A European Green Deal

How offshore wind can help decarbonise Europe

Ørsted

> Offshore wind energy in the northern seas plays an important role in a decarbonised European energy system.

Martin Neubert
CEO, Ørsted Offshore

Delivering a Green Deal for Europe

Europe has taken on the role as a green leader in an effort to limit global temperature rise to 1.5 °C above pre-industrial levels. The new European Commission has set out the ambition to strike a 'Green Deal' that will make Europe the world's first climate neutral continent by 2050.

The decarbonisation of Europe will require an urgent and fundamental transformation of Europe's energy system. Fossil fuels, which made up more than 72% of European primary energy consumption in 2017[1], will have to be replaced by energy from renewable sources. Green power will also help drive out emissions in sectors harder to abate, such as transport, buildings and industry, through electrification and new, sustainable green fuels.

To do this, solar-, onshore- and offshore wind energy are expected to become the backbone of Europe's green energy system. This is a big challenge – and a big opportunity.

Decarbonising Europe represents a unique opportunity for a more prosperous, healthier and greener continent. And offshore wind energy in the northern seas plays an important role in a decarbonised European energy system.

For offshore wind energy this means up to 450GW of installed capacity by 2050, delivering a quarter of Europe's green electricity, up from 20GW today. The current 'business as usual' projection points to less than 150GW installed capacity by mid-century. To achieve 450GW of European offshore wind energy by 2050 will require a steep change in the buildout rate for offshore wind energy.

A new 'Green Deal' approach for offshore wind
The current approach based on national and often project specific planning has worked well until now. However, the scale needed to buildout 450GW by 2050 requires a shift in the approach to offshore wind development.

At Ørsted, we see three questions that must be addressed to facilitate an accelerated offshore wind buildout:

1. How do we find the space for 450GW of offshore wind generation?

2. How do we ensure sufficient transmission capacity to deliver offshore wind energy to Europeans?

3. How do we enable the industry to scale?

Answering these questions is a prerequisite, if we are to deliver a Green Deal for Europe. It will require strong cooperation between all relevant stakeholders. With this paper, we want to point to the direction where we believe the answers can be found.

We look forward to working with governments, industry, NGO's and communities to develop a new approach to building offshore wind energy, allowing Europe to become a climate neutral continent by 2050.

Martin Neubert
CEO, Ørsted Offshore

1. EUROSTAT 2019

Introduction and summary

It is the ambition of the new European Commission to at least halve EU greenhouse gas emissions by 2030 and then to reach net-zero by 2050, to help limit global climate change to 1.5°C, as is the objective of the Paris Agreement.

This marks a significant increase from the previous EU climate targets of a 40% reduction by 2030 and the vague policy ambition of 80-95% reduction by 2050. This is the goal of the 'Green Deal for Europe'.

Decarbonising Europe presents a two-fold challenge: accelerating the transition to renewables in the power sector where fossil fuels are essentially replaced well before 2050[2] – whilst also phasing out fossil fuels in industry, transport and heating through both direct electrification and indirect electrification by power-to-X technologies, using electricity to produce sustainable, green fuels.

This transformation will increase European electricity demand by a factor of up to 2.5 towards 2050, according to the European Commission (EC) scenario analysis,[3] even with ambitious and necessary energy efficiency measures implemented.

To decarbonise Europe, renewable power production must become the main source of energy for the entire economy, which means the pace of the renewable energy buildout has to increase. According to EC scenarios, we will need five to eight times more solar, about 3.5 times more onshore wind and 20 times more offshore wind capacity by 2050, compared with today.

This buildout needs to be attained while also protecting the environment and biodiversity and securing a just transition, offsetting jobs lost in the fossil energy sector with new opportunities in the renewables industry – all while ensuring cost-efficiency to keep the European economy running.

The recent steep cost reductions in renewable electricity technologies, indicate that an ambitious green energy buildout is economically feasible. Renewable energy from solar-, onshore- and offshore wind energy generation now outcompete new coal, gas or nuclear power plants. For offshore wind in Northwest Europe alone, costs have declined by approximately 70% since 2012.[4]

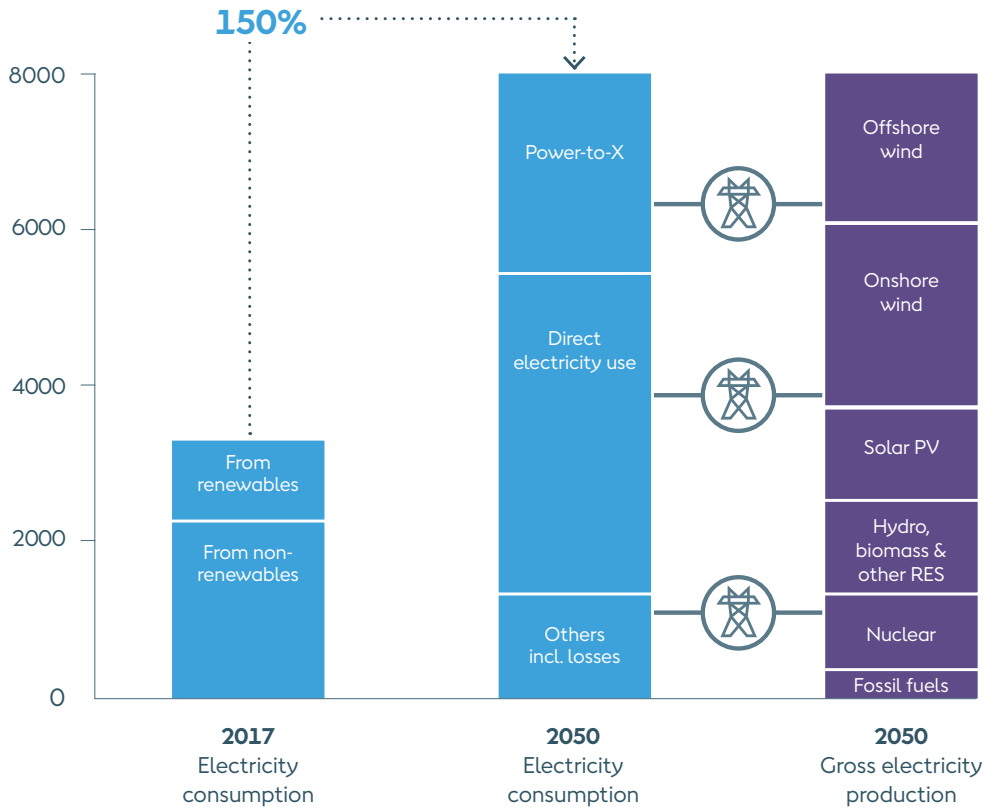
For offshore wind, a 20-fold increase translates into between 400 and 450GW offshore wind capacity installed by 2050, compared to around 20GW today. A simple growth path to reaching 450GW by 2050 implies increasing the current capacity roughly six-fold to 130GW by 2030.

This will require a significant increase from current installation rates for offshore wind. During the 2020's, at least 7GW of offshore wind capacity will need to be added to the European grid each year, with approximately 20GW per year on average from 2030 to 2050 – compared to the 3-4GW yearly installations today. Without this significant increase, Europe's green transformation will either be costlier and more difficult – or not feasible at all.

2. In line the 2018 EURELTRIC vision of the European electricity industry
3. European Commission 2018. The '1.5TECH Scenario' is used as basis throughout this paper
4. Ørsted calculation

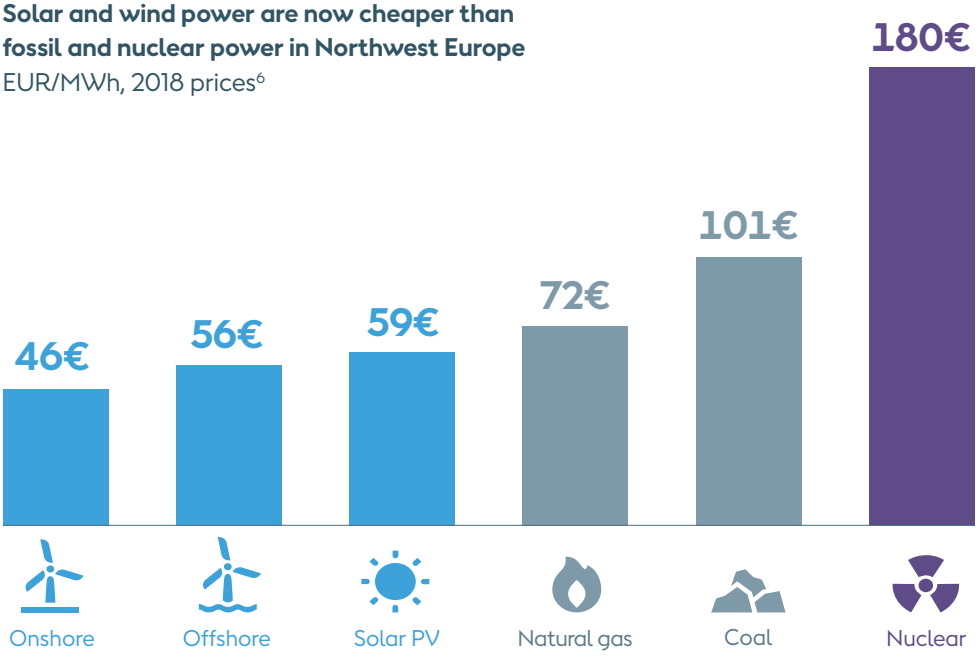
By 2050, power consumption is set to rise by 150% to fuel Europe's green transformation

TWh[5]



Solar and wind power are now cheaper than fossil and nuclear power in Northwest Europe

EUR/MWh, 2018 prices[6]

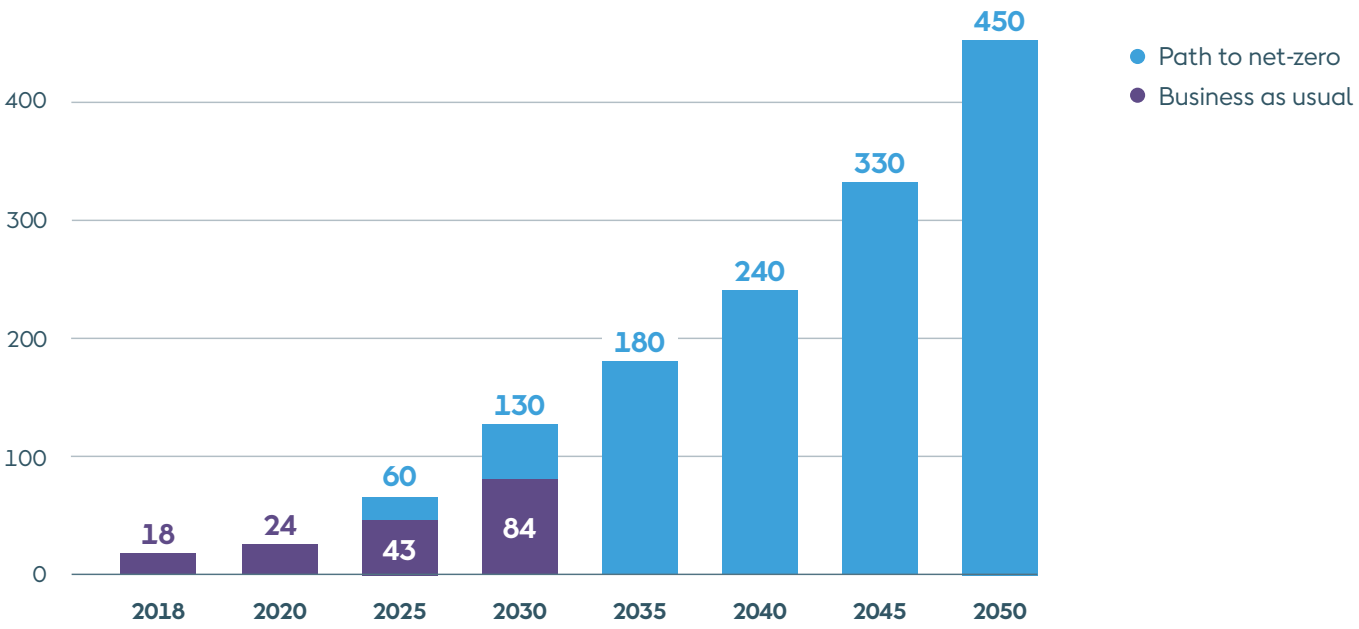


5. European Commission 2018, 1.5TECH Scenario
6. BNEF 2019 and Ørsted calculation. Including transmission

A 'Green Deal'-approach to offshore wind buildout

European offshore wind capacity towards 2050

GW[7]



The current approach to offshore wind buildout has worked well so far. Offshore wind energy has been developed through individual countries' energy policies and marine spatial planning (MSP). It has helped mature the technology, brought down costs and created a strong European industry with a global footprint. But this approach to develop offshore wind in Europe will not be sufficient to establish 450GW of offshore wind generation by 2050. The need for a significant increase in offshore wind buildout requires a new 'Green Deal approach' to the development of offshore wind.

With today's approach, offshore sites are typically chosen as a result of what can be fitted in with existing sea uses. This makes finding space for the required increase of offshore wind capacity challenging in continental Europe. Export cables are generally established as single onshore connections for each project and in most cases, they are built by the Transmission System Operator (TSO). We can reduce costs by including transmission into the competitive tendering, and we can get a higher value from connections, not least through increased security of supply, by connecting wind farms to more countries in a meshed structure. Finally, a new approach to policy formulation and collaboration between national and European policy makers is needed to provide clarity and enable the industry to reach the scale required.

Together, these challenges raise three broad questions about how to ensure the timely buildout of offshore wind towards 2030 and 2050, to help Europe deliver on its green transformation and stay in line with the Paris Agreement. These questions, which are the topic of this paper, are:

7. Source: Bloomberg New Energy Finance, 2019 and Ørsted calculation

1 How do we find the space for 450GW of offshore wind generation?

How do we find the space for an accelerated buildout of offshore wind generation?
European governments are currently working to develop the maritime spatial plans (MSPs) for the future use of Europe's seas. How can these be designed with a goal of net-zero in mind?

How do we ensure the buildout is aligned with the need for environmental protection?
Offshore wind energy is a key part of combatting climate change, which is one of the most important threats to Europe's maritime biodiversity. But offshore wind farms themselves also affect local biodiversity. The benefits and impacts of offshore wind energy is a complex field of marine science, with gaps still to fill. We need to work to improve scientific knowledge to understand and manage the long-term consequences of offshore wind energy buildout.

How do we enable co-existence with other maritime activities?
As European waters share space to other economic activities, finding the space for offshore wind buildout means finding a balance between economic activities, while also protecting the environment and abating CO_2 emissions through increased offshore wind buildout.

2 How do we ensure sufficient capacity for transporting offshore wind energy to Europeans?

How can we ensure an adequate and timely buildout of transmission infrastructure?
New, reformed regulation with more agile approval processes and effective incentives to build transmission can help TSOs undertake the needed transmissions grid enforcements in time.

How do we optimise the value of the offshore transmission grid?
The value of offshore transmission connections to offshore wind farms can be substantially increased by connecting to more markets, eventually creating a meshed grid, based on clusters of wind farms. This will allow for trade between markets, while improving dispatch and security of supply. This vision of an advanced offshore grid with interconnectors doubling as export cables, eventually leading to dedicated energy hubs, should be established through a step-wise approach. This way, governments, TSOs and market actors will be able to gradually develop the organisational capacity the cooperation needed.

How do we allow for competition and synergies to reduce costs
Offshore grid infrastructure has fallen behind in its cost-out journey compared to offshore wind generation. By allowing offshore wind developers to compete in designing and constructing the offshore grid, synergies between the connection and the wind farm, investments in industrialising the supply chain can be unlocked, and costs can be significantly reduced. This will require updated regulation and new models for remuneration of installation and operation grid assets.

3 How do we enable the industry to scale?

What will it take to scale up the industrial supply chain?
To enable significant investment into the industrial supply chain, the industry requires clarity and confidence in a continued pipeline towards and beyond 2030, to unlock the necessary private capital.

How do we make sure the energy demand is shifted towards green electricity and other renewable fuels?
The European green transformation is heavily dependent on consumers in other sectors switching to renewable electricity, either directly through electrification or indirectly through power-to-X technologies. Uncertainty about the pace of the required shift in consumed energy translates into a significant uncertainty regarding investments in renewable electricity and transmission. Therefore, a political push to shift demand to these low-carbon technologies is essential.

What should the governance look like?
Formulating high-level – and eventually multigovern-mental – policies for both the buildout of offshore wind and for the future electrification of the European economy is vital. Both to provide the needed confidence to unlock investments and to facilitate the pragmatic cooperation between governmental entities.

Answering these three broad questions and sustaining an accelerated buildout of offshore wind energy should be a top priority for governments seeking to deliver a Green Deal for Europe.

It will require a pragmatic and inclusive discussion across sectors and countries to identify the right solutions for Europe. Governments, industry, regulators, TSOs, civil society and environmental NGOs should work together to identify and formulate answers, which can sustain an accelerated buildout of offshore wind energy.

To start the discussion, this paper presents the views from Ørsted on where the answers could be found. This is summarised in the overview below, showing the differences between the existing approach to offshore wind buildout and a potential new Green Deal approach.

	Traditional approach	Green Deal approach
 **Space**	• Sites designated by governments. • Sites often specific to tenders. • No or very little tolerance for local environmental impact. • Offshore wind energy sometimes last in line after other uses.	• Larger gross areas or zones designated, where offshore wind is prioritised and in which developers have more freedom to screen and propose new projects. • Environmental consent based on latest knowledge and incorporating benefits from climate change impact.
 **Infrastructure**	• One project – one connection to shore and often to the closest suitable point on the transmission grid. • Often delegated to TSO.	• Transmission included in developer scope. • Multilinked offshore wind farms enter into a larger transmission system potentially sharing connections in hubs or feeding into several markets at the same time.
 **Industrial development**	• Governments setting national targets. • Tenders organised to meet national energy demand.	• Governments set stretch targets, based on a Europe-wide view, but the market will also drive offshore expansion through demand. • Volumes optimised regionally rather than nationally.

Roadmap towards 2050 – it is a shared responsibility

	Today	2020s
Space	Platform for knowledge on impact of offshore wind	**130GW** Planned latest 2021, commissioned by 2030
Infrastructure	Offshore wind developers installing offshore transmission	First multilinked project
Industrial development	Known pipeline towards 2025 is approx. **43GW**	High-level national buildout targets → **2020:** Pipeline of additional **90GW** towards 2030

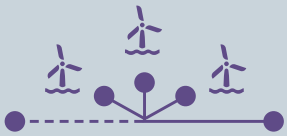
2030s

2040s

Multi-use of offshore wind zones

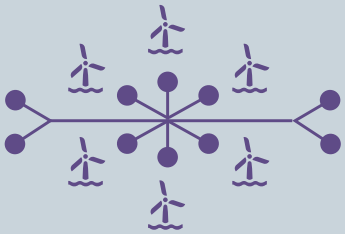
240GW
Planned latest 2027, commissioned by 2040

450GW
Planned latest 2033, commissioned by 2050



Clustering of more wind farms

Offshore wind developers propose and install multilinked projects



'Meshed' network/islands

Multi-governmental approach

2030: Pipeline of additional **120GW** towards 2040

2040: Pipeline of additional **210GW** towards 2050

Finding the space

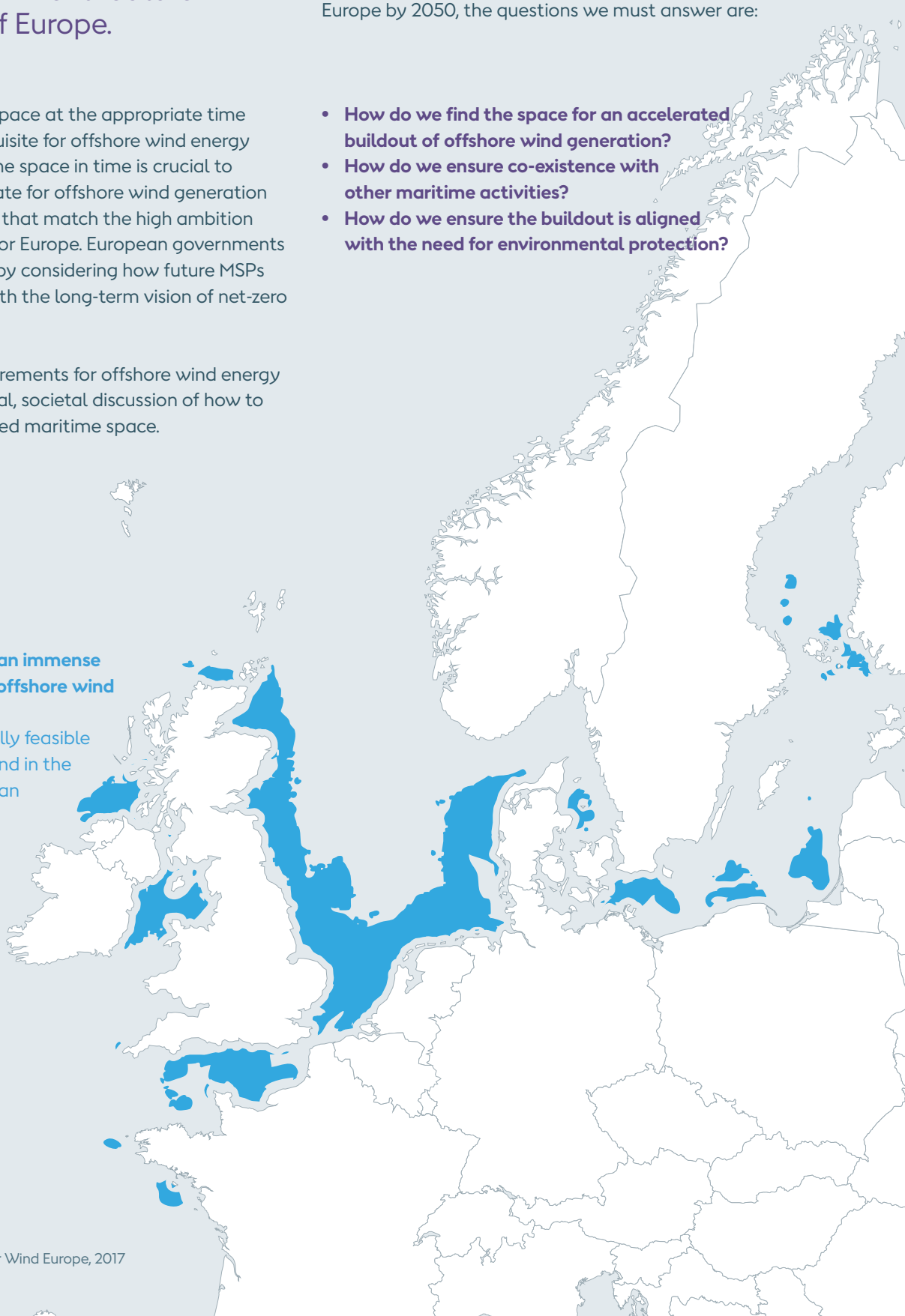
Offshore wind is becoming an increasingly prominent feature off the coasts of Europe.

Allocating appropriate space at the appropriate time is a fundamental prerequisite for offshore wind energy expansion. And finding the space in time is crucial to achieve an installation rate for offshore wind generation towards 2030 and 2050 that match the high ambition level of the Green Deal for Europe. European governments can help find this space by considering how future MSPs can be brought in line with the long-term vision of net-zero emissions by 2050.

The growing space requirements for offshore wind energy also raises a more general, societal discussion of how to best utilise Europe's limited maritime space.

Starting from the premise that we should reach 450GW of offshore wind generation to reach a climate neutral Europe by 2050, the questions we must answer are:

- **How do we find the space for an accelerated buildout of offshore wind generation?**
- **How do we ensure co-existence with other maritime activities?**
- **How do we ensure the buildout is aligned with the need for environmental protection?**



The northern seas hold an immense untapped potential for offshore wind

By 2030, the economically feasible potential for offshore wind in the northern seas is more than

600 GW[8]

8. BVG Associates for Wind Europe, 2017

How do we find the space for an accelerated buildout of offshore wind generation?

Sites or areas with limited existing uses of the sea or seabed are becoming increasingly scarce.

Eventually, there will be too few of these areas to sustain the continued expansion of offshore wind generation needed to decarbonise Europe.

Larger, more coherent areas are required and shared use of maritime space should be considered. Given the lead times from site acquisition to commissioning of offshore wind farms, which can last up to a decade, European governments' planning for 2030 and beyond should start now.

In 2021, European governments are obliged to submit their MSPs to the European Commission, detailing their intended use of their national waters. Spatial planning of sea use has been undertaken in many countries already and continues to develop. Nonetheless, these existing MSP processes are not entirely fit for purpose when considering Europe's energy needs as they do not consider the wider goal to create a net-zero emission economy by 2050.

Short term

Maritime spatial plans in line with decarbonisation target

To help stay on a trajectory capable of delivering a green deal for Europe, MSPs could include provision for an increasing amount of offshore wind generation. This would mean identifying space for a total of 130 GW of offshore wind by 2030 within the next two years. Upcoming plans should also have the need for future offshore wind energy expansion in mind.

National TSOs and energy authorities can facilitate this process by considering and providing a number of landing points in the onshore grid, allowing a future large-scale connection of offshore wind generation.

Long term

Plan with some wiggle-room

As with all long-term planning, even the best plans for an offshore wind buildout might change due to unforeseen factors. The future technological and economic development will almost certainly necessitate adjustments to today's energy planning. Hence, to help prepare for all eventualities, European governments might consider opting to designate a little more space than needed.

In the same way, European MSPs should also include provisions for future technological development which could provide opportunities for offshore wind farms in areas that have not historically been suitable. For example, new foundation types which would allow deeper waters to be developed could become cost competitive.

How do we ensure the buildout is aligned with the need for environmental protection?

Our natural environment is under threat from several factors, not least a changing climate. The North Sea and its various habitats and species are no exception.

One of the most important levers to protect biodiversity in the northern seas is to reduce carbon emissions and keep the temperature increase within 1.5°C. Offshore wind energy from northern seas will be an important part of Europe's decarbonisation.

Offshore wind farms can have localised positive impacts on biodiversity. For example, turbine foundations and underwater structures can create habitats for certain marine species, providing local increases in biodiversity. However, as with all large infrastructure projects, offshore wind generation comes with environmental considerations.

The installation of underwater structures can have effects on seabed habitats during the construction phase, for example. The industry is constantly seeking to improve its understanding of such potential environmental impacts as technology evolves, and how best to develop and apply appropriate mitigation measures.

The impacts of offshore wind farms on the natural environment are complex fields within marine science. It is recognised that there is limited long-term scientific data available on an international level on these impacts. Through an improved and collated evidence base, the future buildout of offshore wind can be facilitated through use of best available science.

Therefore we need to start systematically accumulating existing data and develop new and improved knowledge on the environmental effects of offshore wind farms. Better understanding of cumulative environmental impacts is a critical part of this need.

There is an important dialogue to be had amongst governments, industry and civil society on how to best balance offshore wind generation so that it can contribute to decarbonising Europe,mitigating the global risk of climate change – while ensuring important habitats and species are protected.

Short term

Establish shared platform for research

A shared platform should be established at a European level, to consolidate existing and bring forward further scientific research on the potential environmental impacts of offshore wind farms on the local environment. This programme should include representatives from academia, environmental NGOs, industry and authorities both on a national and regional/EU level.

Long term

Continue to explore how offshore wind farms can have a positive impact on the environment

Academia, NGOs and industry should continue working together to build on the shared knowledge platform.

Such platform should aim to understand and better manage the effects of installation and operation of offshore wind farms, to develop and implement methods of mitigation and to enable fully informed environmental impact assessments that are balanced with the impact of climate change.

How do we enable co-existence with other maritime activities?

Our European maritime space is used for many other offshore activities alongside offshore wind generation.

Such offshore activities include: oil and gas exploration, fisheries, submerged pipelines, transmission cables and ICT infrastructure, shipping lanes and subsea resource extraction, as well as recreational uses and defence.

Some of these uses are mutually exclusive. Others can be combined. And as offshore wind turbines grow larger and are spaced further apart, co-location will increasingly need to be considered to balance all interests.

One example of co-location is that offshore wind farms, if developed as hybrid solutions, could serve as both renewable energy sources and as a transmission link connecting two or more markets. Another example is air defence radars, that might be upgraded, relocated or reconfigured to provide the needed coverage, thus allowing for a coexistence between defence needs and energy generation.

Short term

Important dialogue on co-existence

To facilitate increased consideration of co-location, an inclusive dialogue should be established. Based on evidence and the experiences of the last decade, this dialogue should include all relevant European and international stakeholders. By facilitating discussions on how to expand offshore wind capacity to ensure decarbonisation of Europe and how to prioritise our sea use, this dialogue will be critical to reaching the high-level of political ambition to deliver net-zero emissions by 2050.

Alongside this international dialogue, individual government branches need to work together with all sectors at a national level to support the development of the solutions needed to enable Europe to reach this ambitious goal.

Long term

Develop, test and scale new means of co-existence

Having acknowledged the important value of all offshore economic activities, governments, offshore wind developers and other industries should continue their cooperation to enable and develop new options for co-existence.

Transporting the offshore wind energy to Europeans

Areas with a high resource potential for renewable energy, such as good wind and seabed conditions, are not distributed according to where the future consumption of electricity will be.

Trading electricity from the large production centres, e.g. the North Seas to the large consumption centres in central Europe will create socio economic value and lower electricity prices. This will require an increase of transmission capacity across Europe.

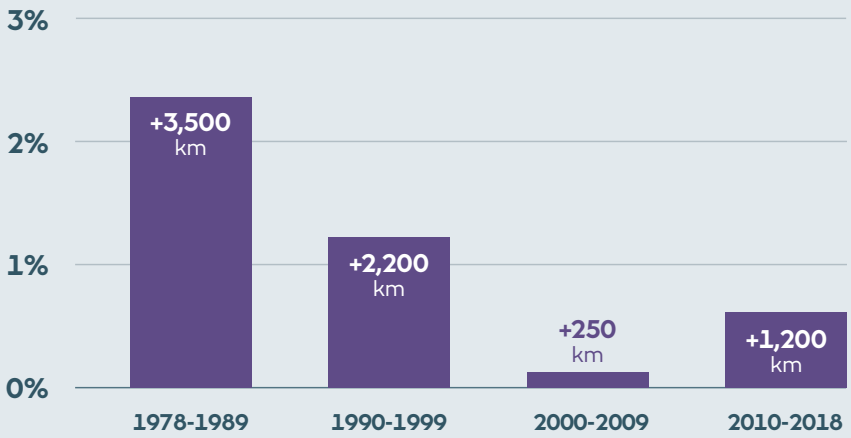
The existing transmission grid is not ready to seamlessly facilitate the trade of electricity across borders and to bring the power generated from 450GW of offshore wind capacity to European consumers and industry. Doing so will require new export cables to take the energy to shore, more interconnectors between markets and more onshore transmission within countries. But in recent decades, the expansion rate of the European power grid has almost ground to a halt.

New technologies, such as battery storage and automated demand-response, together with an optimised operation of the existing infrastructure, including the European gas grid, might reduce or postpone the need for this transmission buildout. But the potential of these options is not expected at the scale necessary to remove the need altogether.

To cost-efficiently transport the energy to European citizens and industries, it is important to plan the future offshore wind deployment in connection with the offshore and onshore grid buildout, in order to maximise potential synergies. In the political and planning process, three questions must be answered:

- **How do we ensure the adequate and timely buildout of transmission infrastructure?**
- **How do we coordinate the buildout of the offshore transmission grid?**
- **How do we allow for competition to reduce costs?**

Annual buildout of 220-400kV transmission
Percentage growth and km per year[9]



9. ENTSOE. Countries incl.: AT, BE, CH, DE, ES, FR, IT, LU, PT, DK, FI, IS, NO and SE

How can we ensure an adequate and timely buildout of transmission infrastructure?

Transmission projects are complicated to plan and execute. Even small expansions or reinforcements of the European transmission grid requires years of planning and dialogue with affected stakeholders, before consent is given and the lines are commissioned.

New lines are often planned according to where bottle necks between areas are observed. TSOs seeking to develop new gridlines are typically met with complex approval processes and outdated regulatory frameworks that do not cover new types of infrastructure. And regulations are put in place mainly to secure diligent spending and lowest cost to ratepayers, without considering the long-term need to decarbonise.

In addition, new transmission projects often meet local opposition. The need for transmission, particularly connecting different markets and creating a long-term value through trading between countries, is often poorly explained to those affected, which fuels resistance.

The result is an insufficient transmission buildout rate – meaning potentially higher electricity bills to European energy consumers and ultimately the risk that Europe will have to renege on its ambitions to decarbonise.

Therefore, we need to make it clear today which kind of transmission grid is needed by 2040 and 2050 – based not on observed congestions but on the expected volumes needed to electrify and decarbonise the European economy.

Short term

Agile approval processes and effective incentives

With lead times for transmission infrastructure upwards of 10 years, regulators, TSOs and the industry can already today start the dialogue on how to prepare for 130GW of offshore wind generation by 2030. This dialogue should encompass planning for both offshore and onshore infrastructure as well as the steps that can be taken to attract the private equity needed to expand the pan-European transmission network.

With regulators on how to create effective incentive mechanisms to unlock increased grid investments. This work should also make sure that Europe's ambition to fully decarbonisation by 2050 is reflected European policymakers can facilitate the infrastructure expansion by seeking to implement agile approval processes and solutions that are more acceptable to local communities. Policymakers can work in the future assessment criteria for infrastructure projects.

Finally, we need to initiate a broader societal dialogue on the changes brought by the energy transfor-mation. Here, policymakers play a special role in explaining the necessity for a new infrastructure on land.

Long term

Complete the Energy Union and establish a strong European 'backbone' grid

A truly integrated energy market will facilitate the transport of energy from offshore wind farms to the consumption centres in central Europe.

Towards 2050, the expansion of the European transmission grid should continue well in time to be able to bring 450GW of offshore wind energy to energy consumers in central Europe. This can be supported by regional buildout plans – including plans for energy hubs in the northern seas, where several windfarms are connected to a large platform, from which the energy can more efficiently be sent to shore, decreasing the need for landing points and offshore cables.

How do we optimise the value of the offshore transmission grid?

In most markets, offshore wind generation is expanded 'inside out', starting with smaller wind farms close to shore, then expanding outwards with larger wind farms built in deeper waters.

At the same time, interconnectors are built in parallel, but not always coordinated with the offshore wind projects.

This approach comes with the risk of too high investments, as the full capacity of export cables or interconnectors is rarely used. By combining offshore wind farms with interconnectors, making them in essence 'multilinked wind farms', there are very substantial synergies and cost savings.

Optimised planning of infrastructure will also decrease space needed for transmission – and avoid the so called 'spaghetti-problem', i.e. offshore transmission lines intersecting.

Instead of planning for one or perhaps a few offshore wind farms at a time, an accelerated buildout presents new opportunities and potential synergies. When designing and combining offshore transmission for several offshore wind farms and combining offshore wind projects with interconnectors between markets, great cost savings for society can be achieved.

Coordinated buildout reduces costs

To facilitate direct and indirect electrification of Europe, increasing power demand by as much as 150% by 2050, will require expanding European interconnector transmission capacity by a factor of 6 compared to today. This is the conclusion of a new study by Ea Energianalyse for Ørsted, focusing on the required infrastructure buildout towards 2050.[10]

Through combining wind farms and interconnectors, the need for stand-alone offshore interconnectors can be reduced by as much as 25%[11]. The study also finds that multilinked projects would enable even more offshore wind energy to be integrated into the European grid and would reduce the necessary transmission for every additional GW of offshore wind capacity by 6%.

Multilinked wind farms increase welfare

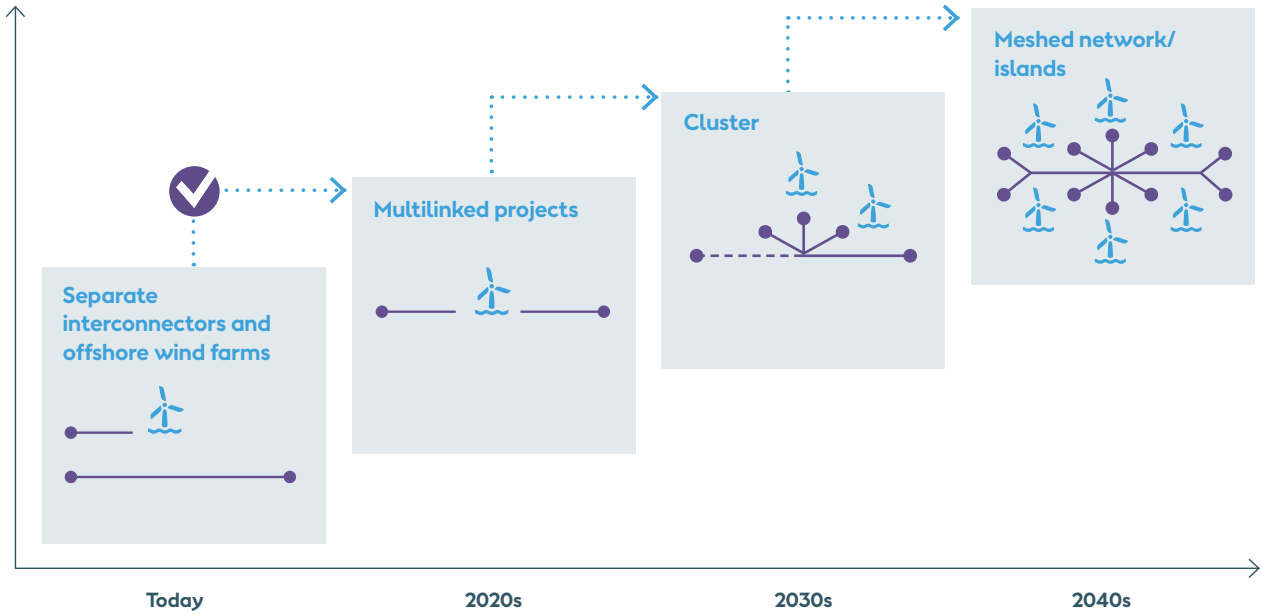
Historical approach: One offshore wind farm – one export cable. Interconnections between markets planned separately.

Multilinked approach: Offshore grid and wind farms planned and built together, combining export cables and interconnectors to multilinked offshore wind farms.

10. EA Energianalyse for Ørsted, 2019. Modelling based on European Commission 1.5TECH scenario
11. Measured as capacity times distance

Multilinked offshore wind farms is the first step towards more complex joint development of transmission and offshore wind energy

Complexity / scale (illustrative)



These cost-efficiencies can be even greater, if multilinked offshore wind farms are combined with optimised localisation of future power-to-X plants, as this leads to substantial system benefits and reduced transmission needs. Together, the required interconnector in 2050 can be reduced by 20%, compared to a scenario without multilinked wind farms and without redistribution of power-to-X products, the study suggests.

In other words: through means of building multilinked wind farms and power-to-X production, the interconnection requirement can be reduced by as much as the entire stock of current European interconnections. Such coordination sounds simple. But even today, planning and constructing offshore transmission lines takes years of analysis and consenting before construction even begins. Add to this several actors, potentially operating under different regulatory conditions, who must agree on both the technical specifications and timing of a project, and the simplicity is diminished.

The necessary coordination between national system operators and offshore wind developers can be realised through a step-wise approach. By gradually increasing complexity, actors can build on regulatory and technical learnings, thereby also allowing offshore transmission and interconnectedness to follow the buildout of offshore wind energy organically.

Short term

Tender five relevant multilinked offshore wind projects

In practice, such cooperation can start by member states bilaterally identifying at least five promising sites for multilinked projects, where offshore wind farms can be combined with interconnectors between markets, and where there is space to expand into larger clusters. These five projects could be built by offshore wind developers following a competitive auction.

Long term

Build on experience and increase complexity

Building on the learnings from the first multilinked projects, governments can begin to work towards more complex solutions. For instance, offshore wind energy clusters with shared transmission hubs, or even hubs situated on interconnectors. Eventually, this growing project and regulatory experience will allow for a more complex meshed network of hybrids, hubs and even islands to emerge during the late 2030s and 2040s.

How do we allow for synergies and competition to reduce costs?

For modern offshore wind energy, offshore substations and export cables typically make up some 20-25% of the total cost of energy today[12]. While a few European countries, such as the UK, include the offshore transmission in the scope of the offshore wind energy tender, most European countries, assign construction of the offshore connection cables to the national TSO.

Comparing, for instance, transmission of offshore wind projects in the UK and Germany suggests submitting the full scope of a project to competition is a more cost-effective way. A study by Ørsted has found assets built by private developers come at 28% lower costs – or about EUR 10 per MWh – compared to assets built by a TSO.[13] This is in large part due to synergies in planning and building the export cable and the offshore wind farm together.

Going forward, as offshore wind farms are built farther from shore, interconnectors and export cables based on High Voltage Direct Current (HVDC) technology will become increasingly common, and eventually the standard for offshore grids. This technology is not new in itself, but it is new to use it at such a large scale offshore, and in complex interconnected solutions.

Fortunately, the factors that made offshore wind generation cheaper than building new fossil power plants can also help reduce the cost of offshore HVDC technology: industrialisation, scale and competition.

If a clear pipeline of projects is established, it will allow the industry to invest in order to industrialise its supply chain. Combined with effective competition, this can squeeze out costs and ensure standardisation and constant technological improvement. Hence, European policymakers should strive to unlock competitive forces to ensure the continued development of new technology and drive the cost-out journey of existing and new offshore grid technology.

Short term

Subject the transmission of offshore wind projects to competition

Governments seeking to expand offshore wind generation should consider how best to apply competitive pressure to every aspect of future projects, including screening sites and constructing transmission assets.

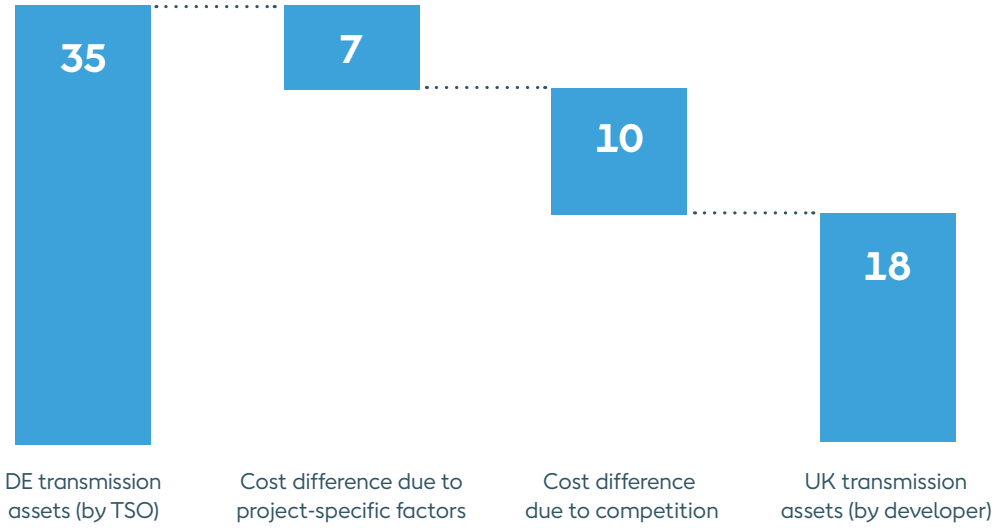
Long term

Allow private developers to screen for new projects

Eventually, a new regulatory model for offshore wind energy and transmission that ensures remuneration and allows private developers to propose and construct multilinked projects in their own right might be beneficial – The transmission assets would then be owned and/or operated by TSOs or third parties.

12. BNEF, 2019, Wind Turbine Contract Order Dataset
13. Based on analysis of offshore transmission assets for 11 German and 24 UK offshore wind projects. In the UK, offshore transmission is developer led, ensuring cost prudence, optimization and innovation.

Offshore transmission developed by TSO's mean competition driven cost reductions go untapped
EUR/ MWh



New trends in Europe's infrastructure buildout

Replacing the bulk of Europe's power generation from centralised production with solar and wind generation, whilst also replacing fossil fuels in transport, industry and heating through direct and indirect electrification, will require a lot of additional infrastructure. Not least to distribute the 450GW of offshore wind generation.

But not all new infrastructure will be 'more of the same'. Maturing technologies, such as HVDC and power-to-X can share the load with onshore transmission lines and change the face of the future infrastructure expansion.

To better understand the underlying dynamics and economics of the future infrastructure expansion, EA Energianalyse has on behalf of Ørsted conducted a study[14] of how best to increase transmission capacity. The study models a decarbonisation of Europe towards 2050, based on assumptions derived from the EC's 1.5 TECH-scenario.[15]

The study finds that combining the offshore wind generation with transmission is the most cost-efficient way to build offshore wind generation in the future. Such multilinked projects result in higher utilisation of the cables leading to a lower unit cost and fewer connection points to the onshore grid are needed. Furthermore, moving a larger share of the transmission offshore reduces demand for onshore infrastructure, leading to fewer communities being impacted by the buildout across Europe. In fact, the study's modelling results suggest that 'simple' offshore transmission lines are no longer the default option after 2030.

Combining offshore transmission with offshore wind generation and eventually developing these into offshore power hubs, will become a more cost-efficient option. This will especially be the case if HVDC follows the same cost-out trajectories as HVAC transmission. This is likely, as the supply chain ramps up and innovation helps reduce the weight of substations and converters.

Towards 2050, a large share of the increased power demand is expected to come from the growing power-to-X sector that will decarbonise large parts of the transport-sector and industry. With future cost reductions from scale, it will be cheaper to produce renewable hydrogen closer to the large wind resources in North west Europe and to then transport the product to the place of demand. This will further reduce the need for onshore transmission buildout as well as reduce the overall investments needed to decarbonise Europe.

14. EA Energianalyse on behalf of Ørsted, 2019
15. European Commission, 2018, COM(2018) 773 final

Enabling the industry to scale

Increasing the installed offshore wind generation capacity by a factor of 20 by 2050 – which is required to drive the electrification of hard-to-abate sectors and to continue the replacement of fossil fuels in Europe's power supply – is possible.

The European offshore wind industry currently installs approximately about 4GW per year. Towards 2030, with current buildout plans, the European supply chain capacity will have to double this to about 8GW per year.[16]

However, to stay on the right trajectory towards 2050, an even faster buildout rate is needed. From 2030 onwards, 20 GW or more will have to be installed each year.

Therefore, for the offshore wind industry to fully deliver on its own part of a Green Deal for Europe, the following questions will require answering:

- **What will it take to invest sufficiently in the industrial supply chain?**
- **How do we ensure that offshore wind energy supply can grow in parallel with increasing demand due to electrification?**
- **What should the governance look like?**

16. BNEF, 2019

What will it take to scale up the industrial supply chain?

For the offshore wind industry to continue its growth and deliver a quarter of Europe's power by 2050, significant investment into the industrial supply chain is required.

Until now, the European offshore wind supply chain has been able to scale consistently, with a compounded annual growth rate in annual additional capacity of 26% in the period 2000-2019[17]. To deliver 20GW per year from 2030 onwards, a growth rate of about 17% each year for the next decade is necessary.

However, as technology develops and offshore turbines grow larger, the number of blades, towers and foundations needed per GW will decrease, easing the ramp-up somewhat. It will be an impressive feat. But given timely and adequate investment, there will be few – if any – material bottlenecks during this expansion.

Such an industrial ramp-up has the potential to of revitalise coastal communities and stimulate industrial economic growth in regions throughout North west Europe, providing societies with tens of thousands of jobs for skilled workers.

Short term

High-level goals unlock investments in the supply chain

To maintain installation rates at the right trajectory towards 2030 and beyond, a significant proportion of this investment is needed at the earliest onset.

European governments and policymakers should seek to formulate ambitious political buildout commitments, as this is key to ensuring the necessary investments in the offshore wind supply chain.

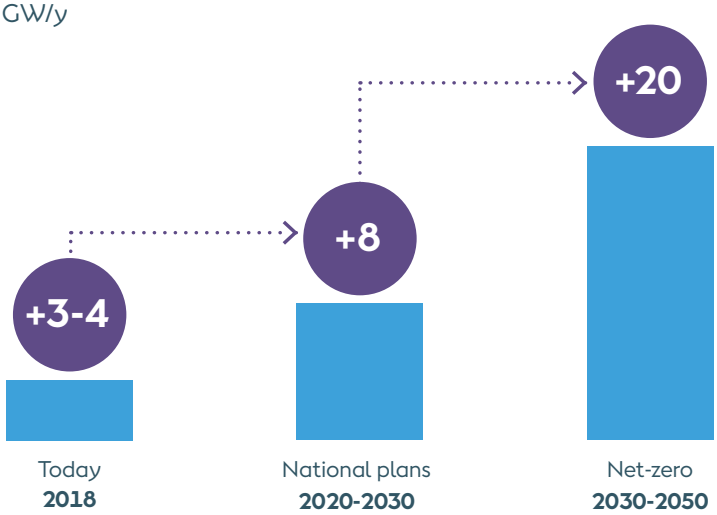
Long term

Fast-track multilinked projects

To kick-start the industrial learning with more complex, multilinked projects, European governments, together with relevant EU institutions, can work to fast-track a series of multilinked tenders towards 2030. In addition to being an efficient way of integrating markets and installing offshore wind generation, this would provide the industry with valuable practical regulatory experience with cross-national infrastructure as a step to more advanced, 'meshed' solutions in the future.

Offshore wind energy buildout rate needs to increase by 2030 to make net-zero possible by 2050

GW/y



17. BNEF, three-year averages 2000-2003 compared to 2017-2019

How do we make sure the energy demand is shifted towards green electricity and other renewable fuels?

While ramping up renewable energy generation is crucial, supplying the transmission infrastructure and shifting the demand to green power is equally important.

Shifting demand comes with a considerable lead-time. It could take up to a decade before either a push for electrification of transport or a conversion to electrofuels from power-to-X technologies significantly affect power demand.

To succeed in the green transformation, Europe should already today begin to promote electrification within transport, heating and industry, as well as power-to-X technologies, e.g. by promoting consumption of renewable hydrogen.

Short term

Grow the market for renewable hydrogen

In the short term, focus should be on creating and sustaining a market for renewable hydrogen and other power-to-X technologies, to incentivise private investment in the development of commercial scale plants. This could be done in dialogue with key offtaking industries as well as through research and development projects.

Many potential offtakers of renewable hydrogen are exposed to global competition. The decarbonisation of these sectors will therefore have to be carefully designed to drive the transformation without pushing the economic activity out of Europe.

Long term

Lock in electrification and power-to-X growth trajectories in line with 2050 targets

Towards 2030, policymakers and all industrial sectors should continue the ongoing dialogue on how best to ensure direct and indirect electrification to ensure development and deployment of new technologies at scale, thereby bringing down costs. It is also important to establish an electrification trajectory to underpin the long-term goal of decarbonising Europe.

Power to X

Direct electrification is the most cost-efficient way of replacing fossil fuels with renewable energy in many applications. But in some cases within industrial production and transport, replacing fossil fuels by direct electrification is unviable.

For instance, heavy transport requires high-energy density from the energy carrier and is therefore often dependent on oil-derived fuels. And certain industrial processes require hydrogen as a reactant which today is typically derived from natural gas steam reforming, emitting CO_2 as a by-product. However, by using renewable electricity to produce hydrogen or alternative, hydrogen-based fuels, these uses can be 'indirectly electrified'.

This is done with a set of technologies collectively termed 'power-to-X'.

Renewable electricity can be used to split water molecules to obtain hydrogen in a process called electrolysis. This renewable hydrogen can then be used to power hydrogen fuel cell applications, for instance in the transport sector, where hydrogen can be tanked and carried. In the future, synthetic fuels made with renewable hydrogen might also play an important role in replacing current fossil jet fuels in the aviation sector.

Indirect electrification of other sectors requires a lot of power and interconnection. However, by optimising the location of power-to-X-plants, the needed energy infrastructure and grid buildout is reduced significantly. By moving a share of Europe's electricity consumption closer to the renewable wind resources power-to-X can alleviate around 20% of the additional interconnection otherwise needed to decarbonise Europe by 2050.

What should the governance look like?

Offshore wind energy has until now mainly been handled within the realm of national energy and climate policy, on a project specific basis.

Energy policies have called for a specific buildout volume, with energy authorities defining how and where to integrate the generation into the electricity grid. Other political branches – business, defence, environment and maritime – mainly come into play when reacting to offshore wind energy plans.

This project-specific, national approach has been suitable so far. It has allowed the industry to scale and costs to be brought down. However, as shown in this paper, the current approach limits synergies and results in a sub-optimal buildout of offshore wind.

Short term

High-level buildout commitments and cooperation

European governments can help by acknowledging decarbonisation – and by implication offshore wind energy – as a necessity, for which all relevant agencies should plan.

Such high-level commitment to offshore wind energy buildout facilitates dialogue between all relevant branches of government and helps aligning procedures to policy objectives. This can create an incentive to identify and remove regulatory barriers, which could ease permitting of both offshore wind projects and transmission infrastructure, help pragmatically identify and prioritise sea uses and help seek and develop solutions for co-existence.

Between governments, bi- and multilateral dialogue could also be strengthened. Offshore wind resources do not adhere to national borders, and the countries with the larger resource potential are not necessarily the ones with the largest consumption.

Long term

Establish principles of a multigovernmental approach to the buildout

Working together and across borders will be crucial in the long run, in order to enable the cost-efficient utilisation of Europe's vast offshore wind resources. Eventually, a common regulation for the European seas could be tabled to facilitate this cooperation even further.

Beyond 2030, the offshore wind energy buildout will to an increasing extent span across borders. European governments and the EU can already start to consider how multigovernmental principles might be formulated, to allow the optimal utilisation of offshore wind resources that are situated across borders relative to demand. In practice, this involves considering: how to ensure that the best sites for offshore wind energy are always used first, regardless of their jurisdiction.

Benefits of delivering a Green Deal for Europe

Making Europe the world's first climate-neutral continent by 2050 is key to delivering on our commitments under the Paris Agreement and to limit the global temperature increase to 1.5°C.

The prospects of unchecked climate change, with the environmental and societal disruption that will undoubtedly follow, are by themselves good reasons to seek ambitious mitigating climate action, nationally as well as globally.

But Europe's green transformation also holds promises of a better, healthier and more prosperous life for Europeans. If done right, the green transformation offers several concrete benefits to our society.

Wind energy generation offshore is already a mature technology, ready to transform our seas into green power plants and to supply a quarter of Europe's energy supply in 2050. For offshore wind energy to fully play its part in delivering a Green Deal for Europe, the buildout should be significantly accelerated.

To help phase out fossil fuels in the power sector and deliver the power required to electrify and decarbonise the rest of the economy, offshore wind energy deployment must increase over the coming decade and maintain a rate equal to adding 20GW of offshore wind capacity per year from 2030 onwards.

We remain optimistic regarding in the industry's ability to continuously scale and meet the growing demand.

But to fully unlock the enormous potential of offshore wind energy, Europe should develop a new 'Green Deal' approach to how the buildout is managed – and this can be done by answering three broad questions:

1. **How do we find the space for 450GW of offshore wind generation?**
2. **How can we transport offshore wind energy to Europeans?**
3. **How do we enable the industry to scale?**

At Ørsted, we believe offshore wind energy will play a central part in the decarbonisation of Europe – and eventually in creating a world that runs entirely on green energy. With this paper, we have outlined where we believe we should look for the answers to these questions.

We look forward to continuing the dialogue with all relevant actors on how to shape Europe's common energy future.

Saving up to 200,000 lives each year due to cleaner air

Each year, almost half a million Europeans die prematurely from air pollution, caused by burning fossil fuels, agriculture, industrial processes and waste, according to the EC.

On top of existing measures, a net-zero emissions economy is estimated to reduce pre-mature deaths caused by fine particulate matter by more than 40% – saving up to 200,000 lives – and reducing health damage by around EUR 200bn each year.[18]

Sustainable growth and green jobs

Today, the renewable energy industry employs about 1.2 million Europeans directly, with a further 2.8 million working in other 'green jobs', e.g. resource efficiency, pollution reductions and recycling.

Over the next three decades, an additional EUR 175-290bn of investments into the energy and transport system will be needed each year to reach a net-zero emissions economy.

By 2050, IRENA estimates a green transformation can increase European GDP by 1-2% compared to a reference case, with new employment associated with the transition significantly outweighing the jobs lost in the fossil fuel sector.[19]

Freeing EUR 2-3 trillion from reduced imports of fossil fuels

Today, most of Europe's energy demand is met using imported fossil fuels, costing the economy more than EUR 250bn each year and making the continent vulnerable to geostrategic shocks in its supply.

In addition to making the European energy supply more resilient, replacing imported fossil fuels with indigenous green energy sources is estimated to free up EUR 2-3 trillion in the period 2030-2050, which can instead be invested into modernising Europe's economy.[20]

18. European Commission, 2018, COM(2018) 773 final
19. IRENA 2019a, IRENA 2019b
20. European Commission, 2018, COM(2018) 773 final

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About Ørsted

Ørsted is a global green energy company headquartered in Denmark with the vision of a world that runs entirely on green energy. Ørsted is the global market leader in offshore wind power and offers large-scale and cost-competitive offshore wind energy, onshore wind energy, and solar energy that reduce emissions, improve air quality, and provide local jobs.

Ørsted also operates sustainable bioenergy plants, offers green power purchase agreements, and explores renewable hydrogen and battery solutions. Ørsted has reduced its greenhouse gas emissions by 83% since 2006 and will be essentially carbon neutral by 2025.

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Get in touch

Get in touch if you have any questions or enquiries about the content of this paper.

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