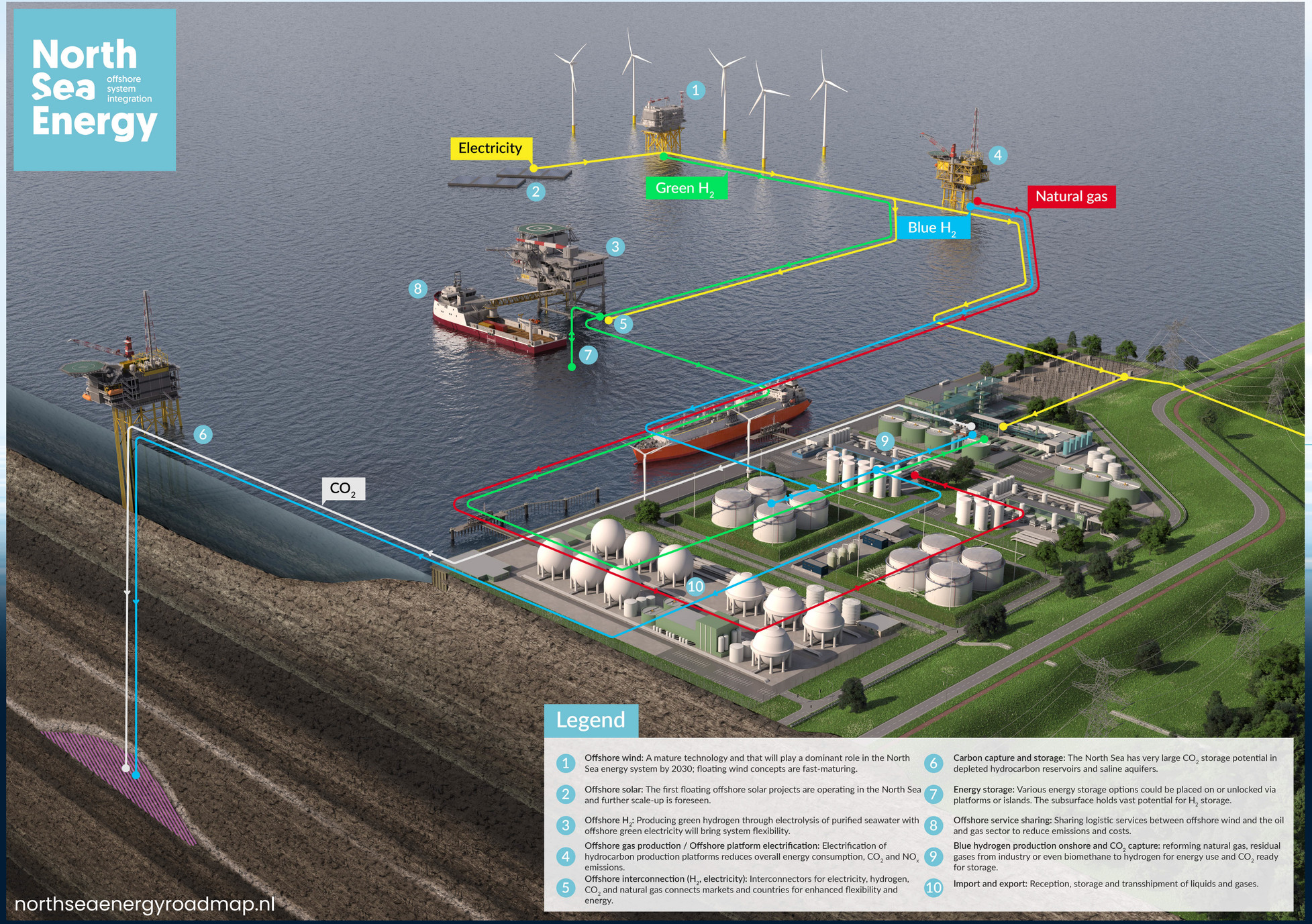
North Sea Energy
offshore system integration



Legend

1. **Offshore wind:** A mature technology and that will play a dominant role in the North Sea energy system by 2030; floating wind concepts are fast-maturing.
2. **Offshore solar:** The first floating offshore solar projects are operating in the North Sea and further scale-up is foreseen.
3. **Offshore H_2:** Producing green hydrogen through electrolysis of purified seawater with offshore green electricity will bring system flexibility.
4. **Offshore gas production / Offshore platform electrification:** Electrification of hydrocarbon production platforms reduces overall energy consumption, CO_2 and NO_x emissions.
5. **Offshore interconnection (H_2, electricity):** Interconnectors for electricity, hydrogen, CO_2 and natural gas connects markets and countries for enhanced flexibility and energy.
6. **Carbon capture and storage:** The North Sea has very large CO_2 storage potential in depleted hydrocarbon reservoirs and saline aquifers.
7. **Energy storage:** Various energy storage options could be placed on or unlocked via platforms or islands. The subsurface holds vast potential for H_2 storage.
8. **Offshore service sharing:** Sharing logistic services between offshore wind and the oil and gas sector to reduce emissions and costs.
9. **Blue hydrogen production onshore and CO_2 capture:** reforming natural gas, residual gases from industry or even biomethane to hydrogen for energy use and CO_2 ready for storage.
10. **Import and export:** Reception, storage and transshipment of liquids and gases.

northseaenergyroadmap.nl

Roadmap to **accelerate the transition to low carbon and renewable fuels.**

The North Sea energy system can provide almost 2/3 of the EU plans for offshore energy

- To unlock the potential of the North Sea within the energy transition to the fullest, boundaries between sectors, stakeholders, commodities and countries should be surpassed.
- Complete system integration needs to happen for the North Sea offshore energy system to be most effective.
- Intensive collaboration between North Sea countries needed to develop and achieve ambitious targets for all commodities in the offshore energy transition.

Go to: System integration

System integration

Vision

North Sea as pioneering powerhouse in Europe's energy transition

The North Sea region has a vast low-carbon energy potential and is set to take on the role of 'Europe's green power plant'. Europe has committed to reduce its emissions by 55% by 2030 and achieve climate neutrality by 2050. This requires a massive rollout of offshore wind capacity, combined with emerging technologies like floating solar, offshore hydrogen production, transport & storage and carbon capture & storage (CCS), as well as the orderly phase-out of gas exploration and production. This will become very challenging without an integrated and coordinated approach for the North Sea. The North Sea Energy (NSE) research program utilizes the concept of Offshore System Integration to reduce the costs, time, emissions, space and capital needed to realize the central role of the North Sea envisioned in the energy transition. Smart synergies are possible between offshore wind, marine energy, CCS, natural gas and hydrogen developments. These are a unique opportunity for the North Sea countries to become and remain an important pioneering region and innovation nucleus for global offshore energy solutions.

The integral vision draws up the North Sea energy transition in balance with nature and society

The North Sea Energy consortium envisions the North Sea as a thriving energy region that has achieved carbon neutrality, perhaps even becoming a net negative carbon sink for Europe. Offshore energy system integration is seen as an enabler to accelerate low carbon and renewable energy options that provide reliable, low-cost energy sources for industry and other end-users on its coastline and in the hinterland. Strategic sector coupling allows deeper and faster reduction of CO_2 emissions, more efficient use of marine space and effective use of energy infrastructure for conversion, transport and storage of energy commodities. This secures livelihoods to millions of people and creates new sustainable jobs for the future. Finally, offshore system integration can provide synergies with non-energy stakeholders to develop solutions that have positive impacts on nature and safety as well as contribute to sustainable food production and to the circular economy.

The North Sea Energy Roadmap sketches pathways towards system integration in 2050

This North Sea Energy roadmap presents exploratory transition pathways for offshore wind, hydrogen, CCS, and natural gas in an integrated assessment towards 2050. These pathways build on insights that were collected during a participatory process with stakeholders inside and outside the consortium; and are in alignment with national and European strategy, ambitions and targets.

It shows that transition pathways for offshore wind, hydrogen, CCS, and natural gas are intertwined and cannot be treated in isolation. Together they enable a carbon neutral energy supply in 2050 in North Sea countries. This energy supply consists of 300+ GW (1450 TWh) of wind power, 30 GW (40 TWh) of ocean energy, 21 Mt (million tonnes) of green hydrogen production (partially offshore), 7.5 Mt of blue hydrogen production, imports constituting 13.5 Mt of hydrogen and storage of 170 Mt CO_2 in 2050. More than 1600 TWh of green gas and natural gas is produced supporting the North Sea region's export position and security of supply during the energy transition. All considered, the North Sea region contributes significantly to reaching the EU's targets for offshore wind (200 GW), ocean energy (40 GW) and hydrogen (the RePowerEU ambition of 10+10 Mt of hydrogen produced and imported by 2030).

The Action Agenda identifies actions on short, medium and long term to realize a thriving North Sea

Challenges to reach the vision are the spatial challenges on the North Sea, alignment of stakeholder perspectives, complex decision-making by national and international stakeholders, gaps in the regulatory framework, sector boundaries and market conditions for long-term investments.

Within the consortium we have identified possible strategies to deal with these challenges and have formulated actions on seven main themes for all North Sea stakeholders. Additionally, we have identified sets of top three actions for six offshore energy technologies and commodities (offshore wind, marine energy, green hydrogen, blue hydrogen, CCS and natural gas) to accelerate their development and strengthen their role in the offshore energy transition. By performing these actions, stakeholders can take key steps towards harnessing the energy potential of the North Sea while respecting the carrying capacity of our economy, society and nature.

Themes and Actions

International, spatial and integral

An international vision needs to be developed with supply, transport, demand and storage targets for the integrated energy system at the North Sea with international cooperation between North Sea region nations.

Governance of the transition

Establish and align a legal and regulatory framework for the realisation, operation and decommissioning of new offshore energy initiatives.

Economic stimuli and market development offshore system integration

Establish international clarity on long-term investment climate including market framework and related support schemes.

Technical improvements (North Sea offshore demonstration Flagship programme)

Set technology specific targets for offshore energy innovations for pilot and demonstration and (early commercial) full scale projects.

Establish European portfolio approach of Research, Development & Deployment (RD&D) initiatives for offshore system integration pilots and demonstration programmes for cross-country and cross-sectoral learning: appoint demonstration areas for pilot and scale-up.

Minimize negative impacts and seek positive impacts on the ecosystem

The Ecosystem Agenda requires embedding ecological principles – of nature-inclusive design and multi-use of the environment – into the design of new offshore systems and establishing a robust North Sea Research and Monitoring Programme.

Collaboration, engagement, dissemination and communication

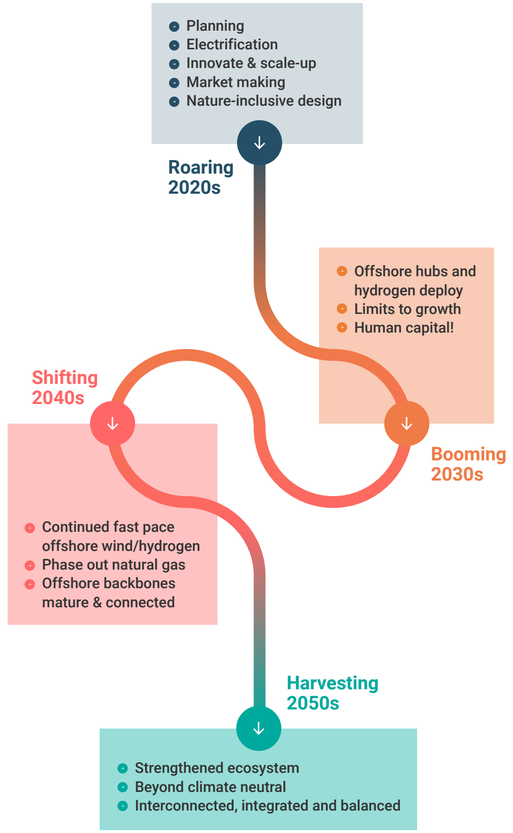
Facilitate effective collaboration and early engagement with stakeholders by establishing a dissemination platform for the exchange of objective and independent knowledge.

The Communication Agenda involves bringing the offshore into people's homes and minds to build public awareness and support for the offshore system integration.

Human capital agenda

The Human Capital Agenda requires the assessment of the medium- and long-term workforce needs and challenges faced by the future offshore energy sectors to develop a Human Capital strategy and action plan.

Take-aways per decade



Go to: Commodities specific pathways

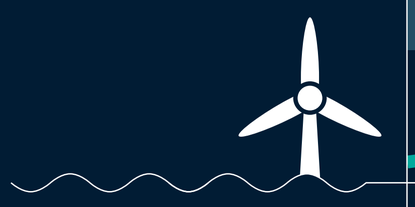
Commodities specific pathways

2022 | 2025 | 2030 | 2040 | 2050

GOALS GOALS GOALS GOALS

ACTIONS

OFFSHORE WIND



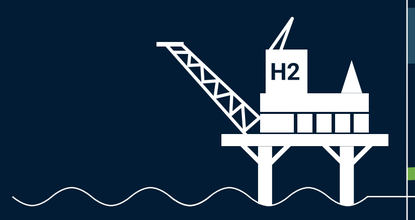
From 2025 10–13 GW annually

After 2045 7 GW

2/3 OF EU OFFSHORE WIND WILL BE REALISED IN THE NORTH SEA

- Acceleration and security of demand by electrification of industry
- Appointment of areas for future development and deployment
- Investments into infrastructure and sources of flexibility

GREEN HYDROGEN



37 GW low-carbon hydrogen production capacity in 2030

After 2035 9–10 GW added annually

2035–2050 VERY HIGH GROW RATES

- Development plan for offshore hydrogen value chains
- Secure offtake and a market framework
- Plan and develop offshore hydrogen backbone

OFFSHORE MARINE ENERGY

8 GW capacity

20 GW capacity

30 GW capacity

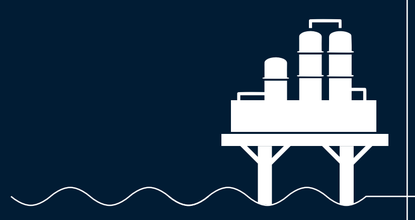
- Accelerating the scale up and development of offshore ocean energy
- Hybrid offshore energy tenders
- Derisking support for multi-energy demonstration areas

BLUE HYDROGEN

Peak of 300 TWh/yr in 2040, reduces hydrogen import dependency but at cost of higher gas consumption

- Provide investment security for blue hydrogen production assets
- Clarity on the taxonomy and priority setting of blue hydrogen in gas demands
- Plan and develop an offshore backbone for H_2 and CO_2

NATURAL GAS



Decline from 2 PWh/yr and phase out towards 2050

- Targets for natural gas
- Strategy for the decommissioning and re-use of legacy infrastructure
- Enabling the electrification of offshore hydrocarbon production

CARBON CAPTURE STORAGE (CCS)

Peak of North Sea CO_2 storage sector is forecasted for 2050 with 170 MT of CO_2 stored on annual basis, 2,5 GT is to be stored under the North sea in total by 2050

Net removal of CO_2 from atmosphere

- Solve long term liability and cross border challenges
- Provide long term market incentives
- CO_2 transport and storage basin strategy North sea