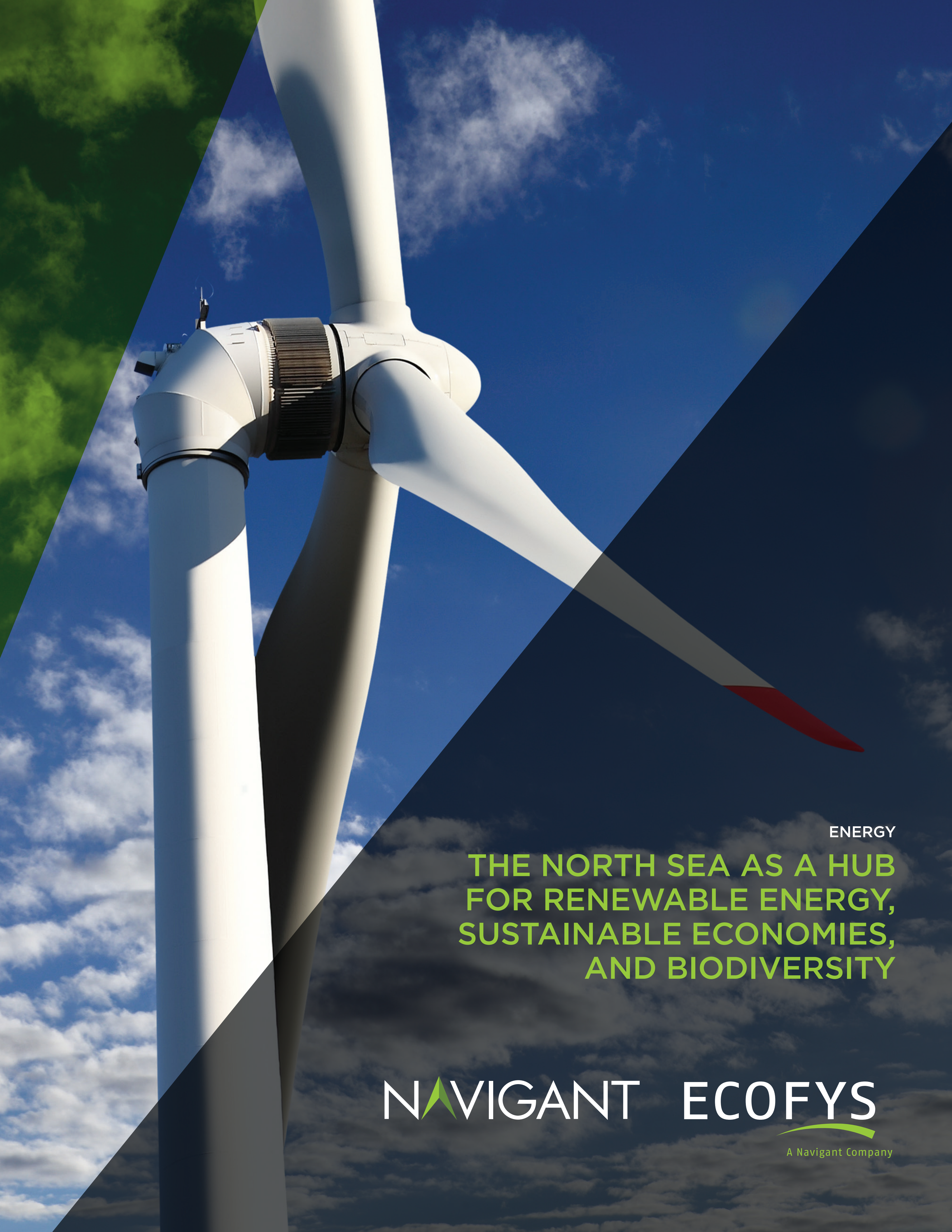

ENERGY

THE NORTH SEA AS A HUB FOR RENEWABLE ENERGY, SUSTAINABLE ECONOMIES, AND BIODIVERSITY

NAVIGANT ECOFYS

A Navigant Company

A VISION FOR THE NORTH SEA GRID

As seen with the boom in solar and wind energy, technological evolutions in the energy industry have historically followed a non-linear path, leading to a fundamentally altered energy system once tipping points are reached. The potential of a North Sea Grid (NSG) has been a dream on the horizon for several decades. The right conditions now exist to trigger further progress, including:

1. Levelised costs of offshore wind that have dropped well below €0.10/kWh.
2. Regional ambitions that have strong political support.
3. Industry that understands the need to align business models with a societal roadmap that keeps the global temperature rise well below 2°C.

The vision of an offshore renewable energy grid as the powerhouse for a decarbonized Northwestern European electricity system by 2050 is widely shared. A joint effort needs to be made in order to overcome the barriers to integrating the largest renewable energy source in a region that is ready to seize the opportunity. This paper discusses the potential for a concise but full-spectrum approach to North Sea energy infrastructure.

ZERO-CARBON ELECTRICITY

The North Sea's renewable energy resources can cover more than 15% of the region's total electricity demand by 2030. Achieving this would make a major contribution to delivering on the renewable ambitions of the post-2020 era. Committing to this development would also grant stability to the energy transition of the surrounding countries, allowing sound decisions to be made on the future of conventional generation and innovative technologies while ensuring security of supply. The first decades of offshore wind deployment saw leaps in technology maturity, cost reduction, and upscaling. To date, any progress has been made with limited national or regional interaction and has faced incompatible support, access, or market schemes. A coordinated approach is essential in realising a unified North Sea energy vision.

ECONOMIC DRIVERS

A sustainable, cost-effective, and reliable North Sea energy system would secure Europe's technological leadership, accelerate job growth, and allow the energy industry to export its success globally. In a world committed to COP21 targets, long-term investors rely on sustainable and attractive opportunities. To succeed, a North Sea energy system of wind farms and grid assets relies on investment. It can only attract this when political commitment and regulatory stability is in place, and when cost-efficiencies can be reached through coordinated support and rollouts. An expanded infrastructure initiative would stimulate economic growth in the North Sea region and spur logistics and construction activity in areas such as ports, shipping, dredging, and offshore operations and maintenance (O&M), industries which are all currently facing increased global competition and the decline of North Sea fossil fuel extraction.

MARINE BIODIVERSITY

The role of the North Sea as a hub of economic activity needs to be balanced with respect for the environment and marine biodiversity. The potential NSG should maximize benefits for the environment through new protected areas for wildlife and extended migratory corridors. Regional cooperation in energy infrastructure planning should be expanded in scope to align all offshore activities, including fisheries, tourism, military zones, oil & gas infrastructure, and shipping. Harnessing and preserving the environment of the North Sea region requires constructive collaboration among all sectors.

A ROBUST FOUNDATION FOR A CARBON-NEUTRAL EUROPEAN ELECTRICITY SYSTEM

COVERING OVER 15% OF REGIONAL ELECTRICITY DEMAND FROM OFFSHORE WIND BY 2030

The key societal benefit of a concerted North Sea energy system is its direct impact on **supplying Europe with CO_2-neutral electricity**.

By 2030, under business-as-usual assumptions (without 2030 targets or COP21 implementation), offshore wind is expected to cover 4% of all EU electricity, rising up to 6.9% with efficient 2030 target implementation and market conditions (energy and carbon) and up to 10.1% with favourable economic conditions and industry efforts. For countries surrounding the North Sea,[1] this would mean **15% of regional demand being covered by offshore resources**. Together with onshore renewables (e.g., wind, solar, and biofuels) and progress in energy efficiency, this would present a strong boost in meeting the region's 2030 renewable targets. It will also be a key component in the move toward **a fully sustainable electricity system by 2050**.

The realization of such an expansion in renewable power sources depends on developments in grid infrastructure, finance access, improved operational tools, supply chain capabilities, environmental safeguards, and more. This paper explores these factors and demonstrates that all of these needs are indeed benefit bearers themselves. In this paper, we focus on the main benefits and ambitions for the coming 10-15 years leading up to 2030.

1. An extended North Sea perimeter is taken, also including developments in the English Channel, Irish Sea, Skagerarrak Strait, Kattegat Bay, and the South-Western Baltic Sea. Also when referring to the region, the full perimeter of all surrounding countries that signed the 2016 North Sea Political Declaration is referred to. In other publications this is sometimes referred to as the "North Seas" region.

OPTIMIZED OVERALL SYSTEM COSTS

Offshore energy supports the energy transition in all countries around the North Sea and by extension Europe. Connecting grid assets in the North Sea would bring the greatest benefit to the entire region when they are planned, constructed, and operated in a coordinated manner. An optimal target grid including (depending on the location) direct wind farm connections to shore as well as hybrid or meshed links between multiple countries and wind farms would bring substantial societal benefits. Such hybrid or meshed configurations could strongly enhance market interconnections in Northwestern Europe and at the same time allow offshore energy potential to feed into the connected markets (Figure 1; Figure 2).

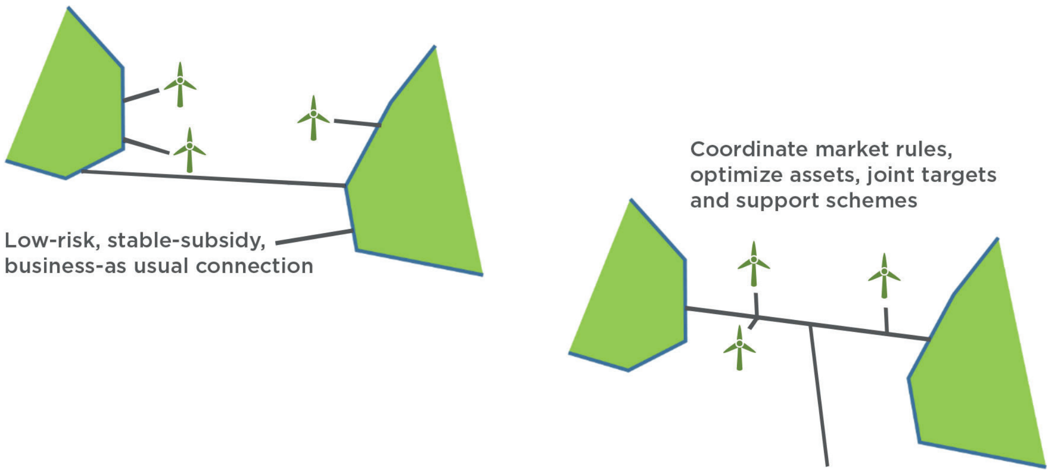

Figure 1 - A move from business-as-usual wind park connections and country interconnection (left) to a coordinated design including possible hybrid connections (right)

This push for interconnection requires the deployment of cutting-edge technologies, such as multi-terminal direct current (DC) connection platforms (possibly in harsh offshore conditions), as well as advanced control and protection strategies. A coordinated design not only deals with hardware solutions related to infrastructure, but also with software in market design and regulation. Such a design requires compatible optimized market rules in all time domains, from long-term forward markets to reserve exchanges. It tackles inefficient interconnection capacity reservations in hybrid or meshed designs due to priority dispatch rules while at the same time avoiding closed national support schemes becoming obstacles to a coordinated target architecture.

Due to developing regulatory conditions and early adoption of technology, the first movers into a coordinated energy system architecture need to take up an additional risk element in their business case. In the absence of future-focused incentives or support mechanisms, facing and avoiding possible project overruns, many NSG projects stay in the familiar lower-risk approach of direct interconnections and wind farm-to-shore radial connections, often pushing back innovative solutions to the status quo.

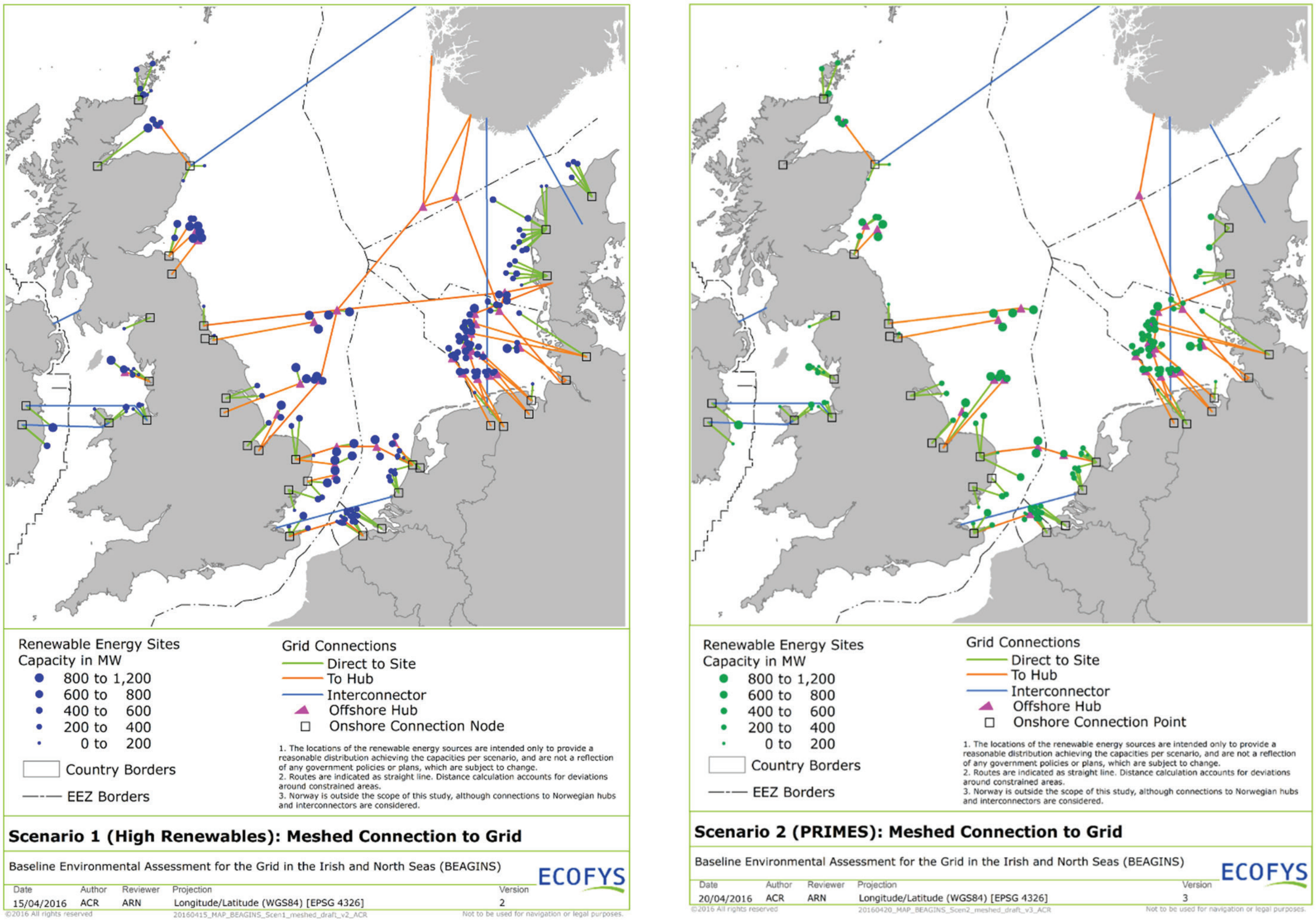

Figure 2 – Illustration of planned North Sea wind farm sites with coordinated configuration in a high renewable energy sources (RES) scenario (left) and in a conservative business-as-usual reference scenario (right)

Investment finance needs for proposed NSG transmission projects by 2030 add up to about €30 billion (not including wind farms). Roughly half of these projects are already in advanced stages and are scheduled for commissioning by 2022. At some point in time a switch in perspective is unavoidable if a coordinated infrastructure is pursued, where all proposals need to be tested for their robustness against 2050 target specifications. It is key to understand that such coordination is not just an alignment of design, but more importantly of process and planning (e.g., of tenders for wind farms and interconnection assets), as well as of commitment. Market-based systems of coordinated tendering need to come with an obligation to construct. Germany already implemented such an approach in its recent Erneuerbare-Energien-Gesetz (EEG) update, which takes effect for offshore wind in 2021 and covers penalty measures for forfeited or delayed projects. Such a commitment is essential in the design of offshore infrastructure to avoid having the dropout of one project result in stranded assets elsewhere.

A recent proposal targeting these objectives is the Wind Connector island by TenneT and Energinet. In this vision, an artificial island combining far-from-shore wind farm connection and interconnections in a hub-and-spoke concept is proposed near the Dogger Bank. The proposal offers a modular approach for connecting more and more offshore wind with alternating current (AC) technologies to the island and DC links to neighbouring countries. It also offers logistic opportunities for offshore maintenance.

Cost-sharing to determine which countries' consumers will pick up the larger part of the bill via regulated tariffs will always be a crucial point and a potential area of disagreement. A coordinated energy system view—one that covers tenders for temporary energy plant subsidies, as well as regulated interconnection investment—will allow the allocation of costs on a total portfolio level and with an integral view (including energy costs, carbon reduction, and subsidy costs) instead of a piece-by-piece approach with uncertain prospects.

European funding can unlock some of these anticipatory investments. The Connecting Europe Facility via the Projects of Common Interest can fund works on transmission infrastructure that are not commercially viable via standard business case assessments, but which offer wider cross-border benefits. The European Fund for Strategic Investments can complement this via support for offshore wind farms.

Doing nothing and missing the opportunity of capturing offshore renewables will be costly for the environment and society. Developing offshore projects and grid infrastructure based on business-as-usual, incremental, case-by-case national solutions will give rise to uncertainty and inefficiencies. Conversely, committing to **a coordinated long-term target design in hardware and software will unlock substantial societal cost reductions in the long run**.

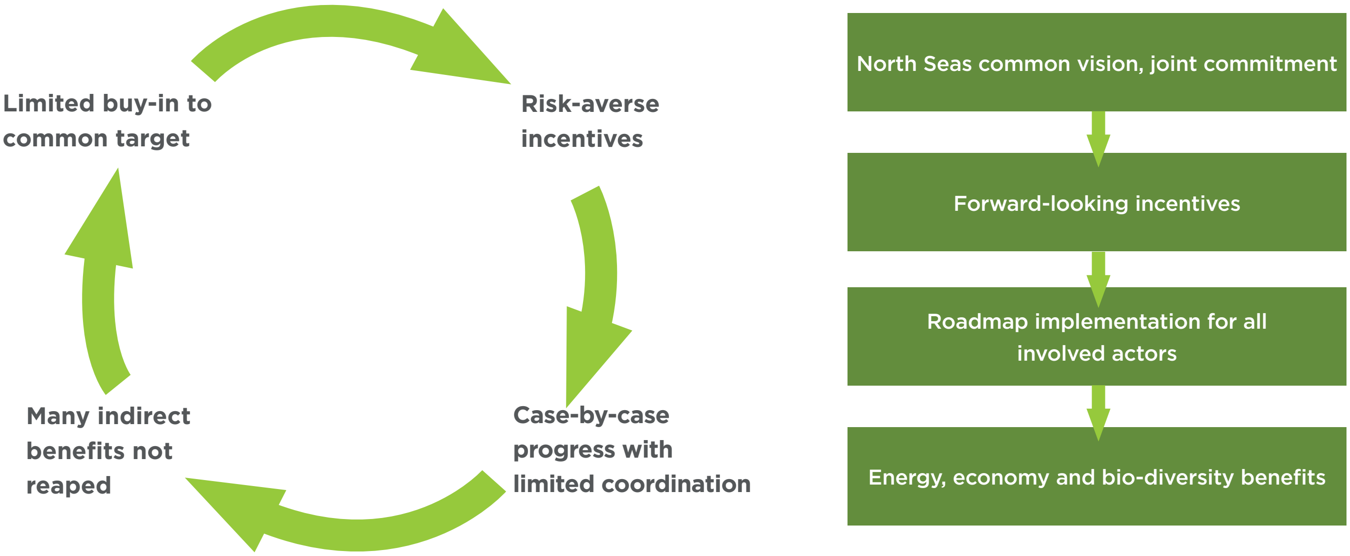

Figure 3 - Breaking the vicious circle of uncoordinated actions by starting from a common vision

SECURING ENERGY SUPPLY

A significant number of additional interconnections between North Sea countries are already being planned, which grants substantial contributions to the security of supply and socioeconomic welfare of the region. These interconnections provide a crucial increase in interconnectivity between the smaller and relatively isolated British and Irish power system (with already high shares of wind generation), the hydro-dominated Scandinavian systems, and the Continental European countries going through a rapid conventional-to-renewables shift. Various studies by member states, research institutes, the European Commission (EC), and transmission system operators have emphasised this benefit.

Offshore energy over a wide area, connected with various onshore national generation blocks, forms a geographically diverse mix of resources with a relatively high number of full-load hours. For each North Sea country individually and the region as a whole, such an energy block offers a reliable contribution in the future energy mix and acts as a **cornerstone for a secure energy provision.**

Forecasting models, generation adequacy methodologies, demand response systems, and intraday and reserve markets have all evolved strongly in the past decade to properly take into account the impact of large shares of variable renewable energy sources. Such a shift to renewable sources of electricity can also counter the ongoing trend of countries' increasing dependency on non-European primary fuel imports in the region.

Rather than seeing offshore wind as a risky new component in what is a reliable electricity system today, the benefit of a strong North Sea energy system is that it enables a real energy transition in the onshore world. Committing to a NSG vision allows member states to take **robust decisions on firm mid- to long-term capacity needs for existing conventional generation and the markets and regulations to secure them**—provided one knows what the common infrastructure view of all neighbouring systems is. This also supports a healthy further progress in demand response and storage development, which will be crucial flexibility sources for the path toward a renewables-based electricity system.

ECONOMIC DRIVER FOR THE COUNTRIES AROUND THE NORTH SEA

JOBS IN CONSTRUCTION AND OPERATIONS & MAINTENANCE IN THE EU AND BEYOND

Stimulating renewables stimulates jobs in the renewables sector in general. But it is when a region takes the lead in renewable ambitions that it can truly take a **leap in regional job creation to deliver ambitious projects and export know-how**.

In 2016, the International Renewable Energy Agency (IRENA) estimated the global number of jobs in the renewable sector to be about 8.1 million. The evolution of the sector remains volatile, as shown in the strong decline of EU jobs in the PV industry from 2011 to 2014 (a drop of 66%) while the EU wind sector was able to record an increase of 10,000 jobs in 2014. The wind sector supported about 330,000 direct and indirect jobs in the EU in 2014, covering industry branches with a clear wind focus (such as turbine manufacturers), as well as those involved in telecommunications, construction work, vessels, dredging, and other areas. The industry itself estimated that under favourable conditions, the number of EU wind jobs could rise to 500,000 by 2020 and 800,000 by 2030.

Over half of European wind energy companies have activities outside of Europe. Other global players are catching up quickly, with China already the dominant player both in terms of wind industry employment and annual capacity increases. Europe still keeps the lead in offshore wind in terms of installed capacity (91% concentrated in the North Sea) and involved companies, while other regions and countries are testing their first offshore projects. The United States currently has its first large projects under development and has ambitious goals to reach 86 GW by 2050. China has set offshore targets for 2020 as well. Early demonstration projects in challenging conditions in the North Sea and technical equipment specifications developed in European collaborations can grant advantages to **European players to expand globally**. A stall in ambition can not only result in a potential loss of cost-effective renewables deployment; it may also result in an actual loss of know-how and related sector employment.

In particular, North Sea projects farther offshore in deeper waters can create additional indirect jobs in construction and maintenance. This also **capitalizes on decades of experience in offshore activities from regional companies** in subsea cable laying vessels, dredging, offshore platform works, and more. This opportunity is all the more relevant at a time when offshore fossil fuel activities are being phased out and more focus is being placed on the temporary activity of decommissioning platforms. In addition, wind industry activities indirectly create employment in other sectors, most notably in the metal industry and the electronics sector.

HIGH-RATING LONG-TERM INVESTMENT OPPORTUNITIES

The capital requirements for committed energy infrastructure development in the North Sea would create many **long-term investment opportunities** for both private and public participation.

The European wind industry has set goals to bring offshore wind to competitive levels by 2030 and expresses confidence that this is possible under a 4 GW per year buildout scenario. The deployment of offshore energy projects strongly benefits from coordinated planning, as it allows all involved industries to bring their supply chain ambitions in line with anticipated market demand. Alignment in permitting procedures, regulatory conditions, and the timing of public tenders **gives confidence to investors** and allows for strongly competitive bids for public support. The recent result of the Borssele (the Netherlands) offshore tenders, the first in a series of five tenders organized by the Dutch government, emphasises the levels of **cost reductions** possible: the winning bids in the first two tenders came in at 73 and 54 €/MWh (excluding grid connection). Such an approach should be continued on a coordinated regional basis to provide a stable North Sea deployment roadmap. A vast share of energy, economic, and environmental benefits can become possible at acceptable costs.

Political support and coordination can attract institutional investors for longer term investment opportunities. Such support would need to grant confidence that grid and wind farm development plans are synchronized, that early demonstrators (which may not yet be economically viable) can rely on public funding as leverage, and that a rollout of tenders and aligned permitting procedures would lower the barrier of entry for developers. The potential envelope of all North Sea investments would be in the range of €190 billion to €220 billion up to 2030 for both offshore wind projects and the supporting grid.[2] This is a threefold increase of the budget the EU deems necessary for electricity transmission grid Projects of Common Interest in the coming 5 years, for which political support, direct public funding, and national regulatory support are already given on a case-by-case basis. An important question remains as to whether 4 GW a year (which amounts to one next-generation 10 MW turbine per day) is sufficient to meet our shared climate targets.

Institutional investors (e.g., pension funds and insurance companies) are focusing more and more on sustainable energy projects. Annual sustainable energy investment has already surpassed conventional generation investment. Institutional investors have looked into direct project support, as well as green energy bonds. **Political commitment to supporting the North Sea energy infrastructure transition with stable conditions and coordinated actions will boost investor confidence**. The finance sector itself would need to enter the early discussion and develop guidelines and criteria to evaluate individual projects in the North Sea energy portfolio to share knowledge and protect value. This would complement the actions many investors are already taking in incorporating climate change and carbon intensity into asset class allocations.

SPEARHEADING EUROPEAN INNOVATION

The region's wind industry keeps its pole position through a firm commitment of reinvesting 5% of its annual turnover in research. For wind turbine manufacturers this goes up to 10%, ranking them among the most research-focused industry branches in Europe. The industry has set a goal of €600 million in R&D efforts per year up to 2020, pooled for 52% by private funding, 31% by EU funds, and 17% by national programs. Europe remains a world leader in renewable R&D expenditures, covering the budget of the United States and China combined. This continues a decades-long trend where universities and research institutes in North Sea countries have become world leaders in wind energy research, and where European companies hold over half of all relevant technology patents worldwide. Up until some years ago, wind energy innovations covered a third of all energy-related patents filed in Europe. However, in recent years the number of European wind energy patents has been in decline, partly due to stronger global competition, unclear post-2020 forecasts, and pressure on R&D expenditures.

A further dive into offshore energy and the ambition to bring costs to competitive levels will require particular research focus. To maximize such research efforts, **both private and public funding programs need to be ambitious and address the relevant challenges of a massive offshore wind energy deployment across the value chain**, spanning from turbines to grid connections to construction.

BUSINESS DEVELOPMENT IN PORTS AROUND THE NORTH SEA

Many of the ports in the region depend heavily on fossil fuel throughput. Historically, this was due to a large throughput of primary energy sources extracted from the North Sea. This throughput has been in strong decline for more than a decade and has already resulted in the decommissioning of many offshore platforms. At present, there are 715 installations in the North Sea—of which more than half are in UK waters—with an average lifetime of 25 years. About 10% has been decommissioned so far, and while this creates a particular industry boom for decommissioning works, it also opens many questions on financing and whether installations are to be completely removed or can partially be left in the seas (e.g., as environmental habitats).

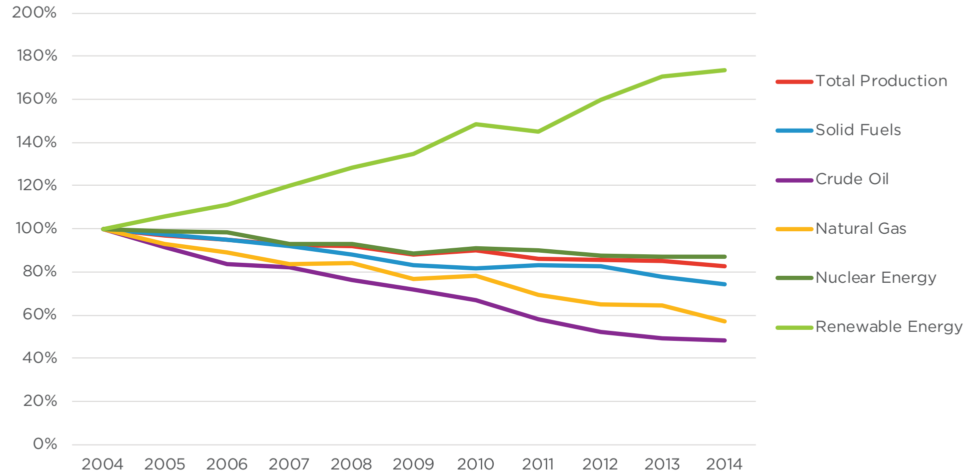

Figure 4 - Evolution of extraction of primary energy since 2004 in the EU, based on EuroStat

2. Focusing only on CAPEX at time of development, without assumptions on O&M, decommissioning, or cost of capital. Figures based on Ecofys wind energy cost model and offshore transmission cost model as applied in various studies, and estimated potential for cost reductions by 2030.

This decline of North Sea fuel extraction increased the EU's dependence on non-EU imports by over 10% in the past decade and has raised concerns on overall energy security of supply, as shown in Figure 4. Over half of the EU's energy demand is now supplied by non-EU sources. In the North Sea region, this is not an issue for Norway and Denmark, though it is a medium risk for the Netherlands (at 33% dependence) and a more substantial risk for the UK, France, Germany, and Belgium (with dependence levels ranging from 45% to 80%).

A large share of the economic growth in North Sea harbours is still based on throughput of crude oil, as illustrated by the doubling of both import and export of oil products in the Rotterdam port (Figure 5, Figure 6). Renewable sources and energy efficiency measures can counter this trend, and offshore wind has a major role to play here.

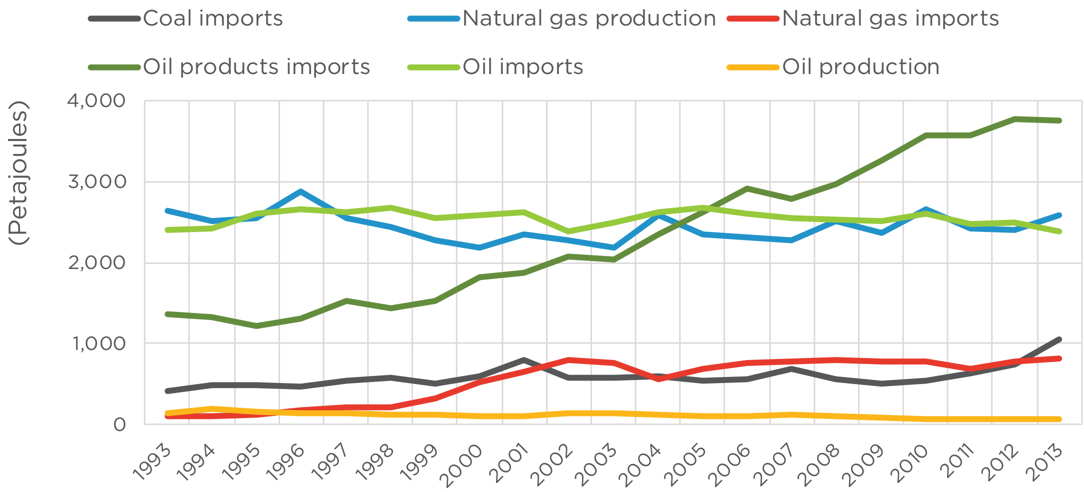

Figure 5 - Primary fuel production and import evolution in the Netherlands

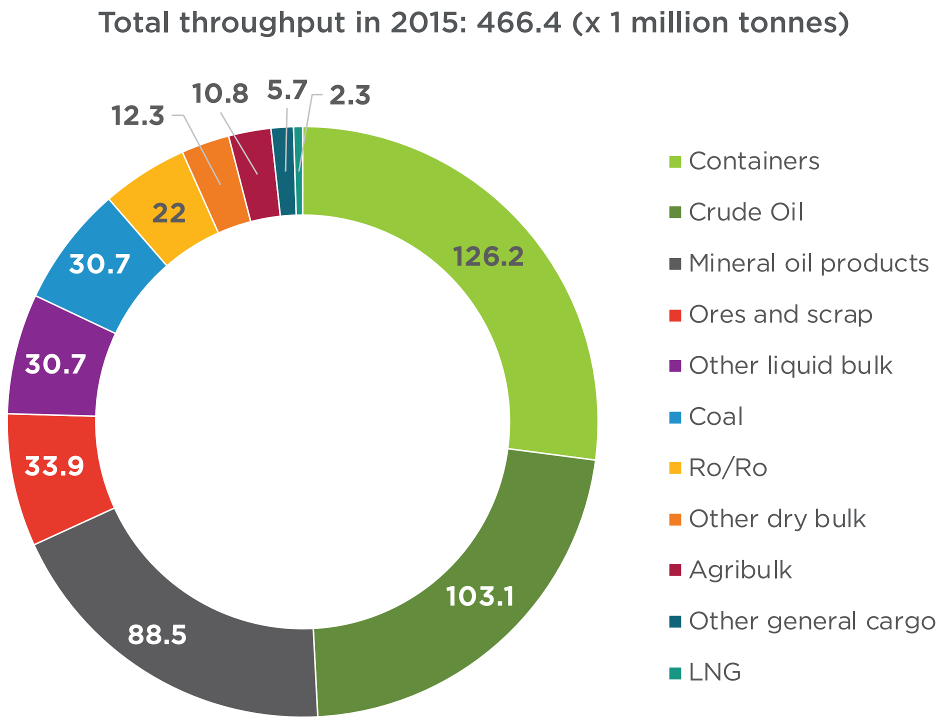

Figure 6 - Port of Rotterdam annual throughput in 2015

A transition roadmap can be devised where carbon storage is applied for more efficient end-of-reservoir extraction of oil & gas, possibly even with a final scheme to store onshore carbon in offshore cavities. Still, such measures are temporary and need to be seen in the context of 2030 sustainable energy targets and beyond.

Many **harbours are already implementing sustainable solutions** such as local renewable generators, power-to-biofuels conversion, and energy efficiency measures. Around 2050, not only the operations but also the throughput of major ports like Antwerp and Rotterdam will need to fit in energy systems that are practically free of carbon. The rapid transition required can be based on **North Sea ports becoming the onshore hubs for an offshore wind energy-based system in terms of infrastructure connection, manufacturing sites, and operational centres for construction and maintenance of offshore wind**.

A massive offshore wind development continuing farther off the coast will have large impact on the way supplying ports are designed. In some cases, such a development may even require some port activities to be taken offshore to an artificial harbour infrastructure. Port activities cover service bases for O&M teams; assembly sites for foundations, turbines, and piles; specialized vessels; storage of spare parts; decommissioning yards; and others. Additionally, manufacturing sites (for turbines, cabling, and platforms) are expected to move closer to the key offshore development harbours. About 70 ports around the North Sea are seen as potential candidates for becoming such key connection points. A minimum number of these ports will have to go through such a transformation in order to avoid further logistical barriers to offshore development. The implementation of a North Sea energy vision needs to consider this onshore infrastructure as well.

CONTRIBUTING TO HEALTHY MARINE BIODIVERSITY

INTEGRATED MARITIME SPATIAL PLANNING

All plans for offshore assets need to go through a thorough environmental impact assessment and comply with the many restrictions (including shipping routes, telecom lines, military areas, and more) in what is one of the busiest seas worldwide. Since the early 2000s, member states have also been obliged to provide Strategic Environmental Assessments (SEAs) in support of land use plans that are enforced by national law. Some SEAs are available in various countries, though they do not always reflect the balance or synergies of offshore economic activities.

Rather than presenting an environmental burden, offshore energy development can involve **creating new protected areas for marine life** in wind farm clusters and around potential offshore hubs. A North Sea energy system needs to be based on an **integrated and coordinated maritime spatial planning approach**.

Figure 7 - Do not look for positive residual impact or offset of negative impact per project, but pursue integrated maritime planning by looking at all offshore economic activities to create additional protected areas and biodiversity

In environmental impact assessments (EIAs), individual offshore wind projects need to address various environmental impacts that are becoming well-known and understood after years of experience and independent monitoring of other offshore activities. Environmental impact during construction of offshore wind farms is mainly caused by piling noise. During the operational phase, substantial long-term impact can persist in bird migration and increased collision risks for birds. Such aspects need to be assessed and addressed to ensure truly sustainable projects get a green light. These discussions have often taken a perspective of default negative impacts per project to be tackled with mitigation measures (e.g., adaptive hammering during construction) alongside some positive side effects of offshore infrastructure as a counter balance. Such positive side effects are (among others) the protection from sea bed trawling, artificial reef creation around foundation and scour protection, new species habitats and aquacultures, and (very limited) bird habitat gain. On a per-project basis, this leads to an environmental constraints view, while on the full spectrum it could be an environmental gain, as outlined in Figure 7.

The European directive 2014/89/EU on maritime spatial planning explicitly calls on member states to provide national planning procedures focusing on multi-purpose usage, looking at energy, maritime transport, fisheries, aquaculture sectors, tourism, and the extraction of raw materials while ensuring the preservation, protection, and improvement of the environment. The directive does explicitly require member states to collaborate and gives a monitoring role to the EC. Implementation of the directive by member states had to be done by September 2016. Essentially, this should lead to balanced economic planning underpinned by a SEA looking at all offshore activities. Coordination or joint guidance is needed to align all of these goals at the regional level. This will be the basis for individual projects with specific and more detailed EIAs to build on.

The Political Declaration of North Sea member states gives a work program in which the first mentioned task is the coordination of maritime planning in terms of procedures, data, and best practice sharing. It is crucial to start from this process perspective. However, the ambition should be centred around what the directive on maritime planning actually aims at: a **truly integrated view on how the North Sea resources can bring benefits to shore in terms of energy, fisheries, and employment, while its precious resources are protected and fostered**.

CREATE MARINE BIODIVERSITY AREAS

A lesson learned from many onshore transmission corridors is that planning of energy infrastructure and catering for environmental protection can create win-win situations via the creation of biodiversity corridors. This lesson is just as valuable in wide offshore domains. Environmental preservation should not be limited to a piece-by-piece approach but should instead be the starting point in designing an offshore energy system.

Local reserves are particularly beneficial to **preserving and increasing population levels of stationary or semi-stationary fish species,** as shown in various monitoring activities. Wind farms can offer restriction from other activities, combined with increases in biomass on hard substrates.

An increasing number of offshore energy sites and the simultaneous decline in oil & gas rigs needs to be done with the **assurance that a target share of the area is protected**. The European Environmental Energy Agency noted that only about 1% of present North Sea marine protected areas have an effective enforcement of protection rules. Wind park sites can provide clear protected areas.

Studies have shown that effective reserves also have a spill-over benefit to the surrounding area. A **chain of such reserves can be the basis for new marine nature corridors**. Integrated maritime planning should explore how new migration corridors for species can be ensured, how artificial reefs can play a role in this, and how new habitats for sea life can be created.

SUSTAINABLE FISHERY AREAS

The North Sea has experienced serious overfishing in past decades, resulting in common fisheries policies and national quotas to ensure sustainable fish populations and fishing activities. Overfishing also had impact on bird populations and other species. Offshore wind parks can be incubators to keep total populations at the right levels. Several wind parks have already successfully created aquacultures (e.g., for mussel cultivation), and there are indications that stationary fish like the greater sandeel could benefit from offshore wind farms for spawning.

Whether an area is more suited for habitat gain with a widespread impact on marine life as a whole or for dedicated fishery activities depends on many site-specific conditions, as well as the way such areas are linked to each other. Again, this underlines the value of an integrated plan based on coordination, commitment, and knowledge sharing to also highlight a sustainable way forward for the fishery industry with respect to geographic planning and the need for innovation.

As such, the circle can be closed with sustainable energy/fishery zones mitigating climate change, limiting the increase of sea water temperatures and acidity levels, and preserving sea life. Sustainable fishery policies need to be part of integrated planning. This does not mean simply looking at constraints; integrated planning is not just scrutinizing opportunities, but also involves jointly looking for win-win situations across sectors and border states.

A CALL FOR ACTION

This paper strongly supports the ambitions echoed for years by the energy industry, system operators, member states, and European institutions to develop a world-leading offshore energy infrastructure in the North Sea. When done right, such a system would bring benefits to the entire region and Europe as a whole in terms of the sustainable development of energy, economies, and marine life.

The realization of such a North Sea energy system requires understanding of all benefits (direct and direct), acknowledgment of the challenges and barriers in an open dialogue, and ultimately the concerted cooperation and commitment of all involved parties.

As pointed out in the recent "Political Declaration on energy cooperation between the North Seas Countries," the work programs by North Sea member states and the EC need to be initiated soon. If we start from a buy-in to the vision as outlined in this paper and take into account the many existing studies that have explored specific parts of the benefits and complexities, the following key questions remain to be addressed:

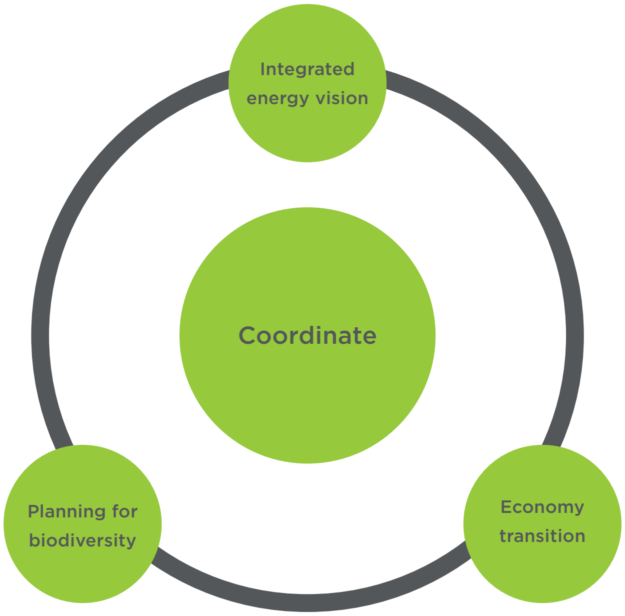

Figure 8 - The benefits of a North Sea energy system

- Who steers the implementation of such a vision? Regional cooperation and involvement of all actors is a must. What are the limits of voluntary cooperation, and how is the perception or drawback of stringent central planning avoided? Do we foresee a leading consortium of industry actors, a renewed commitment of national competent bodies, or a top-down EU legislative initiative?
- At the same time, such an implementation can require fundamental changes in the roles of particular entities as they exist today, including member state competencies in economic development and permitting, grid planning and operation responsibilities, regulatory oversight, and EU climate change governance. Should this review be taken up before diving into practical aspects of developing an offshore energy system?
- How does a regional coordinated offshore rollout affect medium- and long-term renewables targets of member states? What is the potential and the limit of sharing renewables support measures?
- Is a 4 GW per year rollout scenario up to 2030 sufficient in the strive for limiting global temperature rise to 1.5 °C?
- How does your organization/sector position itself in this transition?
- How can a roadmap be implemented to clarify which actors need to take which step by when? A provisional roadmap focusing on outcomes rather than actions is given in the Annex for further discussion.

This paper has been co-shaped with views of key sectors in this energy transition.

ANNEX – POSSIBLE ROADMAP STEPS

SHORT-TERM

- Common North Sea Vision
  - Ensure that the leading collaboration platform for the North Sea energy system vision involves all actors, including policymakers, sector organizations, and local stakeholders; that it is able to steer the discussion on targets; and that it can tackle short-term and long-term actions with a step-by-step approach.
  - Coordinate maritime planning activities, building on sustainable energy ambitions, the need for reconversion and support of specific industries (e.g., fossil fuels, offshore original equipment manufacturers, ports, and fisheries), and the preservation of natural resources. This involves coordination at the member state level across economic sectors, as well as at the regional level in light of common targets.
  - Get buy-in of all affected sectors to join this energy transition and align individual business strategies in different economic sectors. Develop guidance and best practice sharing collaboration for each sector.
- Energy Approach
  - Establish a target energy system specification based on offshore wind and grids and complementing onshore energy mixes (electricity and others).
  - Align market rules and regulatory conditions to remove market barriers for coordinated wind farm and grid development and integrate all energy markets.
  - Develop a joint North Sea offshore support scheme, taking into account fair cost-sharing of support and regulated assets, as well as sharing of RES targets.
  - Get regulatory and member state buy-in for cost allocation of the entire energy system architecture on the basis of all benefits including infrastructure, national support mechanisms, and other economy benefits (e.g., employment, fisheries, and ports).
  - Maximize investor confidence, both for institutional investors across the entire system financing as well as for first movers in terms of risk levels. This requires both political commitment and finance industry guidance.
  - Create a stable planning and permitting trajectory for the coming years so that industry and developers across the value chain can prepare themselves for competitive levels.
  - Maintain technological leadership by continuing (public) R&D, turnover to the market, and exports globally.
- Get it Started
  - Bring full support from all regional actors for flagship projects that combine interconnection and wind farm connection where it has been proven to be beneficial to society. This support needs to tackle financial risk levels and demonstrate the technological maturity and compatibility of procedures and market rules.

MID-TERM

- Monitor/Review/Promote
  - Ensure that new project proposals are tested against the target system.
  - Adapt national support mechanisms/budgets for new projects based on reached competitiveness levels and roadmap progress.
  - Use regional adequacy assessments to steer the transition of the onshore energy mix (e.g., phaseout or capacity remuneration of conventional generation, stimulus for storage, and demand response).
  - Handle cost allocations via a regional tariff component that is stable but can handle regular reviews if needed.
  - Monitor targets on sustainable energy and other offshore economy branches, as well as environmental development. Close the gap building on experience of regional collaboration.
  - Promote European knowledge in other areas worldwide (e.g., the United States and Southeast Asia).

APPENDIX I

REFERENCES

1. EU Reference Scenario, (published June 2016)
2. EWEA, Wind energy scenarios for 2030, (published August 2015)
3. ENTSO-E, TYNDP 2016 Scenario Development Report, (published November 2015)
4. European Parliament report on “achieving the 10 % electricity interconnection target – Making Europe’s electricity grid fit for 2020,” (published November 2015)
5. Ecofys, RPS, “BEAGINS - Baseline Environmental Assessment for the Grid in the Irish and North Sea,” project for EC
6. EWEA, Green Growth report, 2012
7. IRENA, Renewable Energy and Jobs, Annual Review 2016
8. US Department of Energy and Department of Interior, National Offshore Wind Strategy, September 2016
9. Global Wind Energy Council, Annual Report 2015
10. Sofia Gkatsou, Maria Kounenou, Panagiota Papanagiotou, Dimitra Seremeti, Dimitrios Georgakellos, “The Impact of Green Energy on Employment: A Preliminary Analysis,” International Journal of Business and Social Science Vol. 5 No. 1; January 2014
11. WindEurope, “Offshore wind can reduce costs to below €80/MWh by 2025,” June 2016
12. EC, 2nd list of Union Projects of Common Interest, November 2015
13. European Wind Energy Technology Platform, “Strategic Research Agenda / Market Deployment Strategy”
14. REN-21 annual report 2016
15. ARUP, “Decommissioning in the North Sea”
16. TenneT North Sea Infrastructure vision, June 2016
17. ENTSO-E, Ten Year Network Development Plan 2016, final version June 2016
18. Eurostat, Energy dependence, 2014 data
19. Port of Rotterdam, Facts and figures energy port and petrochemical cluster
20. Leanwind, “Logistic Efficiencies And Naval architecture for Wind Installations with Novel Developments,” EU funded FP7 program, 2014
21. International Union for Conservation of Nature, “Greening Blue Energy”
22. Linus Hammar, Diana Perry, Martin Gullström, “Offshore Wind Power for Marine Conservation,” Open Journal of Marine Science, 2016, 6, 66-78
23. European Commission (2014) Directive 2014/89/EU of the European Parliament and of the Council: Establishing a Framework for Maritime Spatial Planning. Official Journal of the European Union, 135-145.
24. LIFE-ELIA project under the EC’s LIFE+ program, ‘Vegetation mapping of powerline corridors in forests’
25. Boston University, “Marine reserves will need stepping stones to help fishes disperse between them,” October 2015

CONTACTS

KEES VAN DER LEUN

Director
+31 (0)30 662 3310
k.vanderleun@ecofys.com

EDWIN HAESEN

Associate Director
+32 (0)2 880 41 05
e.haesen@ecofys.com

navigant.com/Energy

About Navigant

Navigant Consulting, Inc. (NYSE: NCI) is a specialized, global professional services firm that helps clients take control of their future. Navigant's professionals apply deep industry knowledge, substantive technical expertise, and an enterprising approach to help clients build, manage, and/or protect their business interests. With a focus on markets and clients facing transformational change and significant regulatory or legal pressures, the firm primarily serves clients in the healthcare, energy, and financial services industries. Across a range of advisory, consulting, outsourcing, and technology/analytics services, Navigant's practitioners bring sharp insight that pinpoints opportunities and delivers powerful results. More information about Navigant can be found at navigant.com.

linkedin.com/company/navigant

twitter.com/navigant

APPENDIX II

GLOSSARY OF TERMS

AC	Alternating Current
ENTSO-E	European Network of Transmission System Operators
EC	European Commission
EEG	Erneuerbare-Energien-Gesetz (German Renewable Energy Sources Act)
EIA	Environmental Impact Assessement
EU	European Union
IRENA	International Renewable Energy Agency
O&M	Operations & Maintenance
PV	Photovoltaic
RES	Renewable Energy Sources
SEA	Strategic Environmental Assessment
TSO	Transmission System Operator
TYNDP	Ten-Year Network Development Plan