The North Sea

as a springboard for
the green transition

UN CLIMATE CHANGE CONFERENCE UK 2021

IN PARTNERSHIP WITH ITALY

The 26th UN Climate Change Conference of the Parties aims to accelerate action towards the goals of the Paris Agreement and the UN Framework Convention on Climate Change. The four research centres at the origin of this document, NorthWind, NCCS, LowEmission and NTRANS, have as one of their goals to contribute to fact-based policymaking. This document was prepared ahead of COP26 and constitutes the foundation for our advice to policy makers about the green transition in the North Sea.

NCCS
NORWEGIAN CCS RESEARCH CENTRE

The Norwegian CCS Research Centre (NCCS) is a Centre for Environment-Friendly Energy Research in the fields of CO_2 capture, transport, storage and CCS chain including non-technical issues. The centre's main task is to fast-track implementation of CCS through industry- and research-driven innovation. NCCS also aims to ensure that Norway remains an international leading CCS actor and contributes to enabling large-scale CO_2 storage in the North Sea.

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NORTH WIND

NorthWind is a Centre for Environment-Friendly Energy Research dedicated to wind energy.
The centre will contribute to lowering the cost of wind energy, through research and innovation. It has a particular focus on sustainable development, enabling the creation of green jobs and increasing exports.

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NTRANS

Norwegian Centre for Energy Transition Strategies

NTRANS is a Centre for Environment-Friendly Energy Research. NTRANS is established to deliver world leading research on the energy system in the transition to the zero-emission society. NTRANS focuses on the role of the energy system in the decarbonization of sectors such as energy, transport, industry, and buildings, as well as our everyday lives.

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LOWEMISSION

LowEmission works on developing next-generation of low-emission technology to help the oil and gas industry achieve zero emissions on the Norwegian continental shelf.

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These four research centres are financed by the Research Council of Norway and by the centres' respective partners. They have a strong focus on fostering collaboration between research institutions and industry, as well as on educating the masters' students and PhDs that will become tomorrow's experts on green technologies. Since the centres work on research challenges of international interest, they collaborate with international research partners. The centres' research partners in the North Sea region are co-signatories of this document.

The North Sea as a springboard for the green transition

The nations bordering the North Sea have long benefited from its bounty. The fish was abundant, the trade routes were lucrative and in more recent times, the oil and gas were plentiful.

Now these countries, along with the rest of the world, stand before a challenge on a scale never seen before. The Intergovernmental Panel on Climate Change made it clear in August that the climate of the future depends on the decisions we take today. The countries bordering the North Sea have a unique opportunity to use their knowledge and expertise about the area to implement novel solutions to the climate crisis.

The oil and gas activity has given us an enormous amount of knowledge about the North Sea, its seabed and what lies underneath. This wealth of information can be put to use to build wind farms far from the shores, to provide us the renewable energy that is essential to the green shift. This same knowledge base makes the area one of the best in the world for CO_2 storage.

With both renewable energy and CO_2 capture in place, the production and distribution of zero-emission fuels (like hydrogen and ammonia) will be a short step away. This will help us decarbonise shipping in some of the world's busiest waters.

The connections between all these installations – with subsea cables, pipelines and ships to transport CO_2 and zero-emission fuels – can become part of a future North Sea Network, transporting CO_2 and energy between the countries bordering the North Sea.

According to the International Energy Agency's Net Zero by 2050-report[1], the goal of net zero by 2050 is unattainable without greater international co-operation. The report predicts that low international cooperation would cause a delay of 40 years. This is why the co-signers of this document call for a greater cooperation between countries for green transition projects in the North Sea. With concerted and targeted efforts by the countries that border it, the North Sea can become a test bed for green transition technology, creating new solutions that can be applied in the rest of the world.

Offshore wind

Achieving carbon neutrality will require large-scale electrification (of the industry and transport sectors, for example). This will increase the demand for renewable energy even more. The EU plans on meeting a part of that demand by installing 300 GW of offshore wind capacity by 2050[2] – installed capacity currently lies at about 25 GW[3]. This EU commitment represents a golden opportunity for the countries bordering the North Sea to make good use of their industrial expertise working offshore to simultaneously contribute to the green shift and generate economic activity.

The need for more renewable energy

The future is largely electric. By 2050, electricity's share of the total final energy consumption (the total energy consumed by end users) will jump to 50%. In 2020, it was at 20%[1]. To reach carbon neutrality, a large portion of this renewable energy will have to come from offshore wind.

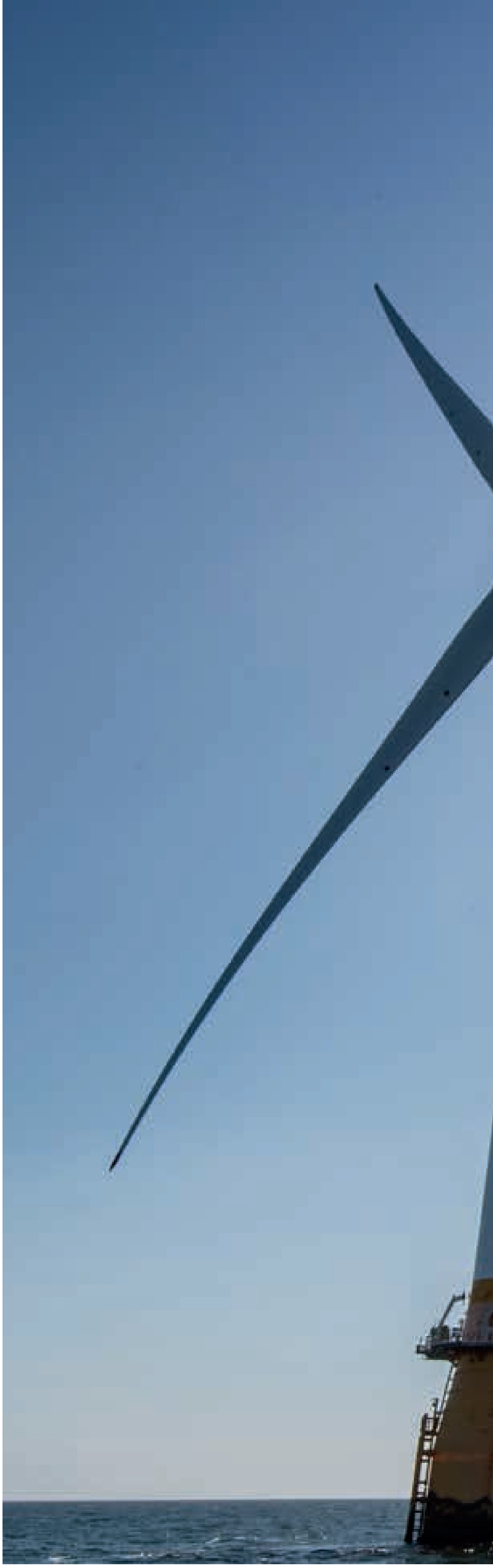
The low cost of wind energy

Wind energy long had a reputation of being expensive and depending on subsidies. This could not be further from the truth today, with land-based wind power being profitable at a cost of around 0.029 EUR per kWh[4], assuming a good wind site. At that cost, wind power is often cheaper than the other alternatives. At sea, the cost is higher but currently undergoing the same kinds of reductions observed in the previous decades for land-based wind power. Dogger Bank Offshore Development Zone (UK)[5] is now under development with bottom-fixed offshore wind turbines, at a cost of 0.049 EUR per kWh. Floating wind is still in its early development phase, with a cost of about 0.098 EUR per kWh*. But research is underway to reduce those costs by half before 2030.

The pathway to cheaper offshore wind

Reduced costs can be achieved for offshore wind through a combination of development, research and innovation. The development part of the equation has to happen at a large enough scale to enable the creation of an industry and supply chain. But development alone won't be enough. There are still a number of research hurdles that need to be dealt with to reduce costs and pave the way to profitability. The challenges currently being worked on range from making subsea cables more durable, lighter and cheaper to install, to optimising the design of support structures, to improving computer models allowing for a more efficient operation and maintenance.

* Here as well, the figure assumes a good wind site



Floating wind turbines at Hywind Scotland, the world's largest floating wind farm, north-east of Aberdeen. Photo: Michal Wachucik /Equinor.

CO_2 capture and storage

CO_2 capture, transport and storage (CCS) is a crucial technology to reach carbon neutrality by 2050 – even in scenarios with huge advances in renewable energy and energy efficiency.

The North Sea boasts ideal conditions for safe and effective CO_2 storage. The potential storage capacity is enormous: There is enough of it to establish a new industry, offering safe CO_2 storage spaces to other countries located further away from the North Sea. A SINTEF study published in 2018[6] concluded that the European market potential for CCS would be at over 40 million euros by 2050.

CCS is important for another reason: it enables the production of blue hydrogen, necessary for a quick scaling up of Europe's hydrogen infrastructure in the decades to come.

What CCS is – and why it matters

CCS consists of an array of technologies and processes that can allow for large cuts in CO_2 emissions. This is achieved by capturing and concentrating waste CO_2 instead of releasing it into the air, then transporting it and injecting it deep underground.

In Norway, this is done beneath the seabed, into saline aquifers (porous geological formations that contain water), or sealed reservoirs that once held fossil fuels. CCS technologies also provide the foundation required to support carbon removal solutions from, for example, bio-based processes or direct capture from the atmosphere (also known as Direct Air Capture/DAC).

While renewable energy and energy efficiency measures have a major part to play in combating global warming, the world's energy demand continues to grow. Prior to the Covid-19 pandemic, the International Energy Agency (IEA) projected a growth in global energy demand of 12% between 2019 and 2030[7]. Decarbonising the non-renewable portion of that energy generation is a must as we move through the green transition. CCS is also the only technology that can decarbonise critical industrial sectors, such as cement and metal production, and waste incineration.

Of the hundreds of emission scenarios showing different evolutions of the energy system towards the goals of the Paris Agreement, CCS plays a crucial role in almost all of them.

Building on the current momentum

Momentum is building for CCS around the world, with research and pilot projects underway in many countries. The recent IEA report "Net Zero by 2050"[1] pegs the current global CCS capacity at 40 megatons a year. It goes on saying that the world will need a capacity of 7600 megatons by 2050, to reach carbon neutrality. Already now projects have been started or are in the planning phase in Norway, Portugal, the UK, the Netherlands and Denmark[8]. The

By 2060, **14%**
of all emissions reductions
have to come from CCS

Source: NCCS

global geological storage capacity is more than sufficient to reach the 2050 goal. However, getting there will require political and industrial leadership similar to what was deployed in the Covid-19 vaccine development and the US Apollo program. Now is the time to call for a global and binding climate action plan.

The North Sea is ideal for CO_2 storage

Deep underneath the North Sea lie rock formations that will provide safe storage for CO_2 in the massive quantities needed to meet the demand. CO_2 storage in the North Sea has been proven over decades[9]. Using this real-world data, research is ongoing to refine models, improve efficiency and reduce costs.

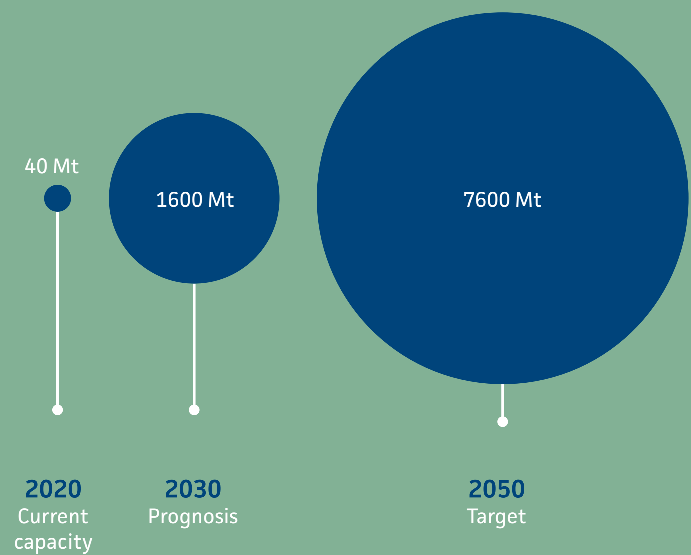
Many storage sites are as deep as 2600 meters below the seabed. That's more than three times the minimum required to get temperatures and pressures that are high enough to keep the CO_2 in its liquid (or supercritical) state. Several rock layers (typically shale layers) provide an impermeable barrier between the CO_2 storage reservoir and the seabed.

One such site is near the Sleipner field, off the shores of Norway. Each year since 1996, the Sleipner project has injected one million tonnes of CO_2 into the subsurface beneath the seabed. The site is closely monitored, and the wealth of data collected over the years is shared openly with the scientific community – through the CO_2 DataShare[10] online portal.

Our vast knowledge of the North Sea is one of the most important reasons the area is so well-suited to CO_2 storage. Companies serving the oil and gas industry have explored the seabed for more than 50 years, building detailed models, knowledge and understanding of the area.

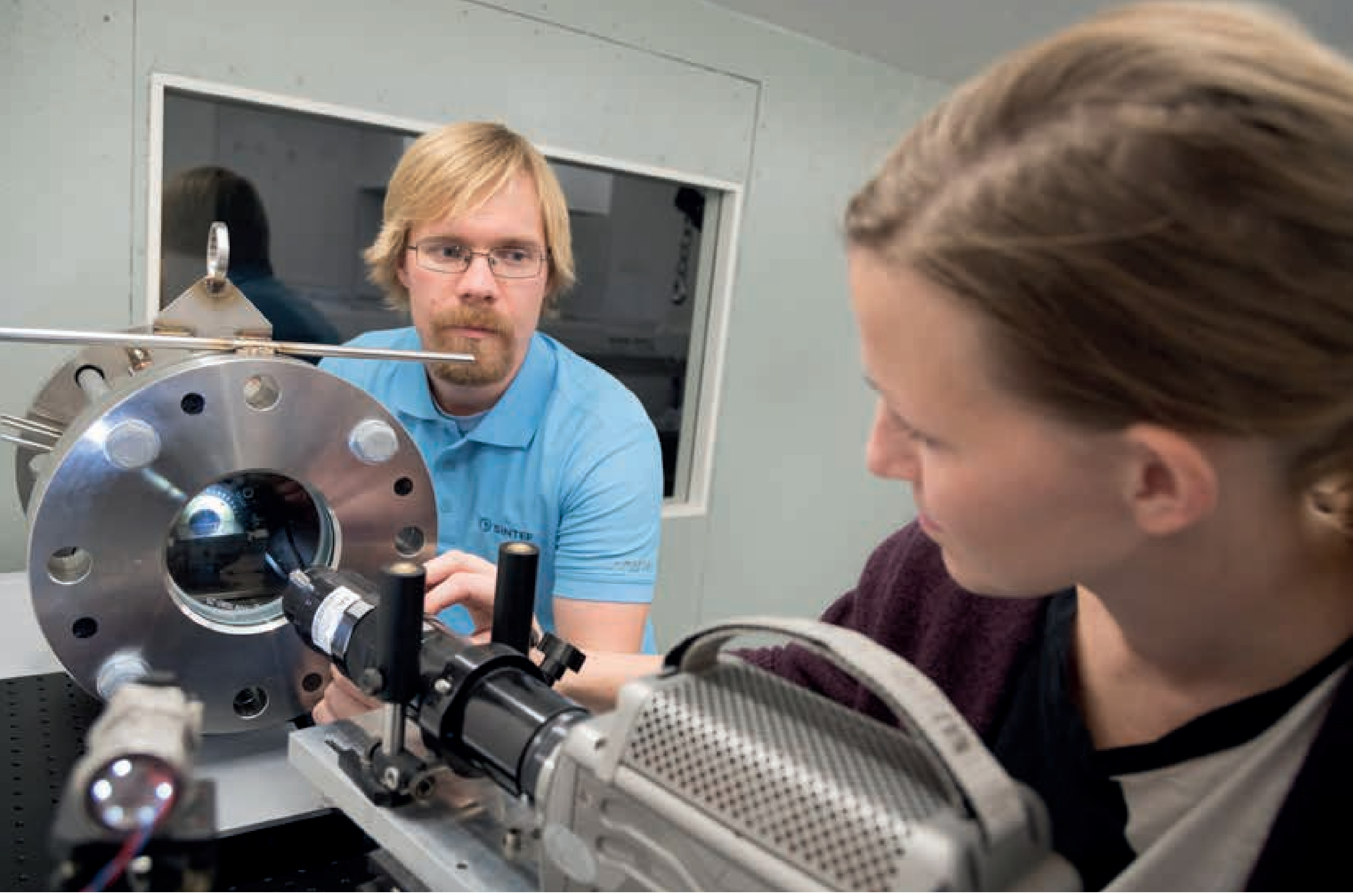
The availability of such data[11] positions the North Sea well ahead of other offshore storage options.

NEED FOR ANNUAL CCS CAPACITY TO ACHIEVE NET ZERO EMISSIONS BY 2050



SINTEF NTNU

Source: Net Zero by 2050 – A Roadmap for the Global Energy Sector, International Energy Agency, July 2021



CCS research: SINTEF scientists Åsmund Ervik and Ingrid Snustad adjust an optical setup to observe dropwise CO_2 condensation. Photo: SINTEF.

CO_2 has been injected at Norway's Sleipner field,
the first storage site in the world, since 1996

About **one million tonnes** of CO_2 are permanently stored there **every year**

CO_2 is being injected safely at 40 storage sites around the world

Source: NCCS

Hydrogen

Hydrogen made from renewable energy sources will play a critical role in Europe's future energy system. But the infrastructure needed to produce the hydrogen through electrolysis will take time to develop, as will renewable energy generation capacity.

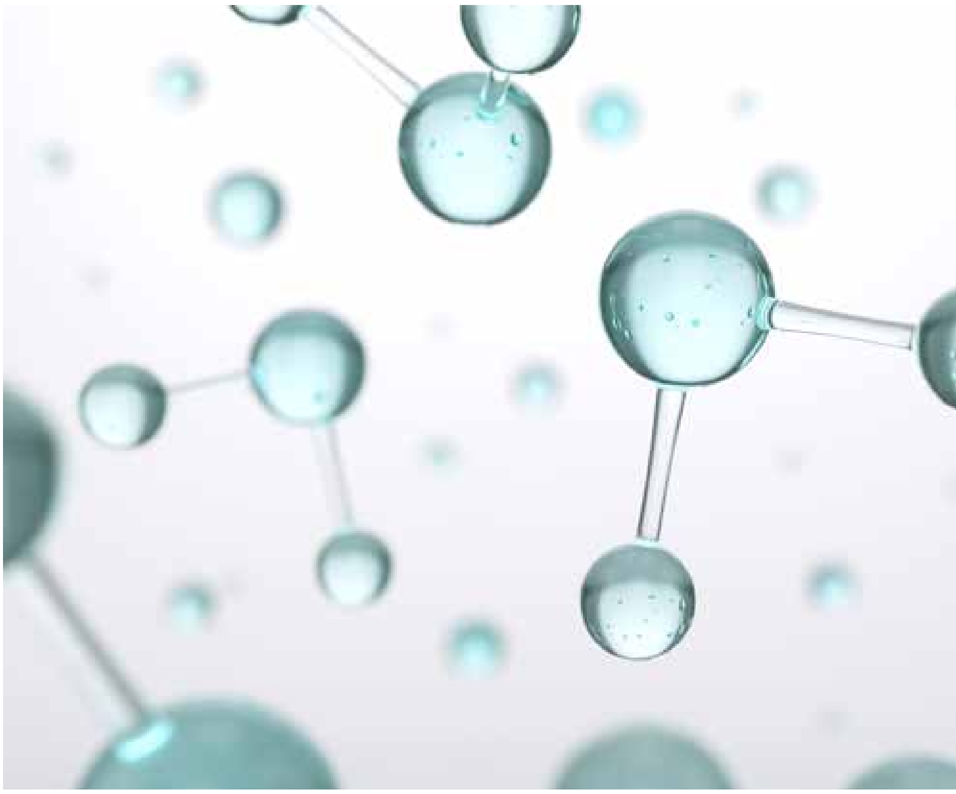
Bridging solutions are required today to help build a hydrogen infrastructure for tomorrow. Alongside longer-term investments in renewables, shorter-term investment in producing hydrogen from natural gas means we can decarbonise more industries, faster[12] – according to the study *Hydrogen for Europe*[13], released earlier this year. This method is low-carbon when the associated CO_2 emissions are mitigated with carbon capture and storage[14]. The demand for blue hydrogen comes from industries that are otherwise hard to decarbonise, such as steel production and process industries, heavy transport, and power generation. As more stringent environmental legislation and instruments such as carbon taxes are discussed, these industries face a real challenge to change.

Large-scale CO_2 storage must play a role

The Hydrogen for Europe study concluded that "unprecedented change" is needed to reach climate neutrality by 2050. We need all available options to reduce greenhouse gas emissions. That includes large-scale electrification of society and large amounts of electricity production from solar and wind, including offshore wind. But we must also develop a hydrogen market using all available production methods – including natural gas. Large-scale CO_2 storage under the North Sea will kick-start the hydrogen infrastructure we need for a renewable future.

Even without the production of blue hydrogen, we still need large volumes of storage capacity and the infrastructure necessary to capture CO_2 and transport it from industrial areas to the sites where it will be retained. This requires more industry involvement in collaborative research projects to fully understand the challenges and develop practical solutions.

But it also requires the development of business models to enable a rapid transition[15]. Governments cannot mitigate global warming alone, but neither can companies. The EU taxonomy provides a broad outline for future economic activity, while CCS projects such as Norway's *Longship* offer a template for how public-private partnerships could work to bridge the gap between pilot projects and full-scale implementation. Government investment at this stage will encourage companies to get on board earlier than they would otherwise be able to, which will drive down the costs of implementing CCS solutions at-scale.



Skills and competence building

Expertise from the oil and gas industry

The creation of new industries in offshore wind, hydrogen and CCS may seem daunting, but much of the skill and competence such industries need already exists. As oil and gas exploration and production winds down over the coming decades, this expertise can be transferred into CCS and hydrogen industries with relative ease. Major companies currently invested in oil and gas exploration are shifting their focus. Early movers will be best positioned to both retain the most experienced engineers and attract the next generation of problem-solvers, for whom climate technologies are an attractive career choice.

A strong focus on education

The new green industries will create thousands of high-skilled jobs. To succeed in establishing them, Europe needs to invest not only in research and innovation, but also in education. By increasing its investments in the education of new technicians and engineers, Europe will ensure it has the manpower required to establish new green industries. By educating scientists and keeping a strong focus on international cooperation in green transition research, Europe will be better able to solve the research challenges posed by the transition.

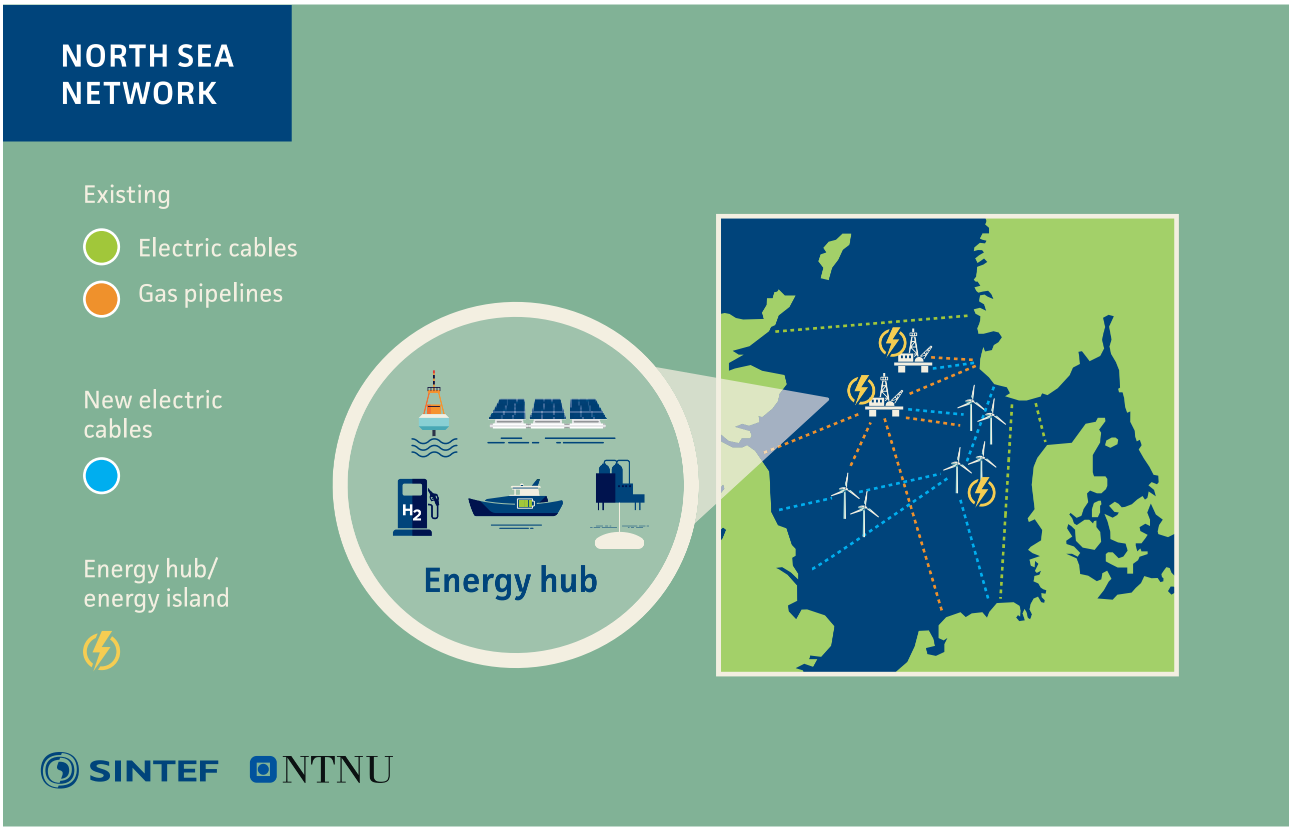
Repurposing oil and gas infrastructure

Offshore installations consist of complex and expensive infrastructure. This includes not only the platforms themselves, but the pipelines that connect to them and not least the wells, that are the most challenging and expensive part to build. As these installations get decommissioned, we should aim to give them new roles in the green shift.

The installations can be reused in many ways. Platforms can get a new lease on life as energy hubs, where renewable energy is used to produce zero-emission fuels such as ammonia and hydrogen, and distribute these fuels to passing ships or send them to the mainland via existing, repurposed pipelines. Another possibility is for platforms to house the substations needed by offshore wind farms, or to become hubs for ocean farming. The platforms can serve as production facilities for blue hydrogen, generated from natural gas with CO_2 capture and where the CO_2 is sequestered below the seabed in the repurposed, decommissioned wells.

Energy islands and the North Sea Network

Energy islands, also called "energy hubs", are set to become an important part of the North Sea's green transition infrastructure. These hubs will function as connecting points for offshore wind farms, linking them to land via the international subsea grid. They can include production facilities for zero-emission fuels, using the overflow production from wind farms to store energy in the form of ammonia or hydrogen. They could even include production of blue hydrogen with CO_2-capture and storage, with the CO_2 being injected under the seabed in a nearby disused oil well. In addition to generating zero-carbon fuels, the energy hubs could also distribute them to passing ships in need of refuelling, or to tankers for transport to land. They can serve as command posts for offshore wind installation and maintenance activities, and charging points for battery-powered ships.



Example of what a future North Sea network would look like, with offshore wind farms, connections between countries and energy hubs that can supply ships with hydrogen and include installations for CO_2-storage. The building of this infrastructure will have to happen in stages. It will require strong international cooperation and coordination between the countries and companies involved in the project.

Denmark's energy islands

Denmark plans to build two energy hubs: one in the North Sea and another in the Baltic Sea[16]. The North Sea one will serve as a connection hub for 3 GW of installed offshore wind capacity in the short term – and up to 10 GW in the long term. The idea behind this Danish energy island is to allow for a better distribution of the wind energy produced offshore, both to Denmark and to neighbouring countries. There are also plans for it to include a port and service facilities for the surrounding wind farms.

Sustainability

The environmental dimension

Like all industrial activity, green transition projects in the North Sea will have an environmental impact. The building of a large network of energy islands, CO_2-capture, transport and storage infrastructure and offshore wind farms cannot happen without impacting nature. With focused research that takes into account nature's intrinsic value[17], we can minimise this impact as much as possible. The right kind of knowledge about the species inhabiting an area slated for development can allow for technical innovations to prevent unnecessary harm to these species. Sometimes the solutions are quite simple. A Norwegian study found that painting a wind turbine's blades black resulted in 70% fewer bird deaths[18]. With the help of environmental design[19], green transition projects can be realised while still preserving species.

The social dimension

The social consequences of the North Sea's green transition projects also need to be taken into account. Other users of the space (the fishing industry for example) will have concerns that need to be addressed in a just and democratic way. This will require mapping the existing users of the North Sea, involving existing industries and stakeholders early in the process, and strengthening social science research on the ripple effects of offshore projects like wind farms, to understand potential conflicts before they appear.

The economic dimension

An analysis of Norwegian oil and gas companies' interest in offshore wind related to the ups and downs of the fossil fuel market has lessons for countries wanting to leverage the potential of the North Sea for the green transition. Historically, these companies have invested in offshore wind in periods where they were expecting lower returns on their primary – oil and gas – activities[20]. In periods where the oil and gas market was favourable again, they turned away from offshore wind and back to their fossil activities. This situation is called "double market failure", and it harms the continuity and predictability of investments needed to build economically sustainable green industries like offshore wind.

The authorities' reaction to double market failure has been to offer subsidies that either reduce the risk of transitioning to a new industry or increase the returns of that industry. We need such incentives to be directed to the oil and gas industry, and to be attractive enough to entice them to continue investing in green solutions even when the price of oil goes up.

That being said, subsidies alone will not be sufficient. Several actors across the whole value chain have to invest in new green industries simultaneously, in a coordinated manner, to ensure an efficient transition[21]. In short: an actor's success in a given industry depends on other actors also investing in that industry at the same time.

The conclusion is that to create, for example, an offshore wind industry, subsidies must be directed in such a way that they encourage a simultaneous and coordinated effort from actors across the whole offshore wind value chain.

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Notes

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