Offshore wind in Europe

Walking the tightrope to success

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EY

Building a better working world

Table of contents

Key findings

In a context of strong commitment on GHG emissions reduction and uncertainty on fossil fuel prices and energy security, the large-scale deployment of renewable energy capacity appears indispensable to Europe moving forward. Offshore wind energy represents a crucial component of the future European energy system:

- Offshore wind in Europe currently represents one of the most stable sources of renewable energy, with increased energy capture expected due to Europe's leading position in offshore wind R&D.
- Offshore wind energy is expected to grow to 23.5 GW by 2020, tripling current installed capacity.
- Industry efforts to reduce capital and operating costs mean that offshore wind will become highly competitive by 2023 when compared to other sources of energy. LCoE could reach €90/MWh by 2030 as long as a continual stream of projects enters the pipeline.
- The policy framework for securing 27% renewables and 40% reduction in GHG emissions by 2030 is currently unclear. However, in an "Offshore Wind Scenario", the installed capacity of offshore wind power could reach almost 65 GW by 2030, allowing wind energy to make up more than 25% of electricity generation in Europe.
- The "Offshore Wind Scenario" could also save Europe €18b each year on fuel imports in 2030. Applying the SCoE model to the "Offshore Wind Scenario" shows that it is possible to build a low carbon energy sector €4b cheaper than in a "Nuclear Scenario".

Compared with other energy mix scenarios, prioritizing offshore wind energy could create the most jobs in the energy sector, displace the most carbon, and would be cheaper for society than nuclear or conventional sources of energy.

Today's needed actions for 2030

In order to secure Europe's commitments to climate change, energy security and a low carbon economy, offshore wind should be considered as an important component to the power mix. Continued cost reduction and support from policy makers are necessary to maximize the potential of offshore wind resources and to realize the socio-economic benefits of a fully industrialized and emerging sector.

Several key priorities have been identified to address these challenges:

- Ensure a stable regulatory framework and define long-term policy schemes
- Improve access to finance for the offshore wind sector
- Ensure cost-effective grid investment and connection
- Address planning system issues
- Face supply and logistics challenges
- Support innovation and training, and enhance synergies to reduce costs

Introduction: Europe's energy challenge

"Business As Usual" is not sustainable

The EU faces a growing need to improve its energy security and protect its economy from fossil fuel price spikes and uncertainty.

Under the European Commission's own projections for the future[1], whilst final energy demand in Europe is expected to remain stable up to 2050, there are significant consequences should there be no major action under a "Business-As-Usual" pathway:

- Total EU energy production will decrease by more than 50% in 2050 when compared with 2010, due to an important decrease in fossil fuel production within European borders.
- Energy imports as a result will continue to increase, up from 52.5% today, itself an increase from 40% in the 1980s.
- Despite the recent fall in oil prices, fossil fuel costs will increase in the long term. As of 2012, the EU already runs a trade deficit in energy products amounting to €421 billion (3.3% of EU GDP), a threefold increase since 2004[2].

It is clear that continued reliance on fossil fuels will not be an economically viable answer, especially in light of recent geo-political events.

In this context, the commercial deployment of renewables will be at the heart of Europe's energy challenges in the coming years.

Keeping the pace for change up to 2030

The EU already positions itself as a leader and pioneer in addressing climate change, reaching a 19% reduction in GHG emissions compared with 1990, while achieving 45% growth in GDP between 1990 and 2012[3].

In 2014, the EU set a 2030 target to reduce emissions to 40% below 1990 levels, as well as to reach 27% use of renewable energies for total EU-wide energy.

The decoupling of GHG emissions to GDP is an aspect on which the EU can share its experience with other countries in preparation for the COP21 conference in Paris in late 2015.

However, the vision of how the pathway from 2020 to 2030 will be structured remains unclear. Unlike 2020 targets, Member States will not be bound to national targets. The proposed European governance framework will require new ideas in order to define a pathway for full participation in reaching the targets set.

The role of offshore wind in Europe's climate, energy, and economic future

The offshore wind sector is one that is creating jobs and reducing fossil fuel imports. It represents an industry that Europe leads, with growth opportunities in the global market.

As we make progress towards a low carbon economy, this report examines the extent to which offshore wind can contribute to Europe's energy challenges and objectives.

In particular, the report focuses on:

- The potential of offshore wind;
- The socio-economic impacts of the industry today and the wider cost debate;
- The socio-economic and environmental benefits of ambitious deployment targets for offshore wind, compared with conventional fuel scenarios;
- Measures needed for fully realizing the potential of offshore wind.

Methodology

This report has been commissioned by the European Wind Energy Association (EWEA) to describe the current state of offshore wind energy and highlight the potential of the European offshore wind energy sector.

It has been elaborated in close collaboration with offshore wind industry representatives.

The 2020 offshore wind capacity scenario for Europe, as well as employment figures for 2030 are derived from studies previously conducted by EWEA.

The EU electricity mix scenarios presented in this report have been elaborated by EY, on the basis of the available scientific data.

1 *European Commission – Energy Economics Developments in Europe (2014)*
2 *Ibid*
3 *European Environment Agency - Why did greenhouse gas emissions decrease in the EU between 1990 and 2012? (2014)*

The potential of offshore wind and the industry today | 1

The potential of offshore wind

European seas hold the key to producing clean, secure and reliable energy. The energy potential of offshore wind resource is immense. Even factoring in other economic activities at sea, the technical potential of offshore wind resources is estimated to be sufficient to fulfill Europe's electricity demand by 2030[1].

The potential of offshore wind resources needs to be taken into account as a component of the energy system if Europe is to meet its renewable energy targets and fulfill its commitment to development of a low carbon economy.

Power production characteristics

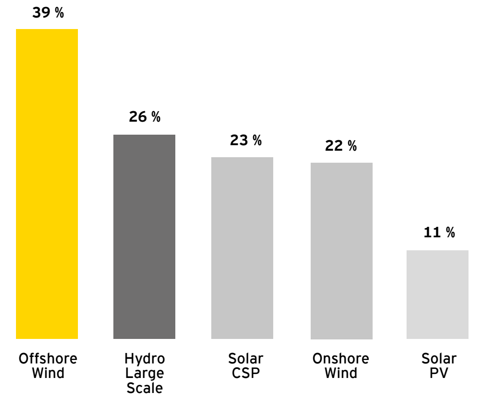
Offshore wind energy features some of the highest load hours amongst all renewable technologies, and will achieve over 4,800 full load hours per year in the future, and more than 8,000 operating hours, representing around 340 days of production.

Against the increasing scarcity of onshore sites with abundant and consistent wind characteristics, offshore wind is becoming increasingly attractive.

Also, power fluctuations are small due to the constant and consistent nature of wind offshore. The need for operating reserve balancing power plants is reduced through accurate forecast data flowing into electricity production models, which improve as more offshore wind farms and masts come online[2].

Thanks to its improved predictability and reliability, offshore wind is also better suited than onshore wind to provide operating reserve capacity to the electricity network. It is even possible that offshore wind energy in Germany could play a key role in network stability and balancing power supply[3].

Load factors of various renewable technologies[4]



Europe's leading innovation

In learning how to take advantage of offshore wind resources, the last two decades of industry development have driven growth and innovation in a wide range of sectors. The transformation of ports, power grids and shipping sectors have resulted from offshore wind investment, and represent the largest infrastructure projects over the last decade.

Boosting Innovation

More than 1250 {*Scientific publications on offshore wind in Europe between 1994 and 2010*[5]

European governments and private companies invest significant sums in R&D and have built a leadership position in the offshore wind market.

The emerging offshore wind industry has made considerable technological progress over the last years:

- The energy produced by the entire world's first offshore wind farm, installed in 1991, Vindeby (Denmark) could now be produced by a single 5MW turbine.
- Europe leads in the development of floating wind concepts, with two full-scale floating devices and four of the world's seven experimental devices in European waters[6].
- The European Commission has invested €565 million into projects supporting offshore wind via EERP funds[7].

Furthermore, Europe also offers a wide array of offshore wind test facilities at sites including:

- Offshore Renewable Energy Catapult, UK
- LORC, Denmark
- Hunterston, UK
- Multiple in-house test and demonstrator sites in Denmark, Germany, and UK, operated by developers on leading-edge large capacity turbines.

As the first region to recognize the importance of offshore wind, European industry has taken advantage of knowledge from onshore wind and offshore oil and gas sectors to evolve into a dynamic new sector.

1 *EEA - Onshore and offshore wind energy potential (2009)*
2 *Fraunhofer IWES - The Importance of offshore wind energy in the energy sector and in the German Energiewende, (2013)*
3 *Ibid*
4 *IEA (2014), DECC (2013)*
5 *Wieczorek et al. - A review of the European offshore wind innovation system (2013)*
6 *EWEA – Deep Water, the next step for offshore wind energy (2013)*
7 *EWEA Analysis into European Commission CORDIS data*

The offshore wind trajectory

A fast-growing emerging industry

Compared with other renewable energy technologies, offshore wind remains an emerging industry.

Offshore wind is generally said to be 10-15 years behind onshore wind, but under the right conditions, the success of onshore wind power can be mirrored offshore. The industry has displayed one of the fastest growth rates of all renewable energy sources, with a 5-year compound annual growth rate of 31%. At the end of 2014[1]:

- A total of 2,488 wind turbines were installed and connected to the electricity grid in 74 offshore wind farms across the continent.
- Total installed capacity has reached 8 GW, enough to cover almost 1% of the EU's total electricity consumption in 2014[2].
- In the space of five years, employment in offshore wind has tripled, with 75,000 FTEs in 2014[3]. During the same period cumulative installed capacity quadrupled, showing efficiencies developed as the industry has gained experience through growth.

The frontrunners of this development have been the UK, Denmark, and Germany, with more than 80% of Europe's operational capacity installed in their waters. The UK is the largest global offshore market, and accounts for more than 55.9% of capacity installed within Europe, followed at a distance by Denmark (15.8%), and Germany (13%).

Five years of quadrupling capacity, with tripling FTEs

A further tripling of capacity by 2020

In the coming years, the offshore wind industry could triple its capacity, from 8GW today to 23.5GW in 2020[4].

This growth is expected mainly from the UK market and a faster deployment in France and the Netherlands, against a background of still recovering regulatory and financial stability[5].

5 GW of extra capacity could come from a fully stable political environment, boosted by a strong climate change deal in Paris at COP21 this year, placing the EU firmly on the path to meeting its long-term 40% GHG reduction target with a trajectory above the planned 27% renewables target.

At 28 GW of installed capacity, offshore wind could cover 3.5% of the EU's future electricity generation.

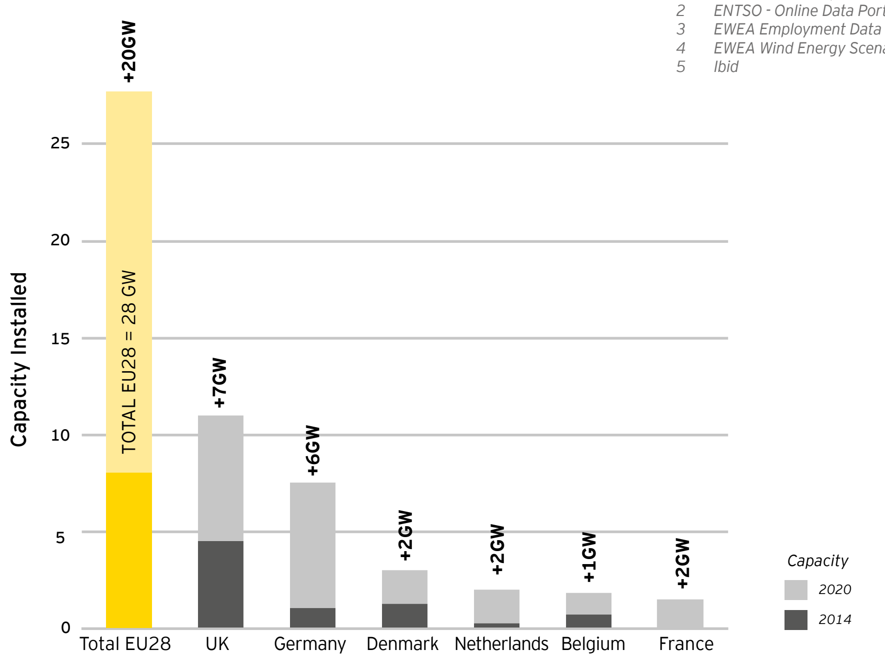
The development of the industry in the coming years is expected to create major growth opportunities for Europe, if long-term visibility and stable regulatory frameworks are in place.

The cost of offshore technologies also needs to become more competitive – and considerable investment in research and development into turbines, supply chain optimization, transmission, operations and maintenance is likely to be needed to help achieve cost reduction targets.

Many of the solutions lie in the industry's own hands, and the industry is already working hard to make progress in cost reduction. The pace of growth in the industry now needs to be matched by an equal pace in lowering costs.

1 *EWEA – The European offshore wind industry – key trends and statistics in 2014*
2 *ENTSO - Online Data Portal (January 2015)*
3 *EWEA Employment Data*
4 *EWEA Wind Energy Scenarios for 2020 – Central Scenario*
5 *Ibid*

A breakdown of potential growth in 2020



2 The cost of offshore wind

Achieving cost-competitiveness

Cost-competitiveness can be reached by 2023

Offshore wind power is still very expensive under commonly used metrics. If it is to remain a viable option in the long-term, its energy production costs must be reduced.

Large-scale deployment will depend not only on how much it can reduce its costs, but also how fast.

In the next five years, in order to become cost-competitive in terms of LCoE[1], cost cutting actions include[2]:

- The introduction of higher capacity turbines with better energy capture and reliability with lower operating costs, leading to as much as a 9% reduction in costs
- A steady project pipeline allowing continuous production of support structures would cut up to 7%
- Greater competition between industrial actors in several key supply chain areas, would lower costs by as much as 7%
- Greater supply chain optimization and logistical integration could potentially achieve a 3% savings

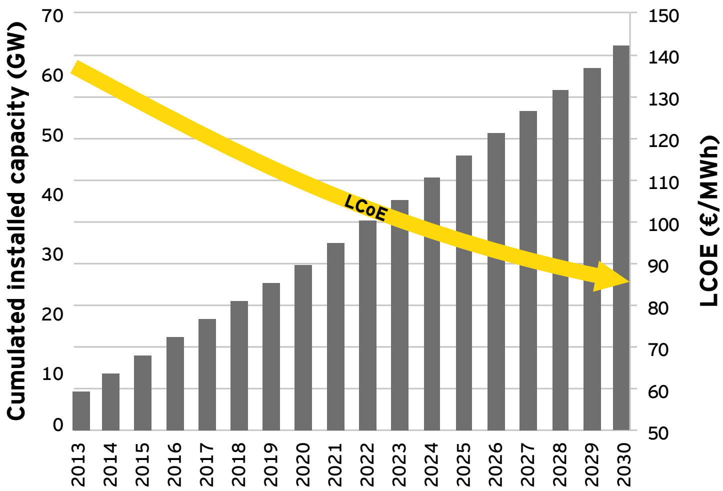
Responding to this, the industry has started rolling out larger 6-8 MW turbines[3]. While there are immediate higher capital expenditure costs, the increased energy capture is reaching the economies of scale needed to lower the cost of energy.

Concurrently within supply chain logistics and O&M, the industry is also working together on long-term projects to optimize processes and plan better for future developments[4].

The reduction of the LCoE will only occur against a backdrop of continuous growth, with the market realizing its technological and supply chain goals, with the combined effects of learning, specialization, investment and scale.

LCoE could go down to €90/MWh by 2030

Evolution of the LCoE according to the cumulated offshore wind capacity installed



An attractive sector for investors – Securing Europe's pensioners

According to the IEA, €35 trillion will be spent globally on energy investments by 2035[5]. High price volatility coupled with a price on carbon could make investments in fossil fuels increasingly risky.

Pension funds and insurance companies are facing a reduction in the value of their investments, which are currently affected by the decrease in oil prices. Offshore wind provides a solution for investors who are looking for stable investments to hedge against this volatility.

In particular, wind energy is an attractive asset for investors. It is a reliable technology, with very low operational costs, a constant electricity generation price and a great natural potential, making this renewable energy source very attractive for future investments.

The lowering risk profile of offshore wind compared to other large-scale infrastructure projects has allowed large amounts of investment into the industry, with financing secured for four "billion-euro scale" projects[6].

Furthermore, offshore wind has attracted the recent involvement of new market players such as "La Caisse de dépôt et placement du Québec" and the "Japan Bank for International Cooperation". This shows a growing interest of the finance community in the sector.

1 *LCoE – Levelized Cost of Electricity: LCoE incorporates all the costs incurred during the life of a power station, including for example CAPEX, O&M (operations and maintenance), fuel and decommissioning costs, and divides the discounted sum of those costs by the discounted lifetime output from the power station, resulting in a lifetime average (levelized) cost per unit of electricity from the power station.*
2 *Crown Estate – Offshore Wind Cost Reduction Pathways Study (2012)*
3 *Wind Power Offshore – V164 named preferred turbine for Walney (2015)*
4 *A 31 member consortium is taking part in the LEANWIND project, an EU-funded project on logistical, supply chain optimization using LEAN business principles*
5 *IEA – World Energy Investment Outlook (2014)*
6 *EWEA – The European offshore wind industry – key trends and statistics in 2014*

The true cost of offshore wind energy

The concept of "Society's Cost of Electricity"

In a context of growing environmental and social challenges, societies need clean, reliable and affordable energy in the future, and the selection of electricity sources should be based on their true costs and benefits.

LCoE can be expanded further to include more intricate cost-benefit indicators when comparing various technologies on a macro-economic scale.

Developed by Siemens Wind Power[1], "Society's Cost of Electricity" (SCoE) broadens the perspectives and considers the total-economy costs and benefits of energy production.

To compare offshore wind with its alternatives, additional factors need to be considered, which include, in particular:

- Employment effects: Offshore wind has more potential to create local employment and a positive GDP impact than almost all other energy sources;
- Geopolitical impact: Fossil fuel prices are volatile and subject to geopolitical sensitivities;
- Subsidies: Conventional energy sources such as coal or nuclear have been receiving subsidies from governments that lower their apparent cost.

SCoE components also include costs related to transmission and variability (back-up requirements), and the social costs (i.e. decline of house prices around power plants and wind farms).

With this approach, offshore wind generates additional benefits which are generally not taken into account in LCoE.

A case study: SCoE projection for Germany

As shown in the projection for Germany illustrated below[2], offshore wind can reach the same level of competitiveness as onshore wind and become one of the most competitive electricity sources in the country by 2025.

This is primarily due to the positive effect on local employment: due to component size and farm sizes, offshore wind energy is more suitable and in need for bringing industrial production closer to the market.

Analysis conducted by Siemens for the United Kingdom, one of the future leading markets for offshore wind, yields similar results.

It should also be noted that the critical mass for building a partially local supply chain is far lower for offshore wind than it is for other energy sources, especially conventional ones.

1 *Siemens - www.siemens.com/energy/wind/scoe*
2 *Ibid*

Germany's SCoE by 2025 shows offshore wind to be more competitive than conventional generation and solar PV

€ct/kWh	Nuclear	Coal	Gas	Solar PV	Wind Onshore	Wind Offshore
LCoE + Subsidies + Transmission + Variability	7.9	8.0	6.7	10.0	5.5	9.5
LCoE + system costs + Social impact + Employment effects + Geopolitical impact	12.8	8.1	6.8	12.6	7.3	11.1
SCoE	9.4	7.7	7.4	7.7	5.8	6.2

The future of offshore wind | 3

Offshore wind in 2020

The 2020 make-or-break

By 2020, offshore wind will have an installed capacity of 20-plus gigawatts, and be within near completion of achieving €100/MWh. Failure to meet both of these criteria will not see the offshore wind industry advance into 2030 and beyond.

By hitting these milestones, jobs will increase at an annual growth rate of 11% to 128,000 jobs by 2019[1].

However, by 2020, Europe will no longer remain the sole market into which the homegrown industry can expand.

A significant export potential for Europe

As a forerunner in the offshore wind industry, Europe currently leads in the design and manufacture of offshore wind components and has the installation know-how to work far-shore in ever deeper waters.

With cumulative installations of both onshore and offshore wind in Asia overtaking Europe for the first time in 2014[2], the offshore wind market will enter an intense phase of competition. The European industry has a vital role to play in this sector in the next decades, with thousands of new jobs at stake.

Europe in 2015 has 90% of the current global installed offshore capacity, and there is a significant potential for offshore wind development in frontier markets with countries outside Europe already setting ambitious targets for offshore wind energy.

90% of the offshore wind market is in Europe today, but will this be the case in 2020?

Asia in particular represents a huge potential for offshore wind, and several countries, including China, Japan, South Korea, India and Taiwan, have defined ambitious plans for offshore wind.

In 2014, there were 480 MW of offshore installations in Asia, but targets for 2020 will see 35 GW[3] potentially being installed, more than Europe's own projection. There is a distinct opportunity here for European technology and techniques to sit in the Pacific and Indian Oceans.

Globally, it is projected that cumulated investments could reach €690b by 2040[4,5]. This could present a huge market for European players that have chosen to invest in skills and innovation in 2015.

Global cumulated investments in new offshore wind capacity

€30b in 2013 **€690b** by 2040

Ensuring another decade of growth after 2020

Domestically, the picture until 2020 is somewhat stable. The "20-20-20" Renewable Energy Directive (2009/28/EC) sets out the commitments for Member States to achieve renewables targets that will result in total EU energy demand to be met by 20% renewables. The National Renewable Energy Action Plans allow progress to be tracked and a policy framework to be established.

However, the turbines in the water are only as good as the grids connecting them to consumers.

As the penetration of offshore wind increases, the necessary transmission and interconnection infrastructure will need to be implemented to ensure efficient transmission to usage centers and completion of the internal market as the development of a free-flowing electricity market will drive down consumer costs.

However, the economic downturn in the last half-decade resulted in a reduction in investment that stalled the validation of projects, leading to a predicted construction gap in 2016. The reestablishment of momentum will be a continuing priority to 2020 and beyond.

1 EWEA Employment Data
2 GWEC Global Wind Statistics 2014
3 GWEC - Asia in stats (2013)
4 Prognos - Cost Reduction Potentials of Offshore Wind Power in Germany (2013)
5 IEA - World Energy Outlook (2014)

Offshore wind in 2030: walking the tightrope to success

Blank pages in a book of opportunities

The 2030 framework for climate and energy policies unveiled a Europe-wide commitment to 40% reduction in GHGs from 1990 levels and an increase of the share of renewable energy to 27%.

While it remains unclear how the European Union and its Member States will achieve these goals, with a blank page waiting to be written by policy makers, the offshore wind industry will need clear indications, sooner rather than later, if its full potential is to be achieved.

Analyzing an offshore wind energy trajectory

Scenario analysis has been carried out showing the impact of offshore wind industry. Using the IEA 450 scenario[1] as a reference point, three scenarios were analyzed and compared:

- The "Offshore Scenario" posits an offshore wind industry that can deliver 64.8 GW[2] of installed capacity by 2030, instead of the reference scenario of 43.8 GW, thereby delivering an extra 93.4 TWh. This additional power generation results in a reduced development of nuclear energy and fossil fuels.
- The "Nuclear Energy Scenario", instead of an increase in offshore wind energy, suggests an increase in nuclear electricity production by 93.4 TWh compared to the Reference Scenario.
- The "Fossil Fuel Scenario" is based on the IEA's "Current Policies Scenario", and offers a point of comparison with a "Business-As-Usual" trajectory, where the EU fails to reach climate change mitigation targets.

Wind in the power stack

By pursuing the development of offshore wind to 64.8 GW, offshore wind in Europe will be able to supply 8.4% of total electricity demand in Europe in 2030. Combined with a flat development of onshore wind – which will be constrained by the growing scarcity in prime resource locations – wind energy alone will make up 25.7% of electricity generation in Europe.

Reduction in fossil fuel imports

The increased development of offshore wind ahead of conventional generation types will also mark a significant decrease in Europe's dependency on fuel imports. Fuel import dependency for electricity production would be reduced to as low as 16%, a noticeable improvement on the 28% in the "Fossil Fuel Scenario". €18b could be saved each year in fuel imports as a result of moving power generation offshore.

Europe's dependency on fossil fuels for electricity generation slashed to 16%

Economic value creation

The effect of prioritizing offshore wind could also create the most jobs when compared with prioritizing other technologies. 1.6 million direct jobs would be supported in the "Offshore Scenario" within the total energy sector, 300,000 more jobs than in the "Nuclear Energy Scenario".

The application of the "Society's Cost of Electricity" to the development of technologies also shows that the "Offshore Scenario" would be cheaper than nuclear and conventional generation, saving an extra €4b compared with other scenarios.

Compared with other scenarios, the "Offshore Scenario" enables Europe to reduce fuel imports, displace the most carbon, and create the most jobs, all for the lowest social cost.

1 *The IEA "450" scenario describes the 450ppm of CO_2 in the atmosphere and the energy scenario which limits global warming to 2 degrees*
2 *EWEA 2030 Offshore Capacity Scenario as of Dec 2014*

4 | Industry and government actions to realize the potential of offshore wind

Actions to realize the potential of offshore wind

Recognizing the indispensable role of offshore wind power in Europe's future energy mix, the following measures should be prioritized:

Industry's achievement of cost-competitiveness

Cost reductions, both in magnitude and timeliness, should be achieved to secure widespread acceptance by consumers, investors and politicians in the long run. While the clock is ticking, industry is giving signs that it is ready to deliver, but it requires a long-term stable regulatory framework that ensures its efforts are not stalled.

Ensure a stable regulatory framework

As a young industry in its quest for cost-competitiveness, the offshore wind market is still policy-driven, depending on public support schemes. Perhaps more than other renewables, it depends to a great extent on the reliability of regulation and the stability of political support.

There is a blank page in the book of opportunities to 2030. While it is clear that there is no appetite for national binding targets for renewables, the EU should encourage ambitious national pledges secured by a clear governance, with strong incentives that signal long-term certainty and promote regional approaches. Nowhere more than in a shared sea, working with neighboring countries is this essential.

Improve access to finance

The introduction of financing instruments directed to the offshore wind sector could facilitate the development of projects. For instance, the implementation of loan guarantee instruments might facilitate private sector involvement and improve the financing of offshore wind projects by significantly reducing the risk for investors.

Ensure cost-effective grid investment and connection

The development of a fully integrated European electricity network to transmit the large amounts of low-cost, carbon-free power generated offshore where it is needed, is a critical step towards widespread offshore to wind energy deployment.

Network upgrades as well as infrastructure investments in most European countries stand out as necessary measures, especially regarding large offshore projects.

The need for a politically backed master plan for offshore grid infrastructure at the national and European level is critical, in order to ensure cost-effective grid investment and connection.

Address planning system issues

Heavy regulatory requirements affect the development of offshore wind projects. As they often require years to complete, procedures - such as the selection of offshore wind zones or the assessment of offshore wind farms - often lead to major delays in project timelines.

Planning and permission procedures should be simplified to enhance efficiency, and issues that affect the timely deployment of projects should be clearly identified and addressed.

Face supply and logistics challenges

The realization of the potential for offshore wind development depends on the capacity to overcome supply chain and logistics challenges. In some European countries (Germany, UK), offshore wind market development may be challenged not only by component unavailability (turbines, foundations, cables), but also by a need for construction facilities and ports as well as installation equipment (especially installation vessels).

In this context, providing a favorable economic environment to key industrial players and addressing availability of construction ports emerge as strategic actions.

Support innovation and training and enhance synergies to reduce costs

Greater competition is considered as a driver to reduce costs, and maximizing the synergies between stakeholders (industries, public authorities, etc.) is a key factor.

Policy makers are required to promote partnerships and encourage trans-regional cooperation. It is especially crucial in the fields of research and technological development and training, as focusing on R&D efforts and ensuring sufficient workforce capacity are powerful levers for cost-effectiveness.

Addressing these crucial challenges will be key in ensuring a sustainable development of the offshore wind industry.

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