Let's open the path to progress

Shaping Europe's offshore wind industry to a new energy reality

Ørsted

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Our industry is facing a complex interplay of new factors which, while individually manageable, collectively form a maze of risk and complexity, we're now learning to navigate

A moment of truth for European offshore wind

The last 18 months ought to have been a defining moment for offshore wind. Russia's invasion of Ukraine caused energy prices to skyrocket and energy security to come to the forefront of government agendas once again across the world. This new crisis, when combined with the increasing urgency of addressing climate change, crystallised offshore wind in the minds of European governments as the ideal nexus for addressing energy security, climate change, and energy costs – with industrial strategy and job creation as an additional bonus.

European cumulative targets for offshore wind to be installed by 2030 have more than doubled since September 2021, from 58GW to close to 150GW. Looking further ahead, policymakers in Europe have acknowledged offshore wind as a key solution to reaching net-zero emissions – as is also shown by several studies assessing the need to deliver 400-450GW by 2050. Combined, these targets should offer an unprecedented investment opportunity for businesses such as Ørsted who have long championed the value of offshore wind.

Yet, notwithstanding this political momentum, 2022 saw a historic lull in wind energy investments in Europe – not a single utility-scale offshore wind project took a final investment decision in that period, or in this first quarter of 2023. The key to these two apparently irreconcilable facts is that offshore wind is a long-cycle business – capital investments by the supply chain and bids made by offshore wind developers must be made several years before steel can hit the water. And today, our industry is facing a complex interplay of new factors which, while individually manageable, collectively form a maze of risk and complexity, we're now learning to navigate.

CAPEX inflation, rising interest rates, and supply chain bottlenecks driven by underinvestment from the supply chain have hit the industry hard. Projects for which the prices were fixed well before the current crisis have become financially fragile. Policy discussions about energy market fundamentals have further added regulatory uncertainty to the mix.

Meanwhile, long permitting times for both generation and transmission projects continue to challenge the industry. Approaches of government, and particularly their treasuries, to cash in on offshore wind as a source of short-term revenue rather than the best option available to rapidly reduce energy prices, and carbon intensity, for consumers and industry, has further catalysed the challenges. Tender pipelines and offshore lease auctions are being meticulously designed to maximise up-front revenue from projects.

Offshore wind is not an opportunity for cash-strapped governments to maximise the cash return on seabed with otherwise limited monetary value. Its benefits stem first and foremost from its clean, cheap, and abundant energy supply and the speed at which, under the right regulatory conditions, it can be deployed. A value further augmented by its generation of economic activity and job creation, and its ability to unlock Europe's renewable hydrogen ambitions. There is certainly a role for the financial benefits of offshore wind to be shared with society – but the current approach has led to a counterproductive race to the bottom on price, challenging supply chains, and limiting necessary investments for solving other important societal challenges, including biodiversity protection, and decarbonisation of the supply chains of offshore wind.

With this paper, we outline a path to progress for Europe. We show how offshore wind can help power Europe's electrification and future renewable hydrogen production. We argue that bringing very large volumes of offshore wind projects to the market, by pooling and front-loading tenders, reduces uncertainty and induces much needed supply chain-investment. We propose a new and complementary 'demand-driven' track to run in parallel with a state tender pipeline, which can unlock additional capacity. We demonstrate how co-locating hydrogen and e-fuel production with offshore wind, can contribute significantly to the security of supply and reduce the costs of both electrons and molecules. Furthermore, we call for an updated and less risk-averse approach to investments in the transmission system, in anticipation of a pathway to net-zero emissions by 2050. All the above will require corporation by all stakeholders and bold, new policymaking. And it builds on a prerequisite that we together find ways to realise current projects that are locked in with inflated costs, and that we can support supply chains out of their immediate distress.

In these times of uncertainty, it's hard to be definitive – and this paper seeks to open the discussion, not to provide the only answer. I can be sure of one thing, however – that we will not achieve any viable pathway to net-zero emissions if Europe continues to follow its current approach. "Business as usual" for Europe is no longer an option – Let's open the path to progress and build green energy right, now.

Mads Nipper
CEO, Ørsted

Executive summary

Europe's commitment to reach net zero by 2050 is as firm as ever. On top of decarbonisation, reaching this target will unlock the additional benefits, reduction in cost of electricity and reduced dependence on external sources of power – and governments, policy makers, and industry are working to deliver. But what does this entail?

By 2050, electricity generation will have to double.

Today, there is 225GW of onshore wind in Europe, mostly developed and installed over the past 25 years. Over the next 25 years, it must more than double. It's a similar story for solar PV – but this must quadruple, in the same time frame. For offshore wind, which has installed 30GW over the past 20 years, it must increase almost fifteen times to 400-450GW – an increase in annual buildout from 7GW in 2025 to 20GW by 2030.

To enable this exponential growth in renewable power generation to be efficiently absorbed into the system and used where it's needed the most, the European electricity transmission grid must similarly grow – and expand into pipelines for the transmission of renewable molecules. Electrolyser capacity to produce renewable hydrogen and e-fuels must grow from less than 500MW installed in Europe today to targets of 60GW by 2030 and 270GW by 2050[1]. And perhaps most importantly, industrial demand for direct and indirect electrification must mature in lock-step.

Wind industry and supply chains are challenged. While renewable energy remains a competitive, rapid-to-deploy, and secure solution to Europe's energy needs, the complex interplay of rising inflation, increasing costs of capital and input, and supply chain and labour challenges have impacted the renewable energy industry just as all other industries.

On current investment trends, the supply chain needed to sustain buildout rates of 20GW offshore wind per year cannot and will not materialise. The complexity of this is magnified for offshore wind by its long development cycles and multi-year execution build out. Strong investment signals are required for developers and the supply chain to unlock the growth and speed of deployment needed. Several projects under development that are locked in with post-inflation government contracts are under water, struggling to become investible with severely inflated costs.

Let's open the path to progress

Notwithstanding these growing pains, Europe is uniquely placed to take back control of its energy destiny. Its enormous but largely untapped energy potential from wind, its world-leading renewables industry, well-managed transmission system, sophisticated labour market, and efficient and advanced economy ensures that Europe has everything it needs to deliver fossil-free energy independence. The barriers to Europe's accelerated green transformation were built block by block, over time, and with good intentions, by policy makers within and across Europe. This pivotal moment, when Europe is already taking bold actions to address its decarbonisation needs, is the perfect opportunity to take the necessary bold and affirmative action to reduce complexity and drive the scale and speed of build out at the lowest possible cost. Specifically, policymakers can:

1 Bring volume to the market

Unlocking market volumes and creating an enabling environment for offshore wind development can build confidence, help the industry overcome its investment impasse, and enable the supply chain to invest in necessary manufacturing capacity. We believe some ways of doing so can be to:

- **Frontload as much volume as possible in state tenders**
  Only once the increased policy capacity targets are allocated via site exclusivity to individual developers can the industry start investing. Governments can speed up this process by tendering out as much of the decided capacity as possible, as soon as possible, and by allowing 'overplanting' within the site, giving developers the flexibility to design and size projects optimally.

- **Require high holistic standards from developers**
  The net benefits of large-scale offshore wind to the economy, climate, and environment mustn't blind public, or private, across to possible unintended impacts of the buildout.

  To be truly sustainable, the next phase of the green transformation must happen holistically with the needs of nature, energy system integration, and local communities. Not only the centralised tender frameworks but also the parallel demand-led track which we propose should require and incentivise developers to demonstrate non-price value creation.

1. Bloomberg NEF 2023, and ENTSO-E TYNDP 2022, Net-zero scenarios, EU only.

- **Balance risks and opportunities between public and private actors**
  When allocating site and project exclusivity solely on grounds of an up-front, price-only auction, all project and price risks are placed on the developer and the industry is locked in a counterproductive race to the bottom. If payment schemes are based on principles of long-term risk and revenue sharing instead, the risks and rewards are more equally shared between the developer and society. This reduces the long-term costs to society which helps keep power prices low and gives public actors more oversight over the long-term financial health of the project, creating broader societal value.

- **Build a bridge for existing projects**
  Across Europe, developers of projects which were awarded, and whose power prices were tied to CfDs or similar power purchasing agreements before the current cost crisis now face difficulties. Governments and industry must seek out ways to overcome recent cost inflation and solutions that can help existing development projects move forward to final investment decision (FID) and commissioning.

2 Allow for a demand-driven buildout trak to complement tenders

Growing demand for bulk power for industrial use, whether direct electrification or indirect via hydrogen production, offers a great opportunity for deploying multi-GW scale offshore wind directly connected to industrial off-takers – for instance, producers of renewable hydrogen or e-fuels, unlocking market-driven buildout. This can ensure a supplementary offshore wind build out without the need for transmission infrastructure, introduce significant grid stabilisation value, reduce costs, and risks for taxpayers, and avoid complex and time-consuming tender processes. Such a scheme would include:

- **Access to seabed outside zones reserved for centralised tenders;** this could be allocated in a first-come-first-served scheme, on a use-it-or-loose-it principle, awarded to developers that can demonstrate a strong path to co-located industrial offtake.

- **Projects developed and financed on merchant terms,** and directly connected to offtake, thus minimising burden on the onshore transmission grid and planning. This could also be in the shape of cross-border projects, e.g. connecting offshore wind in one country's sea territory directly to demand in a neighbouring country – subject to relevant lease payments and/or revenue sharing with the host state.

- **Importantly, require the same environmental criteria** for demand-driven buildout as for projects awarded through centralised tenders.

3 Get the infrastructure right

Meeting future demand for direct and indirect renewable electrification will require more than two times the electricity we use today. This calls for an immense expansion of the European transmission grid both onshore and offshore and also requires establishing a European hydrogen backbone. To achieve this in the most cost- and time-efficient way, Europe must commit to enabling investment in future grid systems and start building tomorrow's grid today. The risk averse, incremental "business as usual" grid expansion approach that has served the continent well until this decade is no longer fit for purpose. This transformational approach to transmission entails:

- **Require future-proof investments,** by incentivising Transmission System Operators (TSOs) to plan and invest in accordance with Europe's long-term decarbonisation targets, factoring in future demand requirements when evaluating transmission projects. This entails the TSOs (and by extension, society) accepting some risk that this demand does not materialise within the expected timeframe, but in the context of the very significant cost and risk of delayed transmission and generation buildout.

- **Incentivise co-location of production, storage, and consumption,** through targeted design of grid-tariffs and flexibility and capacity services that reflects real costs and values to the system. Europe's future production of hydrogen and e-fuels can have substantial positive effects on the resilience and efficiency of the energy system. If hydrogen production is located close to the renewable power production, the design of the electricity grid can be complemented by the European hydrogen backbone, as it's comparatively much cheaper to transport molecules than electrons.

- **Drive very large-scale offshore wind power pan-market clusters** by allowing TSOs and offshore wind developers to work out a better way to share costs and revenue. For instance, by implementing the European Commission's proposal for so-called Transmission Access Guarantees.

What's to gain?

- EUR +6bn per year societal cost savings by 2050 from co-locating hydrogen production near the North Sea[2]
- EUR 5bn per year cost savings by 2050 from establishing offshore wind as hybrids and hubs compared to radial connections
- A demand-driven fast track for 40-60GW offshore wind and large scale, co-located offtake, e.g. electrolysers[3]
- Approx. 40,000 jobs that can be attributed to the economic activity from additional demand-driven projects[4]

2. THEMA for Ørsted, 2021
3. Ørsted high-level assessment from sea space available post 2030 and deducting for constraints and three quarters for state tenders.
4. Based on KPMG for Ørsted and CIP, 2023.

Introduction
A renewed European policy momentum for offshore wind and power-to-X

Many important policy initiatives have been introduced following the unprecedented political momentum to replace fossil fuels with renewable electricity and hydrogen.

Governments are addressing long permitting times. Renewable infrastructure has been designated as of overriding public interest. The EU Commission has taken steps to make state aid guidelines more flexible. And both funding and a significant demand side pull is being mobilised to support and accelerate uptake of renewable energy and hydrogen, recently with the agreed Renewable Energy Directive III and the EU Commission's proposal for a Green Deal Industrial Plan and Net-Zero Industry Act.

Europe has an immense and readily available potential for renewable energy; both onshore and offshore. It can leverage its existing world leading renewable energy industry and its robust and well-managed infrastructure. And power-to-X projects are being explored and announced throughout the European continent to enable the deep decarbonisation of Europe's economy and underpin its future fossil independence.

Amidst increased complexity and risk
Nevertheless, project pipelines are still not reflecting updated policy targets. Lots of projects are being proposed, and more offshore wind capacity planned to be tendered out. But the increased ambitions have not led to firm investment decisions.

For instance, in 2022 not one single large-scale offshore wind project reached a final investment decision – and there is only 500MW of electrolyser capacity FID'd across all of Europe.

The reason, in part, is the complex interplay of challenges presented by rising costs of materials, energy, labour, and capital, and global competition. This adds to the fiscal and regulatory uncertainty, stemming from both short-term measures and proposed market reforms, all of which challenge offshore wind developers and the industry at large.

However, another cause for the shortfall is a disparity between the regulatory approach taken by some governments and a quickly evolving technological and industrial reality. Offshore wind and infrastructure regulation has been designed to minimise unintended effects and get every detail of a given tender or allocation exactly right – recently with a focus on increasing the upfront fiscal revenue to governments. With the growing complexity, uncertainty, and risk presented by ever larger and more integrated projects, this approach is becoming a bottleneck. Decisions are delayed. Buildout is held back. But there is a way forward.

A path to progress for Europe
Now is the time for Europe to invest heavily in its green industrial base, to both speed up the green transformation, secure a strategic production capacity for both the resources and technologies needed in the future – and to manifest its global leadership position in green energy solutions.

Overcoming the impasse will require bold and affirmative policy action. It will mean compromising with the ambition to perfectly plan all elements of the transformation in detail. It will mean taking risks with expectations of future societal benefits. And it will mean assigning new roles and expanding responsibilities for market players, to help efficiently identity new opportunities and realise projects and synergies.

Accelerating the green energy transition of Europe is a no-regret strategy. The future energy system will be based primarily on wind and solar, combined with large scale electrification and power-to-X. But by enabling the transition, Europe can simultaneously overcome its fossil dependence, show climate leadership, and secure a competitive and green industry.

The role of renewable hydrogen and e-fuels

Renewable hydrogen and power-to-X are a crucial enabler for the decarbonization of sectors that cannot feasibly be directly electrified. This includes a range of industrial and chemical processes, and heavy transportation such as deep-sea shipping and aviation.

Leading up to the current energy crisis, European industry consumed approx. 10 Mt hydrogen per year, mainly at refineries and for ammonia production – which requires some 54 bcm natural gas. Going forward, this demand must be displaced by renewable hydrogen. Furthermore, much more renewable hydrogen is needed to meet future demand for indirect electrification and e-fuel production. In short, neither Europe, nor the world, will meet its decarbonisation targets without renewable hydrogen and power-to-X.

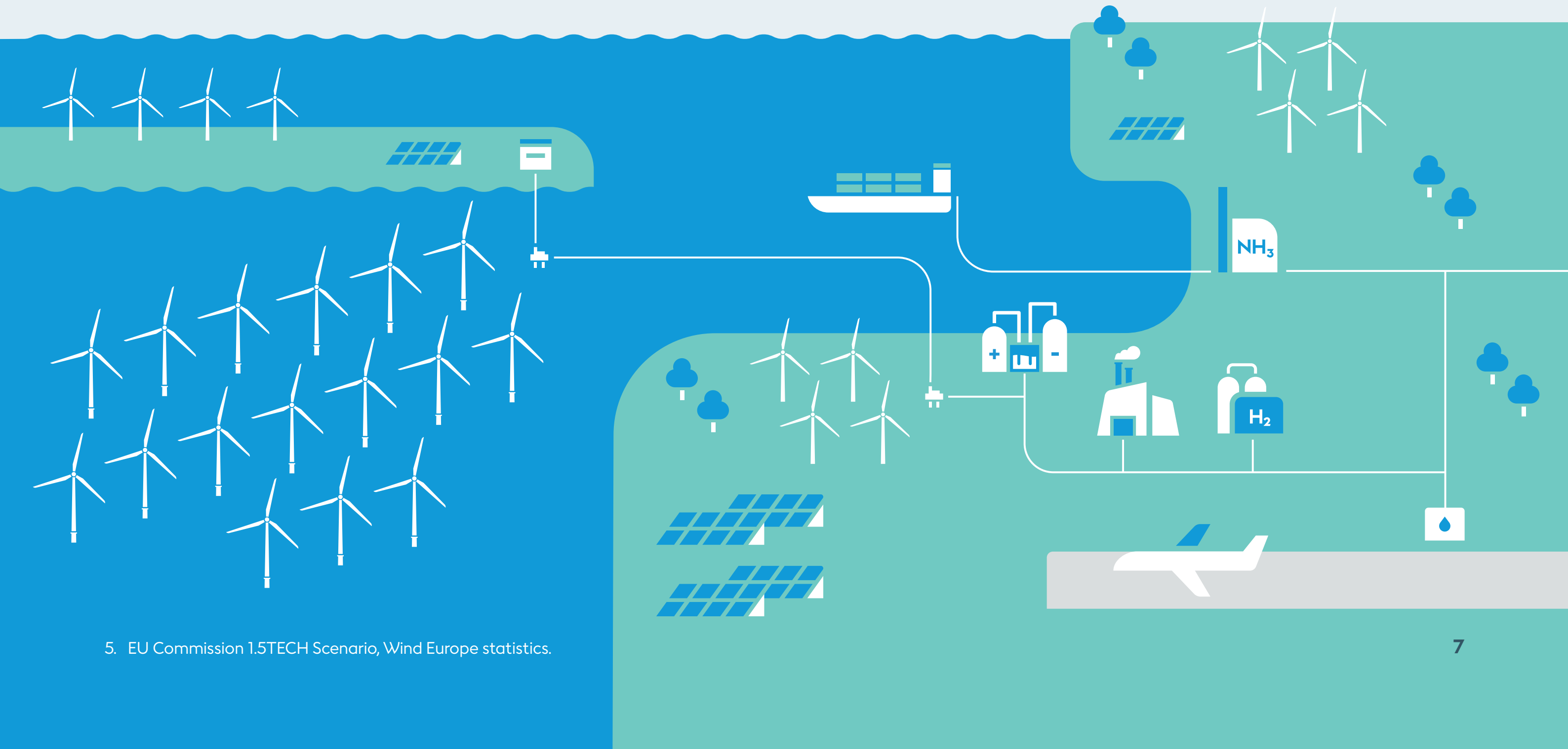
The rapid cost decline and scale-up of renewable energy technology, namely onshore and offshore wind, together with solar PV, have proven a key enabler to the production of renewable hydrogen. However, as large-scale electrolysis is undergoing rapid development, the growth of renewable hydrogen demand can also become an important enabler for further wind and solar buildout.

As electrolysis is likely to take up a significant share of future power production in Europe, as power prices constitutes a large share of the cost of renewable hydrogen – and as it's both faster and significantly cheaper to deploy hydrogen pipelines and storage infrastructure, compared to electric transmission lines, co-locating hydrogen production with bulk renewable generation holds an immense potential for cost-optimised systems integration.

The role of onshore wind, solar, and other greeen energy technologies

Offshore wind and renewable power-to-X are the focus of this paper. Together, they are the two sectors with the steepest growth trajectories, by a factor of 15 and a factor of more than 100 towards 2050, respectively[5], for Europe to become climate neutral.

However, a lot of the principles and solutions proposed here can be applied on land. To reach its 2050 targets, Europe must increase onshore wind and solar PV capacity by factors approx. 2 and 4, respectively. Just as with offshore wind and power-to-X, this will require an anticipatory approach to transmission and distribution grid investments, incentives to co-locate generation and consumption – and a targeted and ambitious industrial policy to sustain and support European industries' ability to deliver.



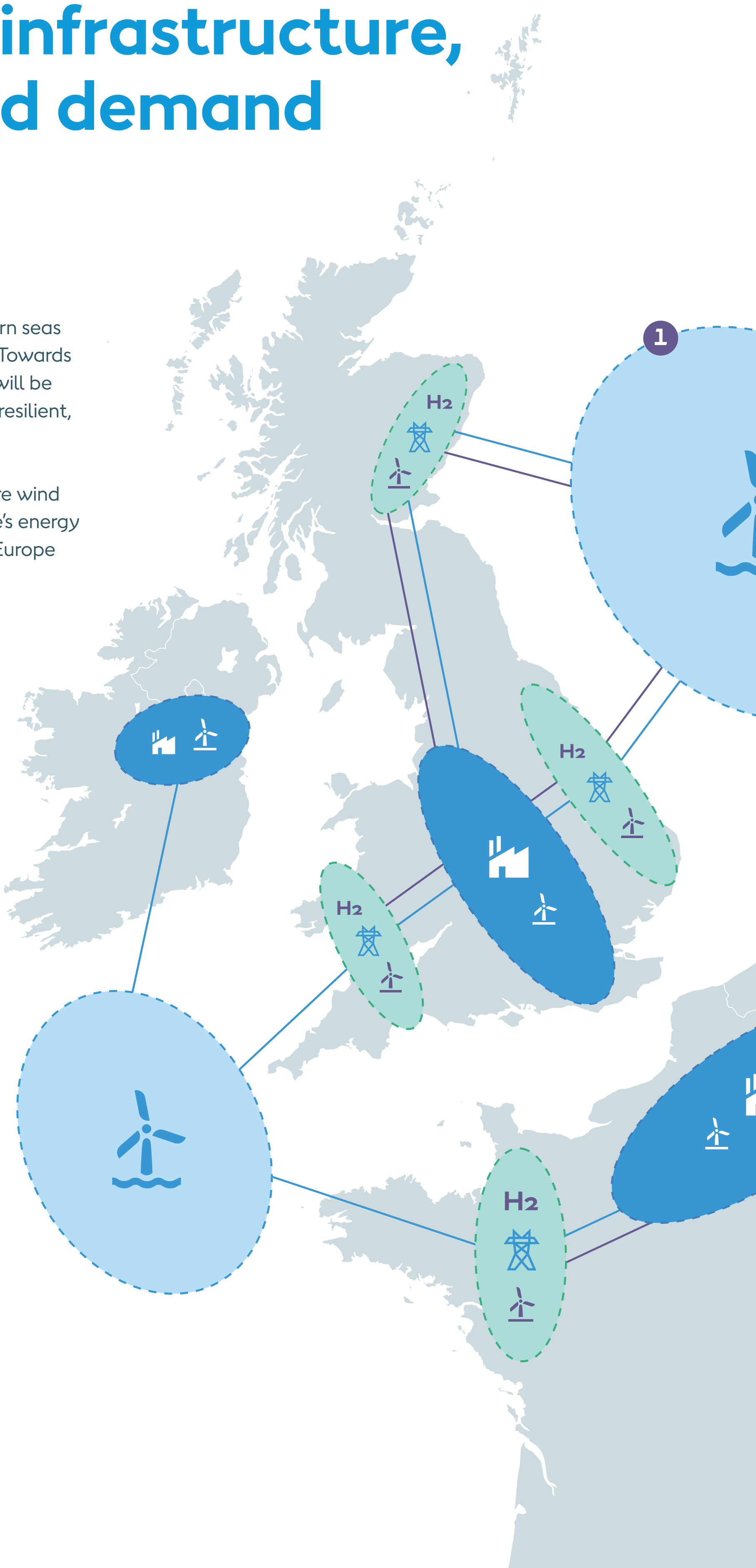
5. EU Commission 1.5TECH Scenario, Wind Europe statistics.

Connect the dots with volume and flexibility to offshore wind, infrastructure, integration, and demand

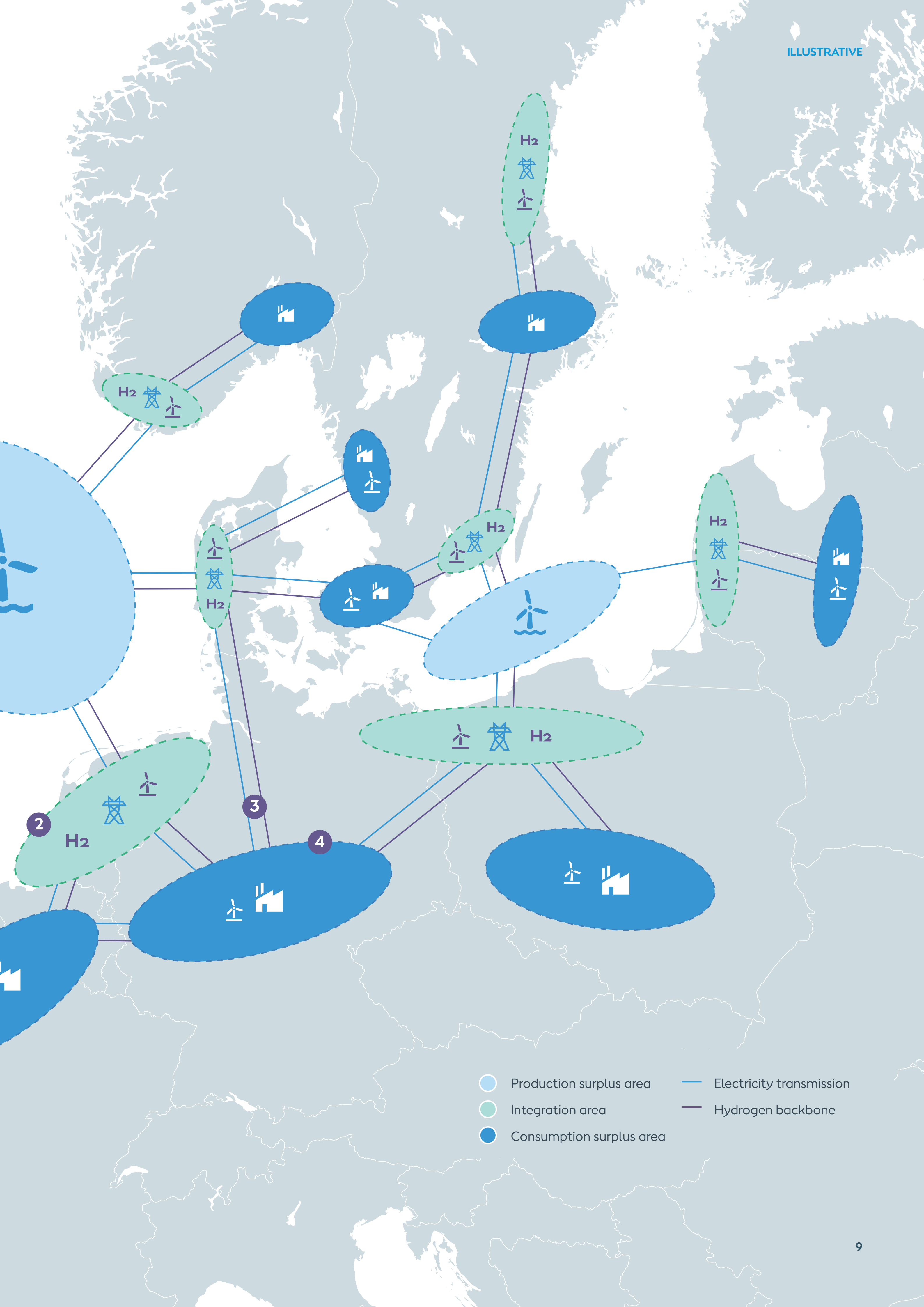
The steady and strong winds blowing over the northern seas of Europe hold immense renewable energy potential. Towards 2050, as much as 380GW[6] of offshore wind capacity will be tapping into this natural energy resource, as part of a resilient, decarbonised, and cost-effective energy system.

Offshore wind power, together with additional onshore wind and solar generation, will be transformative to Europe's energy system. Unlocking this clean energy future hinges on Europe solving four fundamental and long-term challenges:

1. Bring volume to market, as part of large, centralised tenders that emphasise broad societal value creation and value chain growth, or through a complementary demand-driven track.
2. Incentivise co-location of supply and demand to introduce flexibility and reduce investment needs in onshore power transmission, e.g., placing hydrogen and e-fuel production close to where offshore wind power makes landfall.
3. Scale Europe's transmission grid to accomodate direct and indirect electrification, by demanding future-proof grid investment plans, in line with Europe's 2030 and 2050 targets and enabling offshore hybrid connections.
4. Create the necessary demand-pull to drive investments, scale, and cost-out in hydrogen and e-fuel production.



6. Wind Europe 2019: Our energy, Our Future.


ILLUSTRATIVE
H2
H2
H2
H2
H2
H2
H2
2
3
4
Production surplus area
Integration area
Consumption surplus area
Electricity transmission
Hydrogen backbone

Chapter 1
Bring volume to the market

National targets, together with the Esbjerg, Marienborg and recently the Oostende declarations, point to a future offshore wind buildout in overdrive. Realising these ambitious volumes in time will require an equally ambitious implementation plan.

Today, European governments have a cumulative target of close to 150GW[7] offshore wind by 2030, and to meet climate targets close to 450GW is needed by 2050. This compares to 20GW installed today, meaning that within the next 7 years, Europe will have to add four times the capacity it has so far taken more than 20 years to build. And towards 2050, almost 20GW offshore wind will have to be deployed each year.

By increasing its renewables targets, European governments have taken decisive first steps to supercharge the European wind energy industry. The next crucial step is to make offshore wind capacity available to the market and allocate a firm pipeline of projects. This will allow developers to start developing projects and placing orders in the supply chain, which can in turn start to plan and finance their scale-up. The window to allow all this to happen to meet our 2030 targets is closing rapidly.

Frontload as much volume as possible in state tenders

Already this year and next will see a significant increase in tendered offshore wind capacity, as governments meter out a large share of its designated sea space. For instance, in 2023 and 2024 governments plan to tender out approximately, 17GW in Germany, 4GW the Netherlands, 4GW in the UK, 3GW in France, 9GW in Denmark and 3GW in Norway [8].

These volumes represent a historic step-up in tenders and help send a clear market signal. It's a firm step along the right path. Even so, there's still a tendency for some countries to subdivide and award development rights in tranches that are tendered out on a year-by-year basis, like pearls on a string. This approach is well suited to a 'steady state' buildout where all investments have been made in supply chain manufacturing capacity and incremental growth. But it is not suited for the speed, coordination, and innovation needed to reach Europe's ambitious buildout targets. Instead, governments can help reduce supply chain uncertainty by 'frontloading' the tenders and allocating as much capacity as possible within the next two years. This will allow developers to start contracting with suppliers, filling order books, and thereby allowing for planning and investment in the supply chain.

Importantly, frontloading tenders means that developers can get to work with creating additional and flexible demand, which helps to integrate new volumes of offshore wind in the energy system. Having exclusivity over a site means they can start negotiations with industrial offtakers who need concrete access to green electrons to make investment decisions . They can also start maturing electrolyser concepts and offer green molecules to industrial offtakers who need to comply with new EU targets on renewable hydrogen.

Tendering out more sites at once is also a good chance to increase flexibility and place more responsibility on market players. By having developers finance or conduct more site and impact surveys themselves, this removes workload from authorities and agencies that could otherwise hold up the process. By implementing a reasonable time flexibility, strategic sourcing and cost optimisation is enabled. And by allowing 'overplanting' a site with a capacity that's larger than its allotted on-shore grid connection, developers are given flexibility to seek out other potential means of offtake, such as hydrogen or e-fuels production.

Balance risks and opportunities between public and private actors

Less than a decade ago, payments were about subsidies for offshore wind. Now, an immense industrialisation and technological maturation of the sector has turned that image upside-down. In 2017 in Germany, Ørsted submitted the world's first zero-subsidy bid for offshore wind, for a project which is now being developed. Since then, the market dynamics have changed fundamentally, and offshore wind projects have in many instances become either subsidy free – or indeed a direct source of revenue for governments. Through seabed lease auctions or contracts for differences (CfDs) – or a combination of both.

However, the ongoing energy crisis, recent inflation, rising interest rates and cost of capital and supply chain bottlenecks has increased both costs and complexity of projects, changing the dynamics of the market. In combination with price-only auctions and upfront payments for sites, offshore wind projects now entail increased prices and project risks, with many factors impacting the business case out of control of the developer. This is already evident now, as developers are in some cases facing difficulties keeping projects profitable.

7 Bloomberg NEF, 2023.
8 Wind Europe, 2023. UK capacity is indicative.

Since many risks are out of the control of developers, and since there's a multitude of other societal issues that come with offshore wind power projects, that must be addressed in any case, alternative payment structures are critically needed, with less focus on potential short-term state revenue and more focus on holistic, and longer-term value creation for society. Governments looking to support and promote such broad value creation, can take these steps to help rebalance risk and reward allocation:

- **Introduce revenue sharing instead of upfront payment for merchant developments**
  Seabed auctions with uncapped and up-front payments for the exclusive rights to an offshore wind site come with an obvious short-term benefit to the state finances. However, they also maximise developer risk and cause a 'race to the bottom' on price, overlooking or deprioritising other societal aspects. Opting instead for a payment structure based on sharing revenues (income from sales at a reference price), risks and incentives become better aligned between developer and state. This can be combined with a minor fixed seabed lease, which can also apply to demand-driven projects (see chapter 2) if necessary. Such revenue sharing should ideally reflect the risk allocation of a project and ideally be capped to allow for more holistic bid evaluation on other criteria.

- **Offer double-sided CfDs in state tenders for offshore wind**
  CfDs are a core instrument to support renewable energy projects, including offshore wind.
  By entering a long term CfD, the developer gains certainty for a future cashflow, leading to stronger financing options and lower costs for the project. For the government, entering a CfD creates an incentive to align policy with the needed electrification and an economic upside once it materialises as increased electricity demand. Ideally, such CfDs will be indexed, as developers themselves can not influence or predict future inflation that will often be influenced by central banks and government policies. In a competitive tender for CfDs, developers should be able to opt-out of CfDs and instead develop a project on merchant terms, potentially backed by Corporate Power Purchase Agreements (cPPAs).

- **Award projects and sites from both price and non-price criteria**
  Offshore wind must be developed in accordance with nature and protect its biodiversity. It must coexist in harmony with other sea users. It must be developed with due respect and bring positive additions to local communities and economies. It must be integrated efficiently into the broader energy system. And tax transparency and broader social responsibility must be ensured from these extremely large societal infrastructure projects. For all of these reasons, innovative approaches to offshore wind should be incentivised. For instance, by including non-price criteria as qualification criteria in site allocation. For centralised tenders, innovation, environmental, and social sustainability could supplement – or even replace – price as evaluation criteria for offshore wind projects. The tender framework in the Netherlands is a good example of that.

Enable the Industry to Deliver

Meeting Europe's offshore wind targets will require tripling up its supply chains in less than a decade. Currently, the industry is able to deploy approximately 7GW offshore wind per year, with a further 3GW/y manufacturing and installation capacity planned by 2025. Towards 2027, this capacity must reach 20GW per year, to reach its targets for 2030 and 2050. Doing so means unlocking significant investments, to the tune of EUR 12-13bn across the sector.

The solutions proposed in this paper all have beneficial knock-on effects on the investment climate for the industry. To truly create an enabling environment for the European wind industry to scale and deliver, they must be combined with an efficient market design and regulation, and a progressive industrial policy to match.

Ensure an efficient energy market
Electricity prices must continue to be transparent and reflective of the marginal production, to ensure efficient operation of the system. In the short term by matching supply and demand day to day and hour to hour. And in the longer term by creating a price signal to guide system investments.

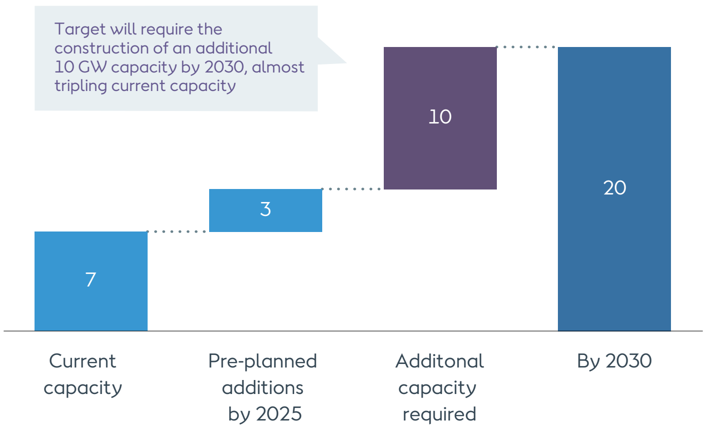
The proposed EU power market reform is a welcome chance to further improve European energy markets and bolster their resilience against the ongoing and potential future energy crises. But it comes at a risk of introducing new uncertainties at a critical time to the market. Policymakers should aim to reaffirm Europe's commitment to a cost-reflective and transparent energy market, that can enable further renewable buildout as a means to securing stable and lower energy prices.

A progressive industrial policy
In the early spring of 2023, the European Commission presented its 'Green Deal Industrial Plan' and 'Net zero Industry Act'. An important and timely initiative, the key focus of which should be to support a sustainable scaling of the entire supply chain. This means defining a long-term masterplan for critical materials and components, including for power-to-X. And it includes working with national governments to unlock investments. This is the case in component manufacturing. But equally important is establishing the industrial infrastructure, such as ports and vessels – as is training and upskilling of the workforce throughout the value chain.

Build a bridge for existing projects
Across Europe, developers of projects which were awarded, and whose power prices were tied to CfDs or similar power purchasing agreements before the current cost crisis now face difficulties. Governments and industry must seek out ways to overcome recent cost inflation and solutions that can help existing projects move forward to FID and commissioning.

Supply chain: Scaling up requires mobilising EUR 15-16bn

Potential ramp up of EU offshore wind supply chain capacity
GW of annual wind turbine production capacity today vs 2030 in Europe



+ Incremental investment [9, 10]

~€3bn

Other supply chain components, where underinvestment risks becoming a bottleneck

- Workforce and upskilling
- Foundations and upstream specialist steel plate fabrication
- Port infrastructure, including space for assembly, storage and staging. Also for floating offshore wind.
- Vessels, including heavy lifting, cable installation and specialist support vessels
- Substations, not least HVDC assembly capacity
- Subsea cables

+ Incremental investment [9, 10, 11]

~€12-13 bn

9. Based on delivering 10GW of incremental annual fabrication / installation capacity.
10. Approximate estimation for key enabling factors in offshore wind supply, excludes non-offshore wind exclusive elements e.g. steel supply.
11. Wind Europe estimates that until 2030, Europe will need to invest EUR 8.5bn in port infrastructure to stay on track to 2050.

Chapter 2
Allow for a demand-driven buildout track to complement tenders

Allowing market-driven buildout of offshore wind in a complementary and parallel track to centralised tenders can both help speed up Europe's green transformation, realise synergies and innovation, and help meet industry-specific needs for renewable energy, hydrogen, and e-fuels.

Central tenders are well adapted for ensuring that broader societal energy demand will be met, in a structured way which allows for centralised grid and permit planning. While most future offshore wind buildout will be allocated through such centralised public tenders, governments can enable additional, market-driven buildout by allowing developers to propose and execute projects outside maritime zones designated for state tenders. Developers would apply for site exclusivity for projects on merchant terms with an identified industrial offtake.

This would effectively open a complementary 'demand-driven' track to offshore wind, where sites and projects can be matched directly to demand from existing or future industry applications, whether in support of direct electrification of end users or indirect via power-to-X. Here, developers can plan, propose, and execute projects that combine offshore wind, grid connection, hydrogen production, and/or offtake contracts, all at once.

Allowing market-driven development for projects with a specified industrial scope can help accelerate the general buildout of offshore wind, by making even more sites available and providing new means for market players to finance and execute projects. It can help increase the offshore wind volumes with limited burden on the onshore transmission grid as projects can be directly connected to offtake. It can help avoid time-consuming tender processes. It allows end-users to take proactive steps to meet their own corporate decarbonisation targets in a cost-effective way, with sufficient timeline clarity for enabling capital investment for manufacturing processes. And it allows for innovative synergies and cost optimisation arising from projects being developed for a specific purpose.

Access to seabed outside zones reserved for centralised tenders

This would require governments to designate sizeable development zones that are outside the scope of areas planned for upcoming tenders. Within these zones, offshore wind developers are free to submit unsolicited applications for exclusive rights to a site. This could be awarded (subject to EU law) on a first come, first served-basis, to use, with milestone deadlines – or lose, with related penalties.

Applicants should be required to submit a detailed project proposal, including preliminary project design, along with declarations of intent from potential industrial partners who can utilise the electricity produced. This could also be plans for an integrated or co-located hydrogen or e-fuel production, connected via a direct line. It could potentially even be an offshore wind farm in one country connected to industrial demand in another, with appropriate revenue sharing or site payments.

Constrained grid connections

Demand-driven projects are, by nature, developed outside the long-term infrastructure planning of TSOs. They can therefore not be guaranteed grid capacity. Instead, the developer can propose and finance a grid connection within onshore grid boundaries. This can be constrained, or without delivery guarantee, making it 'interruptible' by the TSO in situations of system stress.

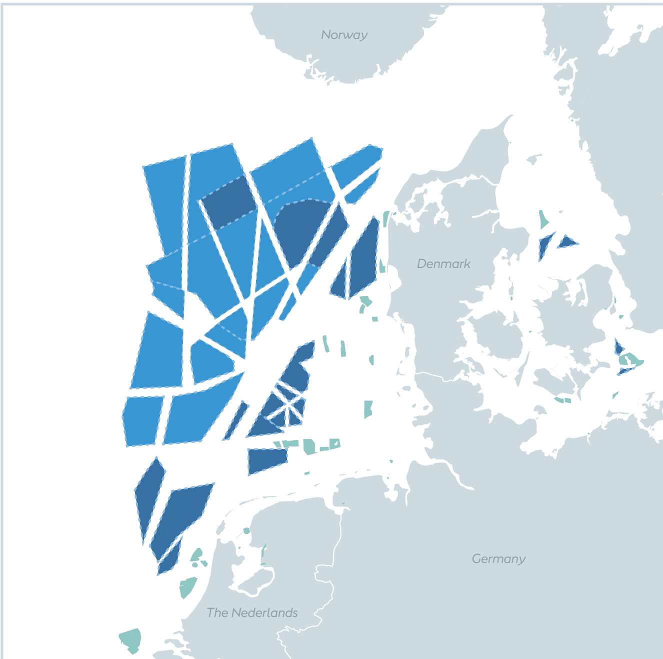
Such projects will therefore not introduce an unknown factor that the TSOs can't plan their grid development. In fact, by introducing both a large-scale source of power generation, a flexible offtake, and an interruptible grid connection, demand-driven projects can act as a valuable source of supply and demand flexibility in the grid. It can offtake power when its plentiful, optimising grid utilisation. And if bypassing its own consumption, it can feed in electrons in times of high prices and/or system stress – essentially making it a 'security of supply machine' from a societal perspective (see pages 22-23).

Allowing for more market-driven, developer-led buildout means we'll have more renewable energy, faster and cheaper, and implemented in a way that's more 'system compatible' as the offshore wind assets are built to match demand.

Potential areas for combined policy-led and supplementary demand-driven zones for part of the North Sea

Here, the North Sea is used to illustratively map out the zones that can be relevant for such a demand-driven buildout.

While further detailed screening is required, taking normal maritime spatial planning practices into account, including other sea uses and nature protection and biodiversity impacts[12]. There is, however, a real and significant potential to make room for round 25-30 GW in this part of the North Sea, when only using around 10% of the gross area for demand-driven projects.



Offshore wind development zones for consideration

- Policy-led state tenders
- Potential demand-driven and policy-led development zones
- Fully Commissioned Sites

12 Ørsted will later this year make a publication on delivering a biodiversity-positive energy transition.

	Policy-led buildout	Additional: demand-driven buildout
	A centrally planned track, to meet society's growing energy needs and policy targets. Offshore wind sites are designated by authorities, offered in competitive tenders, and awarded from politically selected criteria. Projects have overall predefined timelines and connection points.	A flexible, market-driven track to unlock additional capacity and meet the specific needs of large consumers. Developers work with large offtakers to propose and build projects on merchant terms outside sites designated for public tenders, and without guaranteed grid access.
Purpose and value	• Establish offshore wind to efficiently increase energy security, lower consumer costs and meet the growing electricity demand as the wider economy is electrified and decarbonised.	• Directly meet demand from targeted large consumers, e.g., industrial offtake or for hydrogen electrolysis and power-to-X, through market driven, integrated projects.
Site selection and allocation	• Sites are designated in national maritime spatial plans and allocated to developers through centralised tenders. Tenders should ideally allow for design and project flexibility, including overplanting. • The exclusive development rights to a site or project can be awarded on a combination of non-price criteria and price. The non-price criteria can be used either for pre-qualification of bidders or as evaluation criteria, supplementing or entirely replacing the price-component.	• Governments designate or make space for development zones in maritime spatial plans outside areas reserved for centralised tenders. Here, developers can submit unsolicited application for a site, specifying a project description and planned offtake, including declarations of intent from potential industrial partners who can utilise the electricity or hydrogen produced.
Timeline	• Timelines implemented to deliver on policy targets. Centrally planned and controlled milestones – potentially with some flexibility to enable supply-chain planning and efficient project execution.	• Flexible timelines tied to the offtaker, the developer and TSO coordination to ensure efficient project execution.
Grid integration and impact	• Developers are presented with a state-facilitated and guaranteed grid connection, which is settled ahead of or as part of a tender. This can be financed and constructed by either the developer or TSO. The offshore wind farm is connected directly to the onshore grid, potentially to several bidding zones as a hybrid project. • Connections have fixed capacity in accordance with TSO grid planning and buildout, meaning grid expansion is generally needed to support buildout. Offshore wind farms can participate with regular ancillary services and flexibility to grid operators, as well as downregulation or curtailment of infeed when supply exceeds demand.	• Developers propose and finance landfall and grid connections. Typically, production from the offshore wind farm will make landfall directly to a co-located asset, thereby minimising the need for onshore grid buildout, and with only a secondary and constrained connection to the overarching transmission grid, subject to the TSO. • Such co-located assets are offered a non-guaranteed and interruptible connection product by the TSO, meaning it will not directly impact onshore grid planning. The co-located assets can participate in ancillary markets with up and down regulation of infeed to the grid via the constrained grid connection, or by bypassing the production of e-fuels entirely in situations of system stress.
	350-400 GW by 2050	**40-60 GW** by 2050

Chapter 3
Get the infrastructure right

Get the infrastructure right

With electricity consumption set to more than double towards 2050, getting Europe's transmission infrastructure in place, in time, will make or break its green ambitions. Long lead times mean we must start building tomorrow's grid today. But new actors, incentive structures, and technologies can significantly alleviate the investment need by using the grid smarter and more flexibly.

If solar and wind energy, electrification, and e-fuels are the four main pillars of the green transformation, transmission infrastructure is the beams and roofing connecting them.

Looking towards 2050, electricity consumption will more than double under European climate and energy targets. At the same time, an increasing share of power supply will be from wind farms far offshore, further spacing the high consumption and production areas apart. This necessitates tremendous effort in building a future-fit transmission grid, with an inherent need to look far ahead when matching the pace and scale of the transforming energy supply and demand.

Large-scale transmission buildout in Europe has been notoriously challenging. Projects have been subject to long planning and permitting times and are often delayed, in part due to local opposition. Long lead times and cautious regulatory investment scrutiny has left the grid trailing behind supply and demand, with bottlenecks causing inefficiencies, long lead times for grid connection, and rising costs of redispatch and curtailment being passed on to ratepayers.

Going forward, we need to build more infrastructure, faster. And we need to use the infrastructure we have better.

This will require policy action to encourage and enable anticipatory investments. Today, Transmission System Operators (TSOs) and regulators invest in projects with a clear route to near-term return on investment meaning that only certain future projects will be served with a grid connection.

This has been a logical approach in the structured incremental build-out of renewable energy to date. But to reach net zero emissions in a cost-efficient manner it will be necessary to build infrastructure that may risk having a low utilisation in the short term and therefore may have a challenged economy in a classic economic feasibility study.

Building the needed infrastructure to connect very large-scale offshore wind clusters to multiple countries, through hybrids and islands/hubs, is a clear example. This will require TSOs to be incentivised to focus on future grid requirements, and long-term value, in their decision-making and that regulatory risk sharing models to enable this long-term investment horizon are implemented. This is widely acknowledged by both political decision makers and market actors – but discussions an enabling regulatory environment for hybrid connections needs to be reinvigorated and implemented.

Require future proof investments

It's notoriously difficult to develop transmission infrastructure – so it is not surprising that the delay in transmission projects is the single most challenging stumbling block for the net-zero transformation.

Transmission and grid projects are complex and time-consuming. Planning new lines is marked by careful consideration of potential bottlenecks between areas and costs and benefits of individual projects are evaluated on a case-by-case basis and compared to the relatively conservative planning scenario ahead of defining the Ten-Year Network Development Plans (TYNDP) by ENTSO-E the European Network of TSOs.

The planning scenario used for European transmission grid investments are called 'National Trends' and are insufficient to bring Europe to a net-zero economy by 2050. Hence, transmission build out would tend to underinvest compared to a cost-efficient trajectory to 2050 and leave Europe with higher curtailment costs and higher generation costs. ENTSO-E assess that their National Trend scenario, only includes 100GW and 217GW of offshore wind in 2030 and

2040 respectively. This is significantly lower than Europe's cumulative target of around 150 GW offshore wind by 2030, and not aligned with projections of close to 450GW of offshore wind capacity by 2050. If this grid build-out plan is followed, it will frustrate the achievement of the approved build-out targets.

To make the current system cost efficient, the transmission grid investment estimated by ENTSO-e of 2040 will probably already be needed in the early to mid-2030's. If this mismatch is not solved, it will result in massive curtailment, significant revenue uncertainty due to price cannibalisation, higher electricity prices due to more gas power, and with higher CO_2-emission as the effect – or it will force governments to abandon their renewable energy targets.

Europe's TSOs have a unique opportunity to lead the alignment of infrastructure buildout and renewable generation. As responsible custodians and operators of critical energy infrastructure, they must continue to carefully manage and plan grid buildout – in other words 'build forwards from today'. But at the same time, on top, they must be encouraged and enabled to make increasingly visionary and anticipatory investments – i.e. 'building backwards from tomorrow'. Such investments could include preparing projects further in advance to match and incentivise future generation and demand; unlocking new value streams and technologies, such as hydrogen pipelines, energy storage, upgrading existing infrastructure; and smart grid solutions.

However such investments are disincentivized – or even made impossible. Regulation governing the buildout prioritizes strict cost-efficiency for ratepayers but neglects the long-term need for society to decarbonize.

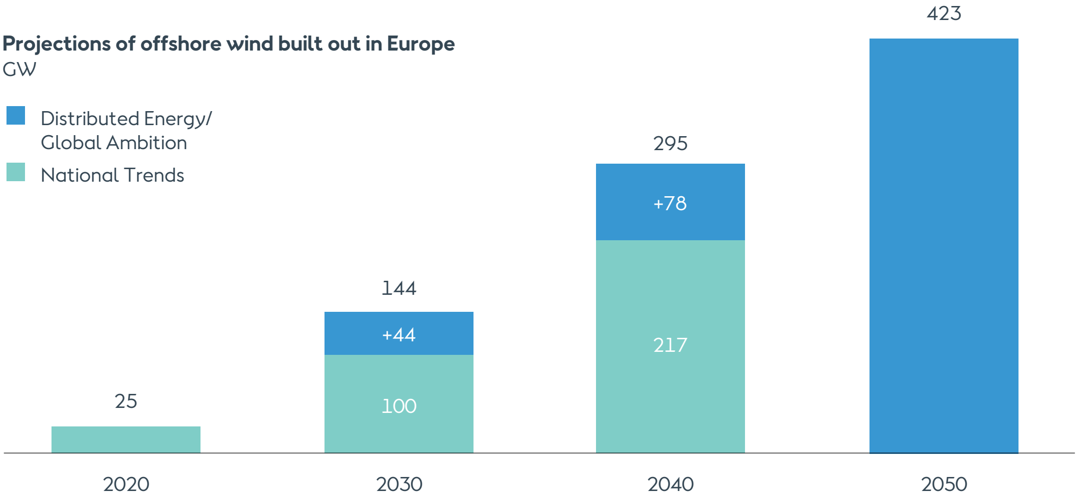
The anticipatory investments we call for inevitably come with risks and upfront costs – but the current energy crisis has demonstrated that the risk of slowing down renewable energy build-out through insufficient grid capacity can be even more costly. Anticipatory investments can also increase cross border flows of energy, benefitting energy consumers, increase grid resilience, and unlock further renewable energy buildout and uptake – in short, propelling Europe's energy transformation forward.

Policymakers looking to help enable and encourage further investments into a future-proof transmission system can:

- Explicitly call on regulators and TSO's to align system planning with long term energy targets and incentivise investments that are net-zero aligned.
- Enable TSOs to factor in future transmission needs and evaluate upfront investments not just as an isolated business case, but also internalising the opportunity cost of delayed buildout.
- Develop risk-sharing models to cover the higher risk on long-term projects.
- Allow regulators more agility to provide regulation in support of new technologies and services critical to deliver the net zero path.
- Acknowledge that the long-term investments needed to reach net-zero will entail a slightly higher risk level – but also comes with the reward of faster buildout and more efficient utilisation and sharing of Europe's renewable energy resources.

The TSO framework for grid investments is underestimating the buildout of offshore wind and other renewables[13]

Projections of offshore wind built out in Europe
GW



13. Source: ENTSO-E TYNDP 2022. Average from the two Net-zero scenarios: Distributed Energy and Global Ambition.

Incentivise very large-scale offshore wind clusters

As offshore wind farms grow larger and move further out to sea, there is a growing societal potential from linking them to more than one market. But current regulation is a significant barrier to realising such 'hybrid' projects.

One of the best examples of the need for anticipatory transmission investments is the very large-scale multiple transmission cables needed to connect offshore wind clusters and hubs to multiple markets. Scaling up offshore wind to the next level will require development of multiple GW clusters of wind farms, connected to multiple markets to manage the integration.

The Krieger's Flak offshore wind farm, connected to Denmark and Germany, is the first generation of this new type of joint asset – a hybrid asset. Ongoing plans and projects with Danish and Belgian energy islands in the North Sea, and the large-scale project and cooperation between Denmark and Germany to connect offshore wind off the island of Bornholm, are taking hybrid projects to the next level.

A hybrid project is a new type of asset with great potential for cost savings and improved integration. We'll need to massively expand interconnectivity, also across the North and Baltic Seas to manage growing renewable generation and cost-effectively reach net-zero emissions. Exploiting these interconnectors to also connect offshore wind can save costs, by saving the radial connection and achieving a higher utilisation of the cables. And the power can flow to where it's needed the most to the benefit of both TSO and European consumers.

A study by THEMA estimates a societal cost saving potential of EUR 5bn per year by 2050 in the North Sea, in a scenario where hybrid assets are fully implemented.

Uneven risk and reward allocation holding back hybrids
With current market regulation, the TSO will harvest all benefits from a hybrid project through the current definition of so-called "congestion rents". This is the rent resulting from transporting electricity from a low-price area to a high-price area. In the current market regulation, the offshore wind connected to a hybrid will receive the lowest price of the two connected markets – with no floor price, giving hybrid projects a significantly riskier revenue profile for limited upside.

Further risk and complexity is layered on through the current regulation allowing TSOs to limit transmission capacity on interconnectors, including to hybrids, to 70% due to internal bottlenecks in the onshore grid. Perhaps even lower due to the way the 70% is applied in a flow-based market coupling. And with hybrids, the offshore wind farms' access to consumers goes only through interconnectors. When less capacity is allocated to the interconnectors than wind generation, then the price drops towards zero and the difference is curtailed; this is a risk which the offshore wind developer can neither mitigate nor reliably forecast and is not compensated for. This is unlike an onshore bidding zone where the price impact would be diluted by the load in the bidding zone and the curtailed generation would be compensated.

Without changes to this regulation, the only way to incentivise offshore wind power in hybrid clusters and hubs is to uphold a subsidy through a guaranteed CfD but unlike traditional CfDs, this CfD must also cover potential generation not delivered to the grid. This can gravely undermine efficiency and delay, or even derail, the very large-scale build-out of offshore wind needed to get Europe out of fossil energy. The offshore wind developed in clusters will be at some of the most ideal offshore wind sites in the world. Some will be relatively far from shore, but still probably very cost competitive with a simple radial connection. But the offshore wind resource will appear to be costly because all uncertainty and downside from the interconnectivity will be imposed on the offshore wind developer, possibly resulting in a relatively high CfD.

An alternative solution is to allow TSOs and offshore wind developers to work out a way to share costs and revenues in a way that leaves all better off. The European Commission has included a proposal in its proposal for Energy Market Regulation that at least allows for a better management of the risk of curtailment. They propose offering offshore wind developers a so-called Transmission Access Guarantee, at least shifting the risk of curtailment to TSOs who can also best manage this risk.

Benefits of co-locating renewables and hydrogen production

At a time where European power lines are strained by growing generation and consumption, hydrogen and e-fuels can integrate more renewable energy into the energy system while alleviating future transmission investment needs – if placed strategically, close to renewable energy resources.

By 2030, hydrogen production in the EU is poised to consume power equal to the entire consumption of Germany. Yet, grid capacity in Europe is a scarce resource – and increasingly so with the direct and indirect electrification needed to reach net-zero emissions. Hence, while policymakers and regulators must strive to align long- term strategic planning and incentives with net-zero emissions, other and more 'tactical' measures such as co-location can help ease pressure and unlock further benefits.

The 2022 RePower EU package targets 10Mt domestic renewable hydrogen production per year by 2030. This will require approximately 500TWh renewable electricity within the EU alone[14].

The green transformation and electrification add strain to Europe's transmission infrastructure. The grid investment costs per unit of electricity consumed could increase if business as usual is continued due to longer distances between production and consumption, possibly lower utilisation rates due to the variability of renewables and negative impacts on the public from more grid. Getting the most out of the existing grid and ensuring an intelligent interplay between new demand and supply, can reduce costs per unit of energy transmitted, reduce the costs of renewable hydrogen, and make the green transformation cheaper, overall.

Co-locating can save EUR 6.3bn per year

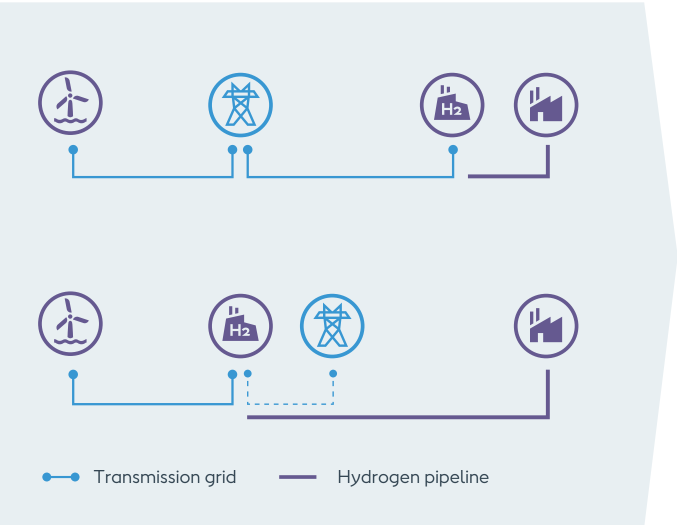
By locating new and large-scale power demand, e.g. for hydrogen and e-fuels production, with power generation, grid investments to accommodate this additional demand can largely be offset.

A co-located and integrated asset, for instance an offshore wind farm connected to a large-scale electrolyser, constitutes a new, integrated asset class. As the required grid connection of such integrated assets only needs to be at a fraction of its generation capacity, it can be flexibly and quickly implemented with only minor burden on the grid. By doing this, much larger volumes of renewable energy can be integrated into our energy systems by simultaneously keeping infrastructure buildout to an optimal level.

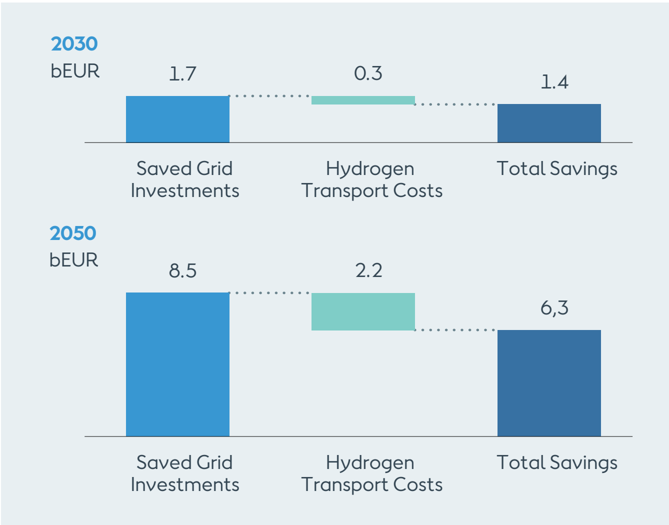
A 2021 study from THEMA estimates the reduced need of grid investments to be gained from co-locating assets in the North Sea Region to EUR 6.3bn per year by 2050.

Less need for transmission and better system integration due to co-location of PtX and offshore wind

Co-location will save grid build out, ensure better utilisation of the grid and open up for deployment of more renewables than otherwise



Co-location can unlock a cost saving potential of 6.3 bn EUR in the North Sea region



14 Assuming 20kg H_2 per MWh, not including compression or other processes.

A new 'security of supply' machine

Combining renewable generation and e-fuels production into a co-located and integrated production asset can bring significant benefits to the broader energy system. This will first and foremost reduce the needed transmission buildout and improve utilisation of the grid, with significant cost savings to society. It will improve utilisation of the transmission grid.

When combined with cost-reflective and lower grid charges, it will reduce the cost of renewable hydrogen to end users. And, from a systems perspective, such co-located assets can function as a flexible demand and power source in the electricity grid.

As such, co-located renewable and hydrogen generation assets can help increase the European security of supply: by displacing the natural gas which would otherwise be needed to supply European industry with grey hydrogen; by overall more renewable capacity; and by adding significant demand side flexibility in times of high prices or system stress.

Several factors impact and shape the specific configuration and operation of renewable generation and e-fuel production, and to what extent they can be co-located and integrated. These include the technical needs of the offtake for hydrogen, the terms of the grid connection, access to the hydrogen pipeline network, and project and market specific conditions. Ultimately, some future power-to-X assets may work better as 'standalone' applications, while others may be very integrated. The previously proposed 'demand-driven' track for offshore wind buildout could be an obvious approach to deliver co-located, integrated assets.

An industry-driven buildout track, as described in chapter two of this paper would implement this efficiently without adding further requirements for grid expansion. For instance, as demonstrated above, a co-located offshore wind farm and electrolyser with a secondary grid connection constrained to e.g. 20% of its production capacity, will play a role similar to a dispatchable power source to the grid – the flexible power consumption of the electrolyser can be reduced in times of high demand, allowing the power generation asset to redirect that renewable power to the grid. In addition, by co-locating large production and demand assets, other ancillary services can also be made available.

Historically, a gas turbine was often the least costly asset and was hence therefore used as a back up. Going forward,

'Security of supply machine' via co-located offshore wind and electrolyser prosumer units

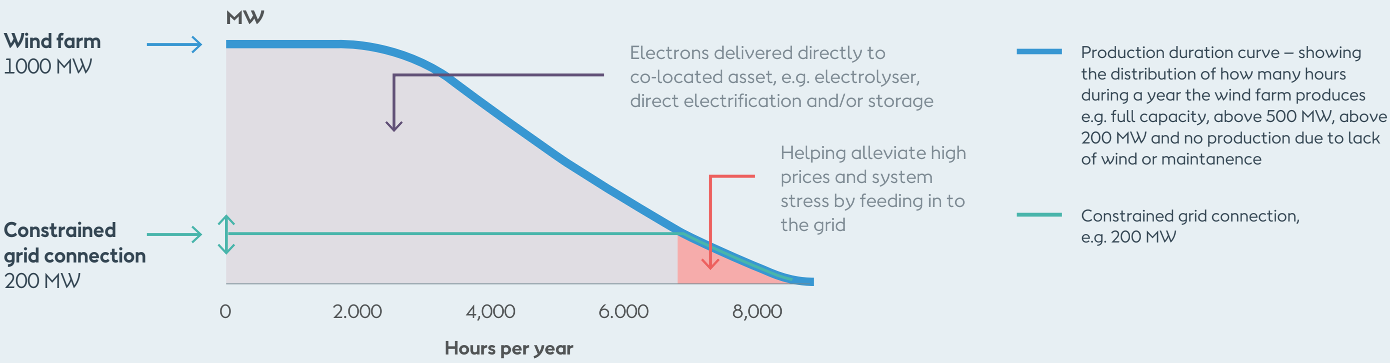
The co-located assets with e.g. an electrolyser will be acting flexible according to market price signals and the grid constraints, and either exporting when there is a need or importing when there is abundance of electricity helping to reduce curtailment and improve grid utilisation rates.

In the future, markets round the North sea and Baltic sea will see a correlation between lower wind output and higher prices.

A co-located offshore wind and electrolyser prosumer unit can, however, still deliver on average 9% of full load in the majority of hours with the very highest prices.

Ten of these units would together make a substantial contribution to security of supply by reacting on price signals and acting like an additional reserve.

Production duration curve – Offshore wind in the North Sea
Example



it could also be oversized electrolysers, and batteries could play a significant role. The key metric for power-to-X supplying flexibility to an electricity system will be the necessary upfront capital expenditure: if this is too high, it will not be economically efficient for electrolyser capacity to stand idle at times of high-power prices, unless incentivised, or required, to do so. In any case, unlocking the systems benefits of integrated co-located assets for system balancing and load following, will require:

- Pricing and innovative grid products to incentivise co-locating assets. For instance, cost-reflective tariffs can provide locational price signals, or new products with interruptible grid connections for both consumption and generation and can incentivise co-location in ways that minimizse the cost incurred on the grid.

- An efficient and interconnected hydrogen backbone and storage infrastructure, to accommodate the interruptible production. The European Hydrogen Backbone vision, the combined effort of 32 European gas infrastructure operators, is an important example of the scale and long-term vision needed to make the European hydrogen economy a reality

- A robust demand growth for renewable hydrogen, both from existing hydrogen consuming industries looking to decarbonizedecarbonise, and from new decarbonisation and e-fuel applications. In the near future, this will be facilitated through the demand pull of recently agreed targets for the use of renewable hydrogen in industry and transport (e.g. FuelEU Maritime; Revised Renewable Energy Directive).

- Additionally, these targets need to be accompanied by initiatives such as the European Hydrogen Bank, in conjunction with important national initiatives and incentives to support renewable hydrogen as a gap between production cost and willingness to pay on the offtaker side.

Ørsted
Love your home

About this paper

Europe is at a critical point in its green transformation journey. The EU has clear and ambitious renewable energy targets, but meeting them requires bold and decisive action to open the path to progress.

This Ørsted paper identifies the barriers to progress for Europe's green transition, and how we can take them down together. These barriers are technical, procedural, and administrative – and they were put there by people. So, while it's not an easy task to break them down, it is within our power, if we work together.

About Ørsted

The Ørsted vision is a world that runs entirely on green energy. Ørsted develops, constructs, and operates offshore and onshore wind farms, solar farms, energy storage facilities, renewable hydrogen and green fuels facilities, and bioenergy plants. Ørsted is recognised on the CDP Climate Change A List as a global leader on climate action and was the first energy company in the world to have its science-based net-zero emissions target validated by the Science Based Targets initiative (SBTi).

Ørsted is the world's leading developer of offshore wind. Ørsted conceived and developed the first offshore wind farm (Vindeby) in 1991 and recently built the world's largest offshore wind farm (Hornsea 2), which will help power more than 1.4 million UK homes. We aim to have installed 30 GW of offshore wind by 2030 - equivalent to around half of all current global offshore capacity.

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