

FLOATING OFFSHORE WIND — A GLOBAL OPPORTUNITY



Disclaimer

Copyright March 2022

This document contains forward-looking statements. These statements are based on current views, expectations, assumptions and information of GWEC and the Authors. GWEC, the Authors and their employees and representatives do not guarantee the accuracy of the data or conclusions of this work. They are not responsible for any adverse effects, loss or damage in any way resulting from this work.

Permissions and Usage

This work is subject to copyright. Its content, including text and graphics, may be reproduced in part for non-commercial purposes, with full attribution.

Attribution

Floating Offshore Wind – a Global Opportunity. Global Wind Energy Council. 2022.

Authors

This report was commissioned by the Global Wind Energy Council and authored by Aegir Insights.

Contributors

Anjali Lathigara and Feng Zhao

Acknowledgements

Additional material provided by Maf Smith. The report was edited by Maf Smith and Alex Bath of the Global Wind Energy Council.

Image credits

Cover: Principle Power

Inside: Principle Power, Stiesdal, Equinor Hywind, Ideol, MingYang

Sponsor



Report Authors



Contents

Foreword by GWEC	5
Foreword by Shell	6
Executive Summary	7
1 Introduction to floating offshore wind	11
2 The chasing pack: Key potential floating wind markets post-2030	18
3 Methodology: Mapping the post-2030 floating markets	20
4 Take-aways from the top 30 floating markets and snapshots of the five key markets	33
Snapshots of five key markets for the future of floating wind	35



Photo credit: Illustration/Equinor

Foreword by GWEC

Floating offshore wind is rapidly emerging as a significant global opportunity. After a decade of early stage commercial deployment and testing, pathfinder markets like South Korea and the United Kingdom are demonstrating that the technology is ready to deliver at scale, with a wealth of would-be developers keen to bring schemes forward, when the right policy frameworks are put in place.

After 30 years of growth, offshore wind is a mature technology. It's deployment across the globe is now accelerating. Mature markets like China and Western Europe continue to scale, while the number of new markets is growing. However, all these markets have until recently been focused on fixed offshore wind.

If offshore wind is to support global action to decarbonise our power system, then we need to seize the opportunity to deploy offshore wind in deeper waters. For most countries around the world, the technical potential of fixed offshore wind is dwarfed by that of floating offshore wind.

GWEC's forecast for floating offshore wind has grown increasingly bullish, rising from our 2020 forecast of 6.5GW by 2030 to 16.5GW in our 2021 forecast. This rapid shift is a reflection of the known project activity across the globe.

But we also want to look at how to ensure that the opportunity in floating offshore wind is understood and embraced by countries new to offshore wind. To help us do this GWEC commissioned Aegir Insights to use their market knowledge to suggest a selection of five markets that right now look like the "chasing pack" behind floating offshore wind's first movers.

The reason to do this is twofold. First, it helps to shine a light on those countries with a fantastic floating offshore wind resource, and encourages them to focus policy and effort to kickstart these markets.

Second, this report and the work behind it can help governments

and industry to better understand what market fundamentals need to be in place to support growth of floating offshore wind. Our work shines a light on the chasing pack, because this also opens up a wider understanding for governments and industry about common factors to look for if floating offshore wind is to grow successfully.

GWEC has been active for a number of years supporting growth of onshore and offshore wind in many different countries. We have been at the forefront of work to grow new offshore wind markets, helping bring industry and governments together in new markets such as Vietnam and Japan. We have worked alongside the World Bank to study potential in new markets, and are active supporting offshore wind around the globe.

As more governments look at floating offshore wind, GWEC will also be active, helping them understand policy and regulatory requirements for successful market growth. This creates a



Henrik Stiesdal
Chair
Floating offshore
Wind Taskforce



Maf Smith
Vice Chair
Floating offshore
Wind Taskforce

win-win in offshore wind. First, an effective market delivers lower cost offshore wind projects and benefits local consumers. Second, it helps build confidence which can help embed and grow local supply chain capability.

With floating offshore wind now ready to scale, we have the opportunity to grow offshore wind in many more markets. We can also couple existing maritime and petrochemical expertise in these markets and help to transition this into low carbon technology like floating offshore wind.

Foreword by Shell

Society faces a dual challenge: how to transition to a low-carbon energy future while also extending the benefits of energy to everyone on the planet.

This transition is underway. It will move at different paces and produce different outcomes in different countries depending on local factors such as available natural resources and weather patterns, national policies that address climate change and local air quality, economic growth and which technologies and products companies and consumers choose.

Increasing use of renewable sources of energy is essential to reducing emissions but they chiefly produce electricity which today meets just under 20% of total energy for end use. This needs to change.

To accelerate the change, governments need to introduce long-term policies that reshape the main parts of the economy as well as enable the development of lower-

carbon and renewable sources of energy supported by emerging technologies.

One of these is floating offshore wind. While fixed-bottom wind projects currently dominate offshore generation, close to 80% of the world's offshore wind resource potential is in areas where the water depth is greater than 60 metres. This presents a huge opportunity and one that, as a society, we cannot miss.

To date, the industry has been able to provide prototypes and pilot farms successfully demonstrating the technology and now the scene is set for the development of large-scale floating wind projects. Countries like South Korea and the United Kingdom are leading the way with large scale tenders enabling the development of lower cost generation.

Shell is committed to becoming a net-zero emission energy company by 2050 or sooner, and we see a major role for floating offshore wind as part

of this transition. Having already been part of the consortium behind the successful pilot project, Tetraspar, we now look forward to working on the development of larger scale projects in Europe, the Americas and Asia where we have a pipeline of over 8 GW.

Shell have been working in offshore wind for over 20 years and as one of the pioneers of floating offshore wind were delighted to support GWEC in identifying some of the key barriers to growth for floating offshore development and how the next generation of countries can accelerate market growth through supporting policy and regulation.



Executive Summary

To deliver net zero, the world faces a huge challenge. We must rapidly transition from high carbon energy sources to low carbon technologies such as wind power. Across the last thirty years we have seen the successful maturation of offshore wind. It is now recognised as a low cost, secure power source, able to underpin global action on decarbonisation.

Offshore wind is a low cost, reliable technology. It delivers significant economic benefits through manufacturing and operation, and importantly can be deployed rapidly at scale. Our global population is clustered around coastal locations, so offshore wind also offers a route to opening up access to renewable energy for a global population.

Offshore wind is a low cost, reliable technology. It delivers significant economic benefits through manufacturing and operation, and importantly can be deployed rapidly at scale. Our global population is clustered around coastal locations, so offshore wind also offers a route to opening up access to renewable energy for a global population.

For many countries however, bottom-fixed is either not an option, or potential is limited. Deeper waters are the norm around most of our global coastline meaning that floating offshore wind is needed if these countries are to develop offshore wind.

Already we are seeing the emergence of floating offshore wind markets in a number of countries, with France, Japan, South Korea, Taiwan and the UK all moving to grow floating offshore wind, with policy making underway to drive this growth.

However, behind this first round of countries backing floating offshore wind, which will be the next set of countries we see blazing a floating offshore wind path? This question sits at the heart of this study and work commissioned from Aegir Insights.

What is clear from this work is that to be a successful floating market, certain physical conditions need to be in place. Put simply, the wind needs to blow to make projects stack up commercially. That said, if a country has the right physical conditions, it still needs the right policies and regulations in place. Successful action to do this will mean countries leapfrogging others to deliver floating offshore wind, and potentially capturing the economic benefits that will come from being an early floating offshore wind adopter.

This report has successfully identified five potential floating markets out of a longlist of 115. But in doing so

Competitiveness
of floating wind
compared to
alternatives

Policy
environment

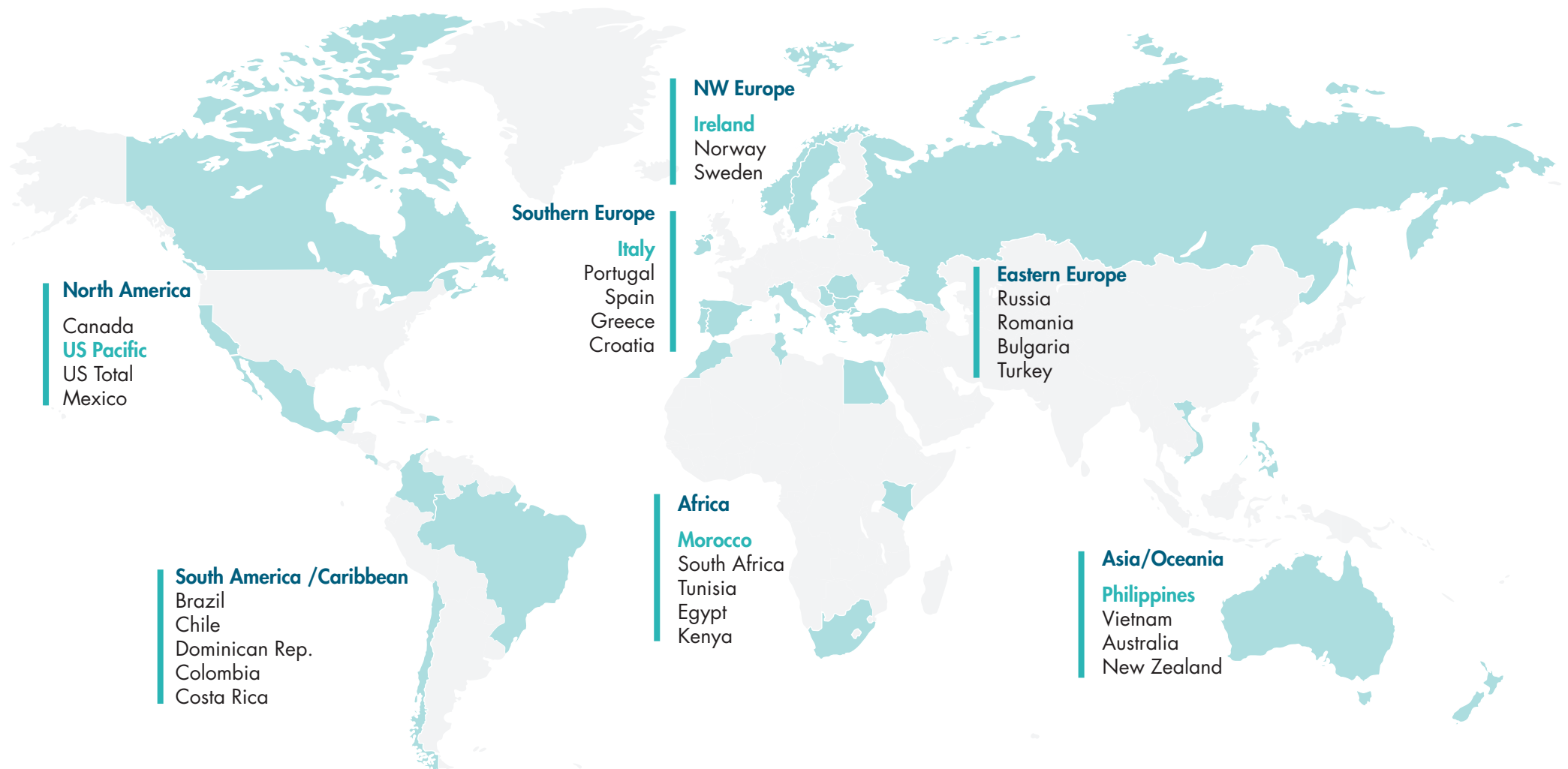
Parameter	Proxy
Floating wind technical potential	<i>Technical potential for floating offshore wind (GW)</i>
Fixed-bottom OSW wind constraint	<i>Technical potential for fixed-bottom offshore wind (GW)</i>
Solar cost level	<i>Average economic potential (LCOE, USD/MWh 2018)</i>
Land constraint on renewables	<i>Population density (people per sq. km of land area)</i>
Renewables policy	<i>Renewable RISE score (1-100)</i>
Targets	<i>Targets dedicated to wind, offshore wind or floating wind</i>
Hydrogen commitment	<i>Four stages of commitment</i>

it became clear that there are many markets with the right technical conditions in place to successfully deploy floating offshore wind. Using 7 parameters (see left) we assessed market readiness and potential, and identified a shortlist of 30 markets with the right conditions in place to evolve rapidly as successful floating offshore wind markets.

For these countries to become hubs of floating offshore wind activity depends however on one critical thing: policy ambition. Our assessment has highlighted that the biggest factor in identifying new breakout floating offshore wind markets is government action and leadership. Governments need to show ambition. Their actions can be the catalyst to kickstarting successful floating offshore wind deployment, which can bring economic advantage and rapid action in emissions reduction.

Below are mapped this shortlist of thirty markets. From these will emerge our chasing pack of floating markets. The five highlighted are those we see as having the right conditions to emerge quickly

as strong floating offshore wind markets in their own right. We have purposefully sought to pick markets from different parts of the world to showcase potential globally.





From this long list of potential future floating markets, we have identified five countries which as “chasing the pack” of leading markets. These all have high technical potential, and other factors that may lead to their emergence as future floating markets.

Ireland is a new offshore wind market on the Atlantic coast of Europe. There we are seeing the development of the first fixed offshore wind projects, but strong ambition for development of floating offshore wind.

Italy is a market new to offshore wind. As a Mediterranean market it offers potential, and the Italian Government has signalled interest in floating offshore wind.

In Africa we have highlighted the potential of Morocco, though there is activity to look at floating offshore wind in a number of countries. Morocco has a significant resource and a Government committed to renewable growth

In the Americas we have highlighted the US Pacific market. The US has huge offshore wind ambitions, with project activity focused down the eastern seaboard on large scale fixed-bottom projects. However,

Offshore wind is a low cost, reliable technology.
It delivers significant economic benefits through
manufacturing and operation, and importantly can be
deployed rapidly at scale.

we are now seeing states such as California and Oregon looking to catch up, and longer term also expect to see floating offshore wind further out from the east coast as well as in the Gulf of Mexico.

Finally in Asia, we focus on the Philippines as a new market. The Philippines has a concentrated resource suited for floating offshore wind, a Government now looking at how to develop its market.

The fact that policy action is so important demonstrates that while we have identified five markets that could all move quickly to become leading floating markets, there is a much larger group of countries where the conditions are right for successful floating offshore wind growth *if* Governments can use policy to prime and catalyse its deployment.

That means our short list of five markets should be thought of as an example of future growth. Each of these countries has an opportunity to capitalise on floating offshore wind, and also seek regional advantage through being an early-adopter. But global growth may be different, and other countries could push ahead in a bid to be floating offshore wind leaders.

Whatever the actual deployment, this report also highlights the many countries that could deploy floating offshore wind. As our understanding of this technology increases through commercial deployment, costs will fall, and make floating offshore wind a clear option for many countries around the globe.

Introduction to floating offshore wind

Interest in floating offshore wind is growing rapidly. In 2020, GWEC's Offshore Wind Market Report forecast growth of floating offshore wind from 17MW in 2020 to 6.5GW by 2030. A year later, our 2021 report increased this 2030 forecast to 16.5GW. A number of early pioneer markets in western Europe and South East Asia are leading the way, with policy in place or in finalization to support this rapid growth. This rapid growth in ambition points strongly to the emergence of floating offshore wind as a technology ready for deployment at scale. This cannot happen quickly enough, given the global need to decarbonise and the fact that the vast majority of the world's offshore wind technical potential is in deeper waters.

1.1 Offshore wind & net zero

The Glasgow Climate Pact from November 2021's COP 26 highlights the urgency of taking action on climate change. Action needs to be focused on the rapid decarbonisation of our power system, and the Pact recognises the critical role to be played by technologies like renewable power.

Offshore wind needs to be a major part of the global response to climate change. Energy production accounts for around three-quarters of global greenhouse gas emissions, so needs to be front and centre of global climate change mitigation. Both the IEA and IRENA have mapped out what delivering net zero will mean for our power sector, and show that to deliver net zero, wind and solar PV energy will need to supply around 70% of electricity generation by 2050.

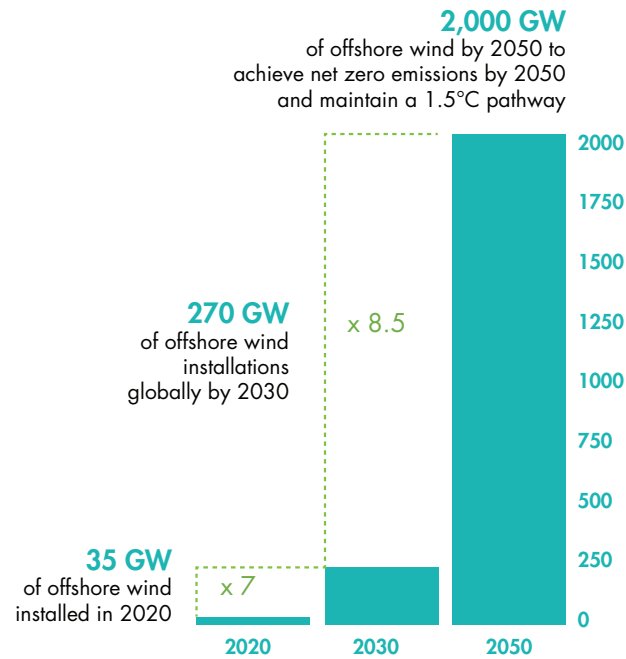
That requires dramatic scale up of technologies. Between now to 2050, offshore wind becomes a central plank of global decarbonisation, transforming the electricity system in generation, infrastructure, flexibility and production of green fuels like hydrogen. Its application does not discriminate between emerging economies and advanced economies, nor one region of the world over another.

Offshore wind is a key technology in these net zero scenarios. While in the 2020s the most significant growth will be in fixed-bottom offshore wind, from 2030 onward we expect to see rapid acceleration in the deployment of floating offshore wind.

The IEA calls for offshore wind to grow as a share of total wind deployment, from 7% in 2020 to more than 20% from 2021 onward. Its roadmap requires offshore wind annual installations to grow 13-fold,

Closing the offshore wind gap by 2050

Unit: GW

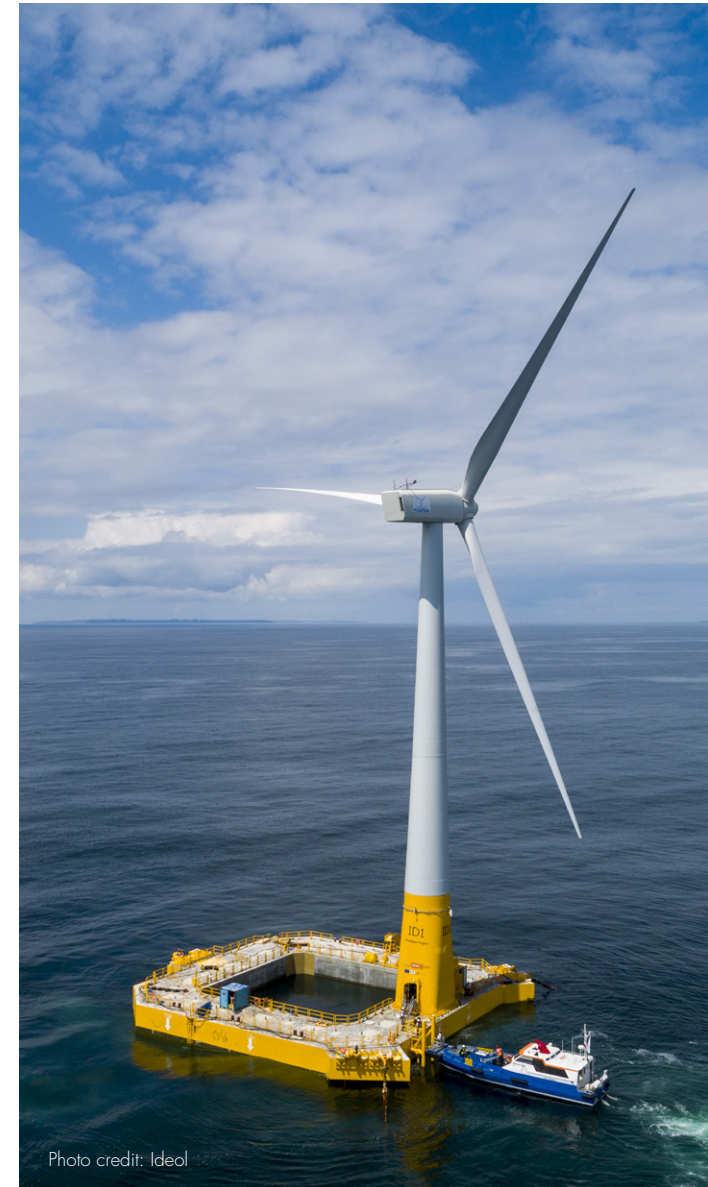


Source: GWEC Market Intelligence; IRENA World Energy Transitions Outlook 2021.

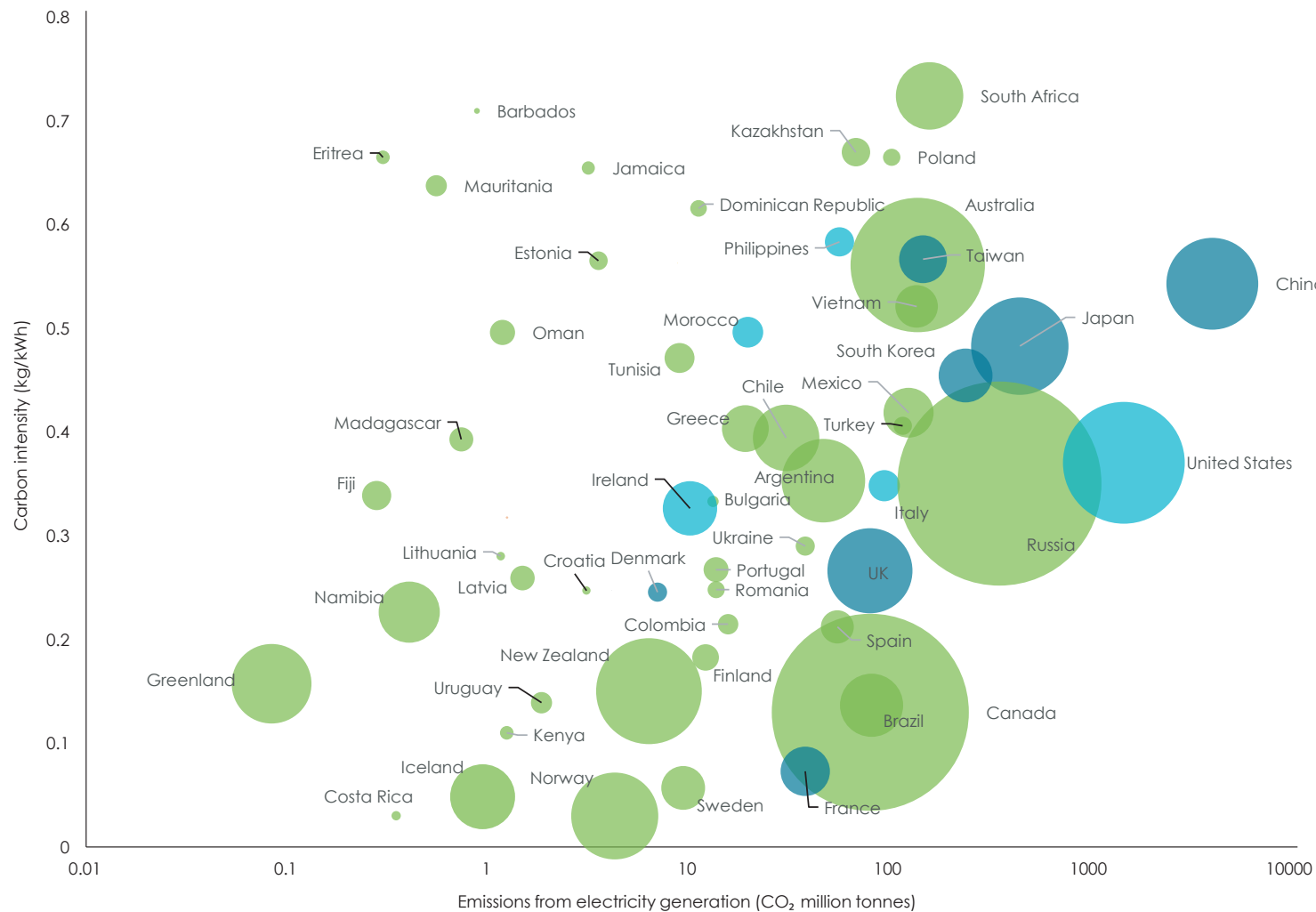
from the 6.1 GW installed in 2020 to 80 GW by 2030. IRENA foresees more than 2,000 GW of offshore wind installed capacity by 2050 in its 1.5°C scenario, nearly one-quarter of total wind power capacity at that time.

As shown in figure on following page, markets such as South Africa, China, Australia, Japan, the US, Russia and Canada all have very high technical potential for floating offshore wind and also are big carbon dioxide emitters. This shows the clear opportunity for floating offshore wind as a route to support longer term decarbonisation.

It is not yet clear what proportion of this future offshore wind will come from floating. But experience from offshore wind shows an ability to rapidly bring down costs. As costs of floating fall so the opportunity opens up to more countries. Given that the global resource is greater for floating offshore wind, this gives us a sense of optimism that we will be able to accelerate the deployment of floating offshore wind and make a significant contribution to these global climate goals.



CO2 emissions v carbon intensity (floating technical potential bubble size)



Floating offshore wind offers many countries a viable path to electricity decarbonization. Shown here are the different floating markets reviewed in this study, with carbon intensity and overall emissions mapped for each country. Bubble size shows technical potential for floating offshore wind.

- [dark blue] Mature Floating markets
- [light blue] Chasing Pack markets
- [green] Other shortlisted markets

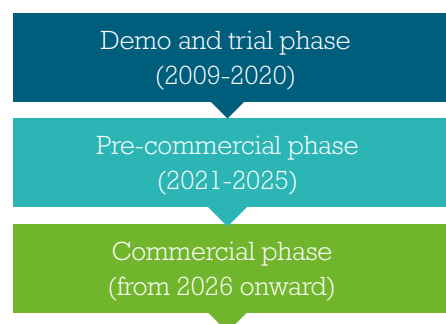
Analysis by GWEC, based on data courtesy of Ember and the World Bank."

1.2 Market status and activities

In the past decade MW-scale floating technologies have been tested through demonstration and pilot projects in both Europe and Asia. However, current floater production is not industrialised yet and development has just entered the pre-commercial phase, with a focus moving to larger first of a generation schemes. However, by 2026 we expect annual installations to surpass 1GW per year, a milestone that fixed offshore wind reached in 2010.

From this point forward, floating offshore wind will be in its commercial phase. Installation rates will continue to increase and project size will grow, contributing to rapid cost reduction.

Roadmap of floating offshore wind commercialisation



Full commercialisation is expected to be achieved toward the end of this decade with the first multi-GW level large scale floating projects connected in both Europe and East Asia.

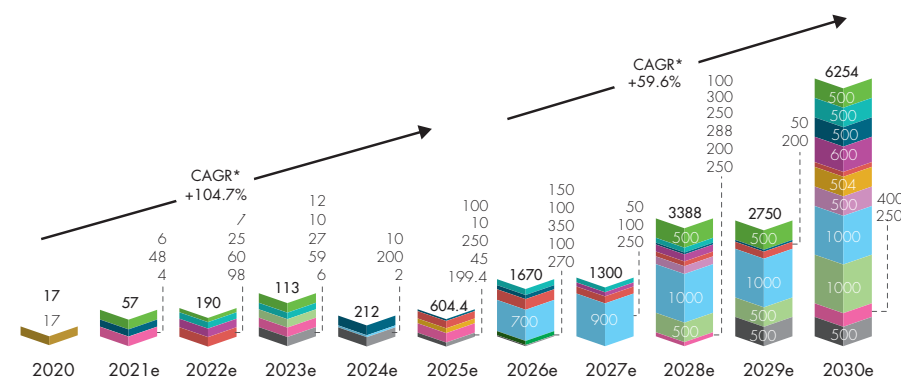
These strong projections can be justified given the volume of known project activity and extent of leasing rounds underway in countries like France, Japan, South Korea and the UK. Experience in markets like the UK and South Korea also shows an appetite from established offshore wind companies and oil majors to move into floating offshore wind development.

Out of the 16.5 GW floating wind installations forecast by 2030, we expect only 7.1% (or 1.2 GW) to be built in the first half of this decade; the majority of new volume will come online from 2026 onward.

Today, the UK, Portugal, Japan, Norway and France are the top five markets in total floating wind installations, but we expect this to change by the end of this decade with South Korea, Japan, Norway, France and United Kingdom then likely to be the top five floating markets.

New Installations MW, floating**

Legend: Norway (green), France (teal), United Kingdom (dark blue), Ireland (purple), Spain (red), Italy (yellow), Greece (pink), Portugal (orange), South Korea (light blue), Japan (light green), China (magenta), Taiwan (dark green), United States (grey).



* CAGR = Compound Annual Growth Rate

** Note: this floating wind outlook is already included in GWEC's global offshore wind forecast

Source: GWEC Market Intelligence, July 2021

As regards to regional distribution, we expect Europe to make up 68.2% of total installations added in 2021-2025, followed by Asia (21.4%) and North America (10.4%), but the global market share of Asian countries is likely to more than double in the second half of this decade, making it the largest region in total new installations in that period. Based on total floating wind installations at the end of 2030, Europe will retain the title as the largest floating wind market with 47% global market share, closely followed by Asia (45%) and then North America (8%).

Floating wind's current contribution to total wind installations is only 0.1%, but it will play an increasingly important role toward the end of this decade, accounting for 6.1% of global new wind installations in 2030.

1.3 The advantages of floating offshore wind

80% of the world's offshore wind resource potential lies in waters deeper than 60m, meaning that as we continue efforts to decarbonise, we must look for opportunities in these deeper waters.

For many countries, their potential for fixed offshore wind is limited, meaning that if we are to see true global growth of this technology, we need to support those countries whose best option is floating offshore wind.

Prime locations for floating wind are located off many of our coastlines and in general the wind resource in these deeper water locations is better than for bottom-fixed offshore wind. Floating wind also offers these countries socio-economic benefits such as jobs and also offers a route for a smooth energy transition to countries with offshore oil and gas activity and expertise. Floating offshore wind can benefit from oil and gas expertise in foundation construction and skills in delivering huge engineering projects in deep water locations.

However, to see growth in floating offshore wind, governments need to ensure the right policies and regulations are in place. In the early days of floating offshore wind commercialisation, this will mean having defined floating offshore wind targets and potentially defined leasing rounds to make seabed available. Governments need to ensure that offshore permitting, grid and regulatory processes are in place, and also ensure support schemes to help this less-established technology grow. As with bottom-fixed offshore wind, early support is expected to lead to rapid cost reduction, with early markets benefitting from high economic activity and a chance to export expertise abroad.

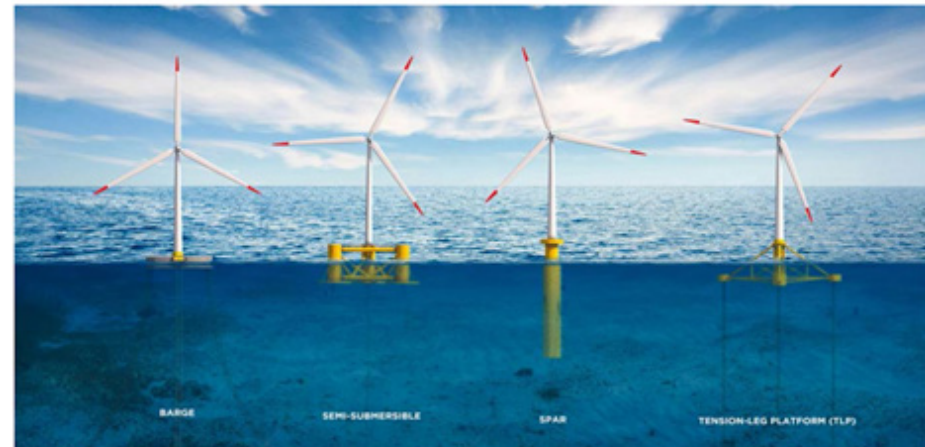
1.4 Floating wind technologies

Beginning with the first MW-scale floating offshore turbine installation in Norway in 2009, the offshore industry connected the world's first commercial floating offshore wind project, Equinor/Masdar's Hywind Scotland wind farm, which used 5 SGRE 6MW turbines, in the UK in 2017.

The current largest floating offshore wind site is the 50 MW Kincardine project in Scotland which uses the Principal Power Windfloat platform and five Vestas V164-9.5 MW turbines.

As illustrated below, there are four dominant types of floating wind foundations in use or development.

Floating offshore wind platform types



Source: WindEurope

These designs are learning from a combination of oil and gas experience and offshore wind experience. The associated benefits and challenges of these basic platform types are presented in table below.

Different geographical situations will favour different solutions, and factors such as political need, opportunity for localization, local infrastructure and different turbine design will also come to play in floating foundation selection. This means that the market is unlikely to rationalise around one floating platform type, but adapt to different conditions.

As the market evolves and looks to build and operate larger floating projects, we also expect to see innovation in construction and operation and maintenance. Floating offshore wind offers the opportunity for construction in port or in sheltered waters, and could make use of different types of vessel to fixed-bottom offshore wind. In addition, we may also see major maintenance and repair activity carried out away from site, with so called “tow-to-port” maintenance regimes in place.

Continued innovation is expected in the market, with new technologies and products expected to support better mooring and anchor solutions, longer term maintenance regimes, deep water substations and dynamic cabling. The extent of innovation in the market is best characterised by the large number of participants and designs in the floating platform market. The bulk of market activity is in semi-submersibles at present, though there are active market players looking at barge, spar and tension-leg platform options. The focus of a number of platform providers is demonstrating their technologies at full scale ready to supply into the rapidly emerging market.

The wide variety of platform concepts highlights some of the different technical and market challenges that projects will need to address. Port access, water depth, ease of manufacture, turbine integration, cost and performance are all issues being explored by different platform companies. It is not expected that the market will consolidate significantly across the decade until industry has gained more experience and different concepts have had sufficient time in the water. However, to survive in this

market platform companies will need to secure developer partners and be able to supply into this first cluster of commercial projects, or be confident that they can deliver significant innovation and cost reduction to be considered as part of a second generation of platform options.



The benefits and challenges associated with four dominant floater concepts

Spar	Semisubmersible	TLP	Barge
Overview: - Simplest concept and attractive dynamics - Minimum depth 80m during whole installation process - Achieves stability through ballast installed below its main buoyancy tank - Complex manufacturing and Weight for 6 MW: ~3.500 t	Overview: - Most popular concept and less attractive dynamics - Typically requires moveable water ballast to limit tilt - Requires dry dock for fabrication - Achieves static stability by distributing buoyancy widely at the water plane - Weight for 6 MW: ~3.000 t	Overview: - Attractive dynamics but not widely deployed - Achieves static stability through mooring line tension with a submerged buoyancy tank - Typically requires purpose-built installation vessel - Weight for 6 MW: ~2.000 t	Overview: - The shallowest draft of all the floating foundation types - Square footprint - Some barge designs include a moonpool to suppress wave-induced loading. - Weight for 6 MW: 2.000-8.000 t depending on materials
Benefits: - Inherent stability - Suitable for even higher sea states - Soil condition insensitivity - Cheap & simple mooring & anchoring system - Simple fabrication process - Low operational risk - Little susceptible to corrosion	Benefits: - Heave plates for reducing heave response - Broad weather window for installation - Depth independence - Soil condition insensitivity - Cheap & simple mooring & anchoring system - Overall lower risk - Simple installation & decommissioning as specialised vessel required	Benefits: - High stability, low motions - Having a good water-depth flexibility - Small seabed footprint and short mooring lines - Simple & light structure, easy for O&M - Lower material costs due to structural weight of the substructure - Onshore or dry dock assembly possible	Benefits: - Operable at depths starting 30 meters to accommodate complex seabed conditions - Buildable in steel or concrete, or hybrids between steel and concrete, offering flexibility in using the highest local content near the project - Simple shape will employ equally simple fabrication techniques - Scalable to support heavy substation
Challenges: - High cost, 5-8 mEUR/MW (based on the 30 MW demo) - Heavy weight, with long mooring lines and long & heavy structure - Deep drafts limit port access and large seabed footprint - Relatively large motions - Assembly in sheltered deep water challenging and time-consuming - High fatigue loads in tower base - Specialised installation vessels needed	Challenges: - Non-industrialised fabrication - Higher exposure to waves leads to lower stability and impacts on turbine - Labour intensive and long lead time - Large and complex structure, so complicated in fabrication - Foundation always built in one piece, requiring dry dock or special fabrication yard with skid facilities - Lateral movement presents potential problems for the export cable	Challenges: - Unstable during assembly, requiring the use of special vessel - High vertical load moorings - Complex & costly mooring & anchoring system making it the most expensive floater design type - Mooring tendons presenting higher operational risk in case of mooring failure and add requirements on site seabed conditions	Challenges: - Particularly exposed to wave, so having greater motions - Demanding more robust mooring systems, increasing complexity

Source: Stiesdal A/S, NREL, DNV-GL, Carbon Trust, IRENA

2 Chasing the pack: Key potential floating wind markets post-2030

2.1 Introduction

This study assumes that there will be a small group of first mover markets supporting early commercialization of floating wind development between now and 2030. In this first round, currently emerging floating markets such as Scotland, South Korea and Japan will deploy their first large-scale floating wind farms.

But which markets will pick up the mantle from these expected first-movers? Floating foundations make offshore wind energy possible in the many countries which have good offshore wind resource but water depths too deep for fixed-bottom turbines.

Until recently, this problem has meant a lack of incentive for these governments to develop a suitable policy framework, governance, or financial framework to encourage

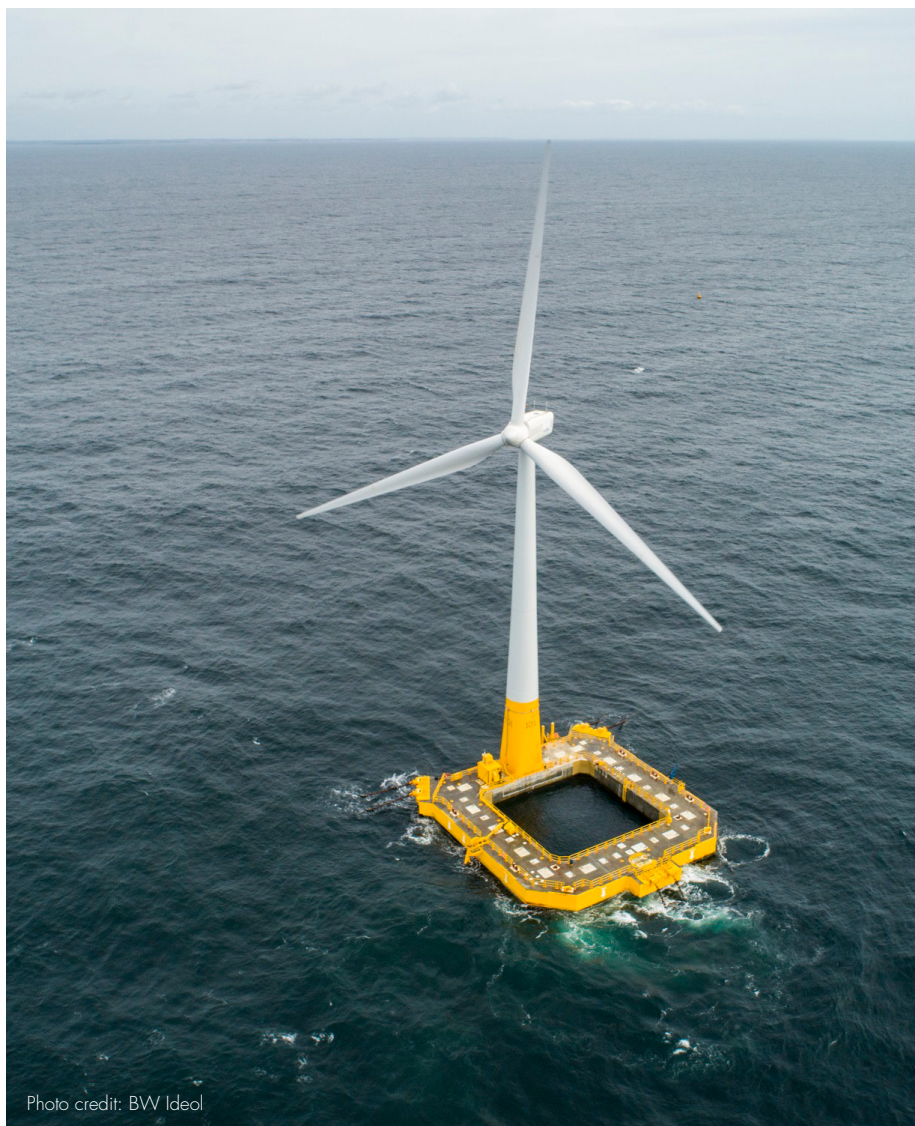
offshore wind development. In addition, many countries have had other renewable options onshore to support early power decarbonization.

However, growth of floating offshore wind in these “round one” markets is stimulating a broader growth of floating offshore wind and an emerging pipeline of projects. As market scale grows, the costs of floating foundations can fall quickly, making it more likely that other governments look to support floating offshore wind. This virtuous circle should lead to rapid acceleration and adoption of floating offshore wind across the globe once the technology has been tested and proven by the first mover markets.

The objective of this study is therefore to identify offshore wind markets that could be part of a “Round Two” of floating wind development.

Round Two is assumed to start rolling around 2030, causing a growth spurt in floating offshore wind delivery. In practice deployment in these different “rounds” will overlap due to the long development lead times of offshore wind projects. However, to help users of this report, markets are sorted into round one or two based on their overall level of readiness as of mid-2021:

- Round One markets either already have fully permitted, large-scale fixed-bottom offshore wind projects and are thus better prepared for floating wind development policy-wise, or they have been investigating their opportunities in floating wind for years and are well-prepared in terms of knowing good sites and having established the regulatory framework and financial support.
- Round Two markets have only recently started to look seriously



at floating offshore wind and still need to develop required regulatory frameworks. This means they will likely lag behind the first movers by a couple of years while they get their policy environment right. However, the markets in this Round Two are expected to benefit from the experiences of the first movers and thus might already see deployment by 2030, despite not being mature markets currently.

2.2 About Aegir Insights

Aegir Insights is an offshore wind investment advisory and analytics firm developing the sector's most advanced tools for policy and investment research. Aegir Insights was founded in 2018 by industry experts with experience working with new market entries, regulatory frameworks, project development and competitive auctions for world-leading offshore wind developers. Apart from analytics tools, Aegir Insights provides deep commercial research and datasets for clients to support their assessment of emerging offshore wind markets.

Aegir Insights prides itself on building long-term relationships with clients which include governments, developers, and investors, helping them make better decisions, faster.

2.3 Disclaimer

This report includes a suggested methodology to identify high potential floating offshore wind markets post 2030, followed by an analysis of the most promising floating markets as well as market snapshot analyses of five promising floating markets. The methodology applied for market selection and analysis of output are meant as overviews and should not be viewed as complete guides to market selection or comprehensive market frameworks.

Aegir Insights has agreed to the publication of this report. To the maximum extent permitted by law, Aegir Insights is not responsible for any loss you or any other party may suffer in connection with the access to or use of this report. The recommendations and findings in this report do not constitute legal advice and no guarantee about their effects is made.

3 Methodology:

Mapping the post-2030 floating markets

This study attempts to establish a robust methodology to identify high potential floating offshore wind markets post 2030. Identifying future markets with such a time horizon is complex by nature and must consider numerous factors that make successful floating offshore wind build-out more likely. Such factors include qualitative assessments of policy targets for renewables in general and specifically offshore wind, as well as quantitative assessments of technical potential for floating offshore wind. The methodology described is thus an attempt of making an exhaustive and methodologically solid selection of markets with the highest floating wind potential.

The selection has been done through a number of steps that progressively narrow down the field of markets, and continuously apply more factors

in order to cover all relevant aspects. The starting point was a list of the 115 markets for which World Bank has completed technical capacity potential for offshore wind. Following this, different steps were applied to identify which markets are most likely to emerge as the next commercial markets. The final product is not to be interpreted as a final list, but rather an analytical model and scoring that highlight most important factors for a market commercializing and how potential markets score in these factors. The following section will outline methodological choices and factors.

3.1 Four steps to identify five key markets

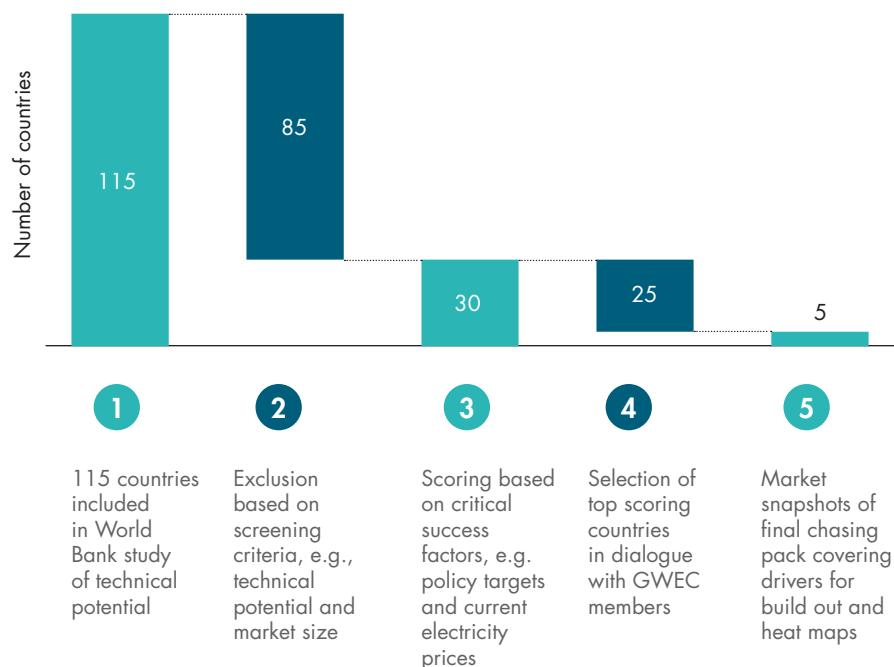
In the following section, it is described how the field of potential markets was narrowed down from the initial 115.

Identifying key future markets is a complex undertaking that must factor in numerous considerations including technical capacity, policy environment, and infrastructural conditions like port capacity and transmission grid. The elimination process is an attempt at a methodologically solid, data-driven model for selecting the floating offshore wind markets that are most likely to succeed.

The data-driven selection is combined with qualitative assessment in cases where relevant aspects of the reality are not adequately captured by the data. Subjective judgements can and should be approached critically, and readers might have different judgements than the authors of this report. Therefore, all steps in the selection model are explicitly documented, so that their

Identifying future markets is complex by nature and must consider numerous factors that make successful floating offshore wind build-out more likely.

Figure 1: Steps for mapping the top post-2030 floating markets



methods and results can be used independently from the rest of the selection process or be combined with the subjective judgements of the reader to produce new end-results.

The selection model progressively narrows down the field of candidate markets by applying a stepwise screening with an increasingly complex number of criteria to be met in each step, as illustrated below:

3.2 Step 1-3: Ranking the top 30 “Round Two” floating markets

STEP 1:

The starting point included all 115 countries for which The World Bank has completed assessments of technical offshore wind potential.¹ The World Bank assessment is done on territory-level where several belong are under sovereignty of the same country, so only unique countries have been included in this selection to enable analysis on market-level.

The World Bank uses Global Wind Atlas as a source for wind speeds

and GEBCO² for water depths when it calculates technical potential, and the World Bank dataset has a cap of 7 m/s, whereafter a multiplier for wind speeds for 7 m/s and above is applied, resulting in areas of 8 m/s being viewed as equally attractive as areas with 10 m/s wind speed.

This multiplier enables deselection of markets that are not suitable for offshore wind and does not capture the full potential. Therefore, the World Bank dataset is only used to achieve a starting point in the shape of a list with all possible markets excluding markets with wind speeds too low to be viable.

See **Appendix 5.1** for a full list of the 115 countries.

STEP 2:

The 115 countries were screened according to five simple criteria to quickly eliminate countries that are highly unlikely to be “round two” markets – either because they are “round one” markets, or because they have too much fixed-bottom potential, too little technical potential overall, because their home electricity

¹ The World Bank, Global Offshore Wind Technical Potential, Country Level Technical Potential for Fixed and Floating Foundations, 2021: <https://datacatalog.worldbank.org/dataset/global-offshore-wind-technical-potential>

² General Bathymetric Chart of the Oceans (GEBCO): https://www.gebco.net/data_and_products/gridded_bathymetry_data/

Figure 2: Overview of the five quantitative criteria

Criteria	Not a "round one" market	Commercial scale technical potential	More floating than fixed-bottom technical potential	Size of home electricity market	Renewable energy policy environment
Data input	Qualitative assessment	World Bank's technical potential (GW)	Floating-to-fixed technical potential ratio	Electricity consumption (TWh, 2019)	Renewable energy RISE score (1-100)
Included if...	Is not one of the countries below	Potential is higher than 10GW	Floating capacity is highest	Electricity market is larger than 10TWh	RISE score is higher than 45
Taken out if...	China, Denmark, France Japan, Netherlands, South Korea, United Kingdom & Taiwan	Potential is lower than 10GW	Fixed-bottom capacity is highest	Electricity market is lower than 10TWh	RISE score is lower than 45
Implications	Already established markets are excluded	Small markets with limited potential are excluded	Countries more likely to focus on fixed-bottom are excluded	Small markets with limited potential are excluded	Markets with limited or no policy ambitions are excluded

market is too small, or simply because they are not that politically oriented towards renewable energy.

CRITERION 1: NOT A "ROUND ONE" MARKET

- Prior to detailed screening, this criterion excluded "Round One" markets: Markets that already have offshore wind farms deployed and are looking to move into floating wind as well, and markets with no offshore wind farms yet, but which are committed to floating offshore wind and display a high level of readiness to move forward with deployment soon – for instance by implementing marine spatial planning, by having worked extensively with their regulatory framework and by planning or carrying out auctions. The markets excluded by this criterion are China, Taiwan, South Korea, Japan, Denmark, France, the Netherlands and the UK.

CRITERION 2: TECHNICAL POTENTIAL HIGH ENOUGH FOR COMMERCIAL SCALE PROJECTS

- Based on data from the World Bank's analysis of technical potential, markets with technical potential below 10 GW were eliminated since these are unlikely to deliver commercial scale and therefore offer less attractive returns. As a result, smaller markets such as Montenegro and Cyprus were excluded from further analysis.

CRITERION 3: TECHNICAL POTENTIAL FOR FIXED- BOTTOM HIGHER THAN FOR FLOATING

- This criterion identified markets with a higher potential for fixed-bottom offshore wind than floating offshore wind by applying a floating to fixed-ratio. Since offshore wind with fixed-bottom foundation is more technologically mature, the cost level is also lower. All markets that have a higher potential for fixed-bottom than for floating wind were excluded, due to the assumption that markets with

plenty of shallow-water areas will prioritize fixed-bottom build-out first.

CRITERION 4: SIZE OF HOME ELECTRICITY MARKET ABOVE 10 TWH

- A large domestic electricity market generally makes markets more commercially attractive for offshore wind. Therefore, markets with a domestic electricity markets below 10 TWh were excluded. Data on electricity consumption has been reported by University of Oxford in “Our World in Data” (TWh, 2019).³ As a result, small markets such as Estonia and Jamaica were removed from the list.

CRITERION 5: POLICY ENVIRONMENT FOR RENEWABLE ENERGY AT A “BARE MINIMUM” LEVEL

- RISE-scores (Regulatory Indicators for Sustainable Energy)⁴ as indicated by the World Bank were used to eliminate markets that are not

³ University of Oxford, Our World in Data: <https://ourworldindata.org/energy>

⁴ The World Bank and ESMAP, RISE (Regulatory Indicators for Sustainable Energy): <https://rise.esmap.org/indicators>

oriented towards renewable energy on a political level. The RISE-score is a compound indicator containing seven critical parameters related to the favorability of a market for renewable energy, such as grid connection and policy environment. The seven parameters are: 1) Legal framework for renewable energy, 2) Planning for renewable energy expansion, 3) Incentives and regulatory support for renewable energy, 4) Attributes of financial and regulatory incentives, 5) Network connection and use, 6) Counterparty risk, and 7) Carbon pricing and monitoring.

The screening by the above five criteria eliminated 86 countries from the list and left 29 countries. Due to the USA being a large and quite heterogenic market with diverse resource and policy conditions in different states, it was divided into two markets for the purpose of the study. The USA's Pacific states, including California, Oregon and Hawaii, differ from the rest of the USA by being predominantly floating markets and having BOEM activities, moving them up on the potential development

timeline. This division was done manually as data on state levels do not exist.

Due to the division of the USA into two markets, the 29 countries outstanding from the first screening turn into 30 potential floating wind markets, which are listed below:

Figure 3: Top 30 markets

North and South America	Northwestern Europe	Southern and Eastern Europe	Africa	Asia and Oceania
US Pacific	Ireland	Croatia	Kenya	New Zealand
US (except the Pacific)	Norway	Bulgaria	Morocco	Philippines
Costa Rica	Sweden	Greece	Egypt	Australia
Dominican Republic		Portugal	South Africa	Vietnam
Colombia		Romania	Tunisia	
Chile		Spain		
Mexico		Italy		
Brazil		Turkey		
Canada		Russia		



Photo credit: Jan Arne Wold/Equinor

STEP 3:

The selected 30 markets all have a potential for floating offshore wind in a near or distant future. This step is a detailed scoring exercise that collect several quantitative factors that indicate which markets are most likely to expand build-out soon. It must be noted that some factors are static - like technical potential and land-constraint - while others are dynamic and subject to change - like renewable targets. Consequently, the relative scoring between the markets will change if, say, a newly elected government introduces are more ambitions political agenda for renewables.

Four parameters relate to the competitiveness of floating wind compared to alternatives:

1. **Technical potential for floating offshore wind (GW)**, taken from the World Bank's technical capacity assessments. Higher technical capacity for floating wind means a larger market potential and greater motivation for build-out, hence giving a higher score.
2. **Fixed-bottom offshore wind technical potential (GW)**, taken from the World Bank's technical capacity assessments. Low potential for fixed-bottom leads to a higher score, as it indicates a bigger need for floating technology if the market wishes to build out offshore wind in the country.
3. **Solar cost level**, measured as the average economic potential (LCOE, USD/MWh 2018).⁵ Relatively expensive land-based solar power indicates a higher need for offshore wind in general, including floating wind, to facilitate a move away from fossil fuels.
4. **Land constraint for renewables**, as indicated by population density (people per sq. km of land area).⁶ More people on little land generally means less available space for solar and land-based wind power, indicating a higher need for offshore wind, including floating wind, to facilitate a move away from fossil fuels.

Two parameters relate to policy environment for floating wind:

1. **Policy environment for renewables** for each market is scored by doing an assessment of the seven RISE indicators relating to renewable energy. A higher RISE-score means a better environment for developing renewable energy in general, including offshore and floating wind.
2. **Renewable energy targets dedicated to wind, offshore wind or floating wind:** Countries with a target specifically for offshore wind development, or, even better, a target specifically for floating wind development, are scored higher.⁷

The seventh and last parameter relates to the country's **hydrogen commitment**, as a target dedicated to hydrogen may indicate preference for relatively high load factor renewables, like floating wind.⁸

The markets are awarded a score from 1-4 for each parameter, depending on how favorable the market appears with regard to that parameter, as explained by Figure 4.

⁵ Solargis, 2018: <https://solargis.com/maps-and-gis-data/download/world>
⁶ The World Bank, 2021: <https://data.worldbank.org/indicator/EN.POP.DNST>

⁷ Public search of government and policy papers

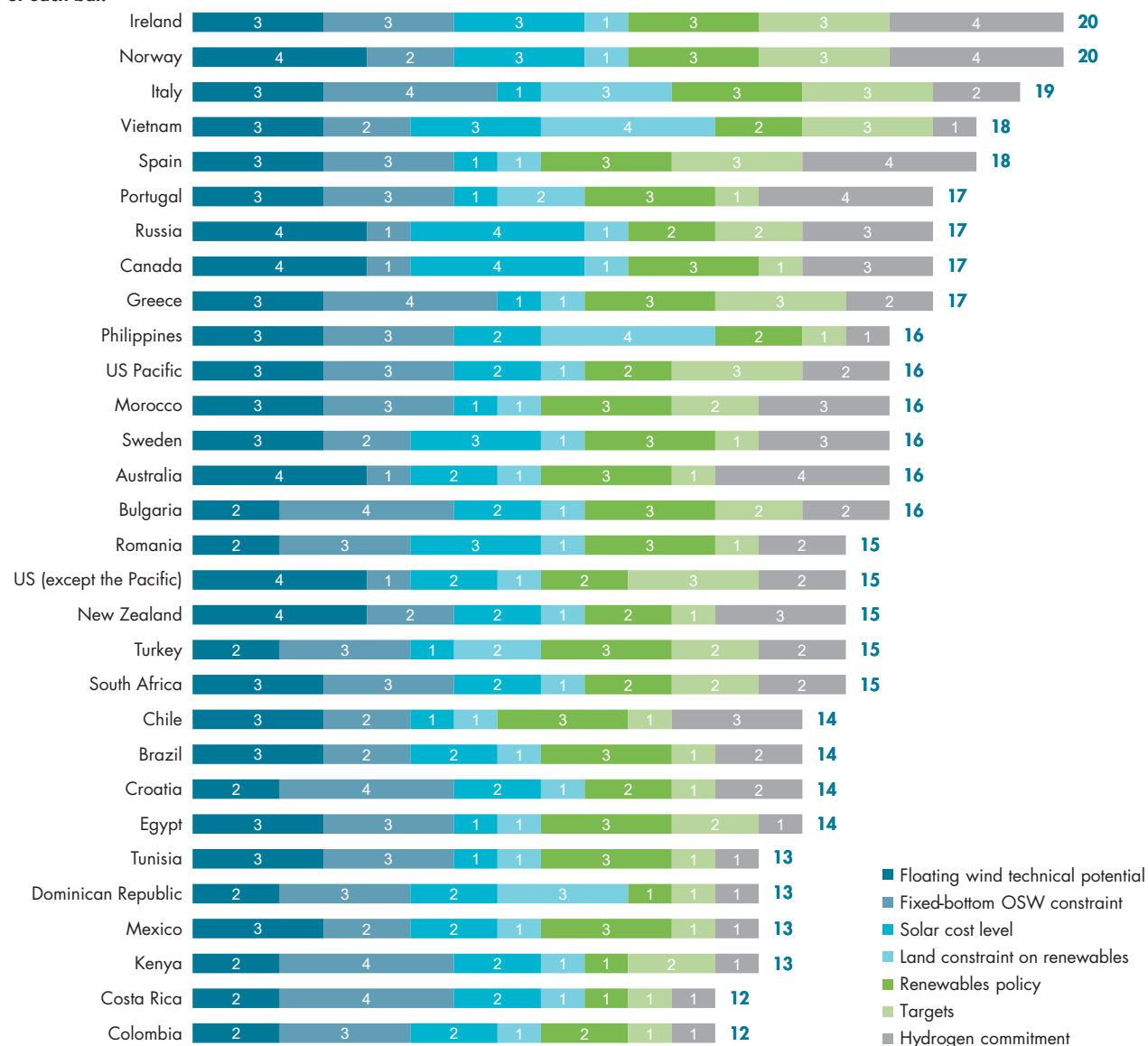
⁸ World Energy Council, International Hydrogen Strategies, 2020: <https://www.weltenergierrat.de/international-hydrogen-strategies/>

Figure 4: Overview of the parameters and their scoring categories

Parameter	Competitiveness of floating wind compared to alternatives				Policy environment		
	Floating wind technical potential	Fixed-bottom OSW wind constraint	Solar cost level	Land constraint on renewables	Renewables policy	Targets	Hydrogen commitment
Proxy	<i>Technical potential for floating offshore wind (GW)</i>	<i>Technical potential for fixed-bottom offshore wind (GW)</i>	<i>Average economic potential (LCOE, USD/MWh 2018)</i>	<i>Population density (people per sq. km of land area)</i>	<i>Renewable RISE score (1-100)</i>	<i>Targets dedicated to wind, offshore wind or floating wind</i>	<i>Four stages of commitment</i>
Score (1-4) equals	1 <10 GW	>1000 GW	<90	<100 =	40 – 55	No target	No significant activities
	2 10 – 100 GW	100 – 1000	90 – 120	100 – 200	55 – 70	Wind target	Initial discussions
	3 100 – 1000 GW	10 – 100	120 – 145	200 – 300	70 – 85	OSW target	Plan in preparation
	4 >1000 GW	<10	>145	>300	85 – 100	Floating wind target	National plan available
What it means	More technical capacity for floating wind means a larger market potential	Less technical capacity for fixed-bottom means a bigger need for floating technology to build out offshore wind in the country	More expensive solar means a bigger need for offshore wind in general, and therefore also floating wind, to move away from fossil fuels	Countries with higher population densities tend to have less available land for onshore wind and solar, providing an incentive for moving offshore	A higher RISE score means a more favorable policy environment for developing renewables	Targets for wind, offshore wind and especially floating wind are beneficial to development as they provide a sense of stability with regards to policy environment	A target dedicated to hydrogen may indicate a preference for relatively high load factor renewables like floating wind

Applying the assessment described above to the 30 markets outstanding from the initial screening and sorting them according to their combined scores from all seven categories results in the following ranking.

Figure 5: The top 30 markets ranked according to their combined score on the seven parameters. Combined scores are denoted to the right of each bar.



It must be noted that this scoring model is an approximation with the purpose of getting an overview of important parameters and the likeliness of future commercialization of markets. Factors related to policy and power prices are subject to change, and thus these scores are only snapshots of the situation at the time of writing this report.



Photo credit: TetraSpar Demonstrator ApS

For instance, Vietnam could claim first place by starting preparations of a plan for green hydrogen and a specific target for offshore wind. As the country currently only has a target for general wind development, it currently scores a 2 on this parameter. Introducing a floating wind target would change the 2 to a 4, and beginning to prepare a plan for hydrogen could change the score on this parameter from a 1 to a 3, giving Vietnam a combined score of 21 and putting the country in first place. As Vietnam already shows great ambition for the energy transition in general, scoring a 3 in the category of “Renewables policy”, it is not unlikely that the country will introduce a target for floating wind and at the same time start preparing a plan for hydrogen, thus making Vietnam a likely candidate for a rank-jump in the foreseeable future. Bulgaria, Greece, Portugal and others are in similar situations and could therefore also be candidates for quickly moving up in the ranking.

In general, markets with low scores on policy-related parameters will be able to change their rank the easiest, illustrating the power of policy in creating a favorable environment for floating offshore wind development.

3.3 Step 4: Choosing five key markets for further investigation

Assessing an initial go-to-market-strategy in a country requires qualitative analysis of a market, and to further this, the analysis dives deeper into five chosen markets.

The final selection for shortlisting was based on a combination of regional categorization of the markets and input from GWEC's Floating Offshore Wind Taskforce. Members of the taskforce provided regional expertise on policy and market conditions within candidate countries, as well as a qualitative assessment to help gauge market confidence. Categorizing by region ensures that the analysis avoids focusing too much on the generally more developed emerging markets in Europe. The regional categories were: North-western Europe, Southern Europe, Eastern Europe, North America, South America and the Caribbean, Asia and Oceania, and Africa.

The regional categories and chosen countries (marked with blue) are illustrated below.

Figure 6: Selected markets for snapshots analysis





3.4 Summary: The process from 115 to the five key markets

As described in section 3.1, the market selection model used in this report combines a data-driven approach with industry insight and expert market observations to arrive at a list of five markets to keep an eye out for, after the first mover markets have started the floating offshore wind race.

Industry insight and market observations were used in the beginning of the process to remove the first movers, “Round One” markets from the pool of candidate markets, and again towards the end of the process when deciding on which five markets to do snapshots on. The expert evaluation towards the end was done to avoid choosing markets that might appear attractive looking only at the data, but which are known to be less relevant for reasons not captured by data, as well as to expand the geographical coverage of the market snapshots to capture a global picture.

The parts of this model dealing only with data have focused on key drivers for floating offshore wind development such as technical

capacity, constraints on fixed-bottom build-out, constraints on land-based renewable energy, price competition from other renewable sources and policy environment.

By subjecting the initial list of 115 markets to an initial screening against five criteria, the list of potential markets was shortened to 30 markets, which were then ranked according to a qualitative assessment of their favorability for floating wind development as viewed through the lens of seven parameters.

The final five markets chosen were then looked at in more detail. These individual market snapshots provide a more granular view of market conditions in these potential emerging markets.

However, while each of these five markets are in a chasing pack of countries and of particular interest for the floating wind industry, it needs to be stressed that this is only a snapshot at a particular time. These five markets chosen for snapshots are only suggestions of markets to keep an eye out for; other markets could quickly overtake them. This work highlights the critical market conditions that need to be in place,

and in particular identifies how establishing a clear policy framework is vital to successful floating offshore wind deployment.

3.5 Approach used for key market snapshots

The five markets chosen as examples of markets that could be chasing the first movers, are assessed in a series of market snapshots towards the end of this report.

The snapshots are built around Aegir Insights' standard method for market assessment, developed over several years of assessing established and emerging markets. The method draws on publicly available data and legislation to determine the favorability of a standardized selection of conditions that impact on offshore wind development as drivers or possible constraints.

The selected key drivers and constraints are listed below, along with a short description of the reasoning for choosing each as a focus point:

Figure 7: Drivers and constraints considered in market snapshots



Site conditions

Wind speeds and bathymetry are key factors to determine the technical potential of a market and gauge the attractiveness of sites.



Policy environment

Government targets and dependability of the regulatory framework for renewable energy influence market maturity and attractiveness.



Support regime

Available subsidies and precedence from previous renewable projects affect ease of financing for offshore wind projects.



Permitting regime

Governance, requirements and clarity of permitting process determine project development lead-time and cost.



Supply chain and infrastructure (ports)

Current port capacities, domestic industrial capabilities and potential synergies from existing industries influence cost of installation.



Transmission grid

Substations close to connection point, current transmission grid capabilities, as well as planned build-out affect the offtake situation

Based on the analysis and evaluation of these drivers and constraints, a short list of soft recommendations for each market is presented. These soft recommendations are not detailed instructions, but rather pointers to help policy makers as well as potential market players focus on the key market conditions to monitor and potentially influence.

Lastly, a value heatmap of each market is displayed. The heatmap analysis combine key value drivers for floating offshore wind and is adjusted to market conditions using Aegir Insights' proprietary algorithm and features calculations based on depths, wind resources and distances to ports and grid connection points.

3.6 Heatmapping the regional competitiveness of floating OSW in snapshot markets

Aegir Insights' proprietary market assessment model was employed in the making of the five market snapshots. This market assessment model is a techno-economic offshore wind performance model for project or regional resources assessment. The model has been developed by Aegir Insights in cooperation with industry and academic partners.





Photo credit: TetraSpar Demonstrator ApS

When assessing the commercial attractiveness of an offshore wind market, reference sites and project designs are developed to indicate how a generic offshore wind project would perform in a given area.

Expected technology development of turbine and other main components are applied for a 2030 timeframe, as well as domestic supply chain capabilities impacting supply and transportation costs. The model then simulates the construction schedule, total project cost and power generation for the lifetime of the wind farm. Together, these form the basis for the reference case LCOE, dependent on the location of the reference case.

Using these calculations, Aegir Insights produces a heatmap illustrating the projected LCOE of the reference case in potential floating offshore wind development areas. Heatmapping is essentially a collection of thousands of individual LCOE⁹ calculations performed across an entire offshore wind market. Each calculation has a unique combination of wind speed, water depth, distances

to port and transmission length, which are key drivers in determining LCOE.

Simply put, the heatmap tells users where they are likely to get the highest value from future wind farms. Value heatmapping is thus an impactful tool to evaluate geospatial variations in resource competitiveness and screen a market for attractive sites to build offshore wind projects.

⁹ Levelized cost of energy (LCOE) refers to the average price of electricity required to cover the lifecycle cost of a project

4 Take-aways from the top 30 floating markets and snapshots of the five key markets

4.1 Take-aways from the ranking of the top 30 markets

The ranking of the top 30 possible “Round Two” floating markets provided a good overview of upcoming potential floating markets, where to find them and their current policy situation. Based on the ranking and the overview it provided, a few points can be made about the upcoming “Round Two” of floating wind development:

- While the top 30 ranking has a global reach, with markets from both Europe, Asia, Africa, Oceania, North and South America represented, it is clear that Western European countries are still among the safest bets for floating wind development – as for offshore wind in general – despite floating technology opening up larger parts of

the world for offshore wind development.

- Asia is only represented by two countries in the top 30 ranking, despite being home to several of the first movers; namely China, Taiwan, Japan and South Korea (which were all removed from the list in the first step of the selection process exactly because they are considered “Round One” markets). However, the two countries representing Asia in this ranking, the Philippines and Vietnam, show great potential with their high ranks on the top 30 list. The combination of a low overall representation, but high scores for the two countries representing Asia, seems to indicate that the policy environment in the Asian regional market is quite heterogeneous currently. Some countries are very ambitious regarding



Photo credit: Principle Power



Photo credit: TetraSpar Demonstrator ApS

offshore wind and will likely be key markets in the near future, but most of the markets in the region remain relatively passive for now.

- In general, technical capacity for floating wind is high in the top 30 countries, with all markets scoring at least a 2. In comparison, all other parameters see market scores across the scale, from 1 to 4. As a result of the relatively homogenous scores for technical capacity for floating wind, this parameter influences the internal ranking of the markets the least out of all the parameters.
- Some parameters jump out due to having a higher frequency of low markets scores. This is the case with the parameters of “Land constraints on renewables”, “Targets” and “Hydrogen commitment”. Markets with very low scores of 1 and 2 have obvious potential for bettering their rank on the list by improving these low scores, especially if the parameter is related to policy, such as the case is for “Targets” and “Hydrogen commitment”.
- In general, the parameters can be divided into two categories, based on how easily they can

be changed through political effort. For instance, scores on the parameters of technical potential and land constraint are generally outside of political control, while the scores on the parameters of targets and hydrogen commitment may quickly be changed drastically by an ambitious government. This means that many of the relatively low-ranking markets in the current ranking could relatively quickly better their rank in the future.

SNAPSHOTS OF FIVE KEY MARKETS FOR THE FUTURE OF FLOATING WIND

Photo credit: Michal Wachucik/Equinor



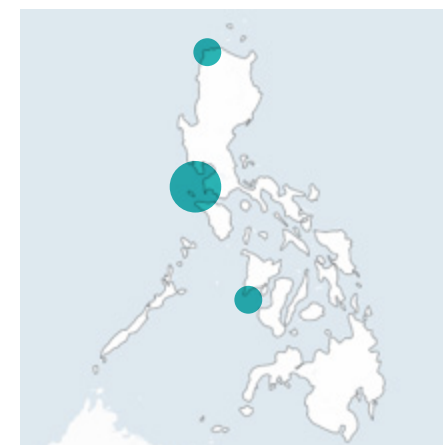
Market snapshot

Philippines Floating wind

High economic growth drives increased electricity demand with favorable sites close to load centers. Tariffs and infrastructure poses potential challenges to commercial scale floating offshore wind

Drivers For Build-out		Key Take-Aways	
 Site conditions	- Philippines benefit from a few but very decent sites with wind conditions in close proximity to the largest load centre by the city of Manila. In this area, sites are identified with wind speeds up to 10-11 m/s and less than 500m water depth making it attractive for floating wind. - Other potential sites are in south by Cebu and Cagayan and the very northern point close to Laoag City, which might be more challenged in terms of infrastructure.	 There are a number of sites with favourable conditions close to load centres, but these are limited providing a strong first-mover advantage.	
	- High growth rates leading to increased energy consumption paired with abundant potential resources of natural energy has made the government set high ambitions for renewables, including geothermal, biomass, solar, hydro, and wind. - Government has initiated an offshore wind roadmap project with World Bank Group and BVG Associates to formulate short and long term targets as well as formulating policy that will support integrating offshore wind in the renewable energy mix.		
 Policy environment	- The government supports renewables projects, including offshore wind, with feed-in-tariffs. In order to attain continuously better energy prices and take advantage of an ongoingly maturing market, FiT are slowly declining. - Initially, tariffs on 0,15 €/kWh were granted, while more recent projects have declined to 0.13 €/kWh.	 The FiT has been a favourable subsidy, but the long term possibility and expected continuous decline must be taken into consideration.	

Key Areas



Based on LCOE calculations from Aegir Insights, three areas of interest are identified as potential sites for floating offshore wind

	Permitting process	• Permitting process is lengthy and complex as it involves numerous different permission involving different government agencies. • Pre-development stage for wind projects is expected to be up to 5 years, but it is uncertain how floating offshore wind projects will turn out.		Complex procedure but a number of industry players are voicing concern to incentivize government to cut red tape.
	Supply chain	• The area of interest in the middle of the country, by Manila, has the best ports conditions with a few large, international harbours, that should be suitable as installation as well as O&M port. • There is no domestic turbine fabrication industry in Philippines, but high activity level in neighbouring countries enable potential supply chain synergies.		Limited harbour capacity can drive cost and complexity. No domestic suppliers can enable better price competition due to no domestic preference.
	Transmission grid	• Substations are in proximity to identified sites as most large load centre are coastal. • Northern Island's (Luzon Island) grid infrastructure seems to be the most capable based on number of substations, where we also find the capital Manila.		Area around Manila is promising as there are a number of substations and high demand. A number of islands are not connected to grid.

Sources: Aegir database, Philippine News Agency: Better policies seen to drive renewable energy growth (2020), Department of Energy: National Renewable Energy Program, Asia Wind Association: Philippines Market Overview, Philippines Energy Regulatory Commission: ERC Approves a Lower Feed-in Tariff Allowance (2021), Ateneo School of Government: Evaluating the Feed-in Tariff Policy in the Philippines (2020), Department of Energy Philippines: Wind Work Program, EVWind: Philippines to build first offshore wind farm (2021), Department of Energy Philippines: Renewable Energy-Awarded Wind, Renewables: Philippines sets out offshore wind roadmap (2021).



Favorable



Not favorable

Current activities/projects

- The offshore wind market in Philippines has begun to pick up, following neighboring countries such as Taiwan and South Korea.
- With a roadmap in process, a growing group of developers eye an opportunity to enter the market.
- In 2021, The Department of Energy issued a list of renewable projects cleared for system impact where at least 8 are offshore wind projects.
- Iberdrola and domestic developer, Triconti, aim at developing 3.5 GW offshore wind in 5 projects.
- Blue Circle and Clean Global Renewables secured development rights to a 1.2GW site in Bulalacao.
- Domestic oil & gas firm Petro-Green entered wind market with several project proposals.

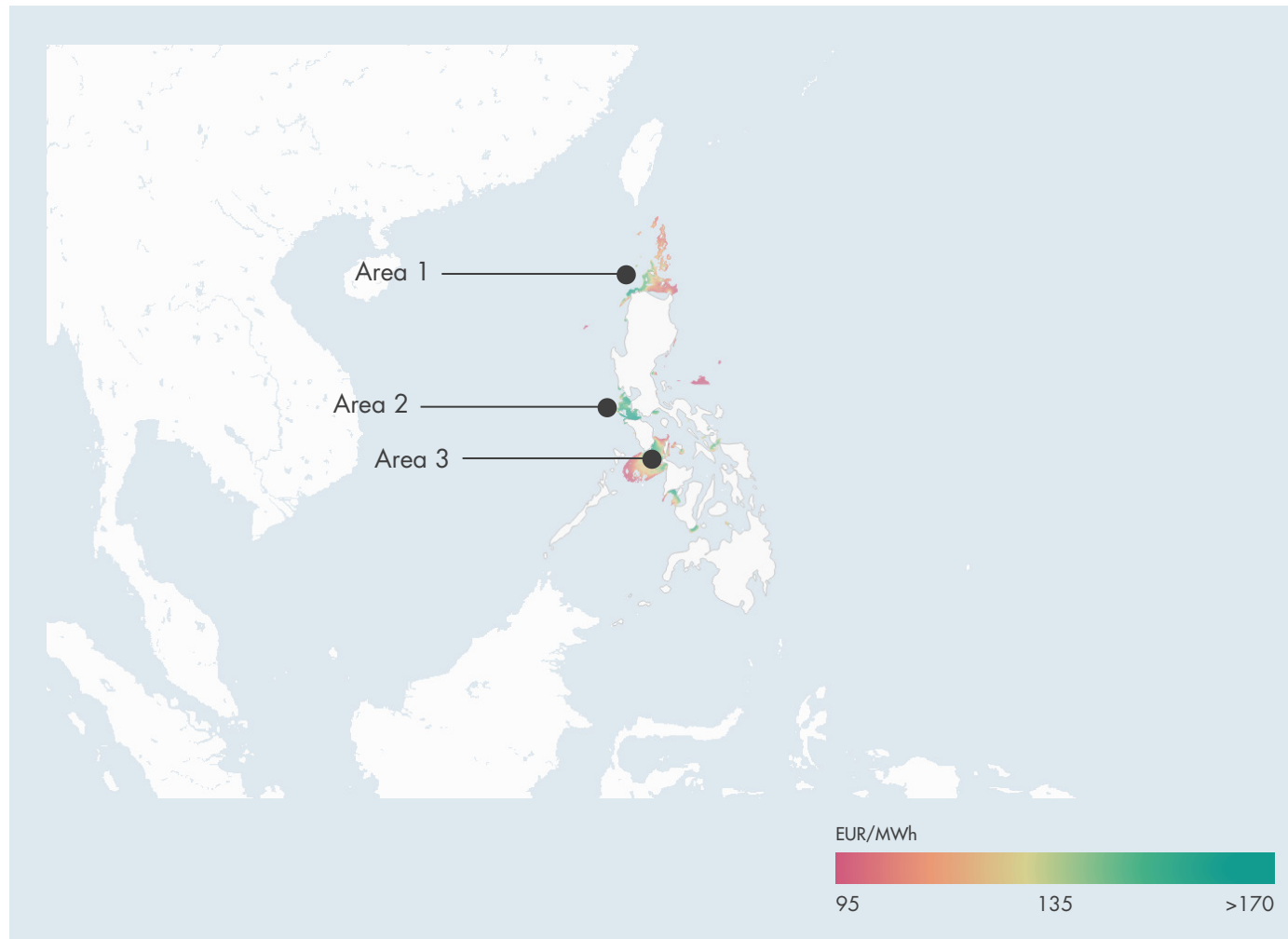
Price competitiveness and development in port infrastructure are crucial for attractiveness and progress should be monitored closely

	Challenge	Impact	Possible Actions
	HIGH VARIATION IN PORT AVAILABILITY ACROSS POTENTIAL SITES Some sites with attractive metocean conditions close to load centres lack ports with sufficient capacity.	Ports nearby attractive sites are expected not to satisfy installation demands of floating offshore wind.	It should be monitored whether government announces initiatives to upgrade ports close to sites that are not in proximity to Manila.
	HIGH VARIATION IN PORT AVAILABILITY ACROSS POTENTIAL SITES Feed-in tariffs grants have been declining as renewables has scaled and might decline further.	Challenges profitability of a less mature floating offshore wind market.	It should be monitored whether government will make targeted tariffs towards floating offshore, or if current levels are sufficient for project economies.
	LITTLE OR NO DOMESTIC INDUSTRY It is uncertain if domestic suppliers can provide adequate materials for floating offshore wind.	Absent domestic industry hinders local job creation and potentially effect policies. Imports can increase transportation costs.	In budgeting, transportation cost must be paid attention to. As of now, there is no indication that government ambitions are limited due to potentially lacking job creation.
	COMPLEX PERMITTING PROCESS There has not been implemented a one-stop kind of process, and developers must be involved with numerous agencies.	Red-tape and bureaucratic complexity drives up project complexity and, as a consequence, expected costs.	It could make market more attractive to engage in dialogue with government to simplify permitting process.

● No mitigation in place adding significant risk
 ● Mitigation plan in place but with some uncertainty
 ● Challenge is expected to resolve but should be monitored

Floating wind opens substantial high value acreage, especially close to industrial center of Manila, but also attractive sites by Cebu City

LCOE Heatmap for floating areas (60-1,300m), EUR/MWh



Key take-aways

- Three areas for floating offshore wind have been identified ranging from 75-100 EUR/MWh
- Area 1 has attractive wind speeds of 10 to 11 m/s and offers LCOE-levels around 75-80 EUR/MWh, but may have operational constraints due to more severe meteocean conditions
- Area 2 is close to the largest city and load center, Manila, and has attractive wind speeds of 10 to 11 m/s. It offers LCOE-levels around 80-100 EUR/MWh
- Area 3 has wind speeds of ~10 m/s and relatively large prospective area for project siting offering LCOE-levels 85-90 EUR/MWh



Market snapshot
Italy
Floating wind

Lack of relevant space on land and meeting green energy goals are main drivers for floating offshore wind in Italy

Drivers For Build-out		Key Take-Aways
 Site conditions	- Italy has a long coastline, but economically viable wind resources are mostly found in the south of the mainland or close to the islands of Sardinia and Sicily. The most attractive sites with average wind speeds of >8 m/s are located north of Sardinia and south off the mainland - Water depths at most potential OSW sites range from approximately 60-300 meters, making floating turbines the main option for any offshore wind build-out	 The best sites are found around Sardinia and in the Strait of Sicily. Water depths make floating technology a necessary prerequisite for any substantial build-out
	- The government is committed to the energy transition via its EU membership, and has presented the National Recovery and Resilience Plan to make the post COVID-19 recovery as green as possible - Italy aims to increase wind power from the current 10.5 GW to 18.4 GW by 2030.1 Only 900 MW of the 18.4 GW are targeted to come from offshore wind, but industry are calling for a higher target as floating wind is becoming a viable technology	 Italy has been careful about OSW due to having few sites suited for fixed-bottom. As floating wind becomes viable, Italy will likely be more bullish on OSW
 Support regime	- It is expected that the primary support for offshore wind will be Contracts-for-Difference, awarded through a competitive auction under the FER1 Decree - Currently, OSW does not have its own category in the FER1 Decree - Italy's first offshore wind farm by Taranto won the rights to a 25-years feed-in tariff of 161,7 EUR/MWh through a tender in December 20163	 Any move towards an OSW-targeted category should be monitored, as this would decrease price competition with other renewables

Key Areas



Based on LCOE calculations from Aegir Insights, the above areas offer the lowest LCOEs. Particularly areas around Sicily and Sardinia look interesting



Permitting process

- The permitting process is uncertain and time-consuming, but Italy's 2030 National Energy & Climate Plan aims to simplify it
- Lack of design envelope option means that projects cannot easily update the technology used in their projects which adds to the permit timeline
- Italy's first offshore wind farm by Taranto started the permitting process in 2010 and only got its final EIA approval in 2019, expected COD in 2022



Updates to the permitting process are needed, as this remains a constraint due to lengthy conflicts with local authorities.



Supply chain

- Italy has several large and deep ports in proximity to potential offshore wind sites
- Investments in infrastructure and labour skills must be made to harness the full job-creating potential of the potential OSW ports, as none are currently serving OSW
- Italy has a supply chain for onshore wind with several manufacturers having a significant track record, but it is yet uncertain how many would adapt to offshore wind



Italy will likely wish to create jobs by supplying components and using domestic ports. But French and Spanish manufacturers will be strong competitors.



Transmission grid

- Italy has an extensive power grid including subsea HVDC cables between Sardinia and the mainland, close to the major load center of Rome
- The Italian transmission network operator, Terna, is responsible for the high-voltage and extra-high-voltage connections from power generators to the national grid
- Every year, Terna publishes a development plan covering the following ten years. The 2021 Development Plan has a strong focus on promoting renewable energy sources



Terna's grid development plan should be monitored, as this will show how Terna plans to connect upcoming offshore wind generators, such as the Hannibal project.

Current activities/projects

- Italy's first offshore wind farm, the 30 MW fixed-bottom wind farm off the coast by the city of Taranto is expected to come online in 2022
- Several projects are pending concessions, including Hannibal, a floating 250 MW project by Sicily, a 2,9 GW floating project in the Strait of Sicily and the recently announced Nora Energia 1 & 2 floating projects by Sardinia
- In general, there is a high degree of developer interest in the Italian market despite long permitting times, often strong stakeholder opposition and a low government offshore wind target
- In October 2021, the TSO Terna announced it had received 39 grid connection applications from offshore wind projects

Sources: Aegir database, Italy's 2030 National Energy & Climate Plan, World Port Index

Notes: 1; P. 69 in Italy's 2030 National Energy & Climate Plan; 2: "Italy pressed to raise offshore wind goal as industry flags 5GW floating potential" by Bernd Radowitz on rechargenews.com, Jan. 28, 2021; 3: "Italy Approves Fixed Price Tariff for First Offshore Wind Project" in offshorewind.biz, Dec. 28, 2016



Favorable



Not favorable

Solid industrial base and port infrastructure could give Italy a key role in Mediterranean build-out, but policy adjustments should be made

	Challenge	Impact	Possible Actions
	POWER GRID UNDER DEVELOPMENT While the Italian TSO, Terna, is aware of the need to integrate renewable sources and promises investments in the 2021 Development Plan, it has little experience with OSW	Uncertainty regarding Terna's ability to provide OSW farms with timely and adequate grid connection	Terna's yearly development plans should be monitored to see if planned development is adequate and renewable electricity generators are prioritised as promised
	UNAMBITIOUS OFFSHORE WIND TARGET COULD USE AN UPGRADE Italy's target for offshore wind stands at 900 MW, a low target that was originally decided on due to Italy's need for floating technology to develop	The lack of an ambitious offshore wind target sends mixed signals to the industry and impacts negatively on investor willingness	Italian industry association ANEV is arguing setting a more ambitious target due to floating technology nearing commercial stage. A more ambitious target would be a strong signal to the market
	PERMITTING REGIME NEEDS UPGRADING Current regime does not allow for design envelopes and is challenged by municipalities. Lengthy process of eight years seen	A long permitting process with a high level of complexity and risk from local stakeholders jeopardizes project timelines and impacts negatively on investor willingness	Efforts to streamline permitting should be monitored, focusing on clarity around jurisdiction (national/municipalities) and implementing a design envelope
	HIGH PRICE COMPETITION WITH OTHER ENERGY SOURCES In recent auctions, solar and land-based wind have been awarded FiTs down to 56 EUR/MWh and 66 EUR/MWh ² , respectively	Large scale expansion for offshore wind depends on being price competitive with competing, renewable sources	The OSW project by Taranto was awarded a much higher FiT than competing renewables. If this practice is continued, OSW should be able to develop in Italy

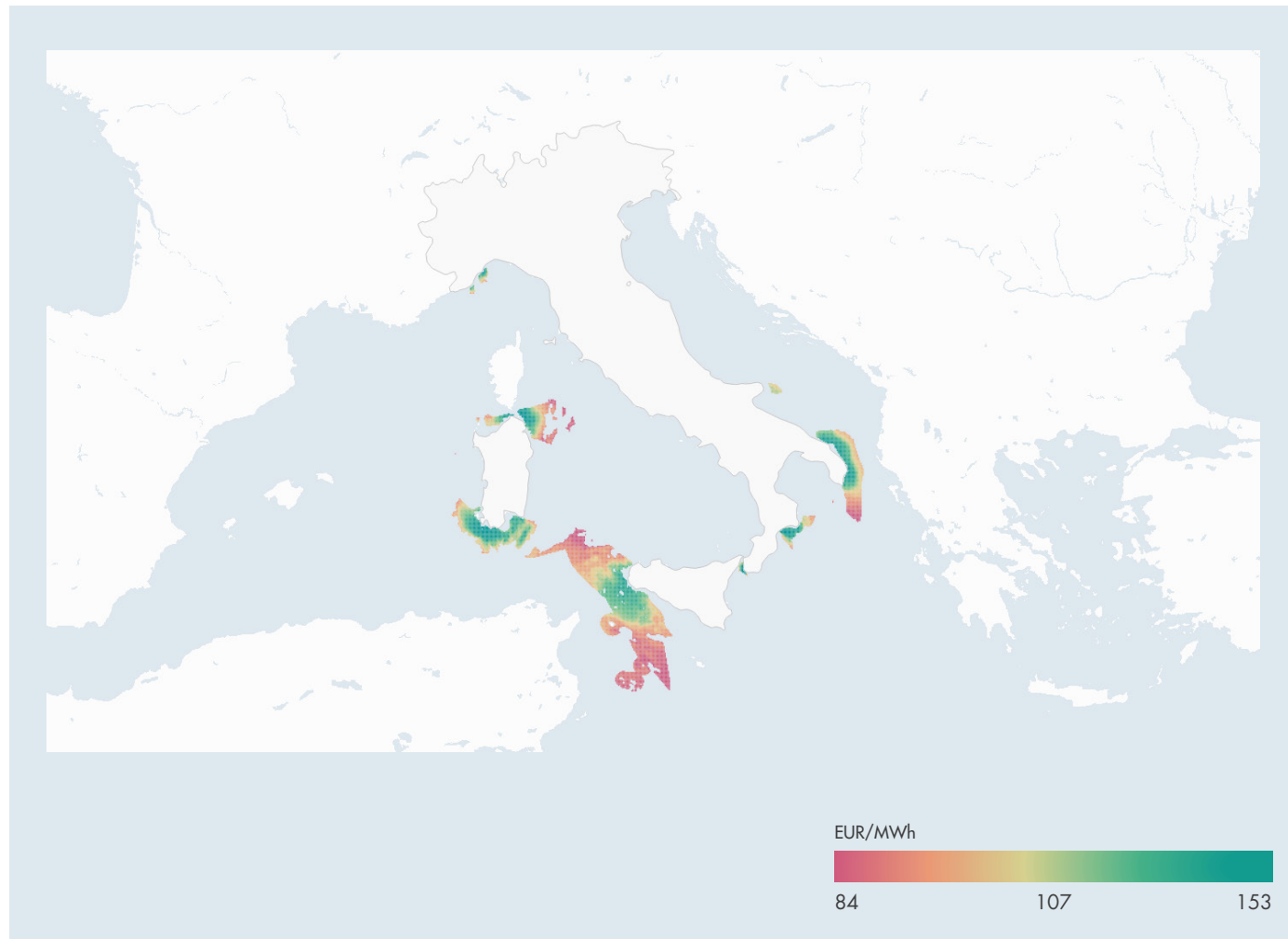
Sources: Italy's 2030 National Energy & Climate Plan, World Port Index

Notes: 1: "Italy allocates 32.2 MW of solar in fifth renewables auction" in PV Magazine, May 27th 2021, 2: "Italy awards €66/MWh tariff to 800MW of onshore wind" in Windpower Monthly, Dec. 23rd, 2016

 No mitigation in place adding significant risk
  Mitigation plan in place but with some uncertainty
  Challenge is expected to resolve but should be monitored

Best sites for floating offshore wind development in Italy are in the south; around the foot of the boot and close to Sardinia and Sicily

LCOE Heatmap for floating areas (60-1,300m), EUR/MWh



Key take-aways

- Compared to the other snapshot markets, Italy is the most expensive in terms of LCOE, mainly due to relatively low wind speeds
- The largest and overall, most attractive sites are found around Sardinia and west of Sicily, which is also where most of the current industry activity is taking place
- Sites off the coast of Calabria and Puglia (the foot and heel of the boot) could also turn out to have relatively low LCOE
- Smaller sites are possible close to the big port of Genova in the north



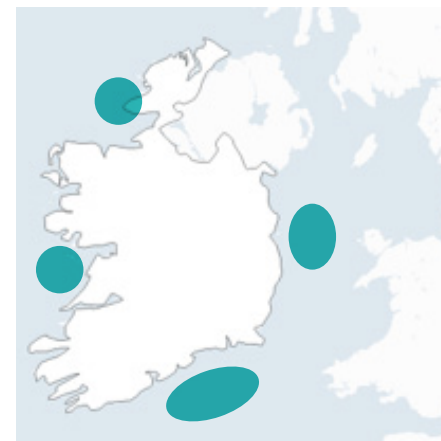
Market snapshot
Ireland
Floating wind



Favorable site conditions and highly ambitious government make for an attractive OSW environment if transmission grid and ports are upgraded

Drivers For Build-out		Key Take-Aways
 Site conditions	- Ireland's Northern Pacific Ocean has ideal conditions for floating wind. In reasonable proximity to the coast, water depth is 100-150m and wind speeds range from 10 to 11 m/s. Wave regimes are harsh here, requiring new installation and O&M solutions. - In the southern and south-western part by the Irish Sea, there are near-coast areas with water depth of 30-50m and wind speeds ranging from 9 to 10 m/s. Further from the coast, water depth is 80-100m with similar wind speed.	 Wind resources are good for shallow to mid floating offshore wind, especially on western and southern coast. Few areas are suited for fixed bottom offshore wind.
	 Policy environment	 Ireland has explicit strategies for transforming their energy system, and specific floating offshore targets provide favourable policy environment.
 Support regime	- The Maritime Area Regulatory Authority (MARA) was established in 2021 to drive transformation towards energy targets by streamlining processes, reducing bureaucracy, and being the government entity responsible to auctions and licenses. - Three auctions for offshore wind are planned, and the first, called ORESS 11, is expected to be held in 2022. Terms and conditions have been published.	 The terms and conditions of the first auction are currently in consultation and ORESS 1 is expected to take place. This gives a positive outlook for floating wind in the future.

Key Areas



Based on LCOE calculations from Aegir Insights, four areas of interest are identified as promising, potential sites for floating wind

 Permitting process	- The Irish government has passed a new maritime planning (MAP) bill that intends to remove the regulative and administrative challenges present under the current Foreshore Acts. During the transition to the new consent regime projects are divided into “legacy projects” which already have received planning consent under the existing regime, and “enduring projects” having not received a planning permission. ~3,3 GW of project capacity have been named ‘Relevant Projects’ to be fast-tracked.	 Existing regime is under revision to align consenting approach with the UK. The MAP bill was adopted December 2021 and should simplify the process.
 Supply chain	- Ireland needs to make investments in ports and labour skills to harness full economic development potential in OSW. - No ports currently satisfy requirements for supporting construction of offshore wind farms, though Foynes on the west coast is used for onshore wind turbines. Arklow on the east coast is being considered to support the extension of Arklow Bank wind farm. There are nearby ports in other countries.	 If Ireland does not adapt its industrial capabilities and ports to OSW, nearby ports and supply chains in other countries could be used. Key stakeholders recognize this.
 Transmission grid	- EirGrid is responsible for the maintenance and development of the transmission grid in Ireland. The current transmission grid is designed for fossil fuels and does not have capacity to satisfy renewables targets. - There is a long and short-term plan in place to modernize the grid as auctions are held to satisfy requirements for new projects, incl. transformation of coal-fired Moneypoint. - Considerations of grid allocation for “Legacy projects” and “Enduring projects” ongoing.	 Implementation plan should be monitored, especially with attention to financing models and progress compared to development project plans.

Sources: Aegir database, Harnessing our potential (Carbon Trust, 2020), Ireland’s Sustainable Energy Supply Chain Opportunity (Seai, 2014), Wind Energy Roadmap 2011-2050 (Seai, 2010), Climate Action Plan 2019 (Government of Ireland 2019), Irish Wind Magazine Spring Edition (Wind Energy Ireland, 2021), Building Offshore Wind 70 by 30 Implementation Plan (Irish Wind Energy Association, 2020), Ireland’s Grid Development Strategy (Eirgrid Group, 2017), World Port Index

Notes 1: RESS, Renewable Energy Support Scheme, recently implemented competitive auction-based subsidy in Ireland

 Favorable
  Not favorable

Current activities/projects

- More than 12 GW of OSW projects at various stages of development, however only one project, Arklow Bank Wind of 25.2 MW, is installed
- International developers have acquired stakes in several floating wind projects in Ireland
- Shell and SimplyBlue have joined forces to develop two floating wind projects: Western Star and Emerald, both off the Irish west coast
- Offshore Wind Ltd., a joint venture between Cobra Instalaciones y Servicios and Flotation Energy, announced plans for a 1.5 GW floating project called Blackwater in 2021
- In Oct. 2021 Inis Offshore Wind was launched with the goal of developing at least 1 GW offshore wind in Ireland

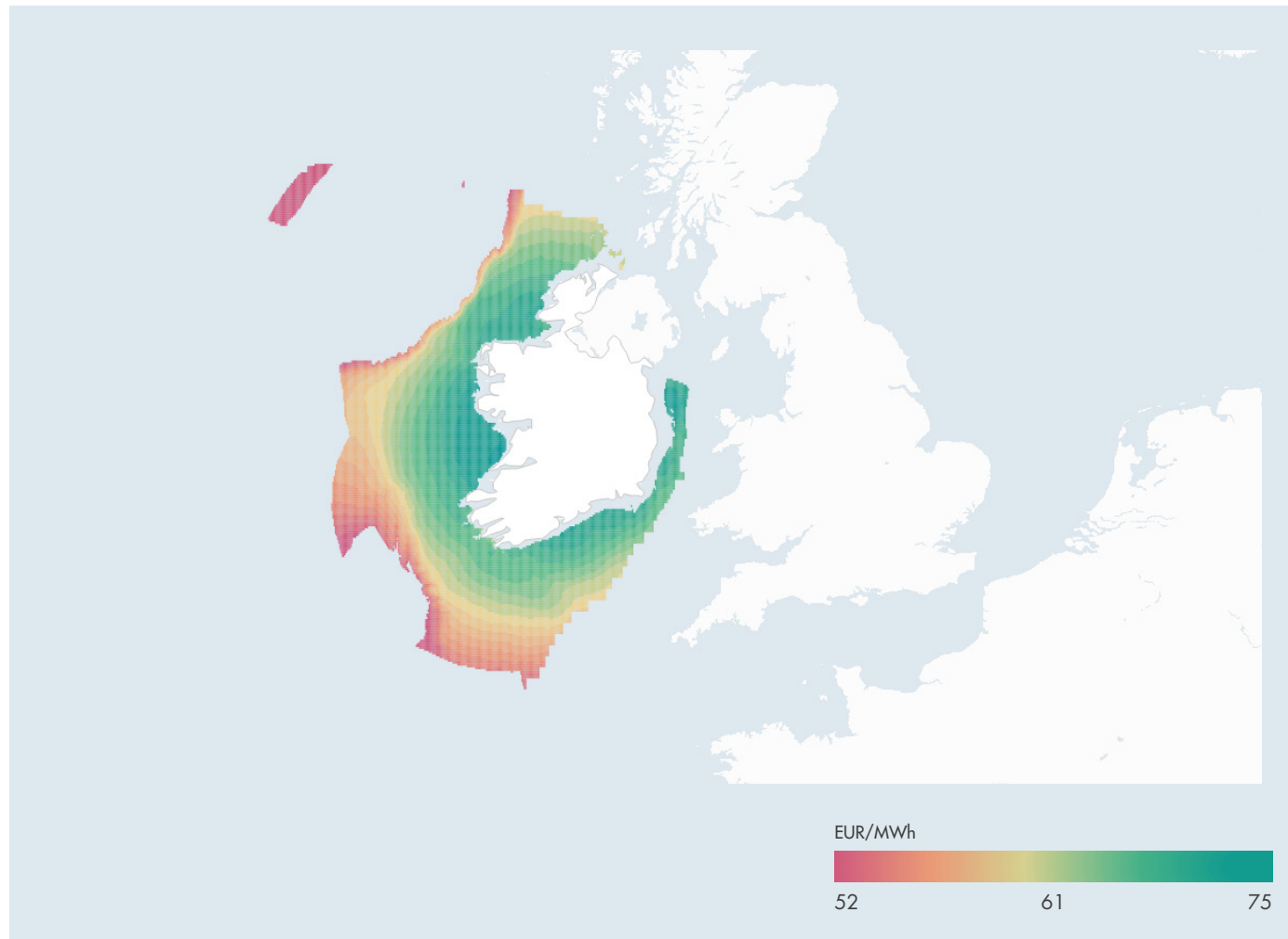
Price competitiveness and development in port infrastructure are crucial for attractiveness and progress should be monitored closely

	Challenge	Impact	Possible Actions
	POWER GRID NEEDS DEVELOPMENT Transmission grid is designed to satisfy fossil energy sources and investments are needed.	The transmission grid must be enforced in order to provide the necessary infrastructure supporting the renewable targets.	There is a framework and plan for developing transmission grid but stakeholder management could be relevant in order to ensure development fits projects.
	NO PORTS WITH SUFFICIENT CAPACITY No ports of sufficient capacity for offshore construction projects. Expansion could drive costs up significantly.	Unless ports are upgraded, it will be necessary to use foreign ports with negative impact on job creation.	Upgrade plans are partly in place. In December 2021 the Irish Government issued a Policy Statement to develop port infrastructure to support offshore wind. Realisation of plans should be monitored.
	PERMITTING REGIME STILL IN DEVELOPEMNT Current regime is not tailored to offshore wind and it complicates reaching government targets due to lengthy process.	Long permitting process drive complexity and risk, while jeopardizing government targets.	New procedure in being defined to reduce complexity, and the process should be monitored to ensure that it fits with project models and expected timelines.
	HIGH PRICE COMPETITION WITH OTHER ENERGY SOURCES In recent auctions, relatively low prices have been offered from solar and onshore wind.	Large scale expansion for offshore wind depends on being price competitive with competing, renewable sources.	There are planned offshore wind auctions, namely ORESS1. Progress should be monitored to see that auctions are held as planned.

 No mitigation in place adding significant risk
  Mitigation plan in place but with some uncertainty
  Challenge is expected to resolve but should be monitored

Floating wind opens substantial high value acreage, especially close to industrial centers of Dublin and Cork

LCOE Heatmap for floating areas (60-1,300m), EUR/MWh



Key take-aways

- Most of the coastline provides potential sites offering LCOE-levels around 55-60 EUR/MWh. These sites are also near main loads centres
- Eastern coastline by the Irish Sea currently has several offshore wind projects. This is close to the capital Dublin and accordingly large substations. Analysis indicates that there is potential sites for floating with offering LCOE-levels as low as 55 EUR/MWh
- The southern part by the Celtic Sea and Cork, the second largest city, is also promising, being nearby a large port and offering LCOE-levels around 55 EUR/MWh
- The western part of the country by the Atlantic Ocean has the best LCOE-levels – as low as 53 EUR/MWh. Here, the largest potential areas are also found, but the distance to large load centers is much longer than the eastern and southern area



Market snapshot

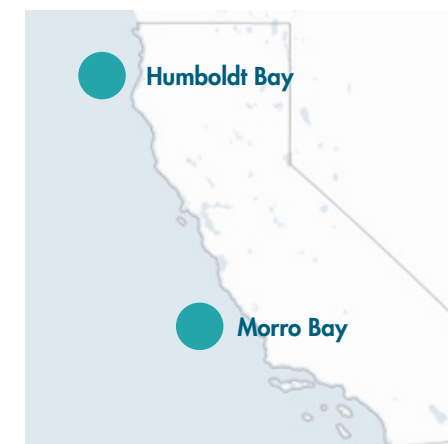
California Floating wind



Favorable site conditions and highly ambitious government make for an attractive OSW environment if transmission grid and ports are upgraded

Drivers For Build-out		Key Take-Aways
 Site conditions	- Good wind resources are found in the two Wind Energy Areas: Humboldt Bay >9 m/s, and ~8.8 m/s for Morro Bay 399 Area - California has exclusively deep floating opportunities within Wind Energy Areas Humboldt Bay and Morro Bay, located in 500 to 1300 m waters. About 50% of Morro Bay call area is in >1,000m depths. Harsh wave conditions with mean wave height of 2.4m (compared to NW Europe with 1.3m), challenge installation and O&M concepts	 The two Wind Energy Areas are in deep water suitable for deep floating and have good wind resources. Metocean conditions require new solutions to handle waves
	100% Renewable Portfolio Standard (RPS) target by 2045. - Diversifying energy mix with a source that is unaffected by nighttime, clouds and forest fires.¹ Decommissioning of LNG and nuclear plants. Need for green source complementary to solar (the duck curve effect) \$100bn budget plan announced in May 2021 aimed at combatting climate change and wildfires²	 Meeting RPS targets, reducing the duck curve effect and retiring power plants are key policy drivers. Use of long-duration storage systems during off-peak
	- Offtake through PPAs/ORECs on state-level through a competitive bidding process - The Investment Tax Credit (ITC) passed in Dec. 2020 provides a credit for 30% of the investment costs at the start of the project for projects deployed before 2026 - Historically, renewable tax credits have been renewed every 2-5 years. It's expected that an ITC regime for offshore wind will be available for post 2026 projects	 State-level support regime for dedicated floating OSW markets do not exist yet, but will most likely follow the structures of existing East Coast PPAs and ORECs ⁴

Key Areas



Wind Energy Areas defined by BOEM and expected to be auctioned in September 2022



Permitting process

- Established process for EIS and final approval in federal waters managed by the Bureau of Ocean Energy Management (BOEM). In May 2021 Vineyard Wind project was the first OSW project to reach Record of Decision (approval) of their Construction and Operations Plan (COP)
- Permitting process in state waters (up to 3nm) is un-tested. Stakeholder concerns; visual impacts, naval military uses, impact from floating power cables on marine life



Although major federal permit milestone has been achieved for first OSW project, framework adjustments to floating OSW projects are pending.



Supply chain

- The Jones Act prevents non-U.S. built vessels to operate on U.S. wind farm projects. Vineyard Wind's feeder concept makes use of EU installation vessels possible. However, limited supply of U.S. install. Vessel are likely to be a major bottle neck for future build-out. Ports exist; Humboldt Bay and Hueneme (>300km from Morro Bay)
- The U.S. supply chain is still in an early stage, with most components being shipped from Europe. Recent manufacturing announcements set-up on East Coast



First projects sourced from Europe/Asia/East Coast, multi-GW market will drive local based supply.



Transmission grid

- North Coast call area Humboldt Bay is highly grid constrained with an estimated max. 150 MW available to be added to the grid (115kV) requiring significant upgrades. Solutions; inland connection of ~200 km overhead lines or onshore connection to load centres have long lead times and are expensive (\$1.4-5.8bn, however most are carried by ratepayers).³ In Central Coast excess transmission infrastructure exists of ~4 GW from retiring power plants in Morro Bay and Diablo Canyon



Major grid investments needed in North Coast for above 150MW, available grid capacity of ~4 GW in Central Coast. Central Coast is expected to build-out first.

Current activities/projects

- BOEM lease auctions of Morro Bay 399 Area (3 GW) and Humboldt Bay Area (1.6 GW) will have a total capacity of ~4.6 GW
- The Wind Energy Areas (WEAs) will undergo environmental analysis before being finalized for auction estimated for for September 2022 with 14 qualified bidders⁵
- Strong competition expected in first lease auctions
- Existing announced projects (all subject to auction): 560-650MW project (stated in unsolicited bid) by Trident Wind/EnBW in Morro Bay, and 100-150MW project by RCEA, EDPR and Principle Power in Humboldt Bay

Sources: Aegir database, 2020 Offshore Wind Resource Assessment for the California Pacific Outer Continental Shelf (NREL, Oct. 2020); U.S. Department of Interior (DOI) press release May 25th 2021: Biden-Harris Administration Advances Offshore Wind in the Pacific

Notes: 1: The 2020 wildfire season was the worst in state history with 9,639 fires burning more than 4% of California's land, which led to grid operator P&G bankruptcy; 2: California Combat Plan, CA government, May 14th 2021; 3: Interconnection Feasibility Study Report, Schatz Energy Research Center & BOEM, Sep. 2020; 4: Offshore wind Renewable Energy Certificates (ORECs); 5: The 14 parties are; Algonquin Power, Avangrid Renewables, Castle Wind (EnBW and Trident Winds), Cierco, CIP, EDF, EDPR, Equinor, MRP, Northland Power, Redwood Coast Energy Authority, RWE and Wpd



Favorable



Not favorable

Price competitiveness and development in port infrastructure are crucial for attractiveness and progress should be monitored closely

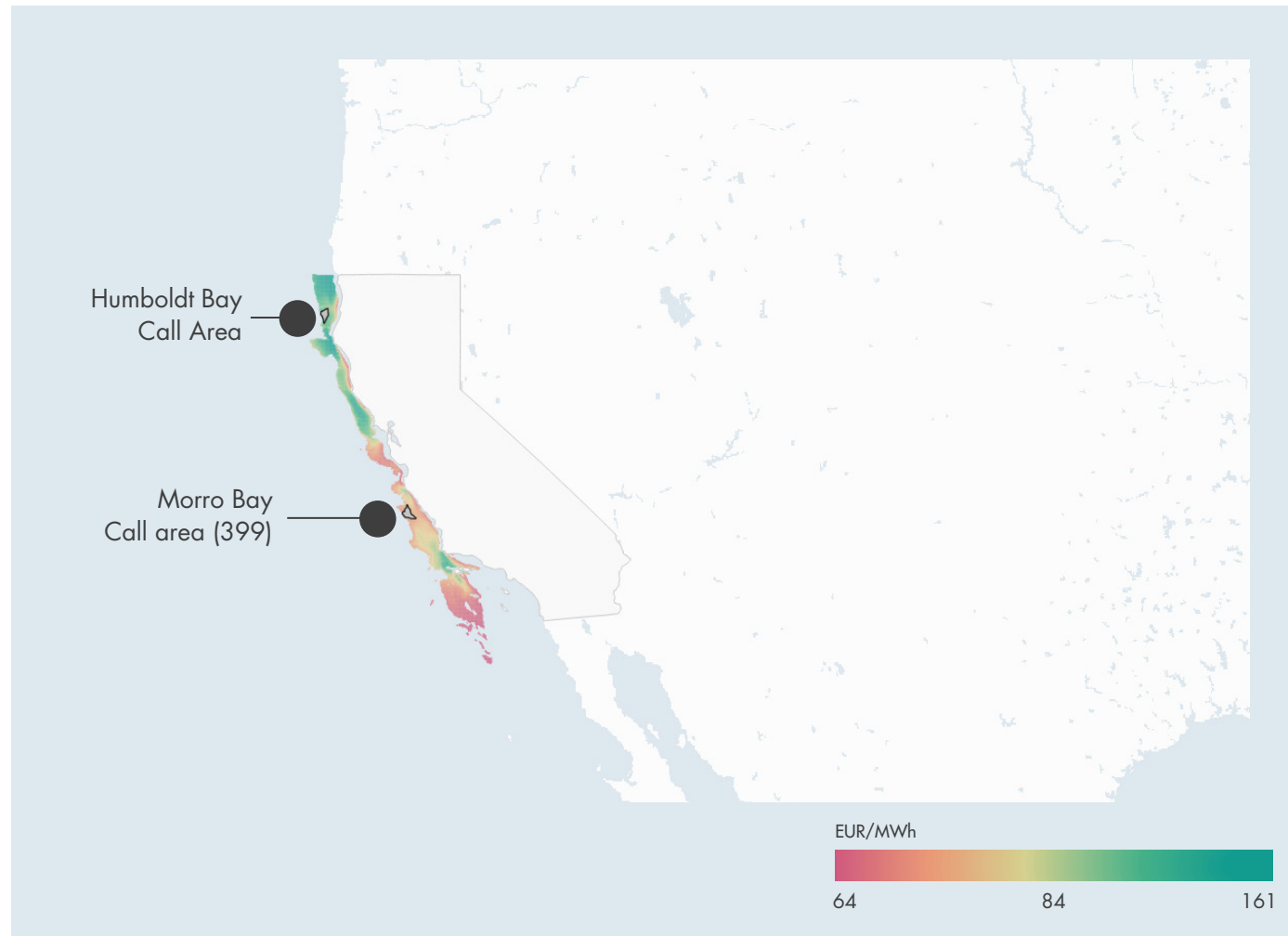
	Challenge	Impact	Possible Actions
	POWER GRID NEEDS DEVELOPMENT A developer led grid solution for the North Coast is unlikely to be viable with the grid operator and will entail a competitive process.	The timeline for a reliability state-led process is several years from lease award, which drives lower interest in acquiring Humboldt leases.	State government to take decision on approach to transmission build-out in the North if commercial scale OSW development should happen before 2035.
	LACK OF DEDICATED OSW TARGET 6 GW of new renewables needed annually to meet RPS standard (100% by 2045) ¹ . OSW can help balance the grid in combination with long-duration storage systems.	Dedicated OSW target for California towards 2045 would be a strong market signal. First projects in Morro Bay of commercial size capacity of 800-1000 MW needed to meet target.	Dedicated OSW target for California towards 2045 would be a strong market signal. Look to make long-duration storage systems a possible route to market for OSW over solar.
	FEDERAL AND STATE PERMITTING REGIME STILL IN DEVELOPEMNT No U.S. OSW projects has started construction to date and federal permitting lead-times have been lengthy.	Although major federal permit milestone has been achieved for first OSW project, framework adjustments to floating OSW projects are pending and can lead to longer permit lead-times.	On the federal level, things could be looking up after Vineyard Wind has moved forward. State level, California Comeback Plan has allocated \$6.5m to accelerate environmental review and \$2.1m for environmental studies
	NO CARVE-OUT STATE PROCUREMENT FOR OFFSHORE WIND State-level procurement and support regime for dedicated floating OSW do not exist and existing bilateral offtake routes with entities (IOUs, CCAs) might be challenging.	The majority of all renewable power is currently expected to be purchased through bilateral arrangements with CCAs ² , however OSW has a premium price and higher capacity size.	Explore central procuring entity requiring Load Serving Entities (LSEs) to procure OSW.

Notes: 1: 2021 SB 100 Joint Agency Report, California Public Utilities Commission (CPUC); 2: Community Choice Aggregators (CCAs)

 No mitigation in place adding significant risk
  Mitigation plan in place but with some uncertainty
  Challenge is expected to resolve but should be monitored

North coast offers most promising sites (disregarding grid constraints), but higher LCOE levels are expected for 2030 projects due to deep waters

LCOE Heatmap for floating areas (60-1,300m), EUR/MWh



Key take-aways

- Humboldt Bay area in the north has better wind and shallow waters (500-1,000m and average 9.7 m/s) compared to central coast area Morro Bay 399 (800-1,300m, average 8.8 m/s)
- Average LCOE-levels of 78 EUR/MWh is found in Humboldt Bay compared to 98 EUR/MWh in Morro Bay 399
- For COD 2030 projects in deep waters of 500 to 1,300 meters, relatively high LCOE-levels are generally seen due to added mooring, anchoring and cables needed for deep water sites
- Dedicated concepts for suspended dynamic cables and mooring to be developed and deployed at commercial scale to be more cost competitive with shallow floating projects
- However, large capacity deployment per project is expected in California which will benefit LCOE levels



Photo credit: Principle Power

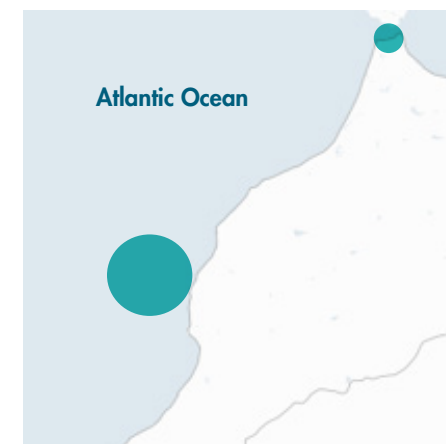
Market snapshot
Morocco
Floating wind



Access to great wind resources, meeting green goals and increasing energy security are main drivers for floating OSW in Morocco

Drivers For Build-out		Key Take-Aways
 Site conditions	- The windspeeds off of Morocco's coastline vary greatly, with windspeeds as low as 5 m/s by the main cities Casablanca and Rabat, while areas in the Strait of Gibraltar and along the southern part of the Atlantic coast have average windspeeds above 10 m/s - The biggest area with access to great wind speeds is found off the southern Atlantic coastline, where the water depths fall steeply close to shore and generally range between 60 and 500 meters.	 The best wind resources are found in the south, while the biggest population centres are in the north. However, the city of Agadir is close to the greatest wind speeds.
	 Policy environment	 The governments have shown political will to not only set targets, but also work towards them. The target for wind is to add 4.2 GW between 2018 and 2030.
 Support regime	- Renewable developers enter into a PPA with the Moroccan Agency for Renewable Energy (MASEN). MASEN then sells the power to The National Office of Electricity and Drinking Water (ONEE)⁴. - MASEN and ONEE take on most risks, such as currency, political, siting and permitting risks, and offtake is guaranteed. The developer takes on resource risk.	 While the support mechanisms haven't yet been used for OSW, they have worked well for onshore wind projects and are regarded as favourable.

Key Areas



Based on LCOE calculations from Aegir Insights, two areas of interest for floating offshore wind have been identified, with the southern area looking the most promising



Permitting process

- The permitting process for renewable energy projects is regulated by law 13-09. First, the developer provides MEM with technical documentation including descriptions of the project and measures to protect the environment. A provisional authorization, allowing the start of construction, is given. Then the developer must apply for the second, final authorization by providing amongst other things a full EIA.
- Lead times for onshore wind projects have been as low as four years (Tarfaya).



The permitting is handled by MASEN, which works as a one-stop-shop on behalf of MEM, and the process appears smooth, however no OSW experience yet.



Supply chain

- Morocco has suitable ports in proximity to attractive potential OSW sites, such as the port of Agadir close to the sites along the southern part of the Atlantic coast.
- Siemens-Gamesa operates a blade factory by Tangier. However, the supply chain is not mature, and developers will in the beginning likely rely on imports from nearby mature markets, such as Spain or France.



With its proximity to Spain, Moroccan offshore wind projects would likely wish to utilise the existing supply chain in Spain.



Transmission grid

- A few 220 and 310 kV cables run roughly along the coast, from the town of Laayune, south of Agadir and close to potential OSW sites, and north to the population centres. No HVDC cables.
- ONEE is responsible for grid connection in most cases. ONEE has a grid development plan for 2019-2023 which foresees grid investments to integrate renewables, but has had trouble following through on investment plans in the past.



The grid in the south of the country needs investment to distribute the large capacities an offshore wind farm would provide and take it to load centres.

Sources: Aegir database, World Port Index

Notes: 1: The National Energy Strategy 2009; 2: "Renewable Energy Potential and Available Capacity for Wind and Solar Power in Morocco Towards 2030" by Mohamed AZEROUAL et. AL., in JOURNAL OF Engineering Science and Technology Review; 3: "Morocco remains net Exporter of Electricity" by Yahia Hatim in Morocco World News, 6. Feb. 2020; 4: "Lessons from Power Sector Reforms – The Case of Morocco", by Zainab Usman and Tayeb Amegroud, published by World Bank Group, and "Electricity regulation in Morocco: Overview" by Wacef Bentaibi and Benoit Pape, published by Thomson Reuters; 5: "Tarfaya 300 MW wind project in Morocco" in Esi Africa, 28. Feb. 2013; 6: "Morocco to build new windfarm near Essaouira along Atlantic coast" in Morocco World News, 1. Jan. 2021



Favorable



Not favorable

Current activities/projects

- As of 2018, Morocco had 1220 MW of wind power installed, all on land
- Several land-based wind farms are planned and have been tendered through Morocco's Integrated Wind Energy Programme, launched in 2010. The planned projects will increase the capacity by about 1000 MW by 2024
- Tarfaya wind farm of 301 MW, currently Africa's biggest wind farm, built under the Integrated Wind Energy Programme. The project reached financial close in 2012 and was commissioned in 2014. It operates under a 20-year PPA⁵
- Another wind farm of 210 MW has been built under the Programme, and ONEE and MASEN signed the contract for a third wind farm of 270 MW near Essaouira in 2020⁶

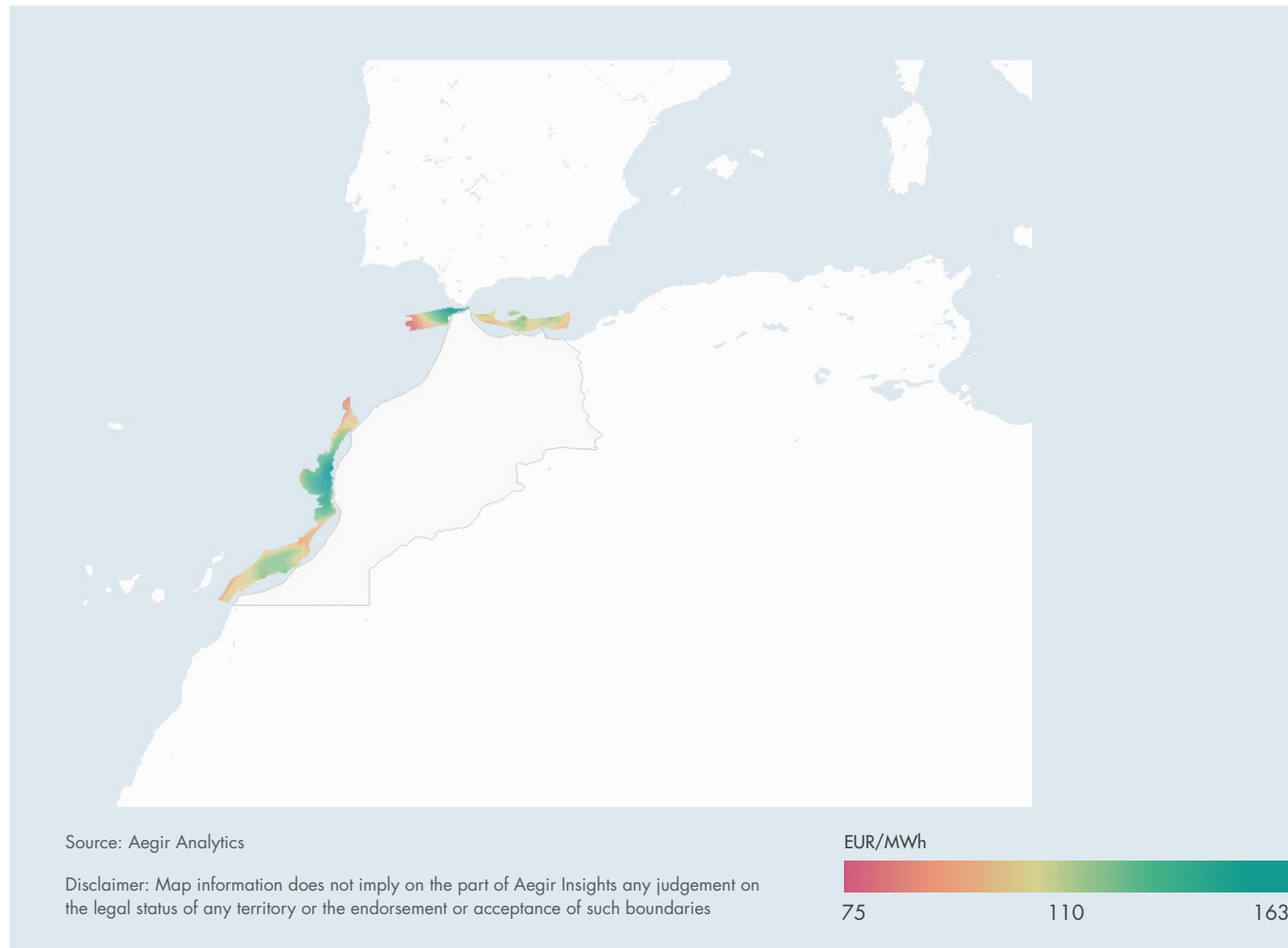
Grid issues need to be addressed to connect offshore wind farms to load centers, and ideally options for energy storage should be explored

	Challenge	Impact	Possible Actions
	POWER GRID NEEDS DEVELOPMENT The power grid in southern Morocco lacks the capacity to handle offtake from large-scale offshore wind farms.	Unless grid connection is guaranteed through actions or binding promises, developers could face uncertainty regarding COD.	In its development plan for 2019-2023, the ONEE promises investments in the grid. However, whether the plan is carried out should be monitored.
	NO TARGET FOR OFFSHORE WIND Morocco only has targets for wind in general, and as there is still space on land for wind farms, offshore wind will likely not take off unless targets for this specifically are declared.	The lack of a specific target for offshore wind sends mixed signals to the industry and impacts negatively on investor willingness.	An ambitious offshore wind target could kickstart the industry, as Morocco has shown that it takes targets seriously, with a government backed program contracting several onshore wind farms.
	PERMITTING PROCESS APPEARS SMOOTH, BUT NO OFFSHORE WIND EXPERIENCE The permitting regime seems simple and has not lead to great delays for onshore wind, but it has not been used for OSW yet.	A predictable permitting process provides certainty regarding the project timeline and will make it easier to finance and manage projects.	A design envelope allowing technology upgrades could be implemented, since the long lead times for OSW increase chances of upgrades being needed.
	FLOATING WIND MUST COMPETE WITH ABUNDANT AND CHEAP SOLAR POWER While fossil fuels are expensive as they are imported, solar power is cheap and abundant.	Large scale expansion of floating wind depends on it being an attractive source compared with competing, renewable sources.	The Moroccan government already prioritizes wind energy no matter the cost of solar, and should do the same for offshore wind specifically, if it wants OSW.

 No mitigation in place adding significant risk
  Mitigation plan in place but with some uncertainty
  Challenge is expected to resolve but should be monitored

Large areas with relatively low cost of energy, particularly off the Atlantic coastline of Morocco, close to the city and port of Agadir

LCOE Heatmap for floating areas (60-1,300m), EUR/MWh



Key take-aways

- Compared to Ireland, floating wind energy in Morocco is expected to be relatively costly, but still cheaper than Italy
- The cheapest sites are by the Atlantic coast and in the Strait of Gibraltar
- The Strait of Gibraltar has strong winds, but as the strait is an important transit passage with many stakeholders, offshore wind development might be opposed
- The sites by the Atlantic coast are close to the port of Agadir and grid connection points, driving the cost down in combination with good wind resources