EUROPEAN UNION

FACILITATING OFFSHORE WIND IN INDIA

FROM ZERO TO FIVE GW

OFFSHORE WIND OUTLOOK FOR GUJARAT AND TAMIL NADU

2018-2032

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DECEMBER 2017

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FOWIND focus states in India
(for illustrative purposes only)

FOREWORD

On behalf of the FOWIND consortium, I am delighted to present our latest report: "FROM ZERO TO FIVE GW: Offshore Wind Outlook for Gujarat And Tamil Nadu (2018-2032)". This roadmap for the states of Gujarat and Tamil Nadu incorporates the learnings from four years of investigation to come up with an achievable roadmap for the two states to develop robust, sustainable offshore wind sectors. It is not a forecast, and may well be exceeded; but when we look back from 2032, I trust we will be able to see how this work has identified both the main opportunities and challenges of developing an offshore wind sector for India's transition to a clean energy-based economy.

India's burgeoning renewable energy industry, led by its 4th in the world onshore wind energy sector, has many challenges to overcome. The country is in the process of reinventing its power sector in just about every way – from the existing system which relies primarily on large centralized power stations connected much like an early 20th century telephone system with a central exchange, to one which more closely resembles the internet, with a wide variety of distributed sources of generation and intelligently managed demand. This process will take some time, and there will be bumps along the way, but the direction of travel is clear.

Plunging prices for wind and solar PV have grabbed headlines across the world during 2017, as have the very recent precipitous drop in the prices for offshore wind procured in the last couple of years, to be delivered primarily after 2020. These projects will rely to some extent on a new generation of turbines, many of them larger than 10 MW in size, with rotor diameters well in excess of 150 meters – twice the wingspan of an Airbus 380, and the largest pieces of rotating machinery ever produced, by quite a long way.

Serious medium and long-term planning, and investment in infrastructure of all kinds, but especially transmission, ports and rail links will be necessary to turn this into reality. Building a robust national supply chain and the infrastructure will take time. But we are confident of the government's commitment to the ultimate goal, and we offer this work as a contribution to the partnership and cooperation between the public and private sectors which experience in Europe has shown is essential for building a healthy, competitive and sustainable offshore wind industry.

It will require both fortitude and persistence, but we believe the long-term rewards – a very large source of indigenous, reliable, clean power to drive India's economic growth, creating a whole new industry with the employment and investment that it attracts – are worth the effort that will be required. From the government side the most important thing is a clear vision, stable policy, lots of support in the beginning – and patience!

Steve Sawyer

Chair,
FOWIND Project Executive Committee
and
Secretary General,
Global Wind Energy Council

FOWIND BACKGROUND

The consortium led by the Global Wind Energy Council (GWEC) is implementing the Facilitating Offshore Wind in India (FOWIND) project. Other consortium partners include the Centre for Study of Science, Technology and Policy (CSTEP), DNV GL, the Gujarat Power Corporation Limited (GPCL), and the World Institute of Sustainable Energy (WISE).

The National Institute of Wind Energy (NIWE), an autonomous R&D institution under the Ministry of New and Renewable Energy, Government of India, has been a knowledge partner to the project since June 2015. Renew Power Ventures Private Limited, a leading Independent Power Producer in India joined as an industry partner to the project in June 2016.

The project seeks to establish structural collaboration and knowledge sharing between the EU and India on offshore wind technology, policy and regulation and serve as a platform for promoting offshore wind research and development activities. The project focuses on the states of Gujarat and Tamil Nadu for identification of potential zones for development through preliminary resource and feasibility assessments for future offshore wind developments, as well as through techno-commercial analysis and preliminary resource assessment.

The project consists of a total of seven work packages. This study has been developed as part of Work Package 7 under the FOWIND work plan. The aim of the study is to present an informed outlook for the amount of new offshore wind capacity that can be reliably incorporated into the two state grids, including the regional transmission and distributions networks, efficiently and in a planned manner over the next three 5 year plan periods, starting in 2018.

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This report is available for download from *www.fowind.in* and the websites of respective project partners.

1 INTRODUCTION

As a responsible global actor, India made strong commitments under the UN Paris Climate Agreement and in 2015 announced its ambitious renewable energy target for 175 GW from renewable energy generation by 2022. This target includes 60 GW from wind energy.

India already has a strong track record and established industry for onshore wind. Onshore wind holds the largest share of the national RE capacity with almost 33 GW installed at the end of September 2017 [1]. This makes India the world's fourth largest market in terms of installed wind generation capacity [2].

In September 2015, India's Union Cabinet approved the National Offshore Wind Energy Policy and the Ministry of New and Renewable Energy (MNRE) was authorized as the Nodal Ministry for use of offshore areas within the Exclusive Economic Zone (EEZ) of the country for promoting the offshore wind sector. The National Institute of Wind Energy (then known as CWET) became the Nodal Agency for development of offshore wind energy, with responsibility for carrying out allocation of offshore wind energy blocks, coordination and allied functions with related ministries and agencies [3].

In November 2017, the MNRE announced its roadmap for ensuring that the 2022 renewable energy target of 175GW from RES is met. Under this plan the MNRE also listed new and innovative options like offshore wind and floating solar as a part of its broader vision for renewable energy development in India. The Ministry has also published a state-wise breakup of RES capacity addition plan out to 2022 [4].

REPORT SCOPE

In line with the forward-thinking approach of the MNRE, FOWIND has developed a medium term outlook for offshore wind development for the states of Gujarat and Tamil Nadu. The work done under this report is based on today's policies, market and technology trends along with our experience with the FOWIND project since 2014.

FOWIND conducted and published preliminary feasibility assessments for the two states in 2015. FOWIND also published detailed assessments of the supply chain and ports for the two states in 2016. Recently FOWIND conducted detailed grid integration assessments in collaboration with the states' utilities (GPCL, GETCO and TANGEDCO) and published the results in 2017.

Our baseline, as explored in the grid integration case studies for Gujarat and Tamil Nadu, is further extrapolated in the work done herein. In summary, the two states can, without any significant costs, integrate approximately 500 MW of new capacity from offshore wind through existing grid infrastructure over the 13th plan period (ending in March 2022).

This study further looks into the policy and regulatory framework aspects of what the two states need to do to go from zero to 5GW of offshore wind installations over the upcoming plan periods out to 2032. The projections draw from the global experience of offshore wind development and builds in constraints of the local power sector development in India. This is done by identifying five global challenges faced by offshore wind followed by five key enablers that have successfully spurred the development of offshore wind installations in other markets. The challenges and

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best practises lead to the development of three pathways that would lead to Gujarat and Tamil Nadu having 5GW of offshore wind installations by 2032.

The 5GW should not be viewed as the best-case assessment, or as a proposed target that the two states should adopt. Instead, 5GW should serve as indicative guidance that helps to focus the attention of policy makers and private industry into proactively developing India's offshore wind sector along with its entire ancillary infrastructure and supply chain to scale.

To this end, the report identifies five action items, which need immediate attention, and are critical to the timely and smooth development of an offshore wind sector. Including developing a long-term offshore wind roadmap, clear consenting and permitting procedures, regional and national grid development, financial support mechanisms and competence/skill development. These are comprehensive themes that need coordinated action from a wide range of stakeholders.

The current government is committed to leveraging the country's renewable energy resources. The need is clear for policy makers and industry actors to deepen this vision, to reap the domestic benefits from offshore wind power development, and to build upon India's growing leadership globally while addressing the electricity deficit and climate challenges.

2 GROWTH OF OFFSHORE WIND

Renewables' capacity addition in 2016 set a record and global installed capacity is now more than 2,000 GW. The global energy system is undergoing a rapid transformation. Large-scale renewable energy development is now a mainstream power generation option. This global growth is increasingly driven by a strong business case for a clean energy transition in the face of rising climate impacts. Further favourable national socio-economic conditions and individual climate change commitments are making the case for renewables stronger. A majority of responsible governments worldwide accept the need for long-term low carbon development pathways, as agreed to under the 2015 Paris Agreement on Climate Change.

For countries in Northern Europe and China, offshore wind is a part of this transformation, as an indigenous source of clean energy supply. Just a decade ago, global offshore wind capacity was less than 1GW, with only the UK, Netherlands and Denmark having commercial wind farms in operation. In 2016, annual additions rose to over 2.2 GW across seven markets globally, bringing total installed capacity globally to just over 14.6 GW [5].

FIGURE 1: GROWTH IN CUMULATIVE INSTALLED CAPACITY OF OFFSHORE WIND IN MAJOR MARKETS

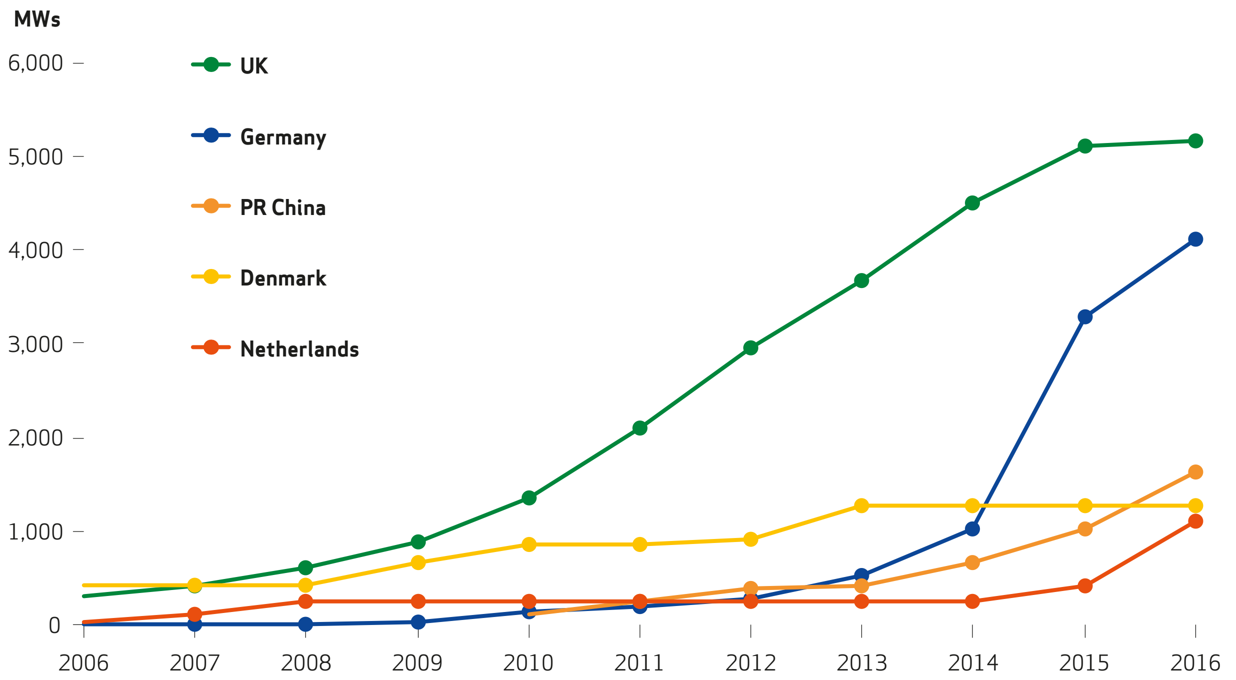

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FIGURE 2: ESTIMATES OF LCOE CHANGE FOR OFFSHORE WIND

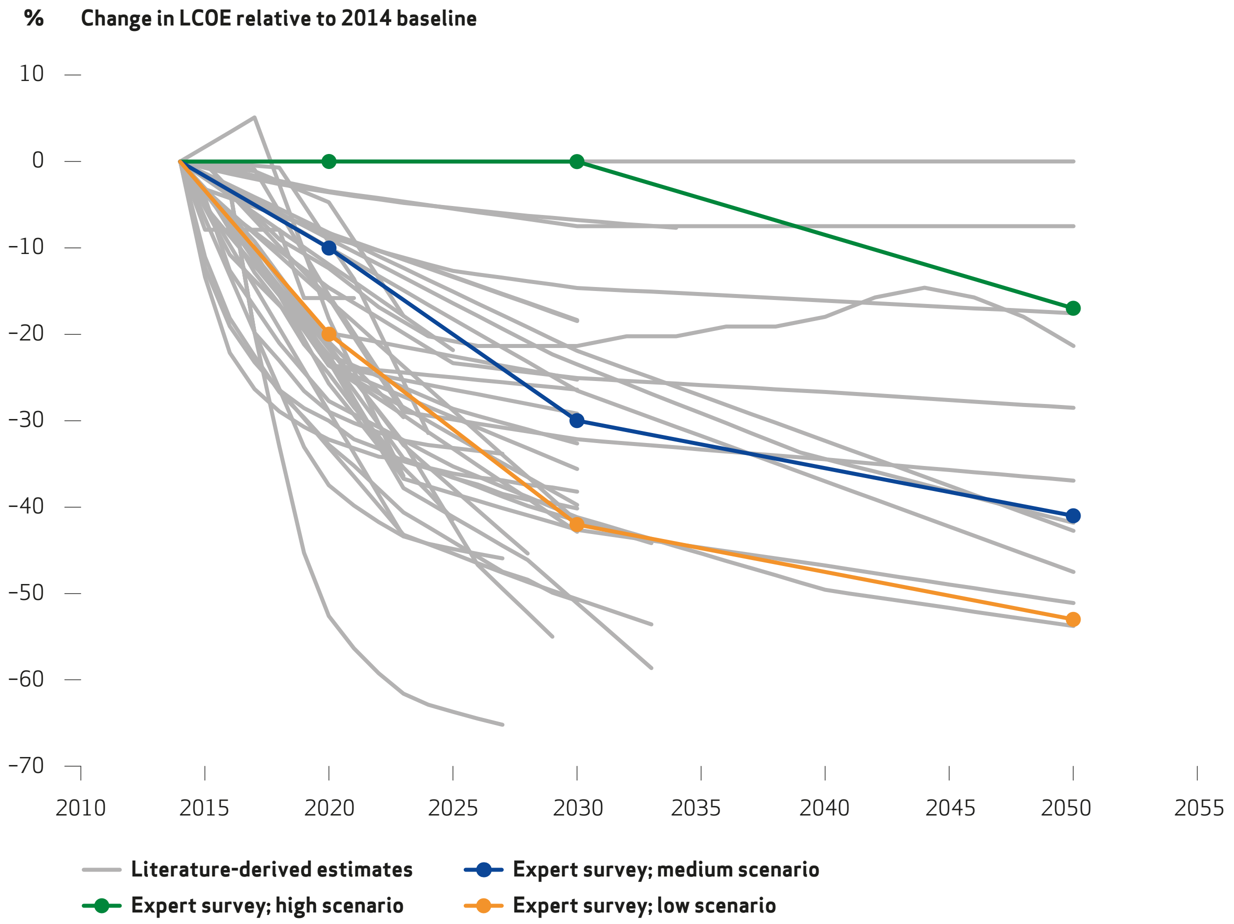

Image: R. Wiser et al., "Expert elicitation survey on future wind energy costs," Nat. Energy, vol. 1, Sep. 2016

Over time, the UK has become the clear market leader with steady growth in its installed capacity. On the other hand, Denmark the early leader of the offshore market has seen slower growth in the last five years. Since 2014, offshore wind deployment has picked up strongly in Germany and to a lesser extent in China and the Netherlands.

The offshore wind industry had a breakthrough year in 2016 with dramatic reduction in prices. In June the Netherlands awarded the Borssele 1 & 2 projects for €72/MWh, well below expectations; followed by a Danish nearshore tender in September 2016 at €64/MWh. Two months later, the winning bid for the Danish Krieger's Flak project came in at an astonishing €49.90/MWh; and in December 2016 Borssele 3 & 4 in the Netherlands were awarded at €54.50/MWh.

If 2016 was a landmark year, 2017 has seen even more spectacular numbers. In April 2017, the German Federal Network Agency announced the results of its first auction for offshore wind projects. Three of four offshore wind projects with a total capacity of 1,380MW were awarded and will not receive any subsidy over and above the wholesale electricity price. This prompted the Dutch government to seek subsidy-free bids for two zones in the upcoming tender process for the Hollandse Kust offshore windfarm. In the UK, the second round of CfD tenders awarded 3.2GW of offshore wind capacity, of which 2.3GW cleared at the strike price of £57.50/MWh. This strike price is about 50% cheaper than the price discovered two years ago, and significantly lower than the government's forecast.


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There are a number of reasons for the price breakthroughs seen across mature northern European markets, including: the maturing of the regional supply chain, the improvement and maturation of the technology and its management, growing investor confidence, and the introduction of larger machines, with enormous swept area ultimately leading to much higher generation.

The size of upcoming offshore turbines is expected to even larger over the coming 5-10 years. Plans for 10 MW, 12 MW and even larger machines are already afoot.

Looking forward, Europe is expected to maintain its market dominance for the foreseeable future. However, the offshore wind industry will continue spreading to newer markets, where vast potential for growth remains unexplored. The first commercial offshore wind farm came on line in 2016 in the US. There is a renewed push in China, with more than 1 GW expected to come online in 2017. Tenders for up to 6 GW of offshore wind by 2025 are in advanced stages of planning in Taiwan. Japan has invested in several demonstration projects for floating offshore projects. South Korea has a long-term plan to develop offshore projects with the help of its local heavy industry giants. It is expected that the offshore wind market will start up in India by the end of the decade with initial projects.

The continued reductions in LCOE will play a key role in sustaining the growth of offshore wind. A wide range of estimates are made in literature with regards to the future cost of offshore wind. These show significant uncertainty in the degree and timing of future advancements.

The wide variation in the findings can be partly explained by noting the differences in learning model specification, assumed geographic scope of learning, and the period of the analysis. One expert elicitation of 183 industry professionals expects a 30% fall in offshore wind LCOE by 2030 and going up to 40% by 2050, in the median scenario [6].

The drivers of the decline in LCOE are manifold: 'learning with market growth', R&D investment, a variety of development, technology, design, manufacturing, construction, operational improvements and market changes that affect electricity price and government support for technologies.

3

FIVE KEY CHALLENGES FOR OFFSHORE WIND

The offshore wind industry is relatively young. However, in just over a decade total global installed capacity has gone from less than 1GW to over 15GW. Today the offshore wind technology and project development process is maturing at a rapid scale across northern European markets and in China.

Offshore wind installations globally slowed down in 2016, with a 31% reduction from the previous year. Yet the global outlook remains positive bolstered in partx by project developers achieving the 2020 LCOE target of £100/MWh four years ahead of schedule. Winning bids of auctions held in the Netherlands, Germany, UK and Denmark in 2017 have delivered up to 48% cost reduction compared to projects just two years ago.

Offshore wind presents a vast potential to drive the energy transition. However, several barriers remain on the path to achieving even greater deployment across the world. These are discussed below.

1. COMPLEX DEVELOPMENT PROCESS

With lead times of 7-9 years from lease to operation, and upfront CAPEX of several hundreds of millions or even billions of dollars, offshore wind projects are long-term, capital-intensive investments. In addition, building an offshore wind farm requires coordinated development of a number of diverse and complex work streams.

As seen from the stakeholder analysis chart (Figure 3), the project developer has to work directly with several stakeholders ranging from the Engineering Procurement Construction Installation (EPCI) contractor, insurer(s), and the port authorities, the utilities to energy sector regulators. Each of these stakeholders has their own domain of expertise and objectives, which must be managed by the project developer. In addition, many of these stakeholders often have their own subcontractors that will have significant involvement in the project and may directly liaise with the project developer, for example the EPCI's subcontractors like the WTG supplier, marine operation firms etc. It is clear that timely execution of getting an offshore wind farm from its feasibility study phase to commissioning requires skilled project management over a period of 7-9 years.

2. LEVELISED COST OF ENERGY

The cost of energy from offshore wind farms has dropped significantly in mature European markets. In the UK for example, the second Contract for Difference (CfD) round[1] for renewable energy in 2017 awarded almost 3.2GW of offshore wind capacity wherein strike prices went as low as £57.50/MWh for projects scheduled for commissioning in 2022/23. This is less than half the strike price discovered in the first round of CfD auctions held in 2015. Figure 4 shows how steep the decline in strike price is from the early investment contracts that were all in excess of £150/MWh.

The latest contracts awarded in the UK reveal that 2017 offshore wind strike prices are cheaper than

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[1] CfD is a long-term contract between a low carbon generator and a government-owned company that guarantees the generator stable revenue at pre-agreed level ('strike price') for the duration of the contract. When the market price for electricity generated by a CfD Generator ('reference price') is below the strike price, payments are made to the CfD Generator to make up the difference. Conversely, when the reference price is above the strike price, the CfD Generator pays the difference.

FIGURE 3: STAKEHOLDER ANALYSIS CHART

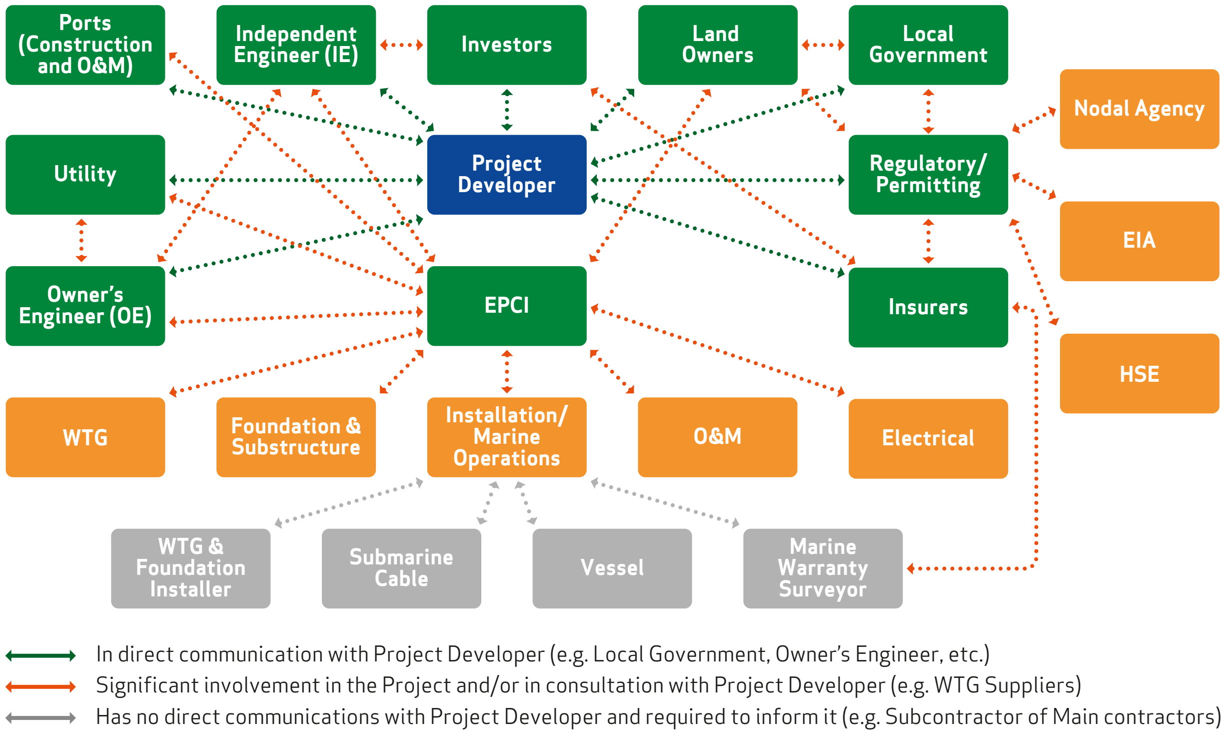


Image: DNV GL

the government's official estimate of the levelised cost of gas projects that start generating in 2020 and 2025 [7]. Strike prices for offshore wind also compare favourably with electricity generation from nuclear power plants. The UK government's agreed strike price for Hinkley Point C is £92.50/MWh for a period of 35 years with the plant expected to be operational around 2025-26. This makes offshore wind about 37% cheaper than nuclear and has the benefit of preventing energy consumers from being locked in with exceptionally long-term (35 year) cost commitments while the plant is operating, and for centuries thereafter.

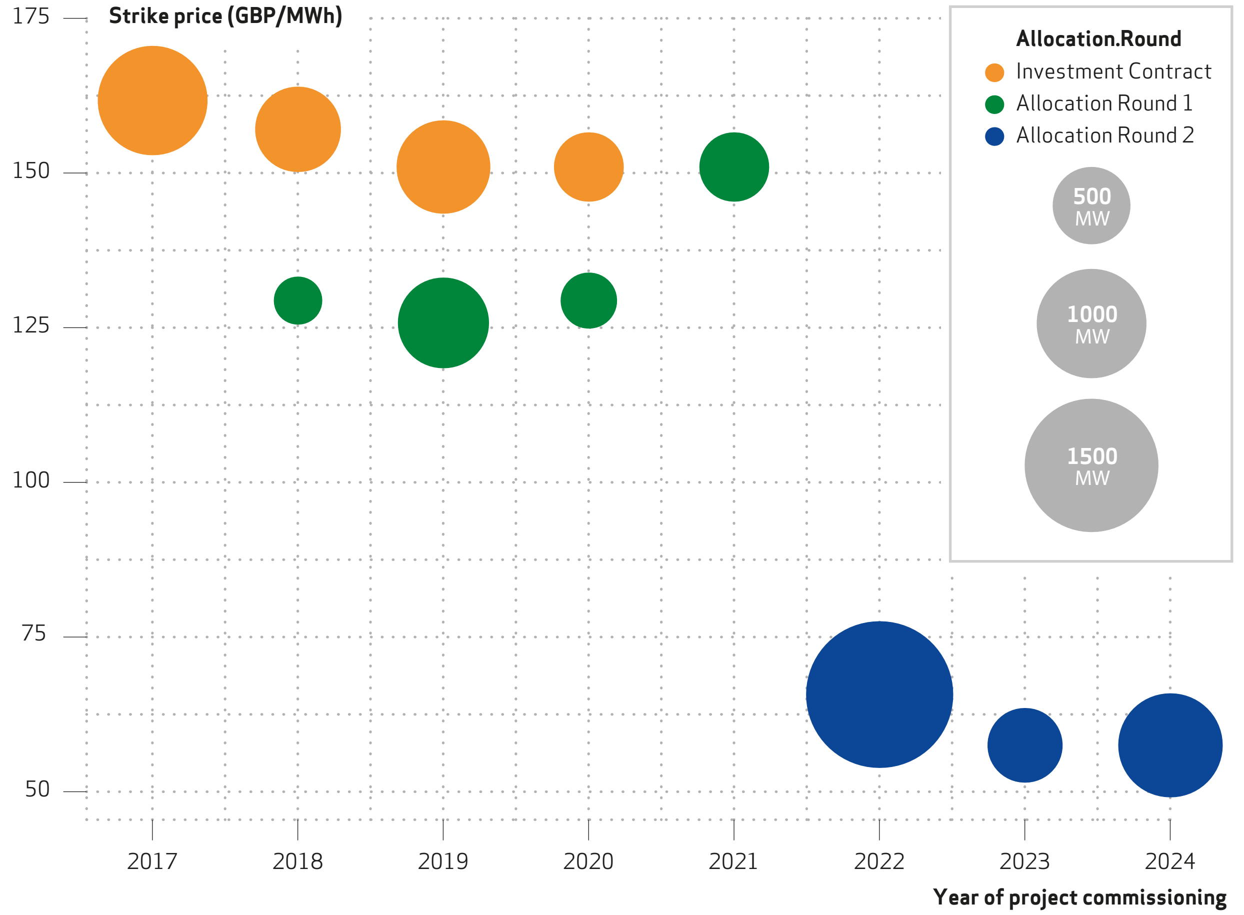
With the maturity of the UK offshore market, the local media narrative has shifted sharply away from the alleged negative impacts of offshore wind deployment to broader environmental benefits and local industrial growth. Now, more than ever, offshore wind is being hailed for the successful and spectacular lowering of costs across Europe.

This optimism is not yet seen in newer markets where the nascent offshore industry has to deal with the difficult issue of cost differentials between offshore wind and other renewable technologies. In India, for example, recent auctions have made solar PV and onshore wind competitive with thermal power generation. In these emerging markets achieving steeper cost reductions for offshore wind technology will be a significant challenge, with onshore wind and solar setting low price records across the board.

3. FINANCING

An increasing number of developed markets are moving towards competitive auctions and the offshore wind sector is likely to see more market based mechanisms being put in place by governments for supporting further growth. This move towards auctions, combined with rapidly falling prices for large project capacities being auctioned creates challenges for individual or smaller project developers to secure attractive long term finance in European markets. In these markets revenues will depend on overall energy production and the prevailing price of electricity in the market.

FIGURE 4: EVOLUTION OF COST OF WIND IN THE UK



However, concerns over financing for offshore wind are allayed to some extent by two emerging trends. First, more corporate and industrial consumers are aiming to procure green electricity directly from power generating assets. Large energy users acting as off-takers through Power Purchase Agreements (PPAs) provide a project with a long term stable revenue stream, particularly in markets where generators are exposed to some level of wholesale price fluctuations. Corporate PPAs could become an established business model that facilitate investments for utility scale renewable energy projects, as it has in the USA. Second, mature markets in Europe are seeing increased participation from a diversity of financing sources, such as pension funds, infrastructure and private equity funds. For example, the Danish pension fund company PKA has acquired an equity stake in offshore wind farms in the Netherlands, UK and Germany. Such increased activity is an acknowledgement of increasing sector maturity and lowering of risk profile.

The access to low cost finance and insurance instruments is an even bigger challenge in most emerging markets. This is further complicated by the expansion of offshore wind projects into deeper waters, and in east Asia into regions with frequent typhoons and earthquake prone seabed. This presents a new engineering challenge for offshore wind developers while also raising the risk profile of their projects. In India, the cost of financing is still very high. Initial offshore wind projects would need significant support through low-cost public funds to leverage private investment along with stable regulatory mechanisms. Multilateral or bi-lateral support with currency hedging mechanisms could be also be utilised.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4. INFRASTRUCTURE DEVELOPMENT: SUPPLY CHAIN, PORTS AND GRID

Supply chain bottlenecks have historically been another area of concern. Until a few years ago, the offshore wind sector lacked a dedicated supply chain, meaning that developers had to 'beg and borrow' from other sectors – such as onshore wind and oil and gas. For example, for early projects one key bottleneck in the UK was a lack of dedicated specialised vessels, as these were predominantly used in the oil & gas sector, and in some cases were oversized for offshore wind farms. However, the situation has improved substantially with increasing competition across most areas of the supply chain. It is important to note that the nature of the supply chain bottleneck depends on the market under consideration; for instance, vessel availability is a particular concern in the USA and Taiwan. In response to these challenges, several researchers have examined ways to minimise the installation costs and/or identify optimal installation schedules considering weather restrictions, distances, vessel capabilities, vessel availability and assembly scenarios spanning the length of the installation period.

FIGURE 5: ELEMENTS OF THE SUPPLY CHAIN ADDRESSED BY FOWIND

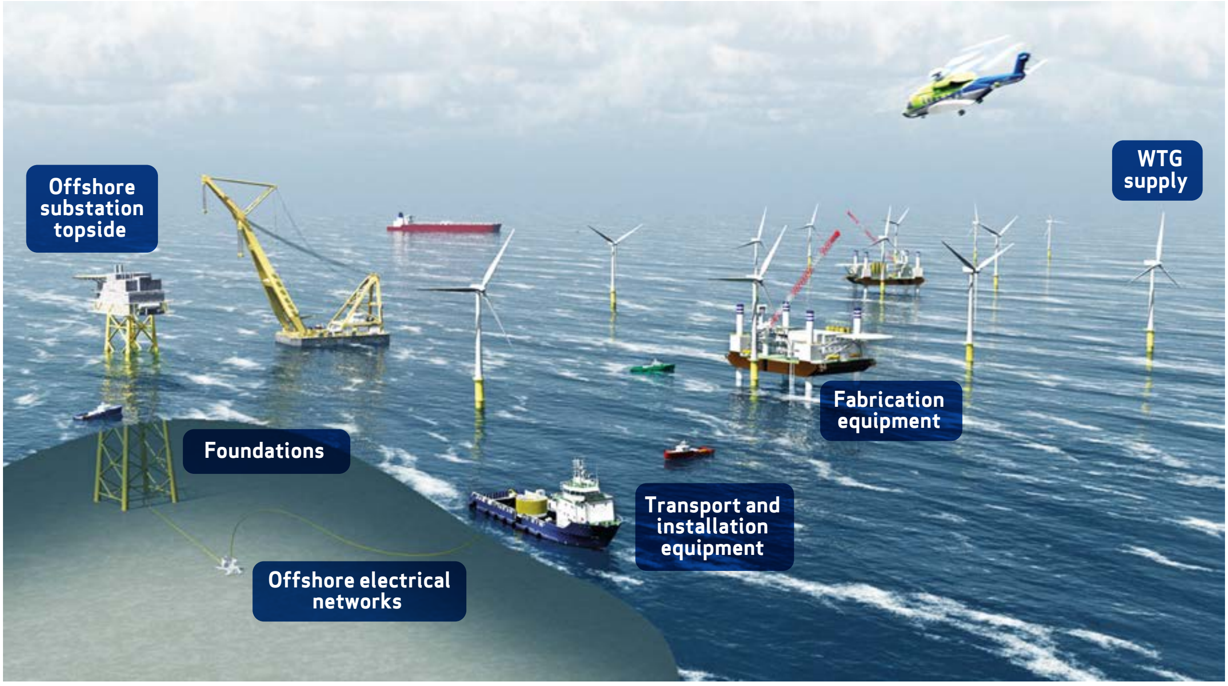

Image: DNV GL

In order to fully capture the diversity and magnitude of a typical project's supply chain, FOWIND's Supply Chain, Port Infrastructure and Logistics Study for India compiled an illustrative procurement list to document some of the important elements required to successfully develop an offshore wind farm from fabrication through to operation [9]. Figure 5 captures the broad themes under which the list was populated. Each item on the list is associated with complex interfacing, risk, health & safety, specialised manpower and environmental considerations. These implications and interactions must be carefully evaluated during project development.

Further, the timely development of adequate transmission infrastructure is essential for connection of offshore wind farms and power evacuation from offshore wind farms. Regulatory models of delivery and ownership of offshore transmission assets that best suit Indian power system conditions is discussed in detail in the Grid Integration Study for Offshore Wind Farm Development in Gujarat and Tamil Nadu, published by FOWIND in 2017 [13x]. Such decisions have a significant bearing on the cost and feasibility of projects and there is a need to grow local capability in the planning, design and delivery of offshore transmission systems amongst key power sector stakeholders and capture learning from more mature offshore wind markets in Europe through dialogue between utilities.

5. SOCIO-ENVIRONMENTAL CONSTRAINTS

Like any major infrastructure project, offshore wind project development affects its local environment. These impacts need to be assessed and where required mitigated to the nationally/locally acceptable levels. Potential impacts could include fishing communities and shipping routes among others. With over 4,000 offshore turbines now commissioned, the sector has a much better understanding of potential impacts.

However, assessing the impacts of offshore wind is extremely challenging given the multiplicity of assessment methods and interpretations. Moreover, interest groups attach varying values to the different uses of the marine environment that may lead to conflict between these parties. A


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recent instance of such divergence comes from Scotland. In January 2015, the Royal Society for the Protection of Birds (RSPB) submitted a legal challenge to the government's consent for four offshore windfarms in the Firths of Forth and Tay citing great risk of harm to seabird colonies. Legal proceedings delayed site construction for well over two years, with a final decision in favour of the site development made in November 2017.

India has a strong oil and gas, marine and shipping industry. It also has a strong tradition of local fishing communities. India could expedite project development cycles if standardised EIA guidelines for offshore wind farm development were developed in tandem with comprehensive stakeholder involvement early on.

4

FIVE KEY ENABLERS FOR OFFSHORE WIND

BEST PRACTICES FROM GLOBAL EXPERIENCE

Globally, there is over 25 years of experience in developing offshore wind farms. Along the way, some policy frameworks have been less successful, while others have helped the sector move forward rapidly. Different countries have approached offshore wind farms using different policy mechanisms, and thus there is a wide range from which to draw lessons.

Five key policy enablers are laid out here, as best practises for Gujarat and Tamil Nadu to consider adopting.

1. DE-RISK DEVELOPMENT

The early stages of developing offshore wind farms present a number of uncertainties for the project developer. For instance, if the developers did not know the ground conditions at the site, they would have to include contingency and risk provisions associated with this uncertainty. The cost of capital is also higher because of the elevated risk premium.

The Danish government addresses this issue by undertaking substantial work prior in the planning phase, i.e. in advance of the call for tenders. Before the tender submission, the following are made available to pre-qualified parties:

- Results of the preliminary investigations of wind, waves and current conditions (MetOcean data)
- Results of the preliminary survey of the geological conditions
- Complete and fully approved Environmental Impact Assessment (EIA) of the designated area

The benefit of this approach is that it also allows for early stage selection of technologies and potential suppliers. The length of the overall approval phase is reduced because of the work done upfront. Thus, the site is effectively de-risked to the developer and the bid can be priced more effectively.

Taiwan is also taking early steps in de-risking project development. The government has carried out detailed wind speed assessments for its territory (Figure 6) and makes available results of preliminary site investigations to developers of demonstration projects.

2. MARITIME SPATIAL PLANNING

Sea basins across the EEZs usually host several diverse activities and resource uses. Offshore wind developments must co-exist with a host of existing and future interests such as shipping lanes, defence, fishing, ecological protection, submarine cable routes, mineral extraction, coastal tourism etc. Within this context, Maritime Spatial Planning (MSP) can be understood as the process of planning and regulating human activities at sea.

The framework in Germany offers key lessons for emerging markets on how to implement a robust MSP process and use it to enable the development of offshore wind farms. The Federal Ministry of Transport and Digital Infrastructure (BMVI) is responsible for setting up the MSPs for Germany's Exclusive Economic Zones (EEZs). Then building on the conditions ascertained and the priority area for offshore wind determined in the MSP, more specific Spatial Offshore Grid Plans were drawn up for the North Sea and the Baltic Sea. This

FIGURE 6: EXAMPLE OF WIND RESOURCE ASSESSMENT FROM TAIWAN

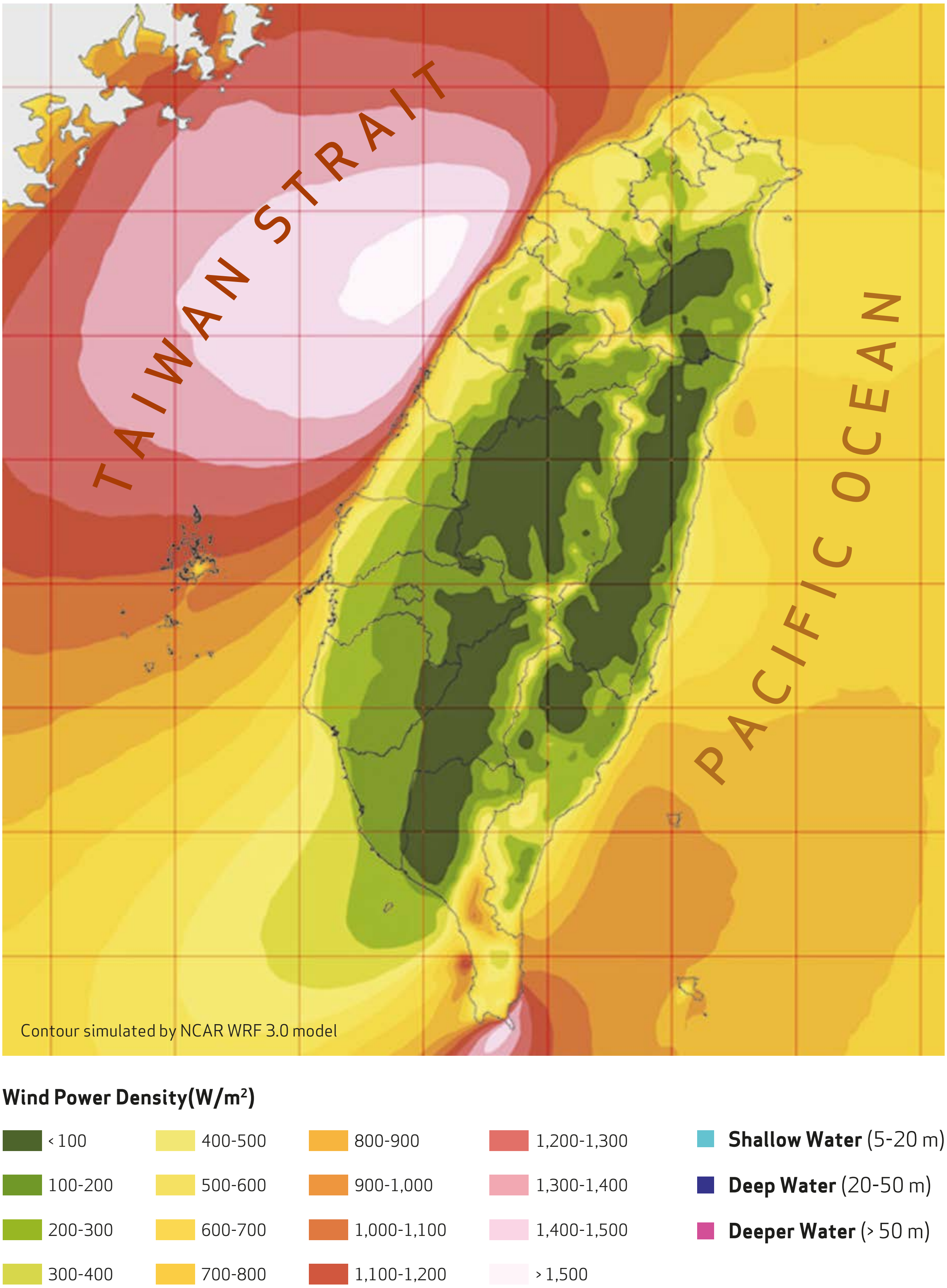
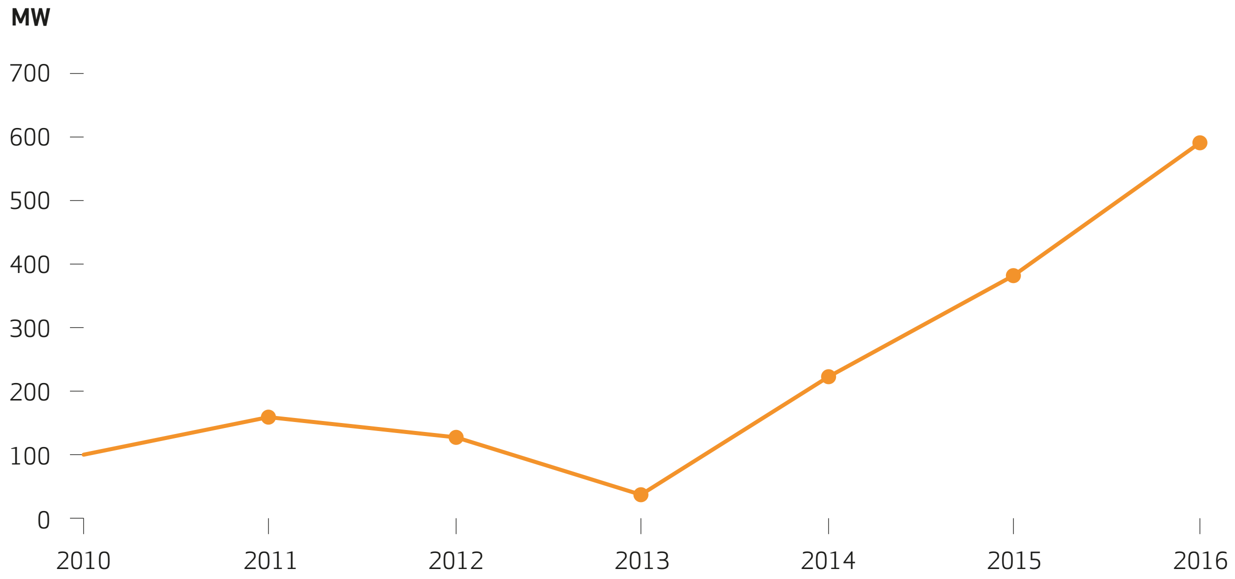


Image: Taiwan Power Company

FIGURE 7: ANNUAL NET CAPACITY ADDITION OF OFFSHORE WIND IN CHINA



Source: GWEC

TABLE 1: CUMULATIVE OFFSHORE WIND INSTALLATIONS BY COUNTRY (IN MWs)

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
UK	304	404	598	883	1341	2094	2948	3681	4500	5100	5156
Germany	7	7	12	42	140	200	280	520	1012	3295	4108
PR China					102	263	390	429	654	1035	1627
Denmark	423	423	423	661	868	871	921	1271	1271	1271	1271
Netherlands	19	127	247	247	247	247	247	247	247	427	1118
Belgium				30	195	195	380	572	712	712	712
Sweden	23	134	134	164	164	163,7	164	212	212	202	202
Japan	11	11	11	11	25	25	25	50	50	53	60
South Korea							5	5	5	5	35
United States							0.02	0.02	0.02	0.02	30
Finland			26	26	26	26	26	26	26	32	32
Ireland	25	25	25	25	25	25	25	25	25	25	25
Spain								5	5	5	5
Norway				2	2	2	2	2	2	2	2.3
Portugal							2	2	2	2	0

NOTE: Known decommissioning of 18 MWs and rounding affect the figures listed

Source: GWEC

FIGURE 8: EXAMPLE OF SPATIAL PLANNING MAP FROM DENMARK

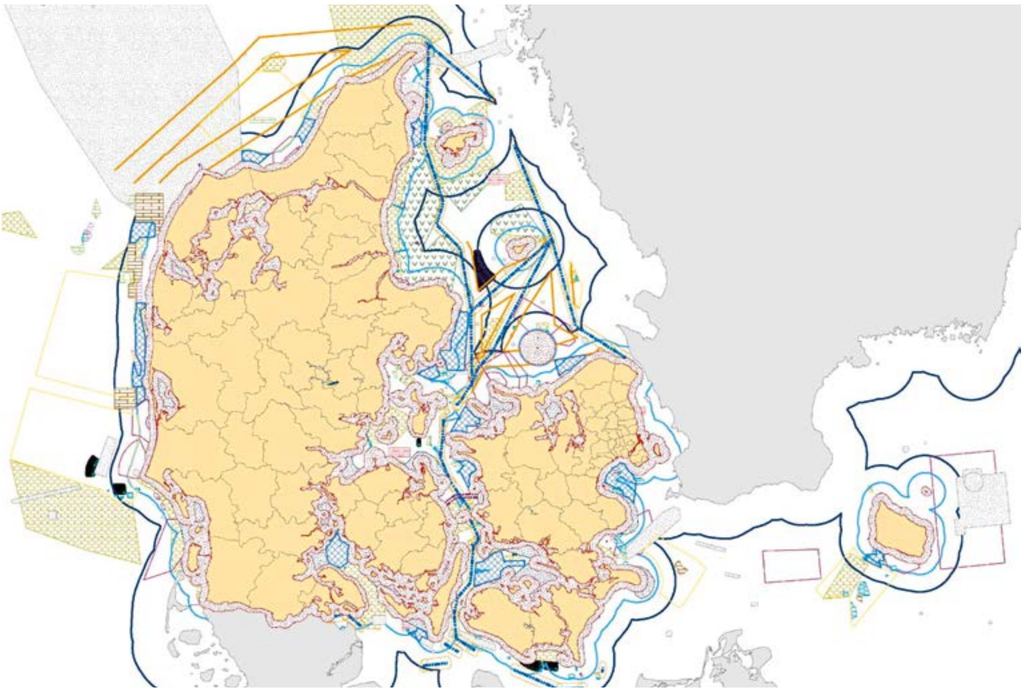


Image: Danish Energy Agency

document covers spatial identification of offshore wind farms which are suitable for collective grid connections and the spatial stipulation of cable routes for subsea cable systems and sites for transformer substation platforms. The Offshore Grid Plans are drawn up in consultation with key stakeholders, such as the Federal Agency for Nature Conservation and the coastal states. The implementation of a coordinated and sequential planning effort ensures that wind farm developments do not face any roadblocks from other maritime users. In Germany, the formal planning process and meaningful engagement in the early stages of doing this, have led to greater support from shipping and environmental groups.

In contrast, early experience of offshore project in China offers a cautionary tale highlighting the key role of MSP. Four projects were delayed, in part due to poor coordination among government agencies with different mandates. The National Energy Administration (NEA) was tasked with developing offshore wind farms and thus awarded contracts near shore to reduce costs and technical challenges of developing in deeper waters. This however, created conflict with other near shore stakeholders, such as the military, fishing and wildlife conservation. In order to avoid such delays in the future, the government issued regulations that clearly demarcate responsibility for selecting developer bids and agreeing FiT (Feed-in Tariff) rates to the NEA, and responsibility for site approval to the State Oceanic Administration [10].

3. DEMONSTRATION PROJECTS

Demonstration projects are a vital component in ensuring the adoption of a new technology. These projects can be viewed as a means to understand and overcome technological, economic, environmental, social and policy uncertainties. They would help to prove the technical feasibility of the technology, establish its commercial viability in the Indian market, facilitate the formation of local expertise and develop industry confidence. Demonstration projects have been shown to lower long-term costs and accelerate technology deployment through the benefits of 'learning-by-doing' and 'learning-by-using'. Finally, they allow policymakers and private firms to draw up and tweak long-term investment plans based on the initial demonstration project outcomes.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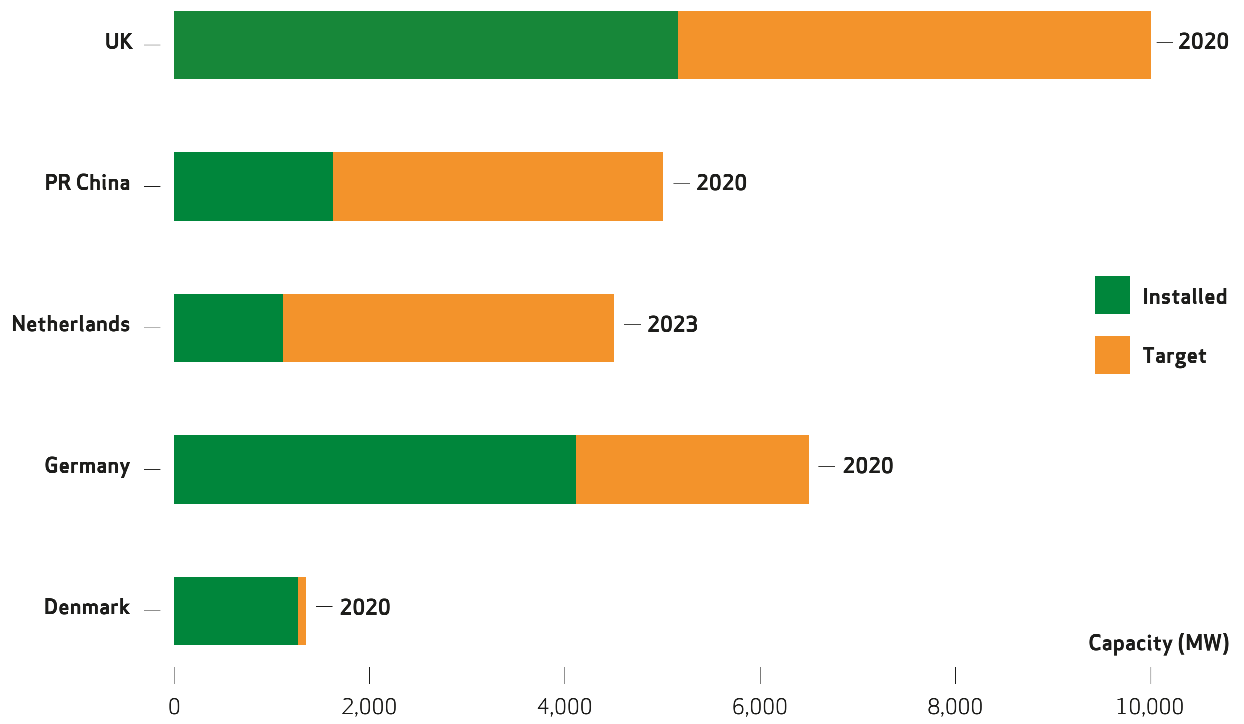
The rapid growth of offshore wind in China is a testament to the benefits of demonstration projects. Its first offshore wind power demonstration project was the 102 MW Shanghai Donghai Bridge offshore wind farm which started generating power in July 2010. Even after the government decided to launch public tenders for offshore wind, it continued approving demonstration projects. For example, the Jiangsu Rudong Zhong Guang He project (150MW) began commercial operation in late 2012. By 2014, China had several demonstration projects in place. This made it attractive for developers and investors to drive the industry forward. As a result, annual capacity additions have grown rapidly. By the end of 2016, China had become the third largest offshore wind market just behind Germany and the UK.

In Europe, the growth of offshore wind in Denmark is also in part attributed to its demonstration projects. The country was an early mover in offshore wind with Vindeby project commissioned in 1991 and had 10MW of capacity commissioned by 1995 in a near shore project. Thereafter, it was recognized that larger offshore wind farms presented unique challenges and thus the national government obliged its utility to carry out large-scale demonstration projects. The focus was not restricted to only technical and economic issues but also to help better understand environmental issues. As a result, Horns Rev 1 (160MW) was commissioned in 2002 and Nysted (165MW) in 2003. The experience of these two projects provided invaluable input to the Danish Energy Authority's plan for location of future offshore wind farms in the period ranging from 2010 to 2025. The demonstration projects also fostered a strong ecosystem of local firms that are now well placed to capitalize on offshore wind opportunities in new markets, such as Taiwan and the US.

FIGURE 9: LONG TERM TARGETS AND 2016 STATUS OF MAJOR OFFSHORE WIND MARKETS



4. FINANCIAL SUPPORT

The availability of capital is shaped to some degree by activities over which national governments have limited control – such as the state of the financial markets, global trends in attitudes to risk, perceptions of technology maturity and the balance sheets of companies operating in the energy sector. Nonetheless, government-backed banks can help to enable offshore wind deployment by easing access to capital. Germany's KfW and Denmark's EKF are examples. However, to have a tangible impact, these banks must have sufficient resource to make an impact on the market. An initial criticism of the UK-based Green Investment Bank (now privately owned) was that its initial capitalization was too low at £3billion, although by June 2017, it reported £1.12bn of assets under management.

Governments have also played a role by providing suitable tender structures in order that financing can be obtained efficiently. A case in point is the Horns Rev 3 farm off the coast of Denmark, which was reported to be one of the cheapest tender processes to date, due to the low risk set-up [11].

The Dutch government has also made efforts that enable access to cheaper and varied financing options by predeveloping offshore wind zones and offering guarantees to bidders for licensing, legal and environmental issues [12].

5. LONG TERM VISION

Experience shows that a clear, time-bound, quantitative target for offshore wind development, and a roadmap of how to achieve it, is an effective tool to leverage on offshore wind potential. Europe provides evidence of the importance of targets and roadmaps. The EU 2020 National Renewable Energy Action Plans played a crucial role in catalysing industry activity, raising public awareness and attracting investors. Many member states translated these into specific national goals for offshore wind looking at 2020 and beyond. In fact, nearly all offshore wind markets today have national targets for renewable energy and specific plans for offshore wind development, see Figure 9. The signals to the industry are strongest where these targets are offshore wind-specific, rather than pertaining to renewables in general.

5

FROM ZERO TO FIVE GW

OFFSHORE WIND OUTLOOK FOR GUJARAT AND TAMIL NADU [2018-2032]

Forecasting the electricity generation mix over the long term is a useful exercise for many stakeholders. Policymakers endeavour to understand how new electricity demand can be met at reasonable cost, the impact on GHG emissions targets and as a means to feed data into other development plans such as grid planning and land zoning. On the other hand, academics and private industry use long term modelling to better understand the growth of different generation technologies and therefore to drive investment plans.

In one such exercise, the world energy system up to 2050 was modelled by DNV GL, providing an independent view on what the world's energy future will look like [13]. This is not a collection of scenarios but a consolidated and consistent vision of what its experts expect to happen, given the current status and expected developments across the global energy markets, based on current and future projected costs of technologies. The projections were done for 10 global regions with the Indian subcontinent[2] as one region but India is not modelled separately. The following graph (Figure 10) shows the offshore wind capacity additions out to 2050 in all 10 regions. It is forecast that global offshore capacity would exceed 2000 GW by 2050 with the Indian region expected to account for 140 GW of this installed capacity.

The FOWIND project focuses exclusively on developments within two states of India – Gujarat and Tamil Nadu. There is vast untapped potential along the rest of India's long coastline and comprehen-

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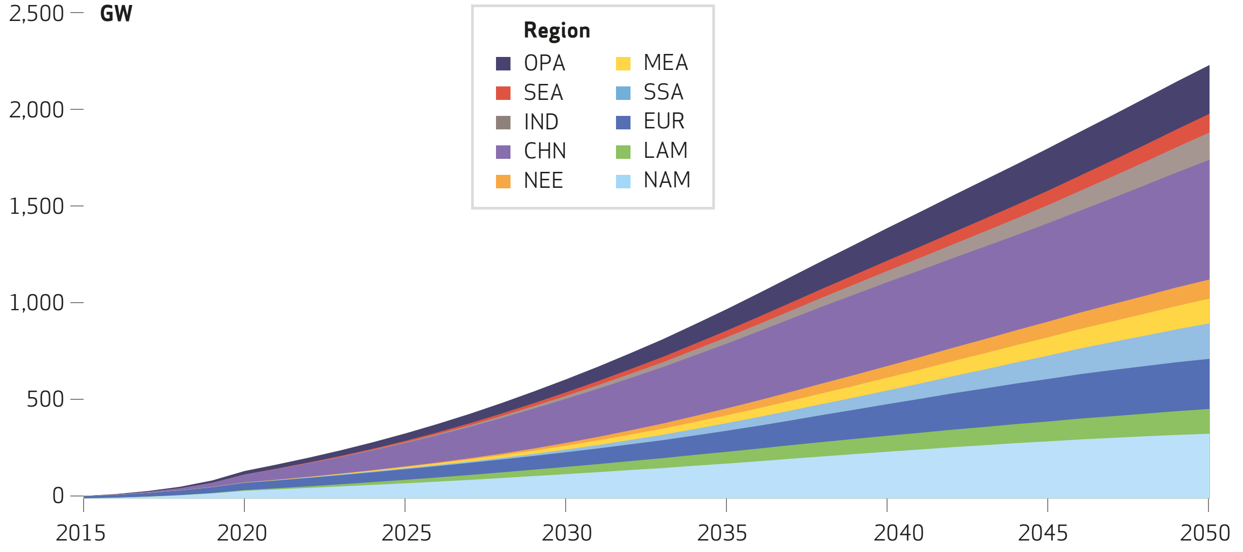
[2] The ETO considers the following countries to be in the Indian subcontinent: Bangladesh, Bhutan, India, Nepal, Pakistan, Sri Lanka.

FIGURE 10: FORECAST OF OFFSHORE WIND CAPACITY BY REGION (DNV GL ETO)



sive resource assessments can further add to the country's offshore wind development profile.

The upcoming decades hold significant uncertainties, notably in areas such as long-term energy plans and policies, the pace of technological progress, and costs of existing and new technologies. In this context, the following sections do not attempt to forecast how much offshore wind generation will be added in Gujarat and Tamil Nadu. Rather, we present an outlook on how these states could go from zero to 5GW of installed capacity by 2032. A complex and fast-evolving mix of factors will determine actual capacity addition but charting scenarios towards a mid term target can help guide policymakers and industry actors in planning for actual projects.

Three scenarios (Figure 11) were generated for the purpose of this outlook towards 2032 going to 5GW of total installed capacity for offshore wind. Under each scenario, it is also assumed that the first 500MW capacity is brought online by 2022.[3] This is consistent with the timeline that FOWIND has determined based on the initial work done under the project, especially the grid integration study [14] and ports assessment. Both reports are available in the public domain. In addition, the full feasibility report to be released by March 2018 will further lay the groundwork for ensuring a successful offshore wind sector in India.

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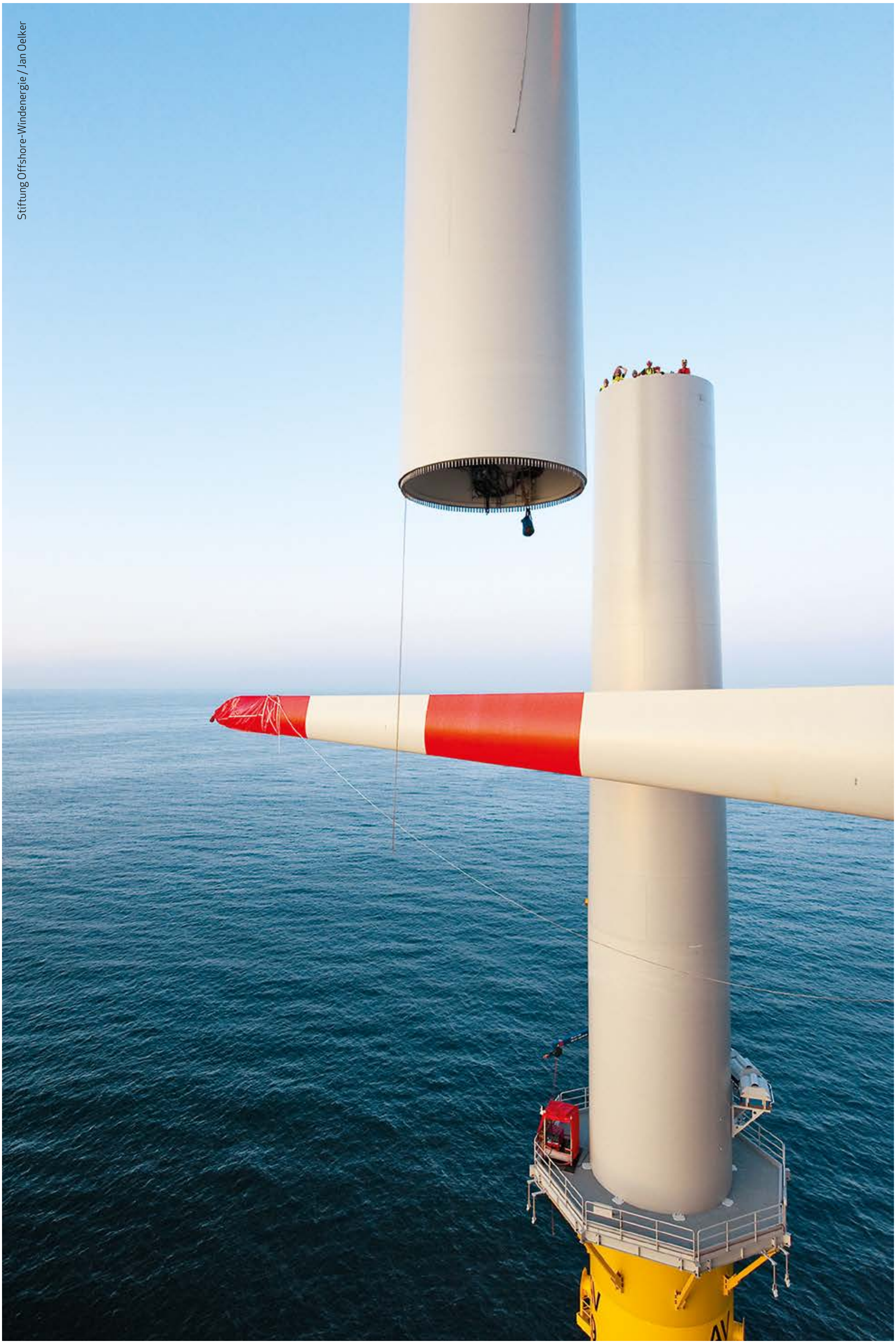
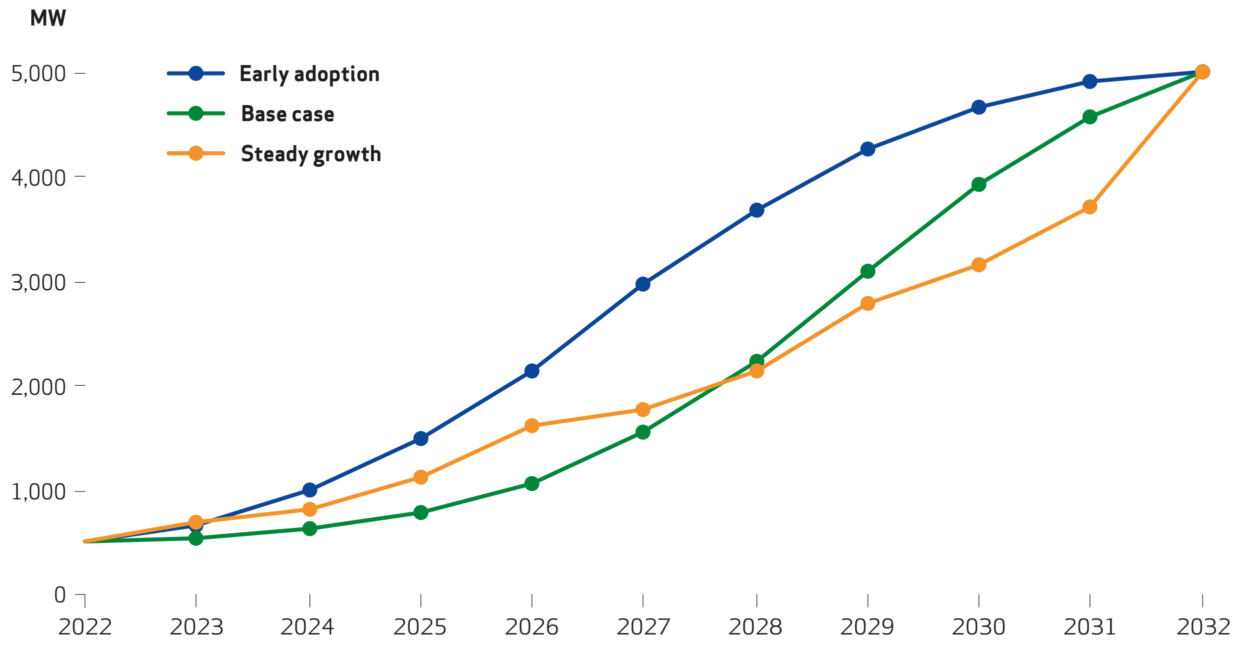
[3] This is consistent with assumptions in previous FOWIND work, inclduing the grid integration study conducted in collaboration with the Gujarat and Tamil Nadu state utilities, GETCO and TANGEDCO respectively.



Stiftung Offshore-Windenergie / Jan Oelker

FIGURE 11: PATHWAYS TO 5GW INSTALLED CAPACITY BY 2032



Scenario	Notes
Early adoption	Attractive support mechanisms, expectation of long-term policy certainty and industry optimism lead to strong growth in the initial years. Capacity addition starts to taper in later years as industry players look outside of Gujarat and Tamil Nadu for new sites.
Base case	Development is slow initially as industry adopts a cautious 'wait and watch' approach. Growth picks up in the middle of the decade as the first projects are commissioned successfully and benefits of offshore wind become clear, supply chain matures and investor confidence rises.
Steady growth	Growth in initial years follows a middle path as early movers develop the first sites and remains steady in the middle of the decade as support mechanisms are fine-tuned. Later years see rapid capacity addition as costs fall and technology evolves globally.

The following sections discuss how the pathways from zero to 5GW can be realised by identifying the key action items that need to be the focus of policymakers. This is based on the identification of the best practices globally, local and national challenges in the Indian context and the learning of the FOWIND consortium from the project work executed.

These scenarios do not represent a pan-India outlook but only focus on the two states of Gujarat and Tamil Nadu. It is also important to bear in mind that this does not represent a forecast or most likely estimate of what will be achieved. On the contrary, these pathways seek to illustrate how development trajectories can differ and how proactive policy frameworks, monitoring and market design is required to keep progress on track to reach 5GW by 2032.

6

FIVE ACTION ITEMS FOR GUJARAT AND TAMIL NADU

Drawing together the global challenges for offshore wind, the policy lessons from mature markets and the pathways to 2032, five action items are discussed here, as milestones on the road to achieving 5GW of offshore wind capacity in Gujarat and Tamil Nadu.

1. CLEAR ROADMAP

A roadmap is a long-term vision document, consisting of three key elements – a starting point (i.e. policy drivers), a destination (i.e. targets) and a route description (i.e. action items). A key function of the roadmap will be to identify the first necessary steps towards establishing regulations and guidelines on how different stakeholders work with each other and the means to develop the necessary framework for any future project development. An example of the interactions between some key stakeholders is shown in Figure 12. Implementing the roadmap will require work streams cutting across several stakeholders. For example – grid expansion and operation will need inputs from maritime users, offtakers and the project developers.

Note that this is a high-level diagram where each party will also deal with a number of government and non-government entities. FOWIND's inception report identified a comprehensive list of stakeholders for the offshore wind sector at 4 different levels – central government, state government, local government and the R&D community [15].

It may be premature for India to set long term national targets given the current uncertainty associated with both the resource and local offshore wind levelised costs. However, Gujarat and Tamil Nadu can take the lead on setting short to medium term targets in line with the national 5 Year Plans on the basis of the groundwork done by FOWIND over the past four years. This roadmap will have to layout a long-term plan for offshore wind specific infrastructure development including ports and transmission systems.

These targets may be implemented in 2 ways. First, the government can include this as part of the RPOs (Renewable Purchase Obligations) that it currently has for Discoms (Electricity Distribution Companies) and other obligated entities. Here, it is important to set a separate RPO level for offshore wind to avoid cases where the obligation is met using other renewable generation. This approach may not be the most favoured because of the poor history of RPO compliance and because the uncertainty associated with early projects' costs may make it prohibitively expensive to achieve a fixed capacity target. A second way is for the government to set aside a dedicated Offshore Wind Support Fund. This can be used to fund part of the development costs for demonstration projects, for Viability Gap Funding[4] and/or for payment of FiT to offshore wind energy generators.

2. CONSENTING AND PERMITTING CLARITY

As described earlier, developing an offshore wind farm is a long and complex process. Delays in obtaining consents and permits not only affect individual developments but can also cast a shadow over future investments in the sector. This calls for clear procedures for consenting and permitting that are applied in a consistent and timely manner

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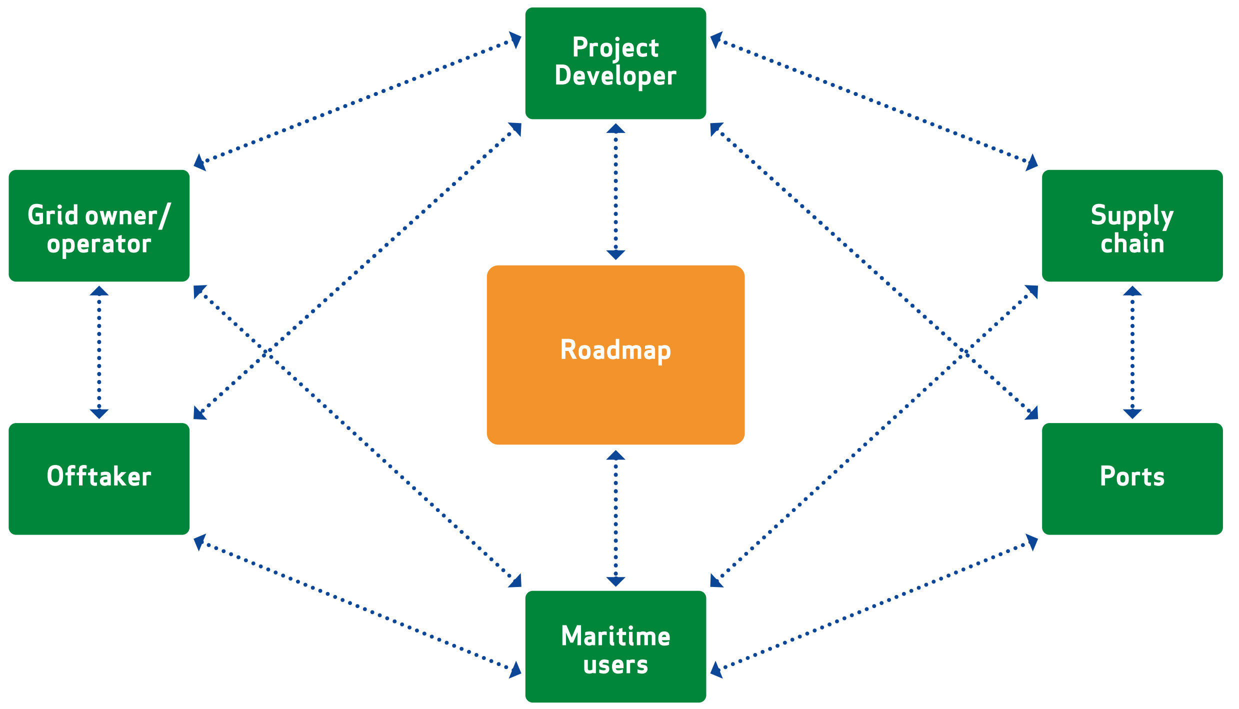
[4] Viability Gap Funding: a grant one-time or deferred, provided to support infrastructure projects that are economically justified but fall short of financial viability.

FIGURE 12: HIGH-LEVEL FORMAL DOCUMENTATION OF STAKEHOLDER RELATIONSHIPS IN A ROADMAP



by the requisite nodal agency. Under the current Offshore Wind Policy published by the MNRE, the National Institute for Wind Energy (NIWE) would lead this action, as the designated nodal agency.

For NIWE the best way of avoiding conflict and planning issues is through good site selection, reducing any risk of impacts well before a project applies for consent. For example, the experience of offshore wind development in Germany clearly illustrates how site selection is best achieved through robust marine spatial planning exercises, which seek to develop a good understanding of the potential environmental constraints, alongside meaningful engagement with key stakeholders. In India, clear consenting and permitting policy is even more important because local community protests have led to several power project delays.

The states of Gujarat and Tamil Nadu ranked first and second respectively for 2016 marine fish landings in India.[5] This implies that early engagement and buy-in from the fishing community will be an important step in avoiding project delays. However, this will involve engaging several parties such as the local fishermen, cooperatives representing fishermen (such as the Gujarat Fisheries Central Cooperative Association Limited), National Coastal Zone Management Authority, Department of Animal Husbandry Dairying & Fisheries, State Fisheries Departments, Indian National Centre for Ocean Information Services and other relevant Research and Development institutes. The engagement and dialogue is not just restricted to the understanding of wind farm impacts on marine life and environment but must also address the impacts on relevant coastal communities.

The government can enable this in 2 ways. First, it must ensure inter-departmental coordination when drawing up plans for sites that will be leased to offshore wind farm developers. An integration of data from energy assessments, fishing colonies, defence considerations, shipping routes and mineral exploration can help make coherent plans for all users of the seas. Second, the government must also define clear criteria for valuation of competing uses of the sea and mechanisms for timely dispute resolution, should parties wish to challenge the selection of sites for offshore

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[5] FRAD, CMFRI, 2017. Marine Fish Landings in India 2016, Technical Report, CMFRI, Kochi

FIGURE 13: DEVELOPER'S PROJECT SCOPE IN DIFFERENT COUNTRIES

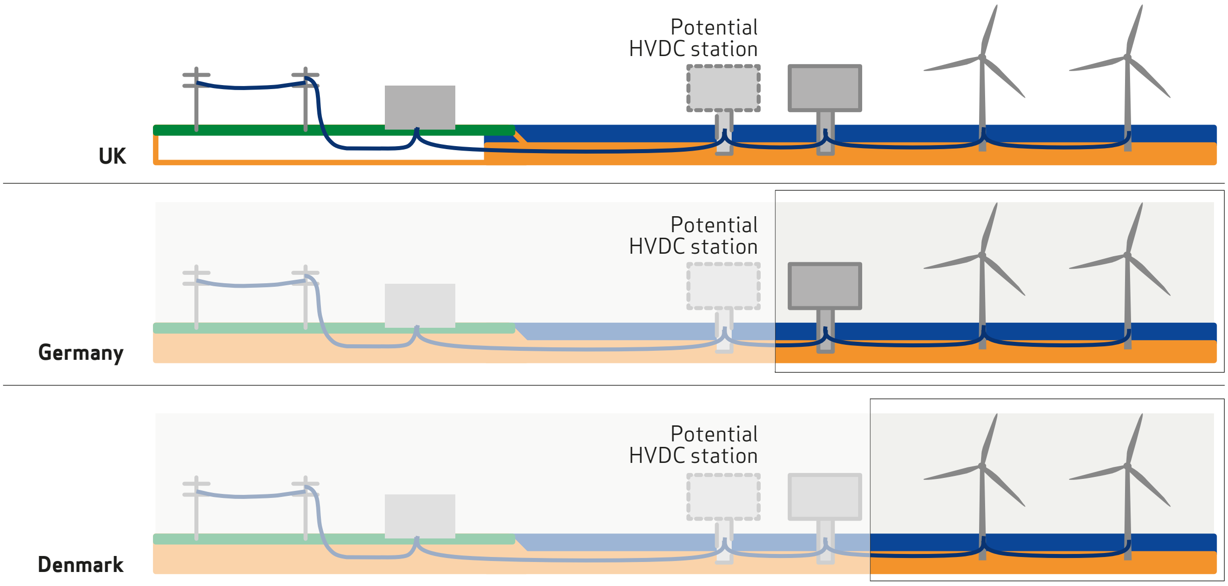

Image: Dong Energy

wind farms. These two steps will help avoid early hurdles faced in China, where wind farms had to be delayed and relocated due to competing marine interests.

3. GRID DEVELOPMENT

FOWIND's report on Grid integration of offshore wind farm development in Gujarat and Tamil Nadu addressed several challenges to timely development of the onshore and offshore grid [14].

First, an underdeveloped grid or poor system operation will lead to sub optimal evacuation of power, placing a financial risk on the wind farm operator and reducing the amount of clean electricity generation available for end users. Curtailment of wind power is already an issue in some parts of India, especially in Tamil Nadu. Second, offshore grids have several unique considerations centred on their relatively higher costs than onshore transmission systems, the space constraints of operating in an offshore environment and the specific characteristics of systems including significant quantities of offshore cable. Third, the boundary of the grid for the purposes of metering[6], grid development and grid ownership (i.e. division of responsibility of different stakeholders) will determine the risk structure and costs incurred by the different stakeholders.

Based on a review of the current status of the onshore grid, the Indian grid code, best practices in offshore grid development and current practices of grid operation in India, the report identified several barriers and respective mitigation strategies. A condensed summary of these is presented on page 35.

4. FINANCIAL SUPPORT MECHANISMS

A number of financial support mechanism have been used to promote the growth of renewable energy. India has had over two decades of experience in supporting onshore wind through different schemes. This section briefly discusses three of these, followed by brief recommendations on how offshore wind should be supported through its infancy (see Table 2 on page 36).

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[6] For the purpose of settlements of electricity fed into the grid, the farther the metering is done from the offshore turbines, the larger is the portion of the transmission losses that will be borne by the wind farm operator.

Area	Barrier	Mitigation	Key Stakeholder
Onshore grid	Offshore wind not included in current grid planning scenarios	Formulate state and national targets for offshore wind Include offshore wind development scenarios in long term planning	MNRE, MoP, CEA, CTU and STUs
	Delayed delivery of necessary onshore grid reinforcements causing power export constraints	Prioritise anticipatory investment in grid expansion (e.g. Green Energy Corridors)	CTU and STUs
Offshore grid	No policy exists for delivery and ownership of offshore transmission systems.	Select either generator built or TSO built model for ownership of the first offshore wind projects Initiate a Central Working Group to frame an enduring national offshore transmission policy	CEA, CTU, STUs||||MoP, MNRE, CEA
	No framework exists for offshore transmission network planning.	Initiate a Working Group to evaluate the optimal transmission topology and system planning regime for Gujarat and Tamil Nadu.	CEA, CTU, STUs
System operation	Uncertainty around the absolute level of grid curtailment at present and expected in the near future	Measure, report and set targets on curtailment levels	CERC, RLDCs, SERCs, SLDCs
	Incomplete/delayed enforcement of national action plan for facilitating large scale renewable integration	Rigorous follow-up and timely enforcement of identified mitigation measures	NLDC, RLDCs, CTU
Technical and regulatory codes	The connection process does not specifically address offshore wind projects.	Publish guidance on connection application process for the first offshore windfarms.	CTU, STUs, CERC, SERCs
	Grid codes do not specifically address specific characteristics of offshore wind and its transmission connection	Future code modifications should be reviewed considering the specific characteristics and installed capacity of power from offshore wind farms. Review the need for a separate grid code or modifications specifically for offshore wind projects. Clarification on the compliance boundary of OWF under individual grid code requirements	CEA, CTU, STUs, CERC, SERCs
	Planning standards do not address reliability standards for offshore connections.	Clarify on the applicability of present planning standards and consider the need for an offshore specific set of planning standards.	CEA, CTU, STUs

TABLE 2: ADVANTAGES AND DISADVANTAGES OF SUPPORT MECHANISMS USED FOR RE SECTOR

Support Mechanism	Advantages	Disadvantages
Accelerated depreciation increases the depreciation on the assets during the initial years of the asset's useful life, thereby reducing the greater proportion of taxable income	■ Significant post-tax benefits for the investor in terms of the timing of cash flows, i.e. made NPV attractive by reducing tax liability in early years ■ For investors, benefit was clear, certain, easy to access and low-risk (i.e. no government/ Discom disbursements)	■ Rewarded the development of capacity rather than generation ■ Excluded large IPPs, project companies with limited book profits and foreign investors
Generation Based Incentive (GBI) is payment linked to every unit of electricity fed into the grid subject to time and monetary caps.	■ Successfully secured investments from new class of investors, namely IPPs and FDIs. ■ Incentivized actual generation and higher efficiencies.	■ GBI scheme is limited to sale of electricity to Discoms and in some states they are reluctant to off-take
SERCs setting generic levelised tariffs (i.e. feed in tariff) combined with non-solar Renewable Purchase Obligation (RPO) for designated entities, mainly Discoms	■ CERC guidelines for SERCs to set FiTs were generous ("cost plus" methodology) and did not significantly drop for period 2010-11 to 2016-17 ■ Research indicates significantly higher capacity addition in states that offered specific feed in tariff and allowed captive consumption [16]	■ Poor compliance with RPO. For 2015-16, 25 of the 31 states/UTs, accounting for 86% of national electricity consumption, reported non-compliance1 ■ Discoms venturing out to re-negotiate old PPAs or reluctant to sign new contracts.

Other schemes have also been used in India to support the growth of onshore wind – income tax holiday, duty exemption on certain wind-related equipment parts, exemption from payment of sales tax in some states.

In light of the discussion above, a two-pronged approach is suggested for offshore wind developments in India. In the first phase of demonstration projects (~5 years), government should consider an AD scheme together with assistance in the form of upfront site specific studies that de-risk project development. This will give project developers better financial support, lower the level of risk for investors, during the early stages of wind power development. The possibility of opening up the AD scheme for Independent Power Producers using Special Purpose Vehicles needs to be investigated more thoroughly so as to attract a large class of potential investors who are experienced in developing and operating large scale profitable renewable energy infrastructure projects.

With time, AD support needs to fall as the focus shifts from capacity addition to ensuring that development is efficient. A clear time frame needs to be announced for reducing the depreciation rate from the initial rate of 100% to a lower level in subsequent years. This means that investors in the first few projects who implicitly take on more risk are rewarded with a more attractive NPV as opposed to later investors who already have greater certainty with regards to project bankability. A long term planned reduction announcement will ensure that investors have clarity on policy transition thereby avoiding a sudden flight of capital.


LM Wind Power

From the mid-2020s, a procurement based incentive (PBI) scheme is suggested for policymakers' consideration.[7] This is to incentivize Discoms to comply with their RPO targets in light of the fact that this has been a major shortcoming of the GBI scheme. A PBI payment should enhance transparency, facilitate timely payment to generators and reduce administrative burden as the government needs to process payments for a small number of applicants. It is also suggested that PBI be retained when offshore wind moves to the competitive bidding route as Discoms will still be the primary procurers of electricity. This procurement incentive may be provided to the Discoms till such time as the cost of offshore wind power generation is less than the marginal cost of their power purchase.

Finally, it is important to ensure that these financial support mechanisms are not withdrawn or altered significantly at short notice. The cost of capital is closely tied to policy and regulatory stability because uncertainty gets priced as risk premium in the cost of financing. In this context, having an investor-friendly, clear and stable policy regime becomes important to lower the cost of capital.

Will financial support for offshore wind projects eventually lead to it becoming cost competitive with other generation sources? The previous sections of this report have illustrated how offshore wind prices have declined in Europe with a sustained rise in installed capacity. Onshore wind

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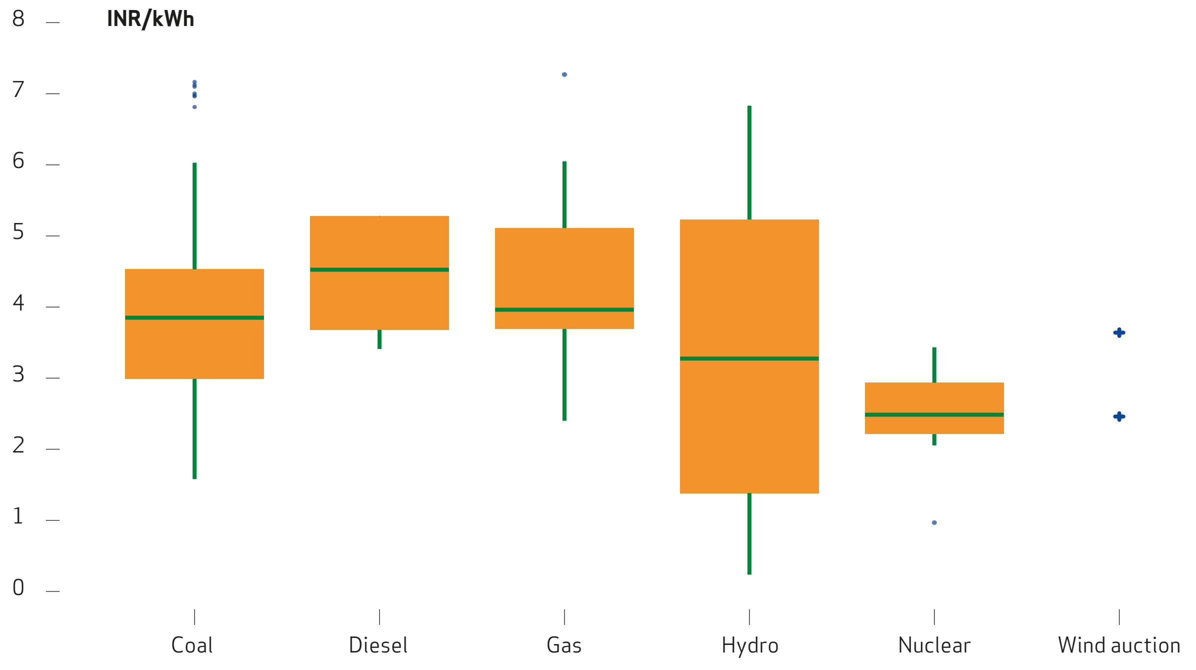
[7] Based on PBI scheme recommended by CRISIL for onshore wind in the study called "Evaluation of Generation Based Incentive scheme for wind power projects", October 2016. *www.crisil.com*

FIGURE 14: RATE FOR SALE OF POWER IN INDIA FOR DIFFERENT GENERATION SOURCES



in India also makes a strong case to demonstrate how renewable technologies can become cost-competitive after a period of government support. Two auctions for onshore wind in India discovered prices of 3.46 INR/kWh in February 2017 and 2.64 INR/kWh in October 2017. These compare favourably with the reported 3.20 INR/kWh for NTPC's average rate of power generated by coal-fuelled projects [17]. A comparison of these auction prices can be made with the latest reported data of sale of power (as approved by SERC/CERCs) for power plants with different fuel sources.[8] The figure below shows that onshore wind is now cheaper than the median fossil fuel generation without any government subsidy. Here, it should also be recognized that other benefits of onshore wind may not be captured fully in the cost data – such as zero fuel costs (imported or otherwise), substantial investment in new industries and jobs, zero GHG emissions during operation, and no pressure placed on local water resources to generate electricity.

5. COMPETENCE AND SKILL DEVELOPMENT

The long-term success of offshore wind, like any new complex technology, is a function of the growth of a local pool of experts, suppliers and skilled human resource that can efficiently work with the technology to scale it up. The development of competent personnel in different sectors of the industry and throughout the value chain is crucial. In this section, a few areas are highlighted where such competence development must be a focus area for the government and the industry.

This paragraph seeks to provide a flavour of the diversity of skill sets needed in the life cycle of an offshore wind farm and is by no means a comprehensive listing. The feasibility stage will involve energy assessments, geotechnical surveys, marine EIA. During the construction phase, jobs will require engineering know-how of offshore wind farm layout, offshore cable routing, foundation design, foundation installation, turbine installation, offshore substation design, offshore substation installation, offshore cable design, offshore cable installation etc. Most of these are specialised jobs that do not have 100% overlap

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[8] Data for year 2014-15 as reported in January 2017 in "Monthly Executive Summary", Central Electricity Authority (CEA). *www.cea.nic.in*

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with any existing competencies in the Indian market. The development of large offshore wind farms will undoubtedly coincide with high levels of renewable energy penetration in the Indian grid which brings with it the challenge of ensuring system stability while keeping curtailment of renewables to a minimum.

The development of competence is a slow and gradual process. In the short-term international suppliers, project developers, consultants and utilities with a track record of working in the offshore wind sector can fill the gap. Over the medium to long term these relationships can then be translated into framework agreements for training, knowledge transfer and joint partnerships during project execution. In addition, the government may introduce accreditation programmes where it deems that a formal recognition of sector specific skills would help in promoting local talent.

7 CONCLUSION

Offshore wind is now widely recognized as a key component of the electricity generation mix of the future. It is a clean energy resource that is increasingly cost competitive with traditional power generation technologies in northern European markets.

In India, electricity demand will continue to rise and the need to rapidly decarbonize electricity production is well recognized. The rewards of a robust offshore wind sector in India have the potential to be great: a strong, steady resource that can play a vital role in supplying clean energy to major load centres in Gujarat and Tamil Nadu.

The challenges for the development of offshore wind farms are well understood in the more mature markets globally. There is also a growing body of literature on what policies have worked well and those that fell short of expectations. These learnings have been succinctly captured in this report. The pathways to reaching 5GW of installed capacity in Gujarat and Tamil Nadu have been laid out with the help of five key action items. The timeline in Figure 16 shows how government and private industry actions will change from 2018 to 2032. However, the need for grid planning, inter-agency coordination and financing, especially during this early phase, will be a core role of the government.

The FOWIND project has laid the groundwork for the development of the first offshore wind projects in India. A number of landmark reports have been published that bring together the partners' global experience in offshore wind and the understanding of the local context in the states of Gujarat and Tamil Nadu (see Figure 15).

The pre-feasibility reports identified several credible technical solutions for offshore wind development in Gujarat and Tamil Nadu (eight potential zones in each state) through constraint modelling using existing public domain data. The reports covered at a high level preliminary studies on project siting, wind farm design and installation strategies. Project costs were suggested using international experience and environmental

FIGURE 15: KEY REPORTS RELEASED BY FOWIND

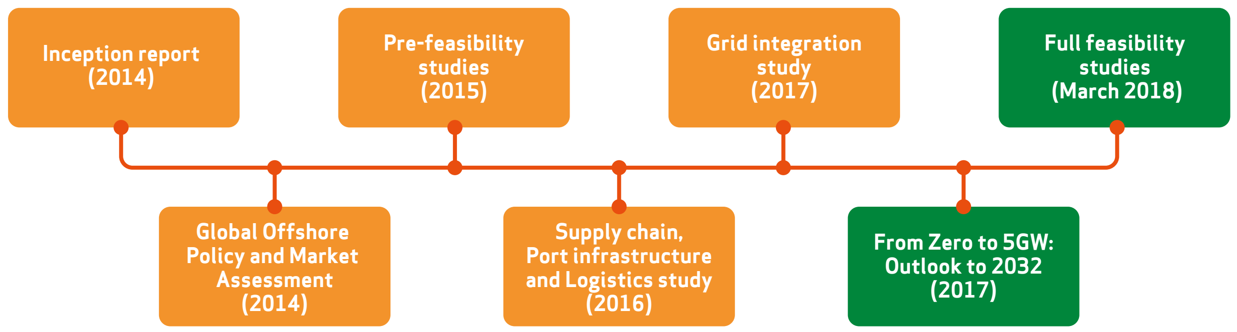
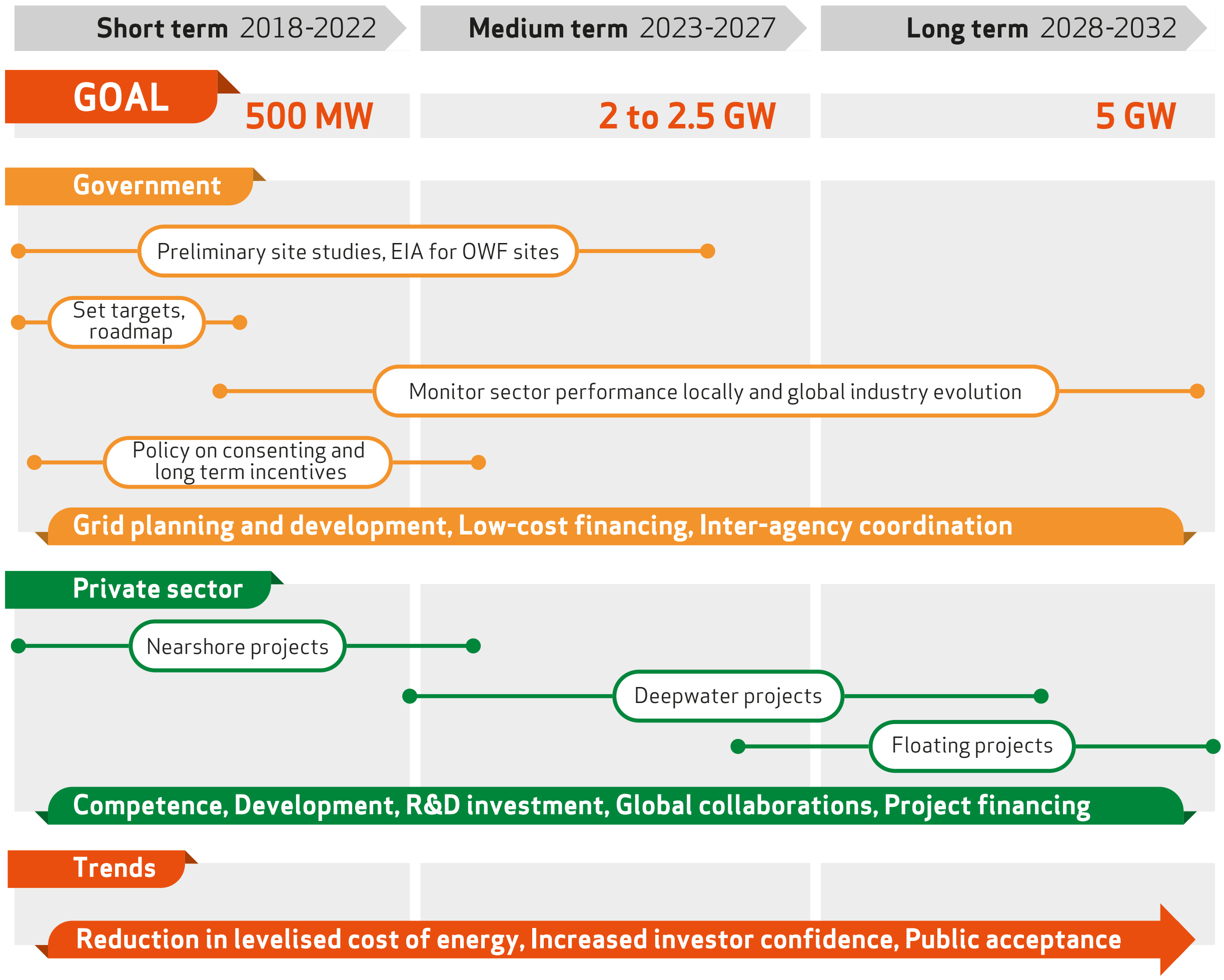


FIGURE 16: TIMELINE OF INITIATIVES TO ACHIEVING 5GW BY 2032



considerations were covered. Finally, initial LiDAR device locations were suggested for crucial onsite offshore wind measurements.

The supply chain, port infrastructure and logistics study provided an overview of the key supply chain elements required for offshore wind and carried out an initial review of the potential for Indian companies to enter the market. Building on this, a port infrastructure and logistics assessment was done to identify key component specifications, vessel requirements, installation strategies and port infrastructure required from manufacturing to installation and through to the operation and maintenance of an offshore wind farm. The report culminated with an offshore wind port readiness assessment for Gujarat and Tamil Nadu and an insight into project decommissioning.

The grid integration study addressed the following key question of how to prepare the state power systems to connect offshore wind project in Gujarat and Tamil Nadu. It laid out the steps necessary to prepare the physical onshore grid for integration of offshore wind projects in the two states while also considering the requirements to facilitate new offshore grid development. The report also evaluated how the states in question will ensure stable system operation with increasing penetration of offshore wind and other renewable energy generation. Lastly, a suite of relevant grid codes was reviewed to ensure that they are suitable for development of offshore wind projects in India.

The FOWIND project culminates with the publication of the full feasibility report for select Zones in Gujarat and Tamil Nadu.

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ANNEX: LIST OF STAKEHOLDERS

Stakeholder	Expected Role
Central	
Ministry of New & Renewable Energy	MNRE is the nodal ministry for the development of offshore wind power in India. It drives the development of renewable energy sector in India. MNRE issues guidelines/directives and provides necessary guidance to NIWE. MNRE will be responsible for drafting the auction/market mechanism guidelines for the sector.
Ministry of Environment, Forest and Climate Change (MoEF)	MoEF is the nodal agency for the India's environmental and forestry policies and program The role of MoEF would be to provide clearances and provide the guidance for the rules of environmental impact assessment for offshore wind projects and promulgate the necessary coastal zone regulations.
Ministry of Finance (MoF)	MoF would allocate the finance for offshore wind power development in budgets and brings amendment in case of tax exemption\ and other financial incentives.
Ministry of Civil Aviation (Director General of Civil Aviation)	Ministry of Civil Aviation is nodal ministry for civil aviation. It will issue clearances related to air traffic route and air safety.
Ministry of Petroleum and Natural	MoPNG provide clearances for utilization of seabed outside the oil and gas exploration zone and pipeline route. The experience of Ministry of implementation of projects in offshore exploration can be utilized for offshore wind power development
Ministry of Shipping (MoS)	MoS provide clearances to operate outside the international and national sea route, utilisation of national port, and permission for utilisation of vessels and ships for the offshore wind power projects.
Ministry of Defence (MoD)	Relevant Naval command would need to clear all movement and exploratory activities in strategic areas offshore prior to their commencement. MoD would need to provide clearance for any construction work happening on Indian seabed. Here NIWE could provide blanket permits for activity packages for project development as the nodal agency.
Ministry of Home Affairs (MoHA)	MoHA would provide security clearances, permission to utilization of seabed, for offshore wind farms
Ministry of Communication & Information Technologies (Department of Telecommunication)	DoT would provide the NoCs for utilization of seabed outside the seabed telecommunication cable route
Ministry of Earth Science	Ministry of earth science will deal with science and technology for exploration and exploitation of ocean resources and play a nodal role in Western and Southern Ocean research.
Central Electricity Regulatory Commission (CERC)	CERC would issue guidelines and policies related to offshore wind such as, but not limited to, tendering mechanism, power procurement, tariff determination, transmission, open access, power market etc.
Central Electricity Authority (CEA)	CEA would specify the technical standard for electrical lines and grid connectivity, safety standard for construction, operation and maintenance of electrical lines.
National Institute of Wind Energy	NIWE as specified in offshore wind power policy is responsible for standardization and certification of wind turbines, research and development, Wind resource development and will be the nodal agency for the development of offshore wind.
Power Grid Corporation (PGCIL)	PGCIL would determine the availability of transmission facilities and would plan and coordinate all functions related to interstate transmission systems and will manage the offshore substations

Stakeholder	Expected Role
State	
State Government	State Govt. would provide clearance for working in coastal economic zone
State Electricity Regulatory Commission (SERC)	SERC would determine tariff, approve tendering documents, validate power purchase agreement, regulate electricity purchase, decide renewable purchases obligation, facilitate intrastate transmission and wheeling, specify grid code at the state level
State Maritime Board	SMB would provide permission for utilization and development of minor port, and related infrastructure for offshore wind development
State Transmission Utility (STU)	STU would provide permission to utilize the onshore state transmission line, provide infrastructure support for onshore grid connectivity, operation and maintenance of grid
Department of Environment & Forest	DoEF would provide clearances related to environmental impact for activities on the coastal areas
State Fisheries Department (SFD)	Fisheries department issue clearances on no impact on fisheries zone due to offshore wind project after impact assessment process
Power Distribution Company (DISCOM)	Distribution utilities would sign the power purchase agreement, provide infrastructure for local distribution
District, Taluk and Village Level for Planning Stages Including Civil Society	
District Collector office (DC)	DC office will issue land use permits and conduct public hearing for environmental impact assessment
Gram Panchayat (Local Self-governing Body)	Gram Panchayat will provide clearances for the use of land in the coastal areas. Also it can be involved to create awareness and engage in discussions with villagers through gram sabhas.
Civil Society	Civil society representatives would participate in public hearings and express their concerns on impact of offshore wind on employment, environment and health on local population. Civil societies may includes NGOs, environment and nature protection groups, local industrial bodies, local tourism committees, trade unions, etc.
R&D Community	
National Institute of Wind Energy	NIWE as specified in offshore wind power policy is responsible for standardization and certification of wind turbines, research and development, Wind resource development and will be the nodal agency for the development of offshore wind. NIWE could also lead the R&D Community in promoting cutting edge research to lower the COE from offshore wind farms in India through indigenisation of various aspects of the development cycle.
INCOIS	INCOIS is an autonomous body under Ministry of Earth Science. It would provide information ensuring appropriate marine zone planning – accounting for potential fishing zones, marine meteorological advisory and weather forecasts etc.
National Institute of Ocean Technology (NIOT)	NIOT is an autonomous body under Ministry of Earth Science (MoES). A key focus of NIOT is to develop reliable indigenous technology to solve the various engineering problems associated with resources in the Indian Exclusive Economic Zone (EEZ). NIOT has been associated with FOWIND as an advisor to the NIWE for LiDAR platform design and installation in Gujarat since 2016.
National Institute of Oceanography (NIO)	NIO is one of the constituent laboratories of the Council of Scientific & Industrial Research (CSIR). It conducts research and studies on observing and understanding the special oceanographic features of the North Indian Ocean. These studies include oceanographic data collection, environmental impact assessment and modelling to predict environmental impact. The institute also provides consultancy on a number of issues including marine environmental protection and coastal zone regulations. They could be tasked with undertaking widespread geotechnical and geophysical surveys for the Indian seabed in relevant areas of interest in the Indian EEZ.

PROJECT PARTNERS

Global Wind Energy Council (Brussels, Belgium) is the international trade association for the wind power industry. The members of GWEC represent over 1,500 companies, organisations and institutions in more than 70 countries. ***www.gwec.net***

Center for Study of Science, Technology and Policy (Bangalore, India) is one of the largest think tanks in South Asia; its vision is to enrich the nation with technologyenabled policy options for equitable growth. ***www.cstep.in***

DNV GL (Arnhem, the Netherlands) is the world's largest provider of independent renewable energy advice. The recognised authority in onshore wind energy, DNV GL is also at the forefront of the offshore wind, wave, tidal and solar sectors. ***www.dnvgl.com***

Gujarat Power Corporation Limited (Gandhinagar, India) has been playing the role of developer and catalyser in the energy sector in the state of Gujarat. GPCL is increasing its involvement in power projects in the renewables sector, as the State of Gujarat is concerned about the issues of pollution and global warming. ***www.gpclindia.com***

World Institute of Sustainable Energy (Pune, India) is a not-for-profit institute committed to the cause of promoting sustainable energy and sustainable development, with specific emphasis on issues related to renewable energy, energy security, and climate change. ***www.wisein.org***

KNOWLEDGE PARTNER

National Institute of Wind Energy (NIWE) will support FOWIND efforts towards offshore wind feasibility assessments for potential offshore wind project development in the states of Gujarat & Tamil Nadu – with a special focus on wind resource validation. NIWE is an autonomous R&D institution under the Ministry of New and Renewable Energy, Government of India, established to serve as a technical focal point for orderly development of Wind Power deployment in India. ***www.niwe.res.in***

INDUSTRY PARTNER

ReNew Power Ventures Private Ltd. join as an industry partner. ReNew Power is a leading clean energy IPP with more than 3 GW of commissioned and under-construction clean energy assets, and a pipeline of close to 1.8 GW wind, solar and distributed.

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