TNO innovation for life

Net Zero Technology Centre
Technology Driving Transition

# One North Sea

## 2022 Review


# Progress of energy transition projects in the North Sea

> Cross-border partnerships, alignment and joint planning in the North Sea region are key to make the energy transition a success.

# Contents




The team that developed and prepared this report included:
Ana Pires de Almeida, Cammy Booth and Luca Corradi from NZTC,
and Lydia Rycroft, Hamid Yousefi and Rene Peters from TNO.

# 1.0

# Executive Summary

**The energy crisis of 2022 forced various countries surrounding the North Sea to reconsider their stance on fossil fuel imports and exports. However, it's indicative of the energy transition's momentum that, despite the events of 2022, investment in energy transition technology projects in the North Sea continues to rise.**

Since the previous **One North Sea** (ONS) report in 2021, significant growth has been recorded in energy projects that utilise existing infrastructure. In 2022, the number of projects in the **ONS** database increased, reflecting the increased diversification of emerging energy technologies in the North Sea.

With nations surrounding the North Sea sharing the goal of reaching net zero by 2050, collaboration underpinned by the development of essential technologies will play a vital role in enabling the path to Net Zero. The database is structured to highlight changes in the technology mix being developed for use in the North Sea, and to highlight the areas of commonality between nations.

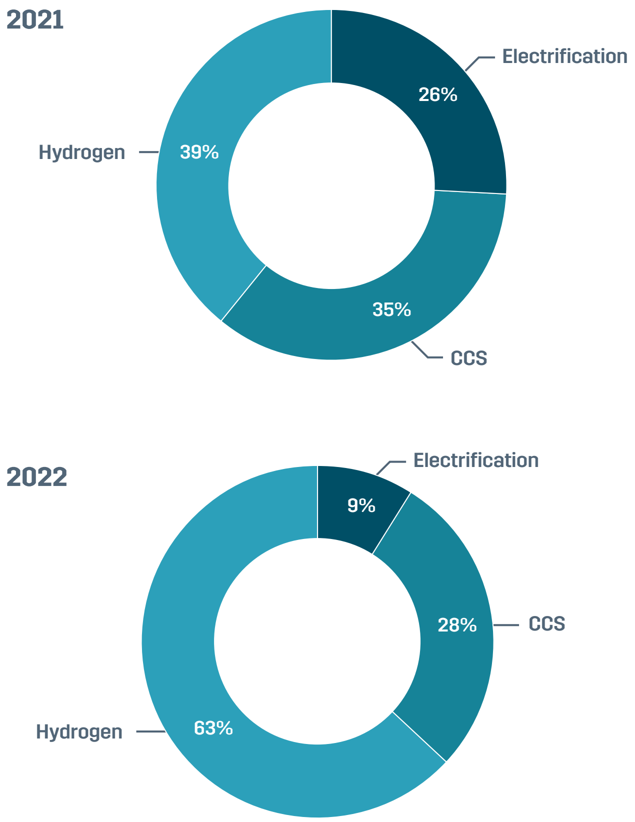



Figure 1: ONS Database Project Distribution by Theme.

2022 saw significant growth in the proportion of projects in the commercial and demonstration stages of development, indicating increased technology maturity. Projects in the commercial phase accounted for 15% of the database (up from 11% the previous year), while projects in demonstration phrase accounted for 44% of the database (up from 35%).

A lower proportion of R&D projects and increased proportions of commercial and demonstration projects is proof that clean, large-scale energy production and storage technologies are developing and beginning to have a genuine impact on the North Sea.

**Project Maturity**

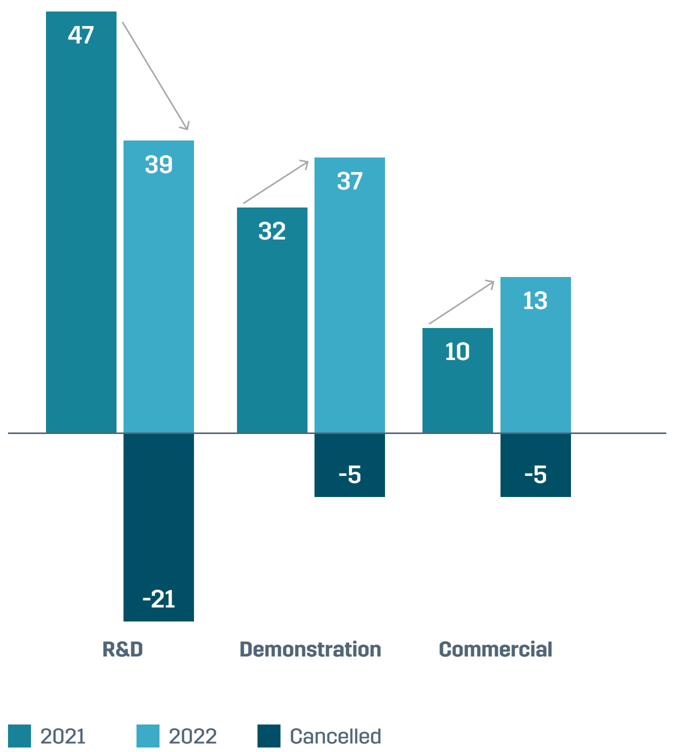



Figure 2: ONS database project count by maturity stage - 2021 v 2022

**Conclusions**

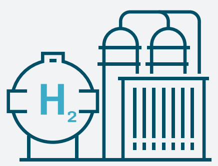
Demonstration activities will be essential to build trust in CCS technologies.

Innovative power architectures providing easy integration into existing assets, along with the maximisation of offshore wind-energy utilisation and creation of power hubs that import energy from different sources, can greatly increase the electrification options available.

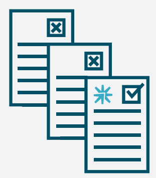
Greater efforts are needed for the establishment of supportive regulatory frameworks and standardisation initiatives to help reduce the risk associated with early-stages initiatives.

**Trends observed this year:**

Hydrogen production, storage and transportation has seen significant growth. Around 55% of new projects added to the database have a hydrogen focus.




90% of the new hydrogen production, storage and transportation projects are focused specifically on green hydrogen technologies.



Nearly one third of projects reported in 2021 have been cancelled, providing a clear indicator of the challenges faced in early stage development of technologies.

# 2.0

# Introduction

**The scope of energy projects and activities in the North Sea is rapidly changing. With oil and gas production in decline and renewable energy production steadily increasing, new synergies are emerging between novel forms of energy production, creating potential to leverage existing infrastructure in innovative ways.**

In 2021, to chart the changing landscape, the **Net Zero Technology Centre** and **TNO** established **One North Sea (ONS)**, a collaborative website that focusses on the development of emerging technology and bringing together the ideas and initiatives of research organisations, industry and government.

With a focus on the North Sea as a crucial asset to catalyse a net zero energy transition, the project aims to identify and tackle common technology barriers with nations that have a stake in the North Sea. Development of sustainable, large scale energy production and storage infrastructure in the North Sea will be key to enabling partner nations to reach net zero targets.

As offshore wind and energy storage technologies continue to rapidly develop, it's expected that a significant number of novel opportunities will arise for the electrification of North Sea installations.

The **One North Sea** database aims to provide an open catalogue, mapping out the projects and technologies being deployed in the North Sea. By allowing developers and asset owners to submit information and disseminate the outcomes of their activities, the **One North Sea** website can help increase awareness of the state of play and drive alignment and collaboration across borders.

The project provides a publicly accessible, free-to-use platform where organisations and countries can access a wide range of technologies that best fits their needs, to accelerate the journey to net zero carbon emissions. To access the ONS database, please go to: **https://onenorthsea.com/**.

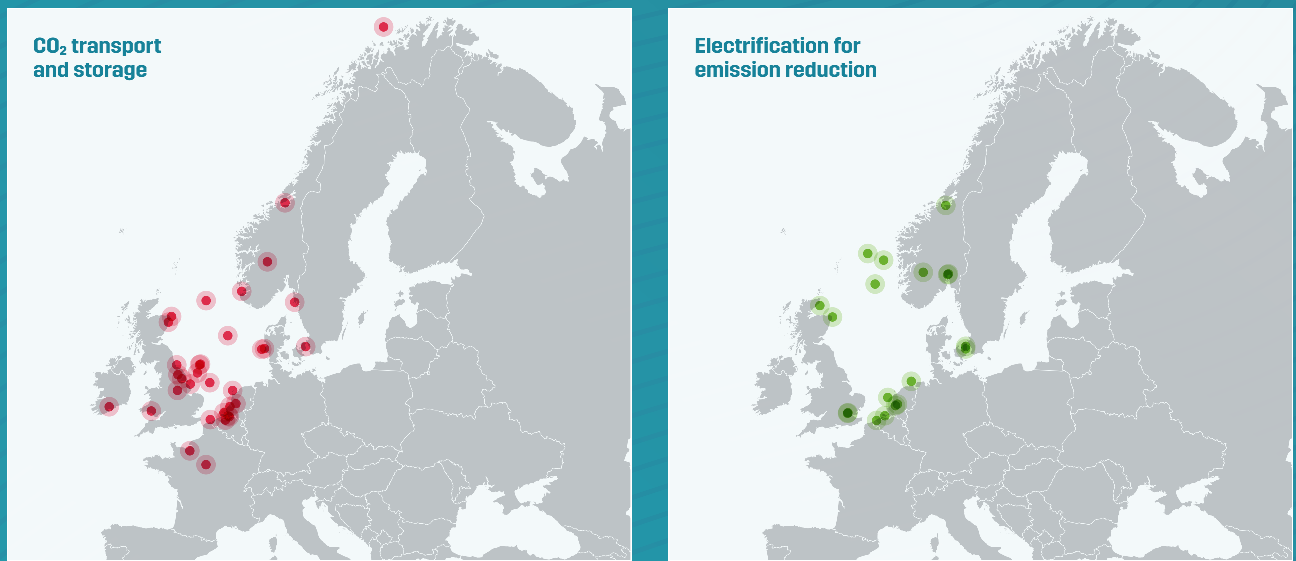
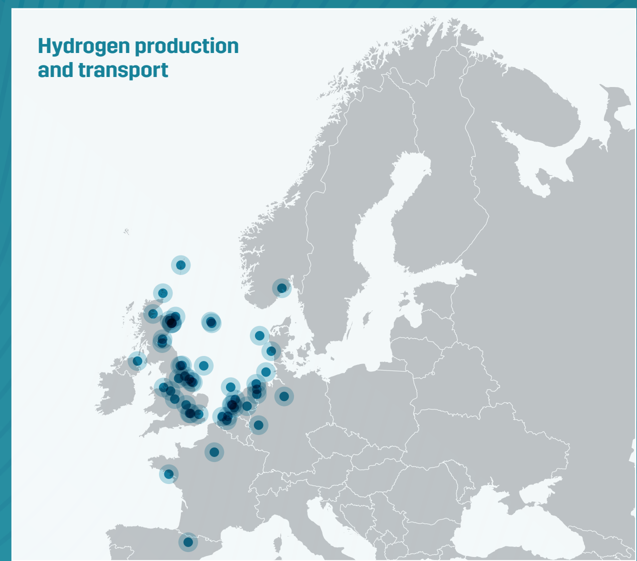



Figure 3: ONS website

| | Targets | UK | Netherlands | Norway | Germany | Denmark | Belgium |
|---|---|---|---|---|---|---|---|
| **Emissions Reduction** | 2030 | 68% | 49% | 100% [1] | 55% | 70% | 35% |
| | 2050 | 100% | 95% | 100% | 80-95% | 100% | 100% |
| **Hydrogen** | 2030 | 10GW (low carbon, 5GW green) | 3-4GW (green) | – | 10GW (green) | 4-6 GW (green) | Import of 20 TWh |

Figure 4: National Emissions Reduction and Hydrogen Production Targets

Targets taken from official, public sources




All nations surrounding the North Sea, whilst differing in approach, have very similar key goals around emissions reduction and hydrogen production targets, as shown above in Figure 4.

With the shared goal of reaching net zero by 2050, collaboration underpinned by the development of essential technologies will play a vital role in enabling the path to net zero. Ambitious hydrogen production targets are indicative of the focus that the North Sea region is placing on accelerating technology development.

[1] Norway aims to reach carbon-neutrality in 2030, but this target is dependent on emissions cuts by other countries.

# 3.0

# Deep Dive by Theme

## Since previous reporting, the ONS database has seen an increase in the total number of projects, which is a reflection of the continuous investment in emerging energy technologies in the North Sea.

This is despite the fact that over a third of the projects initially reported have since been cancelled, which is a clear indicator of the challenges faced in early stage development of technologies. Greater efforts are needed for the establishment of supportive regulatory frameworks and standardisation initiatives to help reduce the risk associated with early-stages initiatives.

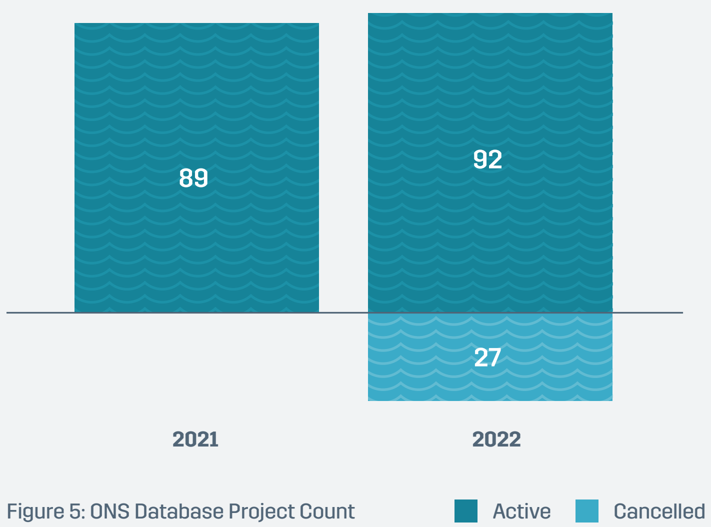



Figure 5: ONS Database Project Count

The proportion of projects in commercial and demonstration stages of development increased considerably, while the number of projects in the R&D stage went down. The early stages of development bring considerable challenges and this was evidenced by a significant number of project cancellations at the R&D stage (around one quarter or the R&D projects recorded were cancelled in this period). Projects in the commercial phase accounted for nearly 15% of the database (up from 12% the previous year), while projects in demonstration stage represented over 40% (up from 35%).

These variations highlight a notable rise in technology maturity, which is a direct outcome of stakeholder's efforts to move fast and profit from the existing window of opportunity.

**Project Maturity**

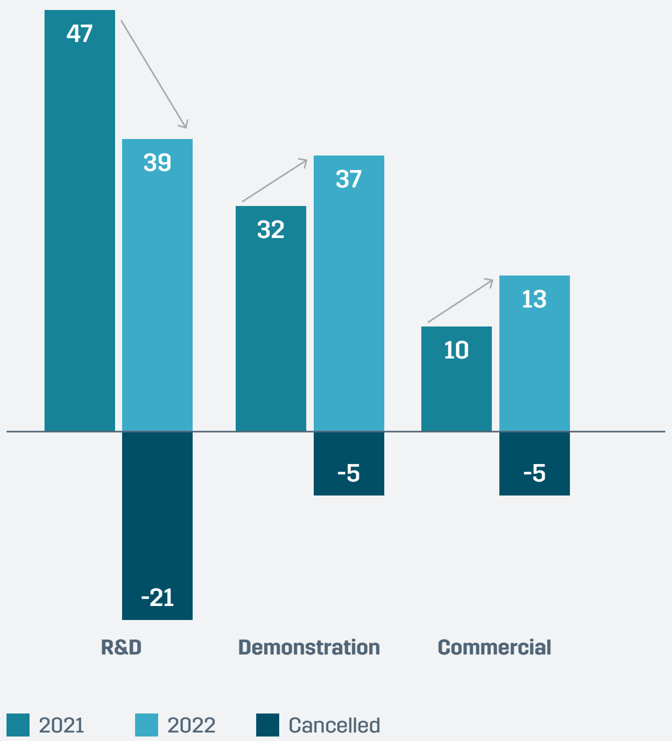



Figure 2: ONS database project count by maturity stage - 2021 v 2022



# 3.1

# Hydrogen production, storage & transportation

## Several countries have identified clean hydrogen as an investment priority to drive their progress towards climate targets, while boosting economic growth and creating local jobs and advanced infrastructure. This has been reflected in the significant growth observed in the number of new hydrogen projects coming online in the past year.

Over half of the new projects added to the ONS database were focused on hydrogen, 90% of which were green hydrogen production. This reflects how the steady increase of offshore wind deployment can play a major role within the hydrogen sector's development. Investments in critical transport infrastructure for international hydrogen delivery are expected to increase as demand continues to rise on hard-to-decarbonise sectors. Large-scale hydrogen storage is also expected to develop significantly, with innovative storage solutions providing sources of energy security and supporting the stabilisation of energy supplies.

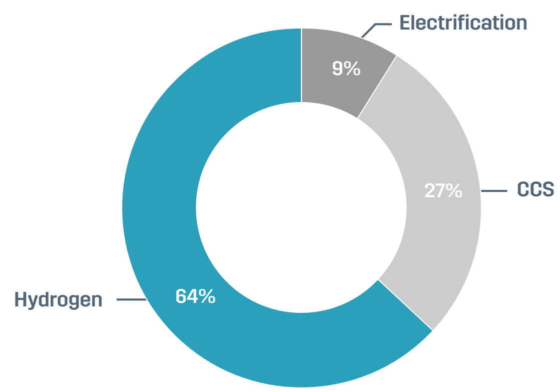



Figure 7: Project Theme Distribution (Hydrogen)

In terms of maturity level, there is a similar split of projects on R&D and Demonstration, which make up over 80% of hydrogen projects. The high number of recorded projects at Commercial stage (nearly one fifth of hydrogen projects) is another indication of successful efforts to drive technology maturity and infrastructure development in this area.

National hydrogen targets, combined with considerable industry investment, suggests a fast scaling of hydrogen technology is forthcoming. The proportion of projects in commercial stage is therefore anticipated to increase considerably.


Figure 8: Project Maturity – Hydrogen theme

All countries surrounding the North Sea have high levels of activity within this theme – over half of recorded projects in the database are focusing on hydrogen.

### What do we expect to see in the next 18 months?

Considering the ambitious hydrogen production targets being set in North Sea countries and globally, there is a need for long-term strategies that can mobilise action and investment at levels that support the growth of the hydrogen market. Current projects require full support to encourage advancement at a rapid pace.

The region's geological features, renewable energy potential and established O&G industry provide crucial resources for leadership in clean hydrogen production. We expect to see a significant increase in hydrogen production capacity, in particular through green $H_2$ production projects, which are supported by the steady increase in offshore wind deployment. Options to maximise the consistency of electricity supply offshore are expected to develop considerably, further driving the reduction of production costs.

Blue hydrogen is a relatively mature technology that provides a lower cost route for hydrogen production, representing an important complementary production option, however development may be limited by the increased cost of natural gas. The focus is likely to be on the supply of hydrogen to industrial clusters, where the reliability of supply is more important than its production method. Blue hydrogen production, with associated CCUS infrastructure, is likely to offer more constant supply than green hydrogen.

The establishment of hydrogen value chains and associated infrastructure represent another crucial element that can drive competitiveness, technology scale up and maximise production and export potential.

3.2

# Carbon capture and storage

**The development of carbon capture and storage (CCS) infrastructure involves linking up several critical infrastructures in order to enable the collection and transport of $CO_2$ from the point of emission all the way to storage locations.**

While the technology is considered a critical element for the achievement of net zero targets, progress in the development of technologies suitable for offshore environments has been slow. 27% of projects currently in the database are focused on CCS. This represents a decrease from what had been reported in the past, mainly due to high R&D project cancellations in this area. It is essential that technology and infrastructure development continues at pace in order to build out the supply capacity required to generate emission reduction potential in line with international targets.

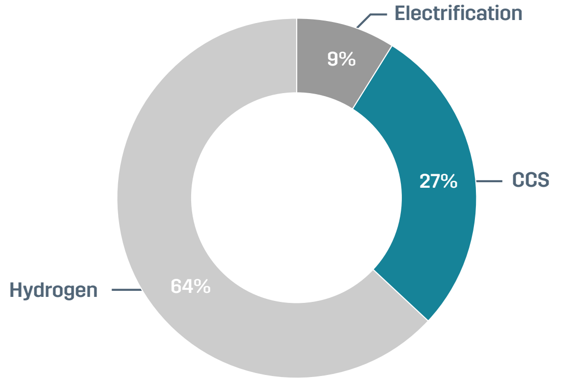



Figure 9: Project Theme Distribution (CCS)

In terms of maturity levels, over half of CCS projects are still in the R&D stage. An increase in Demonstration activities will be essential to build trust in CCS technologies and widen the reach of development efforts. A number of the nine demonstration projects currently in development are close to financial investment decision (FID), with projects in the UK, Netherlands and Denmark expected to be operational by 2025. As these CCS technologies become established, the number of projects at Demonstration and Commercial stage is expected to increase significantly in a relatively short timeframe towards 2030. However, many R&D projects will struggle to progress to demonstration phase without the pull of more operational projects coming online in the short-term.


Figure 10: Project Maturity - CCS theme

The UK, Netherlands and Norway currently have the most advanced projects, leading in the development of commercial CCS projects, but there is a need for accelerated deployment of carbon capture plants, storage facilities and cost effective transportation options over the next few years. Modularisation and standardisation of components can play a significant role by making these technologies applicable in a wide range of regions and conditions.

### What do we expect to see in the next 18 months?

The North sea basin can provide a global hotspot for CCS development, backed by supportive policy and regulation. The development of CCS clusters is a crucial element of carbon management ambitions but the fast development of capture and storage capacity is required to meet global targets. More transport and storage capacity is required to reduce cost of deployment and accommodate the levels of capture currently planned.

The EU is set to release a new CCS vision document in 2023 which will hopefully stimulate a new wave of R&D and demonstration projects (not only in North-West Europe) which are likely to utilise the North Sea basin for storage. The next 18 months will be crucial for many demonstration projects with Porthos in the Netherlands and HyNet and the East Coast Cluster all expected to take FID by mid-2024. Northern lights will also have started operations.

A key challenge at the moment is transitioning CCS in Europe from R&D and first-of-a-kind projects towards a more commercial market ready for wide-spread deployment. The new EU vision is likely to help with this, but the role national governments play in stimulating this first wave of projects will be crucial. Many risk elements, specifically their impact on financial liabilities, are currently being discussed at project level and each national government is providing varying levels of support from fully regulated to a more hands-off approach. Commercial aspects such as developing insurance schemes, tariff setting and ensuring open access to T&S infrastructure will all see new developments in the next 18 months.

Although there is already a good technical understanding of $CO_2$ transportation and storage new multi-user pipelines need to be developed which are costly and need to remain open access. More work is also needed to fully understand the cost and risk-methodology needed for the re-use of infrastructure both on- and offshore. Innovation is expected to drive the reduction of energy consumption by CCS plants through adoption of improved materials and the decrease in delivery times through use of modular units and standardised components. These will be crucial in driving the efficiency gains and cost reductions required for widespread deployment of CCS technologies.



3.3

# Electrification for emissions reduction

**Electrification initiatives can drive huge potential for emissions reductions from offshore assets and be a key driver to reaching net zero in the North Sea, but these are often complex projects with unique challenges. Electrification projects represent just under 10% of activities within the ONS database.**

Greater work is needed to encourage cross-sector collaboration, standardize approaches and risk-proof early initiatives.

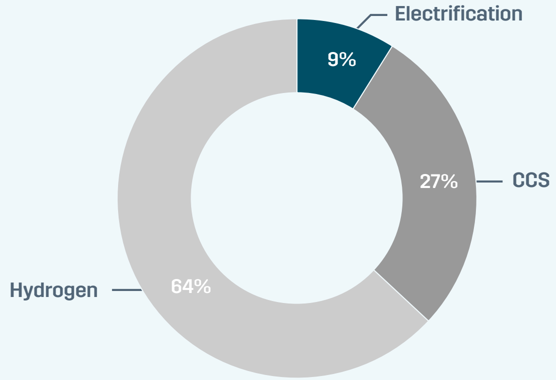



Figure 11: Project Theme Distribution (Electrification)

In terms of maturity, nearly two thirds of ongoing projects are at R&D stage with some initiatives moving into demonstrations. Significant development efforts will be required to reduce cost and increase deployment opportunities. The expansion of capacity in offshore grids will be an important enabler for electrification initiatives and is already being planned across several North Sea countries.

Technology developments are expected to lead to an increase in the number of electrification options for North Sea assets, which would drive a higher number of projects at the demonstration and commercial stages.


Figure 12: Project Maturity - Electrification theme

### What do we expect to see in the next 18 months?

The commercial viability of electrification solutions currently presents a considerable challenge due to high CAPEX costs, but the potential introduction of carbon taxes could provide commercial incentive for the implementation of electrification measures. As offshore wind deployment and energy storage technologies continue developing at a fast pace, it is expected that a significant number of novel opportunities will arise for the electrification of North Sea installations.

Innovative power architectures providing easy integration into existing assets, such as local offtakes, dedicated turbine strings or islanded wind networks, could help extend the lifespan of existing assets and provide significant contributions to emissions abatement efforts of oil and gas platforms. There is a significant interest from both the offshore wind and oil and gas sectors to identify electrification pathways that provide new routes to market for new offshore wind farm developments, however the timelines for consenting and design may constrain the pace of these initiatives.

The maximisation of offshore wind-energy utilisation and creation of power hubs able to import energy from different sources can greatly increase the electrification options available, meeting some of the challenges that asset owners currently face and increasing deployment opportunities. This area will be a major contributor to progress towards targets on the reduction of offshore production emissions and cross sector collaborations in innovative electrification concepts will be crucial in accelerating future developments.

# 4.0

# Project Showcase from the ONS Database

**R&D projects will be crucial to accelerate the pace of the transition and unlock the full potential of the North Sea, while demonstration and commercial projects are also needed to demonstrate technology at scale and build trust in new facets of the energy system.**

Below are some examples of projects in the ONS database that stretch across the R&D, Demonstration and Commercial project categories. View the full list here: **https://onenorthsea.com/project-database**

## Hydrogen
### Hydrogen Backbone

**Affordable hydrogen transport is fundamental, with a huge opportunity for the oil and gas sector to support in the development of the hydrogen economy, by repurposing existing infrastructure.**

The Hydrogen Backbone Link project will position Scotland in a leading role for the development of pan-European hydrogen infrastructure, creating export capability by repurposing and optimising existing pipeline infrastructure both on and offshore as well as developing complimentary options such as marine transport by ship.

The project will consider how a hydrogen pipeline network could be established between the proposed energy hubs and existing national grid infrastructure linking ports and other infrastructure.

It will address the opportunity for Scotland and the UK to supply hydrogen to Europe as part of an extensive hydrogen transport and distribution system. To realise the international opportunity, the project will explore synergies with the Gas for Climate (G4C) plans for a European Hydrogen Backbone. The strategic link to Europe diferentiates this hydrogen project from others in the UK, such as Acorn, Dolyphn, Gigastack, HyPER and HyNet, which focus on the generation rather than distribution and export of hydrogen.

Reusing existing pipeline assets to export hydrogen will accelerate the delivery of a hydrogen network as well as reducing $CO_2$ emissions from pipeline decommissioning and from sustainable transport of hydrogen.

## CCS
### Project Bifrost

**Depleted oil and gas reservoirs in the North Sea offer opportunities for large-scale carbon storage, but the unique nature of fields means technical studies are required.**

Project Bifrost consists of an alliance between Orsted, Nordsofonden, TotalEnergies and the Technical University of Denmark to investigate the possibility of carbon storage in the Harald field in the Danish North Sea.

The project was successful in its request for funding under the Energy Technology Development and Demonstration Programme (EUDP), meaning Project Bifrost will be matured towards a final investment decision if the study is successful.

Once repurposed, the Harald field is expected to provide annual storage capacity of 3 million tonnes $CO_2$.

## Electrification
### SolarDuck Offshore Solar

**As well as abundant offshore wind resource, the Netherlands is increasingly interested in offshore floating solar technologies.**

Dutch-Norwegian company SolarDuck have signed an agreement with RWE to develop the use of floating solar parks at sea, including a first offshore pilot project. The Hollandse Kust West (HKW) hybrid offshore wind and offshore floating solar project includes a 5 MW demonstrator and integrated storage solutions. It's due to become operational in 2026.

The technology offers an attractive solution for countries like the Netherlands, where the need for decarbonisation and limited land space means the solution lies offshore.

This is an example of a modular, floating offshore technology which could offer electrification solutions for offshore oil and gas production.

## Energy Integration
### PosHYdon

**3 km off the coast of Scheveningen, Neptune's O&G platform Q13A is the first fully electrified platform in the Dutch North Sea.**

Following a feasibility study by TNO and Nexstep, the Q13A platform has been chosen for the two-year PosHYdon project to produce electrolytic hydrogen from seawater. The hydrogen production unit of 1 MW capacity is small enough to fit on the platform.

Electricity is currently supplied from shore but the plan is to transition to offshore wind energy in the future and hence the expected fluctuations in electricity will be simulated in this project. The electrolytic hydrogen will be mixed with the gas and transported via the existing gas pipeline to the coast.

4.0

**Project Showcase from the ONS Database (Cont'd)**

## Hydrogen
### H2FUEL

**A new technique for the production, storage and release of $H_2$ is currently in development in the Netherlands. The storage takes place under atmospheric conditions in a powder and the release takes place without added energy with very clean water.**

Consequently, not only 100% of the hydrogen stored in the powder is released, but also the same amount of hydrogen from the water is harvested.

The powder is sodium borohydride ($NaBH_4$) and each molecule of sodium borohydride contains 4 hydrogen atoms (4H). One cubic metre of powder contains 9 MWh of energy. Delft's University of Technology (TU Delft) and the University of Amsterdam (UvA) are currently developing the fuel, and a consortium of companies called Solid Hydro.Re.Gen is cooperating to develop sodium boron hydride as a hydrogen carrier.

Once all the techniques have been proven and have also been demonstrated to be economically viable, sodium boron hydride could be used on inland vessels, short-sea vessels, maintenance vessels and ferries.

## CCS
### Pace CCS

**The effects of long-term exposure to $CO_2$ on infrastructure are still a concern. Existing corrosion models for pipelines do not consider the potential impact of impurities, and de-risking could result in significant cost savings.**

Pace CCS Ltd is developing a software to predicts the corrosion risk to polar impurities pose to CCS pipelines. New models are required to predict the formation of the free liquid phases and their composition. This web-based app technology considers all applicable polar impurities and potential cross-reactions to determine the worst-case corrosive liquid phase for any CCS specification.

The app can also provide data to support decision-making on equipment and materials selection to avoid the over-specification of equipment. The ability to predict corrosion, will help mitigate failures and lead to a reduction in the number of $CO_2$ leaks.

## Electrification
### WINTOG

**Part of the Energy Transition Alliance (ETA) programme, this project is a feasibility study to evaluate and analyse the potential of a floating wind turbine generator (WTG) connected to an Oil and Gas platform for a first-time deployment in the United Kingdom Continental Shelf (UKCS).**

It will deliver a concept for a prototype demonstrator project and will explore the market opportunity for this 'Partial Electrification and Clean Fuel' opportunity across the Central North Sea (CNS) and Northern North Sea (NNS).

The design will be modular and aims to minimise topside modifications by utilising subsea technology. The project will objectively consider opportunities for technology development across the system.

5.0

# Conclusion

**Technology is considered a key enabler for the energy transition in the North Sea, but there are still significant hurdles to the widespread deployment of novel technologies offshore.**

Innovation within the energy ecosystem can play a critical role in cost reduction and maturity, but cross sector collaborations at national and international levels will be essential to foster a supportive environment for maturing technology solutions and to unlock investment opportunities that stimulate existing capabilities.

With significant levels of interdependency between energy sources, there is a need for concerted and strategic effort, paired with adequate incentives to ensure the North Sea region continues developing on its commitment to the delivery of clean energy and economic development.

In light of these results and developments since the previous report, we expect to see a considerable increase in the number of hydrogen projects, particularly green hydrogen production, alongside a considerable maturity increase in CCS and electrification technologies.

With large storage potential across saline aquifers, the North Sea region has the opportunity to contribute to significant development in the understanding of CCS technologies. There is a strong need for infrastructure development, supporting the transport and storage of emerging energy products.

The development of net-zero energy systems will be dependent on the acceleration of any deployable technology solutions in order to deliver environmental and economic benefit to the North Sea region.

**To view the full database, visit https://onenorthsea.com/**

**If you'd like to see your project added to the ONS database, please contact info@nztc.com .**

Net Zero Technology Centre

Technology Driving Transition

**Contact number:**
+44(0)1224 063200

**Media enquiries:**
pressoffice@netzerotc.com

**Net Zero Technology Centre**
20 Queens Road, Aberdeen AB15 4ZT

www.netzerotc.com