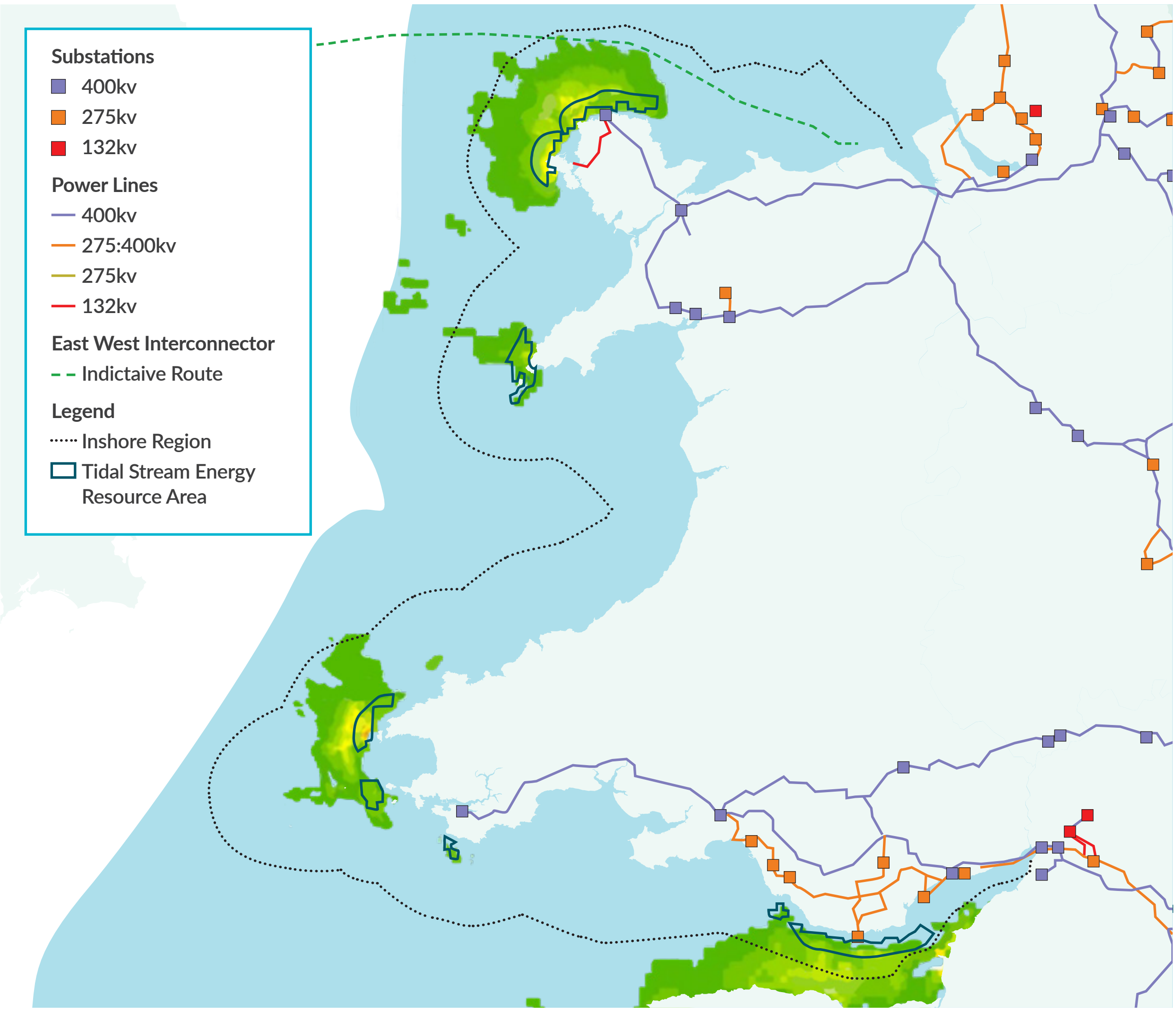


Figure 11 Tidal stream resource area around Wales. Source: Sector locational guidance: tidal stream energy (January 2022) (Welsh Government).

Whilst it is technologically feasible to generate power from a large portion of this region, the areas of highest tidal velocity are the most economically feasible whilst the levelized cost of energy (LCOE) for tidal stream energy remains relatively high, although this is expected to fall rapidly with increased deployment. There are currently no consents in place to deploy devices to the SWIC region beyond the site operated by Cambrian Offshore. Furthermore, while the Cambrian Offshore site has adequate onshore and offshore infrastructure to send power to the grid this would need to be significantly developed and expanded to accommodate array scale power generation. While the South of Pembrokeshire has high voltage cables running from Pembroke Power Station there is currently no comparable grid infrastructure in the North of Pembrokeshire to handle large scale power export. This provides an opportunity for green hydrogen production, as described in the FLOW section. Co-location of hydrogen with tidal stream will enable an increase in usable energy from individual projects as well as providing long-term storage and an alternative fuel source for increased UK electrification.

For further information the Offshore Renewable Energy Catapult published a study in 2018, Tidal Stream and Wave Energy Cost Reduction and Industrial Benefit detailing the carbon emissions reduction potential of the tidal stream industry along with a projection of associated costs at varying levels of deployment. Further adding to the literature covering cost reduction and commercial roll out is the Carbon Trust's 2011 report, Accelerating Marine Energy. Additionally, Metoc completed a report on behalf of the Sustainable Development Commission in 2007 that provided a UK tidal resource assessment. This report highlights in detail the grid constraints at the time of writing. A more detailed grids report commissioned by Welsh Government has also been recently released.

In both these areas, environmental constraints and the likelihood of achieving the necessary consents and licenses must also be taken into consideration, with the associated costs and programme implications. However, to date the tidal stream sector has been able to demonstrate minimal environmental impact associated with tidal turbine deployment. Whilst this is based on a limited number of deployments, there is a growing base of evidence that can be increasingly called upon to support Environmental Impact Assessments and regulatory decision making and given time, it is anticipated that achieving consent for sustainable renewable energy will become less challenging.

Welsh Government released a Tidal Stream Evidence Package in 2021 which identifies the resource areas and contextualises them alongside areas of concern for conservation, these areas likely being a key area of consideration in the consenting process.

In 2021 Welsh Government also published Sector Locational Guidance (SLG) for tidal stream and wave energy, implementing Welsh National Marine Plan (WNMP) sector supporting policy which encourages a collaborative approach to understanding opportunities for sustainable development. The SLG aims to help guide the tidal stream and wave energy industries in planning for future development. It brings together and presents interpreted evidence to describe opportunities and natural resources of potential interest for future sector development. It also signposts considerations (e.g. around infrastructure or environmental sensitivities) with potential to cause risk or complexity for project development and consenting. SLG also describes how those sectors might interact with other activities within the marine area, signposting potential for co-existence and, also, potential conflicts.

TIDAL RANGE

The Bristol Channel and Severn Estuary is home to the second largest tidal range in the world after the Bay of Fundy in Canada.

The Bristol Channel and Severn Estuary is home to the second largest tidal range in the world after the Bay of Fundy in Canada. Figure 12 shows the spring tidal range of the region. As can clearly be seen, the tidal range increases eastward, further up the channel/estuary. Having such a globally significant tidal range resource therefore represents huge potential in untapped clean power generation. Due to the nature of tidal range impoundments (whether they be lagoons or barrages) the potential power output increases exponentially with every meter of height differential on either side of the impoundment wall. It is important to bear this fact in mind when selecting sites for development. The size or total area of the impoundment is also a major contributing factor in determining power output.

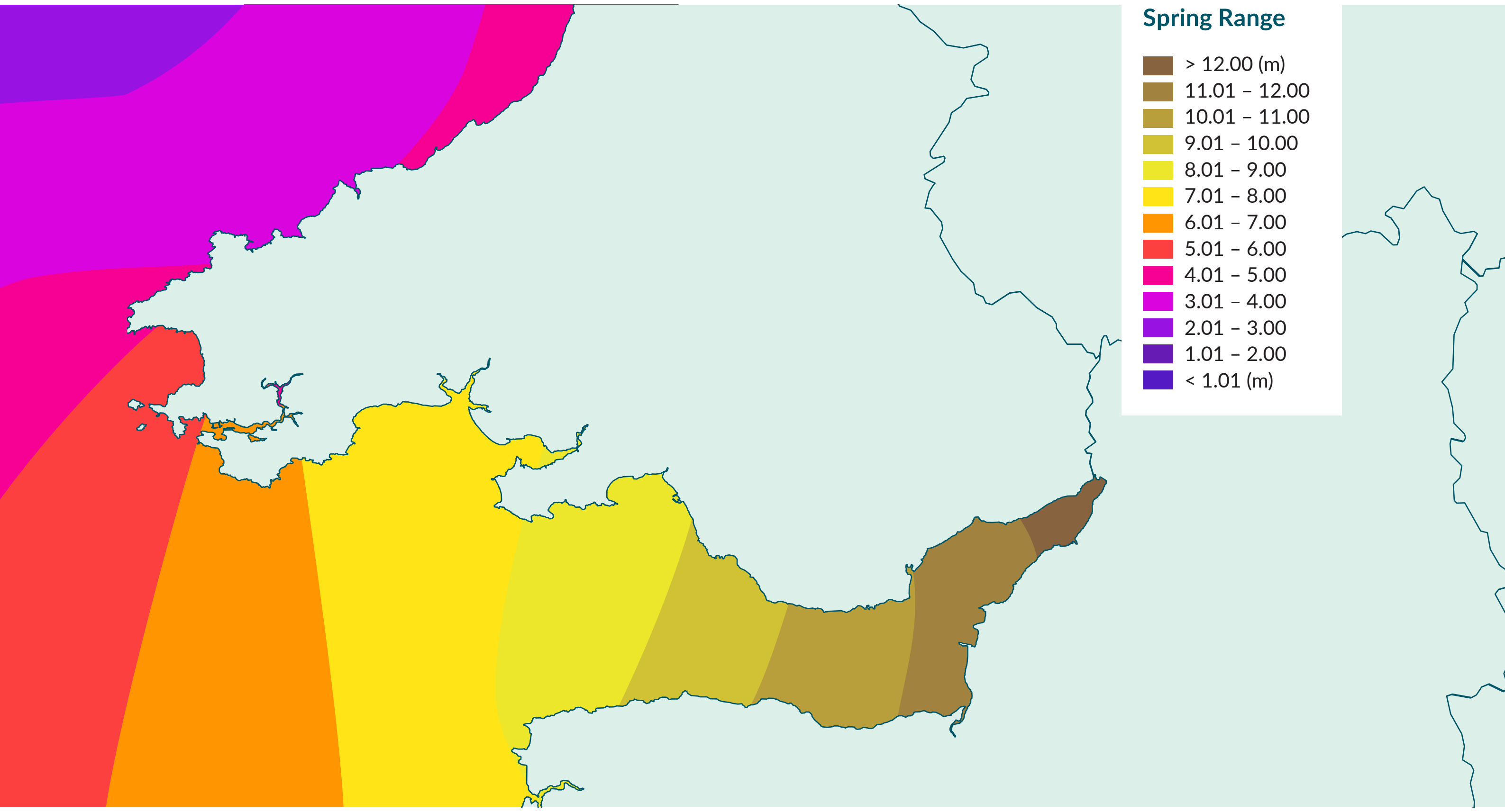


Figure 12 Spring tidal range off the coast of South Wales. Source: renewables-atlas.info (July 2021).

To date there have been several proposed projects in this region that have been either halted or abandoned, the highest profile of these being the Severn Barrage and the Swansea Bay Tidal Lagoon (SBTL). SBTL was initially proposed by the company Tidal Lagoon Power (TLP) as a 320 MW project, a smaller pathfinder project before moving on to construct larger more powerful lagoons in Newport (1.4 GW) and Cardiff (3 GW). Due to the first of its kind nature of the SBTL, complications arose in the consenting process that spanned local, Welsh and UK levels of governance that ultimately halted the project in 2020. The proposed Severn Barrage was much larger in scale at up to 12 GW and although originally receiving a large amount of backing from UK government the idea was abandoned post-feasibility study as a result of projected costs and environmental impact.

Significant costs have often been cited by politicians as a reason for not backing tidal range projects, but assessments have rarely accurately reflected the cost of impoundments across their entire lifetime of power generation. Conventional economic assessments evaluate the costs and payback of energy projects over a period of around 20 to 30 years. It should be noted, however, that tidal impoundments can continue to generate power for around 120 years and this has not been reflected in most economic assessments. It is important that any cost benefit analysis is viewed over this longer timescale, considering the entire lifecycle of an impoundment.

The 2014 report by Cebr, The Economic Case for a Tidal Lagoon Industry in the UK attempts to quantify potential benefits with these longer timescales in mind, drawing on other economic assessments carried out at the time of writing. Using a social discount rate of 3.5%, a rate commonly used by UK Government to evaluate future costs and benefits to consumers, lagoons become cost competitive with wind, nuclear and natural gas when taking into account their full lifetime. Under the assumed operating life of 120 years, tidal lagoons will be able to generate low-cost renewable energy long after the initial capital investment has been paid for and long after CfD expiry.

With no lagoon project having progressed to construction to date there are still significant consenting challenges in moving forward with projects. Significant engagement with Welsh and UK governments will be needed in order to create a framework that allows for the development of tidal range impoundments. Welsh Government is currently exploring options to help support a first of its kind pathfinder project and it is believed that a successful pilot will help to create the necessary framework for larger projects to go ahead.

Despite challenges, the extent of the resource makes tidal range the source of highest potential for clean power generation for the South Wales region. There is the potential for gigawatts of capacity of 100% predictable power in an area in close proximity to major industrial zones.

As covered in our tidal stream section, a grid report was commissioned by the Welsh Government and produced by the Offshore Renewable Energy Catapult outlining Welsh grid constraints in detail.

WAVE

The highest areas of wave energy resource are situated in the Southwest of the country with resource intensity increasing steadily further offshore, as seen in Figure 13.

This is associated with the longer fetch of swells pushed in from Atlantic weather systems and into the Celtic Sea region between Wales, Ireland and Cornwall. To date, wave energy projects in Wales have focused on comparatively lower resource areas closer to shore as there is a much higher infrastructure cost to access the higher resource areas further offshore and these high resource areas pose their own survivability challenges. i.e. technology still needs to demonstrate that it can survive the harshest offshore conditions.

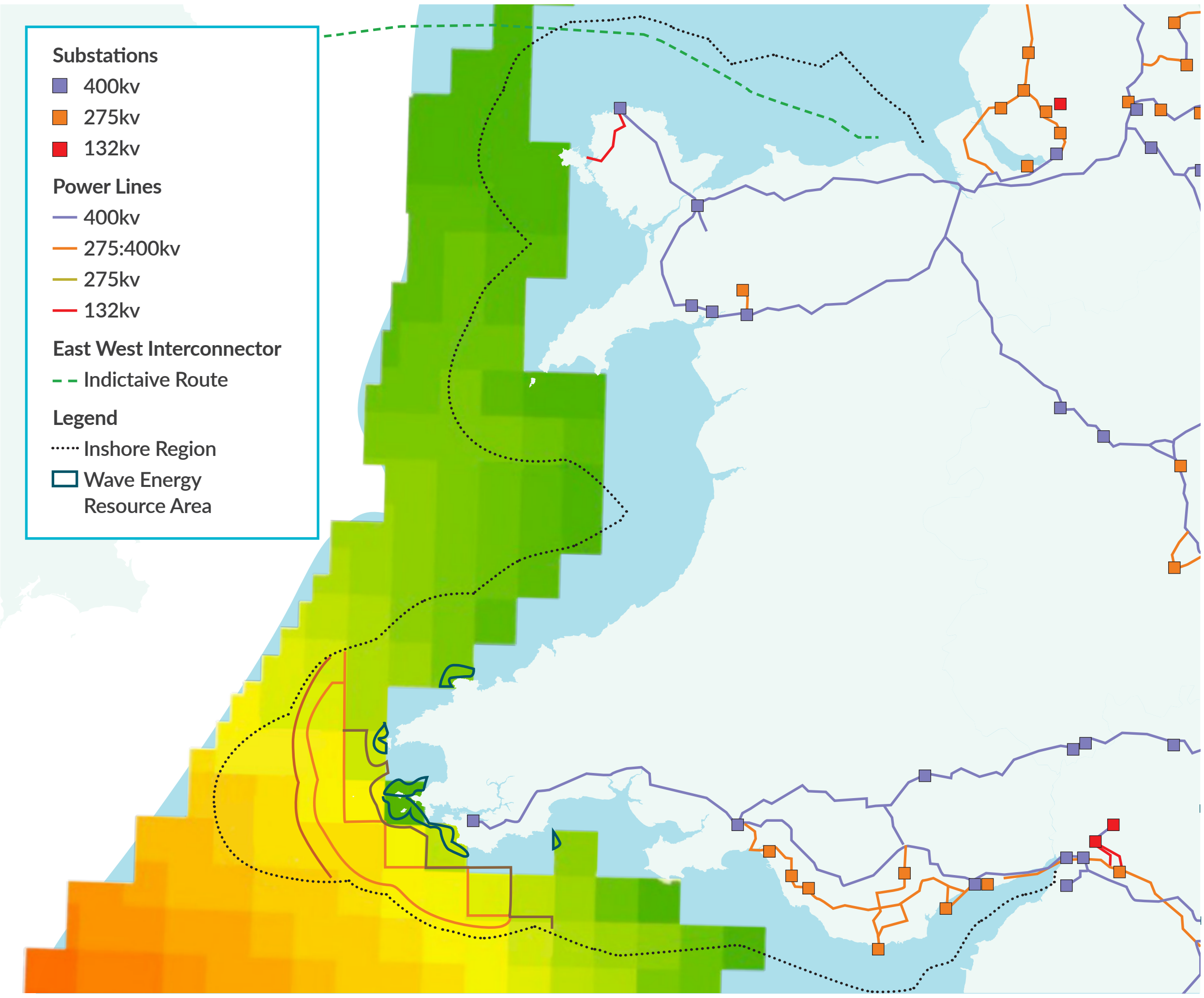


Figure 13 Annual mean wave power. Source: BERR Atlas of UK Renewable Energy Resource (April 2010) & RPS.

Several wave energy convertors (WECs) have been designed and built out of Pembroke Dock in Southwest Wales and several smaller pilot projects have been proposed over the years that never came to fruition. The testing of Bombora's 1.5 MW mWave device is due to take place at the Marine Energy Test Area (META) in 2023, making this the trial of the largest WEC to date globally. This project will not be grid connected but will be a major step forward in demonstrating the feasibility of generating electricity from wave energy in the Southwest Wales region. In the pipeline, but still several years away is the PDZ which will be a 180 MW grid connected test area off the Southwest coast of Pembrokeshire for the purpose of testing and validating WECs and floating offshore wind floater and turbine configurations. Combined with the non-grid connected nearshore sites at META, PDZ is expected to act as a steppingstone and springboard to larger projects in the region and could lead the way to the first commercial arrays.

The first commercial arrays are likely to remain relatively near shore in an attempt to keep costs down and the projects profitable. Similar constraints are likely to impact upon site selection as those discussed in the FLOW section of this report with a few key differences: there will likely be a greater weighting towards shallower sites, WECs will have a lower visual impact than wind turbines, will cause minimal or no radar disturbance and are not expected to have as adverse an impact on bird species. The combined result of this is low constraint areas for wave energy arrays will be situated much closer to shore than the low constraint areas determined for FLOW in Figure 6. It is also likely that wave arrays are co-located with FLOW arrays in the future in order to share infrastructure and maximise energy generation from a single site. A detailed exploration of constraints can be found in Offshore Renewable Energy Catapult's 2020 report Floating Offshore Wind Constraint Mapping in the Celtic Sea.

Similarly, to tidal stream, a Wave Evidence Package was also released by Welsh Government in 2021. This identifies the resource areas and contextualises them alongside areas of concern for conservation, these areas likely being a key area of consideration in the consenting process. A high-level overview of the information presented in the Wave Evidence Package is presented in Figure 14, the packages also provide further maps showing bird, marine mammal, fish and habitat areas in more detail.

For further information, the Offshore Renewable Energy Catapult published a study in 2018, Tidal Stream and Wave Energy Cost Reduction and Industrial Benefit, detailing the carbon emissions reduction potential of the wave industry along with projection of associated costs at varying levels of deployment. Further adding to the literature covering cost reduction and commercial roll out is the Carbon Trust's 2011 report, Accelerating Marine Energy.

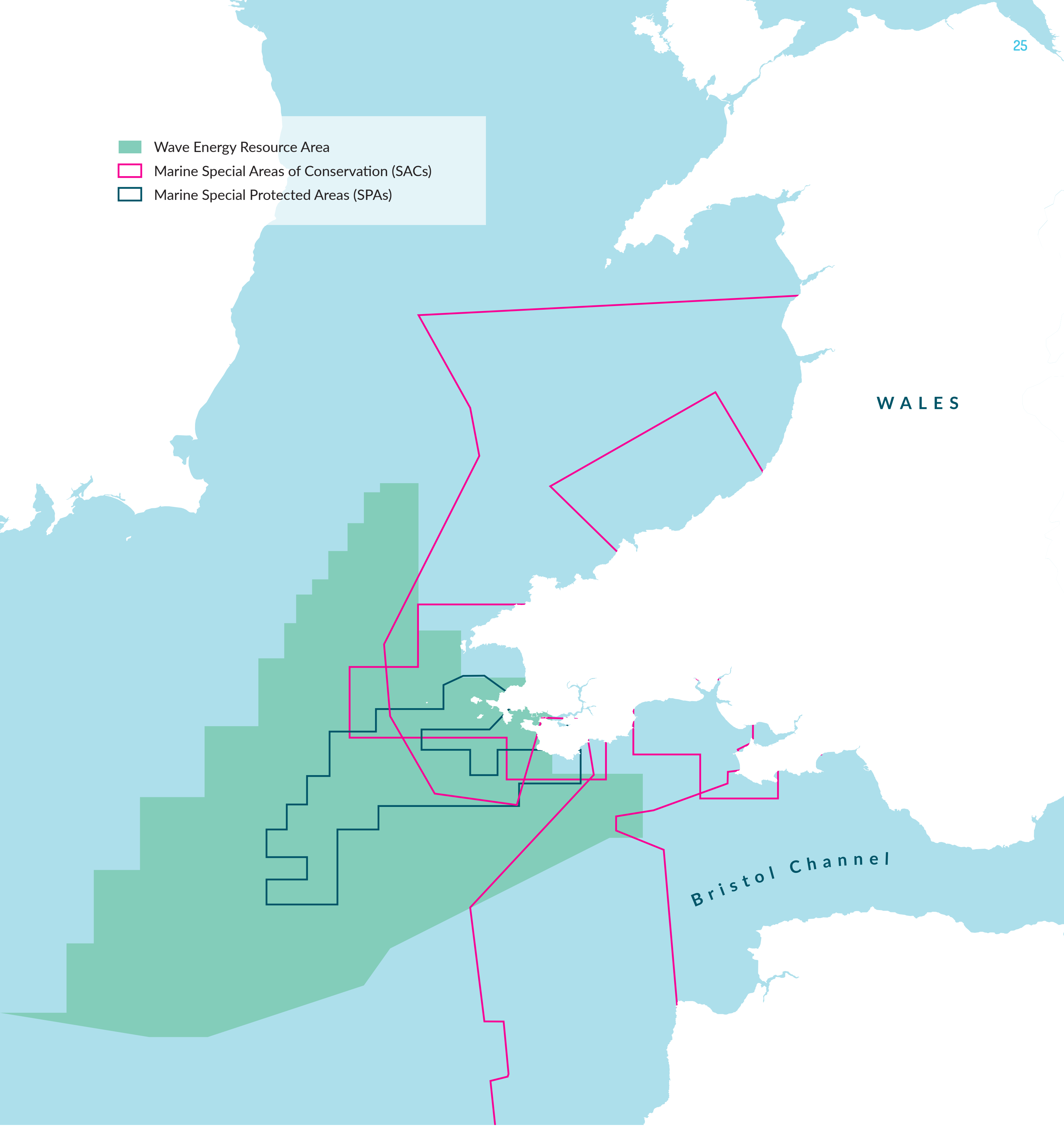


Figure 14 Wave Resource Areas & Marine Protected Areas. Source Wave Evidence Package

DISCUSSION AND RECOMMENDATIONS

Accounting for all publicly known emerging offshore renewable energy projects currently under development in the waters of Southwest Wales, it is reasonable to assume 777 MW of installed capacity within the next decade should all of these projects reach completion.

In the near term it is expected that floating offshore wind will be responsible for the largest growth in installed offshore renewable energy capacity. This number could grow as more projects are announced in the near future and if projects in English waters make cable landfall in Wales. Following on from this, assuming a continued growth in the number and size of projects, the 2030s could then see multiple gigawatts of installed capacity, leading to further growth again in the 2040s. Early and continued engagement with all project developers in the region is therefore recommended.

Tidal range offers huge potential to provide gigawatts of clean power to South Wales industry. In contrast to floating offshore wind, this offers a predictable and consistent power source closer to sites of energy usage. However, the lack of any project to date and no clear framework to consent and approve projects presents a clear challenge. Engagement with both Welsh and UK Governments in order to stress the demand for this form of power generation is needed to encourage the development of an enabling legal framework that will allow tidal range projects to progress.

Wave and tidal stream will not be able to deliver similar installed capacities to floating offshore wind and tidal range in the near term. Technology developers are currently in the process of transitioning from single devices to multi-megawatt arrays and it will likely take longer to reach gigawatt scale production. With continued deployment and technological refinement, gigawatts of installed capacity could be achieved in the 2030s and onwards. In order to achieve this, support should be provided as and when companies progress plans for their first arrays in the region. MEECE (part of the Offshore Renewable Energy Catapult) is currently developing more detailed modelling of the wave resource for the region which builds upon prior work by Swansea University, and Intertek own some of the most advanced hydrodynamic models for the tides in the region. Both of these resources will likely be key for future site development. In addition to this, it will likely be advantageous to carry out a detailed constraint mapping piece of work that brings together resource modelling with environmental data such as those in Welsh Government’s evidence packages and details of other constrains to produce constraint mapping for wave and tidal energy of parity to the FLOW work carried out by ORE Catapult.

Port and grid capacity will be a major deciding factor in where and when offshore renewable energy developments take place. Welsh Government has commissioned the Offshore Renewable Energy Catapult to conduct studies presenting port and grid constraints along with recommendations.


Photo: Equinor

Cover photo: GWEC Wind Europe Denis Schroeder