North Sea Energy
offshore system integration

D2.3

North Sea Energy 2023-2025

Human Capital agenda for offshore energy system integration

Navigating the North Sea transition!

For centuries, the North Sea has been a source of economic strength, ecological richness, and international cooperation. Always subject to change, yet steadfast as a connector of nations, cultures, and economies. Today, it once again takes center stage—this time as a lighthouse region for the transition to a sustainable, affordable, and reliable energy system. The North Sea Energy program marks an important step in this development.

North Sea Energy is a dynamic research program centered around an integrated approach to the offshore energy system. Its aim is to identify and assess opportunities for synergies between multiple low-carbon energy developments at sea: offshore wind, marine energy, carbon capture and storage (CCS), natural gas, and hydrogen. At the same time, the program seeks to strengthen the carrying capacity of our economy, society, and nature.

The offshore energy transition is approached from various perspectives: technical, ecological, societal, legal, regulatory, and economic. Our publications provide an overview of the strategies, innovations, and collaborations shaping the energy future of the North Sea. They reflect the joint efforts of companies, researchers, and societal partners who believe in the unique potential of this region as a hub for renewable energy and innovation.

What makes this program truly distinctive is not only its scale or ambition, but above all the recognition that we are operating in a dynamic field of research. The energy transition is not a fixed path, but a continuous process of learning, adapting, and evolving. New technologies, a dynamic natural environment, shifting policy frameworks, and changing societal insights demand flexibility and vision. Within this program, we work together to ensure that science and practice reinforce one another.

This publication is one of the results of more than two years of intensive research, involving over forty (inter)national partners. This collaboration has led to valuable insights and concrete proposals for the future of the energy system in and around the North Sea. All publications and supporting data are available at: https://north-sea-energy.eu/en/results/

We are deeply grateful to all those who contributed to the realization of this program. In particular, we thank our consortium partners, the funding body TKI New Gas, the members of the sounding board, the stakeholders, and the engaged public who actively participated in webinars and workshops. Their input, questions, and insights have enriched and guided the program.

At a time when energy security, climate responsibility, and affordability are becoming increasingly urgent, this work offers valuable insights for a broad audience—from policymakers and professionals to interested citizens. The challenges are great, but the opportunities are even greater. The North Sea, a lasting source of energy, is now becoming a symbol of sustainable progress.

With these publications, we conclude an important phase and look ahead with confidence to the next phase of the North Sea Energy program. In this new phase, special attention will be given to spatial planning in the North Sea, European cooperation, and the growing importance of security in the energy system of the future.

North Sea Energy offshore system integration

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North Sea Energy 2023-2025

Human Capital agenda for offshore energy system integration

As part of Work package 2: "Society and stakeholders"

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Table of Contents

Executive summary

Between June 2023 and June 2025, the NSE-5 project was carried out. This report presents results related to the human capital work strand of NSE-5, as part of work package 2: "Society and stakeholders". The project consisted of three "sprint" periods.

In Sprint 1 (June 2023- Feb 2024): around 30 NSE stakeholder interviews were conducted, and a desk study was performed to collect information on human capital requirements for four future energy technology areas in the North Sea until 2050: wind, hydrogen, CCS and (decommissioning of) oil and gas platforms.

In Sprint 2 (March-Oct 2024): a quantitative human capital model was built to estimate headcount requirements for the period 2025-2050. In the model, the current two prevailing NSE production scenarios for 2050 for wind (45-72 GW) and hydrogen (4-35 GW), on the Dutch part of the North Sea, were taken as a reference point. For decommissioning until 2030, projections were used from NexStep. CCS was not included in the model. According to experts' judgements, based upon experiences of the first offshore projects, human capital demands for CCS are low and will remain low in the future as well.

Model results indicate that for the total of the three technology areas considered, around 104.000-226.000 FTE (full-time equivalents) will be needed between 2025 and 2050 to enable the realization of the NSE production scenarios. The yearly human capital demand will be around 4.000-10.000 FTE. Although these numbers appear to be modest, realization will still be a challenge, in view of the shortage of technical personnel on Dutch labour markets and future growth ambitions of various technical sectors, including the energy sector on land.

Model results were discussed and challenged in a Human Capital working group session with eight NSE stakeholders, September 3rd, 2024. During this session, bottlenecks and opportunities were identified for fulfilling the future human capital demands.

Next to the modelling activities, mapping was done on skill sets, education levels, and job types for the offshore energy sector. For successful system integration on the North Sea, the following technical knowledge & skills areas were identified as important to upgrade for offshore professionals: system integration, digital and data science, circularity, geology, and ecology. Education levels and job types have been mapped for the offshore sector, but further detailing still needs to take place.

Finally, in Sprint 3 (December 2024-April 2025), a human capital Framework was created. The Framework is meant to facilitate (management of) human capital transitions for NSE for the period 2025-2050. The Framework is built around three human capital themes: human capital capacity, certification/skills, and monitoring. From those three themes, 10 "human capital issues" were deducted. Each issue was mapped along the following criteria: opportunities, bottlenecks, interventions, impact, current development programs, stakeholders, and ownership. During a human capital working session with 10 Human Capital experts of NSE-5, March 11, 2025, the validity of the Framework was confirmed. For nine out of ten human capital issues, it could be established that "ownership" lies with one or more of

the current NSE partners, in relation to existing human capital roadmaps or programs. Only for the tenth issue, “system integrated” human capital monitoring, a role is foreseen for further development activities in NSE-6.

1 Introduction

1.1 Background

North Sea Energy program and the relevance of human capital
The North Sea Energy program (NSE) is a research program led by TNO and aims to harness the North Sea's potential in Europe's energy transition through a system integration approach for offshore energy. System integration demands coordinated integration of chains of different energy carriers and end users into one sustainable, reliable, affordable, and safe energy system with broad social support.

Offshore energy system integration is not only a technical transition. People are needed to make it happen. Manufacturing, building, and maintaining the infrastructure require a well-skilled workforce. Are these people available? What is needed for system integration concerning (novel) labour communities? What new skill sets do we need for employees in the offshore sector?

In NSE 4, the availability of manpower, knowledge, and skills of workers in the offshore sector was identified as one of the essential pillars for the offshore energy transition. Therefore, in the NSE-5 program, a human capital work strand was organized, as part of WP2: “Society and stakeholders”. This report is the result of a stakeholder management trajectory on human capital carried out between July 2023 and June 2025.

1.2 Scope of human capital work package

The Human Capital work package of NSE-5 is focused on four technology areas for offshore energy, as considered in NSE:

- Offshore Wind,
- Offshore Hydrogen production,
- Carbon Capture and Storage,
- Decommissioning of oil and gas platforms

All four technology areas have their human capital requirements. They differ in the number of people required and in the skillset that is required.

1.3 Research questions of the human capital work package

The following research questions were addressed in the human capital work package:
1. What employment can be expected for the various offshore activities within NSE between now and 2050?
2. Which bottlenecks and opportunities are expected?
3. What are promising interventions, and how can these be aligned with existing organisations and programs?

The focus of this work package is on the employment that will arise in the Dutch part of the North Sea. The European perspective from the countries bordering the North Sea was out of scope but will be addressed briefly (see chapter 3).

The deliverable of the work package is a human capital Framework for NSE-5, in line with existing human capital roadmaps.

1.4 Reading guide

In Chapter 2 project timings and research methods and questions are explained.

In Chapter 3 the current labour market is described for offshore energy in the Netherlands. The European perspective is addressed also. Chapter 3.3 provides boundary conditions for future human capital developments.

Chapter 4 describes modelling results for human capital demands of offshore wind, hydrogen production and decommissioning for the period 2025-2050.

In Chapter 5 contains a first mapping of the required skills for offshore energy system integration

Chapter 6 provides a Human Capital Framework that can be used for (management of) human capital transitions towards 2050

Chapter 7 provides final conclusions on the research questions.

Chapter 8 gives recommendations of this workpackage for future research and the role of NSE6.

2 Approach

2.1 Project phases and timings

NSE-5 consisted of three "Sprints". In this report, the results of all three sprints are described. The image below shows the phases over time.

Sprint 1
Jul 2023-Feb 2024

Data Collection
- Desk research
- Interviews NSE-5 partners
- Data analysis

Sprint 2
Mar-Oct 2024

Human capital modelling
- More interviews with companies
- Working sessions with stakeholders
- Intermediate report

Sprint 3
Nov 2024-Apr 2025

Agenda and reporting
- Working session on actions and interventions
- Final Report

2.2 Research methods

Literature study
Desk research was conducted on employment in the offshore energy sector and future projections. Comparisons were made with the European countries bordering the North Sea and EU projects focussing on developing technical skills.

Interviews
Ca. 30 semi-structured interviews were done, of which the list of interviewed people and organizations can be found in Appendix A1. Perspectives were collected from marine companies, ports, technology experts, policy makers and educational institutions on HR policies, strategies and collaborations in the offshore energy world and beyond.

Modelling
Based on existing human capital studies on offshore wind and on hydrogen, quantitative human capital modelling was conducted. Future labour market estimations were obtained for NSE production scenarios within each technology area, and for all technologies as a whole, between 2024-2050. The wind and hydrogen production energy scenarios were multiplied by an expected labour intensity (per energy unit). The assumption is that this labour intensity is not constant, and it would take fewer people over time to manufacture, install, and maintain the infrastructure.

Working sessions with stakeholders
Two dedicated human capital stakeholder workshops were held, one physical meeting in September 2024 in Utrecht (10 people), and one digital meeting in March 2025 (10 people), to discuss the outcomes of Sprint 2 and Sprint 3, respectively. During each of the three formal Sprint review meetings of NSE-5, hosted by TNO (Feb 2024, Nov 2024, March 2025), the progress of the human capital was discussed with the wider NSE community, and included human capital "breakouts". One of the NSE-Sounding Board meetings was dedicated to Human Capital, in November 2024.

3 Labour market for offshore energy

3.1 Current state in the Netherlands

The Dutch workforce in the offshore energy sector is already quite developed. Estimations from the maritieme arbeidsmarkt en havenmonitor[1] show that in 2022, roughly 30.000 FTE (full-time equivalents) were directly employed. 36.000 FTE were employed indirectly (supply chain). CBS yearly monitors the employment of all economic sectors of the Netherlands. For SBI 06 (Standaard bedrijfsindeling 06: Extraction of oil and natural gas), about 2.500 employees were reported in 2023[2].

The workforce is also being monitored for the Dutch Topsector Energy as a whole. 205.000 employees were reported in this sector for 2022, including the following subsectors: extraction of oil and natural gas (SBI 06, 09); industrial production for energy (SBI 19, 25, 28); energy supply (SBI 35); construction industry (SBI 42, 43); and related activities (SBI 27, 72). A full definition can be found here[3].

The offshore sector has an international orientation. Dutch companies are active worldwide. International companies are also active on the Dutch Shelf of the North Sea. Besides the large companies, many niches exist with specialist services. The offshore energy market represents significant value, knowledge, and employment for the Dutch economy. In 2022, it was estimated that the Dutch offshore energy sector represented 11.7 billion in revenue and 3.3 billion in added value[4].

3.2 European perspective

The Offshore energy sphere of the North Sea must be seen as one coherent international ecosystem and not as a patchwork of national systems. The human capital in European countries bordering the North Sea can deliver a part of what is required on a Dutch level. The countries also compete in specialist areas and advanced engineering techniques.

In the table below, estimations can be found of the existing workforce in the European countries bordering the North Sea. Not all statistics offices have the same definitions for employment (some measure in FTE, others in number of employed people), but it indicates the size of the current international labour market related to offshore activities.

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[1] Maritieme arbeidsmarkt en havenmonitor 2023 https://open.overheid.nl/documenten/206befda-6c1b-496d-b939-c039a570d1bc/file [accessed 29th of October 2024]

[2] Arbeidsmarkt monitor topsectoren 2024 https://sbi.topsectorenarbeidsmarktmonitor.nl/arbeidsmarktvolume/sbi-indeling?sector-indeling=SBI-indeling&sector=06%20|%20Winning%20van%20aardolie%20en%20aardgas# [accessed 29th of October 2024]

[3] Arbeidsmarktonderzoek ICT met topsectoren - 2021 https://www.caict.nl/wp-content/uploads/2021/09/210924-Vervolgonderzoek-Arbeidsmarkt-ICT-met-topsectoren-2021-CentERdata-eindrapport.pdf [accessed 29th of October 2024]

[4] Maritieme arbeidsmarkt en havenmonitor 2023 https://open.overheid.nl/documenten/206befda-6c1b-496d-b939-c039a570d1bc/file [accessed 29th of October 2024]

Country	Current workforce estimations		Year
Netherlands	30.000 36.000	FTE (direct employment offshore energy) FTE (indirect employment offshore energy)	2022 [5]
Norway	156.000	people (only petroleum industry)	2021 [6]
Denmark	33.000	people (offshore wind)	2020 [7]
Germany	30.100	people (offshore wind)	2022 [8]
Belgium	14.000	(direct and indirect employment offshore wind)	2022 [9]
United Kingdom	220.000 32.000	(of which 133.000 oil and gas direct and indirect jobs and 86.000 induced jobs) (Offshore wind)	2022 [10] 2023 [11]

Table 1: jobs in the European countries bordering the North Sea

Transition deal in United Kingdom
In the UK, the oil and gas sector is united in Offshore Energy UK (OEUK). In 2023, a transition deal was made with the UK government. In the transition deal, it is highlighted that a decline in oil and gas production will cause a decrease in jobs, for which mitigation measures are needed.

3.3 Boundary conditions for human capital

From interviews and working sessions the following boundary conditions were identified that will impact future human capital needs on the North Sea:

Business case for the new technology
As being researched within NSE, the business cases of the new technologies bring uncertainties. The business case must be positive before investment decisions are made and people are hired.

Marine Spatial Planning: including legal constraints.
In protected areas, it is not allowed to build anything. The North Sea is already heavily used by a large group of stakeholders and marine spatial planning is the tool to coordinate the spatial planning of offshore infrastructure.

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[5] Maritieme arbeidsmarkt en havenmonitor 2023 https://open.overheid.nl/documenten/206befda-6c1b-496d-b939-c039a570d1bc/file [accessed 29th of October 2024]

[6] Employment in the petroleum industry – Norsk Petroleum https://www.norskpetroleum.no/en/economy/employment/ [accessed 29th of October 2024]

[7] Danish shipping, Wind Denmark and Danish Energy with support from the danish maritime foundation - Socio-economic impact study of offshore wind, 2020 https://danishshipping.dk/media/gbdme2zt/technical-report-socioeconomic-impacts-of-offshore-wind-01072020-3.pdf [accessed 29th of October 2024]

[8] Statista 2023 Anzahl der Beschäftigten in der Windenergiebranche Offshore und Onshore in Deutschland in den Jahren 2000 bis 2022 https://de.statista.com/statistik/daten/studie/271271/umfrage/beschaeftigtenzahl-in-der-deutschen-windenergiebranche/ [accessed 29th of October 2024]

[9] Invest in Flanders – Energy, 2022 https://invest.flandersinvestmentandtrade.com/en/sectors/energy [accessed 29th of October 2024]

[10] OEUK – ECONOMIC REPORT 2023, 2023 https://oeuk.org.uk/wp-content/uploads/2023/09/Economic-Report-2023-Offshore-Energies-UK-OEUK.pdf [accessed 29th of October 2024]

[11] The Crown Estate - Offshore wind industry unveils Industrial Growth Plan to create jobs, 2024 https://www.thecrownestate.co.uk/news/offshore-wind-industry-unveils-industrial-growth-plan-to-create-jobs [accessed 29th of October 2024]

Required infrastructure, supply chain, and availability of raw material
This is a key precondition; enough space is required in ports, the infrastructure and supply chain need to integrate with each other, and the availability of raw materials is key for manufacturing high-tech infrastructure.

Connections between onshore and offshore
An important aspect in the engineering of the offshore energy system is the timing of the construction of the offshore wind connection to the high-voltage grid at sea by Tennet. Delays can have major consequences for manpower needs.

Health, Safety, and Environment
This is a key precondition for building offshore infrastructures. At all times, the health, safety, and environmental aspects need to be considered when offshore infrastructure is being built.

Innovation learning curve
Learning curves will (positively) influence human capital requirements for new technologies. Not all technologies addressed in this report have reached the appropriate maturity yet.

Education and training facilities
Clearly, it takes time to educate people to work in the offshore energy sector. Sufficient education and training facilities are needed to make the step from “Technology Readiness” to “Human Capital Readiness” of (future) employees.

4 Human capital modelling

4.1 Offshore wind

Background
For offshore wind, a growing workforce is needed. Activities are related to four main phases:
1. Manufacturing of wind farm building blocks
2. Installation,
3. Operations and maintenance
4. Decommissioning of old wind farms

Each of these activities has a certain temporality and intensity of how many people are needed. Contractors are usually responsible for the design, engineering, procurement, construction, and installation of the foundations, the interconnection cables, and the offshore substation, as well as for the transport of the wind turbines. During the construction and decommissioning phases, a temporary workforce is needed.

Most of the staff are active in the operations and maintenance phase. Trained technical people are needed for this, and they need to live in the vicinity of a port. Depending on the type of wind turbine, different sets of (mechanical, hydraulic, and electrical) skillsets are needed.

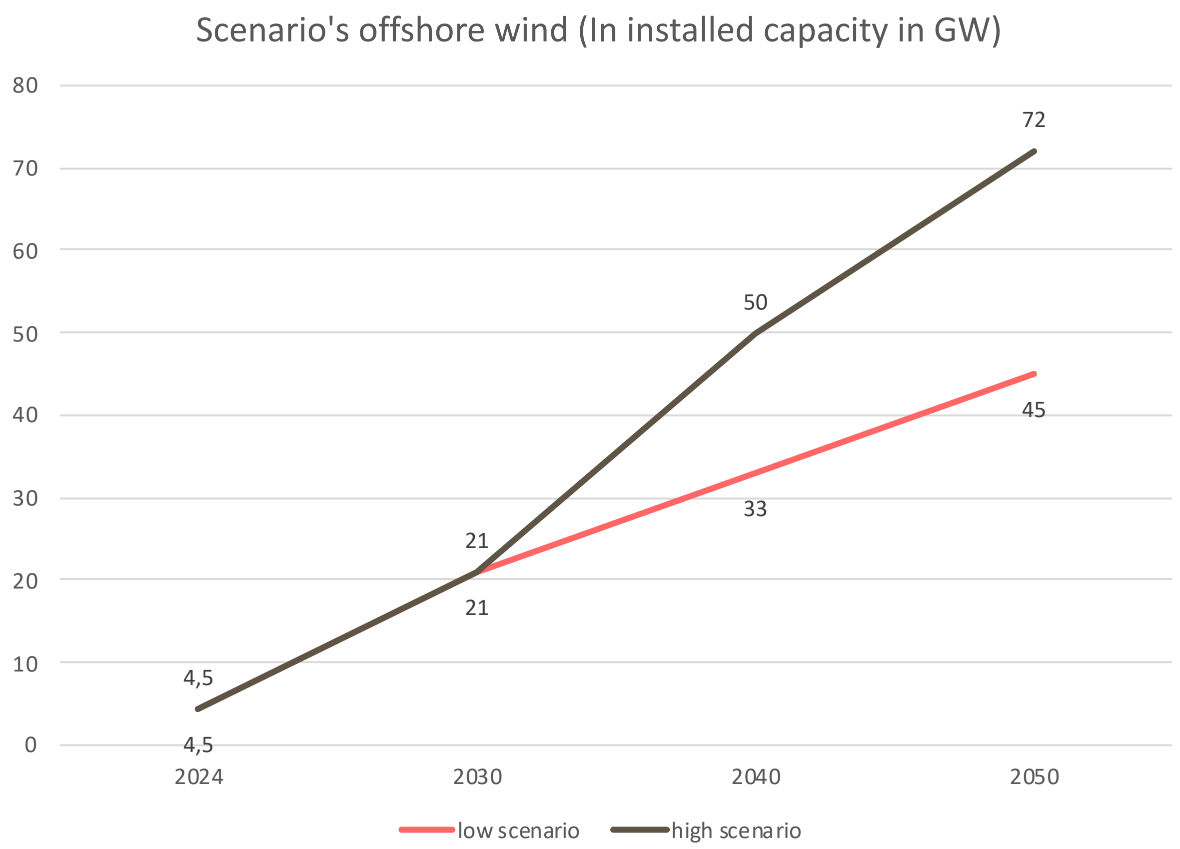
The wind industry turbine manufacturers and suppliers are indirectly part of the tender procedure; the parties that will make a bid will contact the turbine supplier first before they make an offer for a tender with a specific turbine, and then make their bid for a tender. The turbine suppliers work with a Defects Notification Period (DNP), which is a period where the suppliers provide a warranty for the turbines. This also secures their income on the O&M side. During the DNP, the windfarm owner will be able to do more and more on the turbine. After the DNP, the windfarm owner can do the O&M themselves, or they can choose to make use of a market party.

For maintenance, Crew Transfer Vessels (CTV's) and Supporting Operating Vessels (SOV's) are used. CTV's sail back and forth daily, and SOV's stay longer in a park. Personnel can stay overnight, for wind farms further out to sea (about 2 weeks). It depends on the location and how much maintenance is needed, which type of vessel is used.

In this human capital study, the scope of offshore work extends until the delivery of electricity to the substations. The responsibility for this lies with TenneT. For offshore wind, repowering of existing sites will take place after 2040, this is currently not considered. From 2028, the first wind farms will be decommissioned, but this is also not yet considered. DecomNorth is an initiative focusing on the decommissioning of offshore wind farms in the Eemshaven. Several companies are organizing the recycling of wind turbine blades.

Modelling inputs for offshore wind

- 2 Scenario's from NSE with a high and lower bound. These are similar with the II3050 scenario studies from Netbeheer Nederland.
- RVO study on employment in offshore wind post 2030 (2020[12])



Graph 1: Future NSE scenarios for installed capacity of offshore wind in the Netherlands

Assumptions

- A linear GW interpolation between reference years (for example, 20 GW for ten years will be 2 GW on average per annum)
- Standardization of wind turbines after 2030 results in less people required.
- Direct employment per GW will decrease over the years as a result of learning curves and improved economies of scale. Percentages are based on a comparison with wind farms in Denmark and can be found in the table below [13]

[12] Knol, E. & Coolen, E. (2020). Post 2030 offshore wind employment in the Netherlands: first indications of an outlook on direct employment regarding construction and operations & maintenance phases. Working paper prepared for RVO (Netherlands Enterprise Agency).
[13] Knol, E. & Coolen, E. (2020). Post 2030 offshore wind employment in the Netherlands: first indications of an outlook on direct employment regarding construction and operations & maintenance phases. Working paper prepared for RVO (Netherlands Enterprise Agency).

Correction factors for direct employment estimations	Roadmap 2030	Outlook 2050
Construction phase	Mean correction percentage over extrapolated figures over period 2024-2030: -11%	Mean correction percentage over extrapolated figures over period 2030-2050: -18%
O&M phase	Mean correction percentage over extrapolated figures over period 2024-2030: - 13%	Mean correction percentage over extrapolated figures over period 2030-2050: -23%

Table 2: correction factors for the expected employment in offshore wind

Scope of "Dutch" work

The share of work in the Netherlands are estimated in this study[14]. For example, in the manufacturing phase for turbines, nacelle, rotor and tower most of the employment is in Germany and Denmark. In the Netherlands, foundations, sub stations and some of the cabling are made.

Manufacturing	Share in the Netherlands
Nacelle supply	○○○○
Rotor supply (including blades)	○○○○
Tower supply	○○○○
Cable supply	●○○○
Substation supply	●●●○
Foundation supply turbine	●●●○

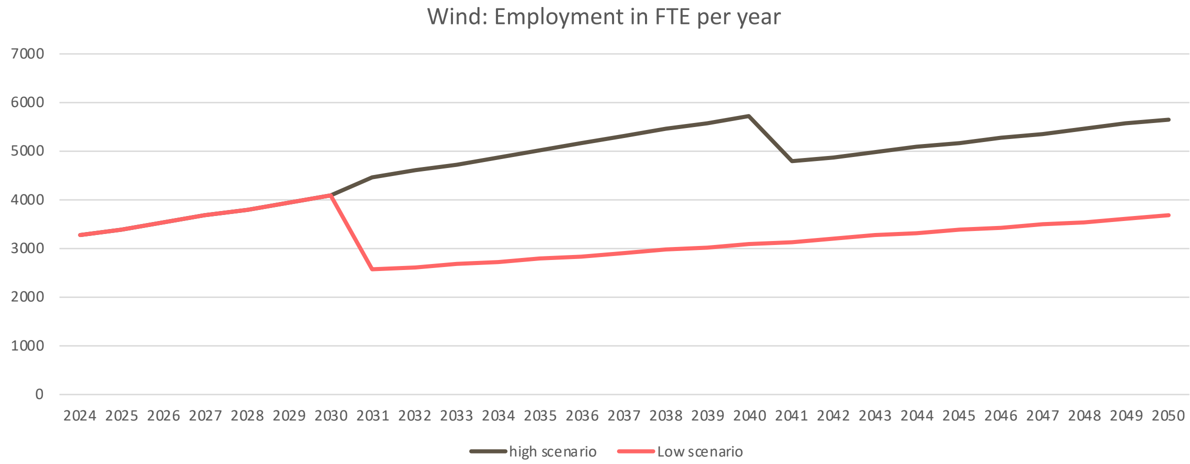
Construction	Share in the Netherlands
Foundation installation turbine	●●●○
Turbine installation	●●●○
Array cable installation	●●●○
Installation support	●●●○
Export cable installation	●●●○
Substation installation	●●●○

Operations and Maintenance	Share in the Netherlands
Wind farm operations	●●●○
Turbine maintenance	●●●○
Structural inspection & maintenance	●●●○
Maintenance & service logistics	●●●●
Crew cable and substation	●●●○
Array cable inspection	●●●○
Export cable inspection	●●●○
Substation operations & maintenance	●●●○
Maintenance & service logistics substations	●●●●

Tables 3, 4 and 5: indication of employment in the Netherlands for each phase

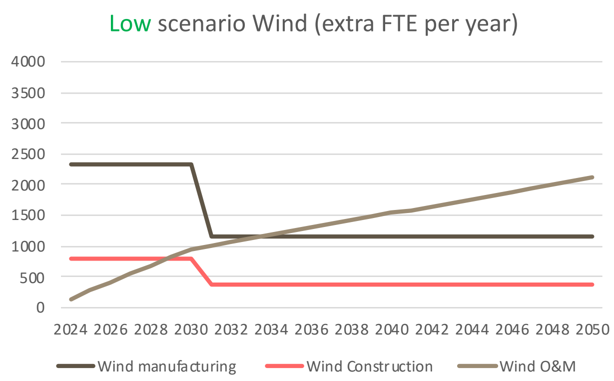
[14] Knol, E. & Coolen, E. (2020). Post 2030 offshore wind employment in the Netherlands: first indications of an outlook on direct employment regarding construction and operations & maintenance phases. Working paper prepared for RVO (Netherlands Enterprise Agency).

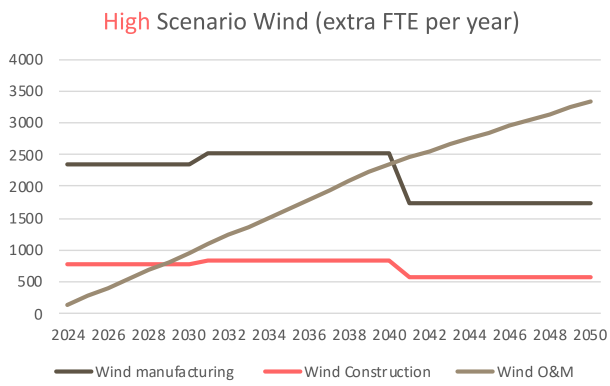
Modelling results



Graph 2: The employment in FTE per year for the two NSE scenarios

In the high scenario there is a clear ramp up of activities between 2030 and 2040 while in the low scenario the pace of installation slows down and remains lower. In the high scenario the pace of deployment of new offshore wind farms slows down after 2040, hence the sudden decline in the employment.





Graph 3 and 4: Employment for manufacturing, construction and O&M per year for the two NSE scenarios

From these graphs it follows that the annual required workforce for Operations and Maintenance steadily increases over time. Towards 2050 the O&M workforce will exceed the workforce on manufacturing and construction of offshore wind farms. More detailed information can be found in Appendix A2.

Total human capital need for offshore wind in the Netherlands

Based on the tables 3, 4, and 5 estimations are made for the employment in the Netherlands. In total the following headcount is needed in the period 2024-2050, for the various phases and sub activities.

The numbers indicate the Dutch part of the supply chain. Most employment in manufacturing is abroad (Germany and Denmark) and is not included.

Manufacturing

Role:	Low scenario in FTE	High scenario in FTE
Cable supply	1,025	1,650
Substation supply	12,300	17,963
Foundation supply turbine	26,138	39,503
Total	**39,463**	**59,115**

Wind farm construction

Role	Low scenario in FTE	High scenario in FTE
Foundation installation turbine	2,153	3.098
Turbine installation	2,460	3,593
Array cable installation	2,460	3,593
Installation support	2,768	4,088
Export cable installation	2,460	3,593
Substation installation	923	1,485
Total	**13,223**	**19,448**

Operations and maintenance

Role	Low scenario in FTE	High scenario in FTE
Wind farm operations	6,033	8,594
Turbine maintenance	17,492	25,170
Structural inspection & maintenance	3,263	4,660
Maintenance & service logistics	4,351	6,213
Crew cable and substation	493	726
Array cable inspection	493	726
Export cable inspection	493	726
Substation operations & maintenance	493	726
Maintenance & service logistics substations	1,784	2,483
Total	**34,896**	**50,022**

Tables 6, 7 and 8: total FTE in the period from 2024-2050 for each specific activity [15].

[15] Knol, E. & Coolen, E. (2020). Post 2030 offshore wind employment in the Netherlands: first indications of an outlook on direct employment regarding construction and operations & maintenance phases. Working paper prepared for RVO (Netherlands Enterprise Agency).

4.2 Hydrogen production

Background
Offshore hydrogen production is currently in the demonstration phase. Large-scale offshore hydrogen production will probably take place on newly built platforms due to different Health and Safety requirements compared to existing oil and gas platforms. Depending on the scale and variability of supply and demand, infrastructure for transport (to land) and storage (at sea and/or on land) will be needed.

This report provides results for the onshore conversion of electricity to hydrogen. To get an idea of the required investments and manpower for offshore hydrogen production, a comparison between the investments (and manpower) for an onshore electrolyser (which have been and are already being built) with an offshore electrolyser can be made. The Holland Hydrogen Project is the first electrolyser at scale in the Netherlands, and the asset manager was interviewed for this report and provided his insights on what would be required to build large-scale electrolysis plants.

Various teams are working in the start-up phase: an HSE team, an engineering team, a construction team, a commissioning team, and an asset team. In the operations phase, there is an O&M team, an engineering team and support from HSE, IT, engineering support, HR. The production of green hydrogen involves reactive power, and a lot of attention is paid to the electrical components.

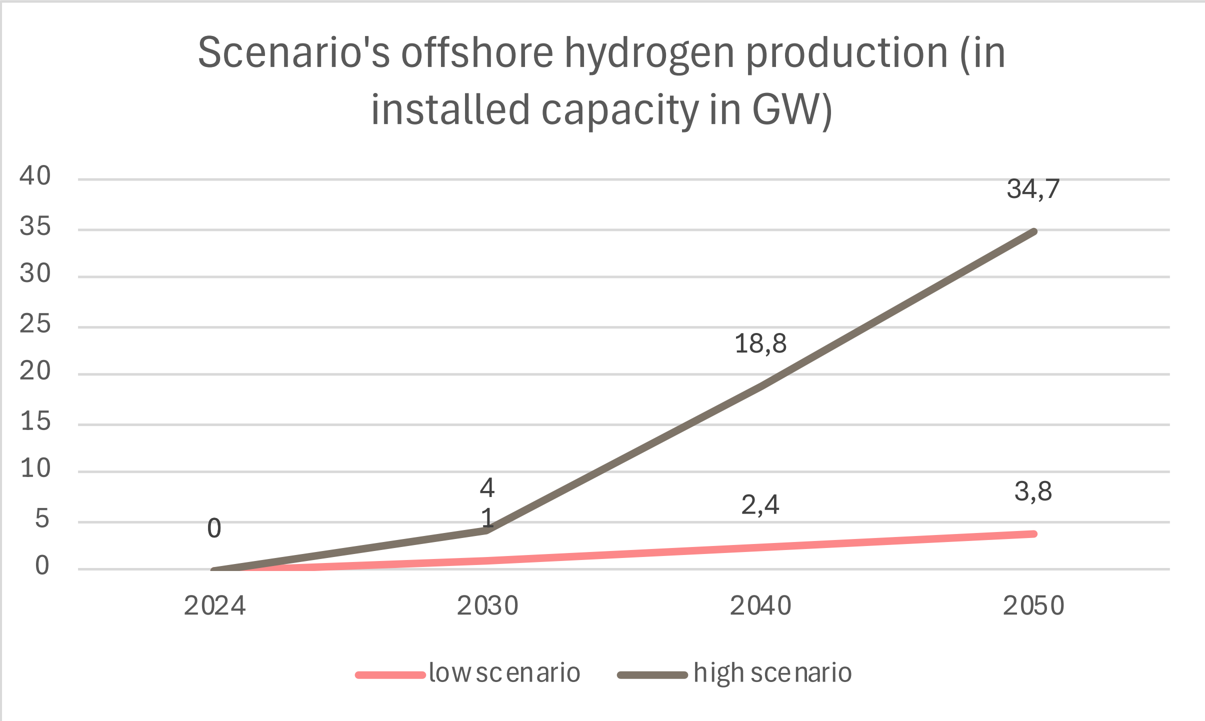
Technicians with good knowledge of electrical engineering are already scarce and especially for offshore. In addition, the large-scale investments by Tennet in the Dutch electricity network will cause extra tightness in this market over the next ten years.

Electricity and water are the most important ingredients for green hydrogen production. Impurities in the water have an impact on the efficiency of the cells of the electrolyser and more electricity is needed for the same production. For offshore production a desalinization plant is required and there are stricter safety requirements for building this kind of infrastructure on a platform.

Model inputs

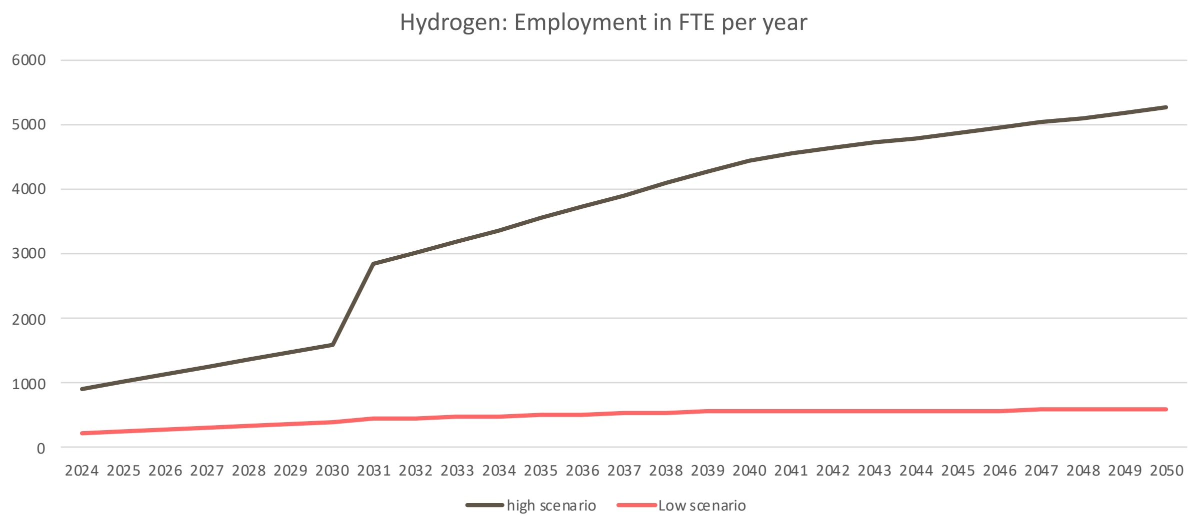
- CE Delft study for GroenVermogen NL on employment in hydrogen (2021[16]). This study calculates the onshore production of hydrogen. The number are not representing offshore hydrogen production.
- Scenarios are taken from NSE and II3050.
- Assumption: a linear GW increase over the years (for example 20 GW over 10 years means 2 GW per year; in reality this will not be the case)

[16] Cor Leguijt, Emiel van den Toorn, Amanda Bachaus en Chris Jongsma - Werk door investeringen in groene waterstof – update en uitbreiding - 2021



Graph 5: Scenarios for offshore hydrogen production in installed capacity in GW[17]

Model results

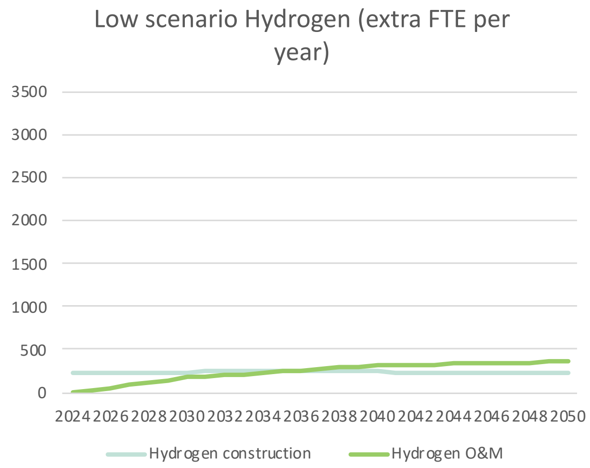


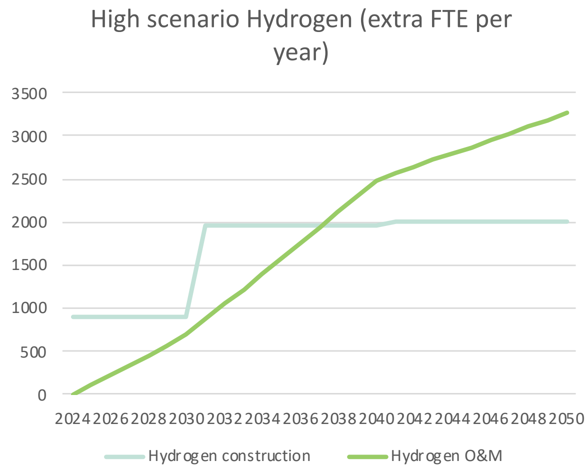
Graph 6: Employment per year for the two scenarios (Netherlands)

The results show big differences in employment, which is in line with large difference between both production scenarios.

[17] Cor Leguijt, Emiel van den Toorn, Amanda Bachaus en Chris Jongsma - Werk door investeringen in groene waterstof - update en uitbreiding - 2021

Results in detail





Graphs 7&8: construction and O&M of hydrogen production facilities

Again, the annual workforce for Operations and Maintenance exceeds the construction of production plants over time.

4.3 Decommissioning

Background

Decommissioning in the Netherlands is organized under the NexStep collaboration platform, a national platform initiated by the oil and gas operators and EBN.

An average decommissioning process takes 3 to 5 years. After the Cessation of Production (CoP), the operators make a cost estimation. The market is highly dependent on the oil and gas prices. Decommissioning mainly takes place in the ports in so-called “dissemble and recycling yards” and on location offshore. Decommissioning is always a tailor-made process. Often, this is done in campaigns where multiple operators hire equipment and crew together.

The labour market for decommissioning is internationally oriented. A joint platform removal campaign is currently being organized by four operators in the southern part of the North Sea for similar platforms, different from the ones in other and deeper parts of the North Sea. It concerns 40 platforms that are removed over a period of 10 years, approximately 3 to 5 platforms per year, with a certain flexibility in this planning.

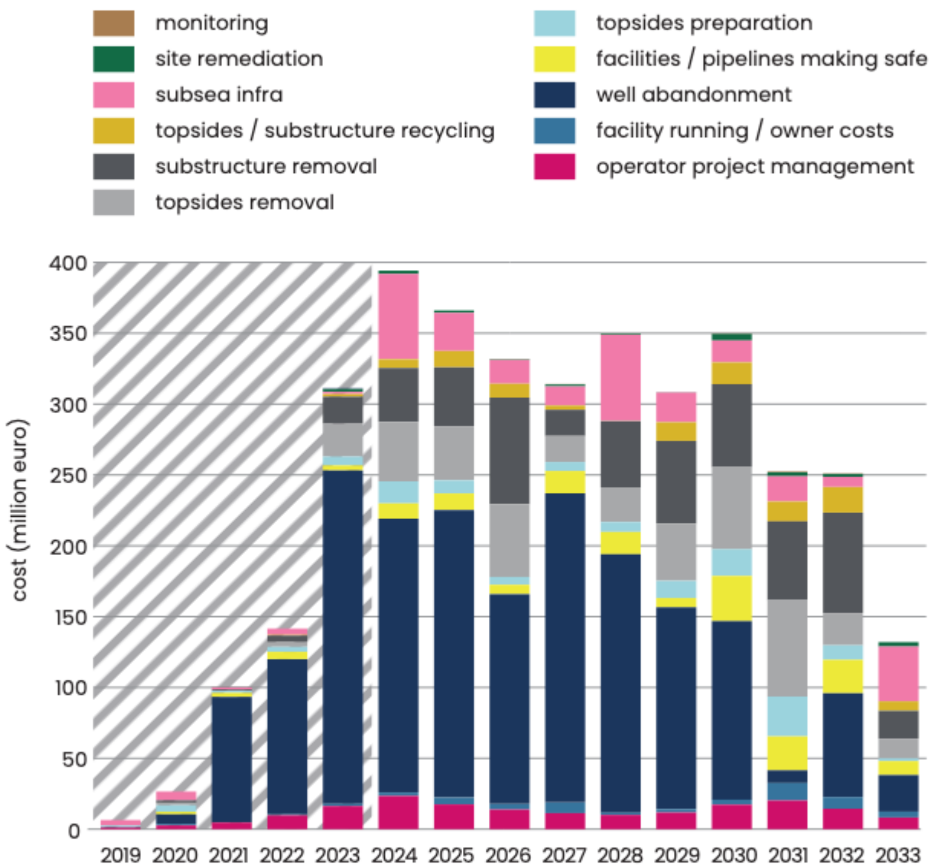
The following phases of decommissioning are distinguished:

1. Plug and Abandon (P&A) for sealing the production wells, this involves a lot of work and includes specialist diving work, platforms often have multiple wells from which gas is pumped and are sealed with about 100m of concrete.
2. Topside removal for the removal of the installation/platform above water: this requires large ships and cranes, and requires a long preparation time for calculations and engineering design.
3. Jacket removal for the removal of the installation under water. This is often cut into pieces on-site.
4. Pipelines: These are cleaned and are often buried on the seabed.

5. Offshore dismantling: dismantling of materials onshore and removal of liquids that are still present in a platform. There are special decommissioning yards.

Model inputs

- The 10-year decommissioning and reuse projection from the NexStep decommissioning report 2024 was used. The report provides numbers for the planned well abandonment, removal of platforms and removal of pipelines in detail. NexStep also provides investments per year for the next ten years, this is around 300 million per year. See the graph below.
- An assumption was made on the costs of one FTE (125.000 euro) An assumption was also made on how much of the investment is related to equipment (85%) or human capital (15%). Assumptions were discussed and verified with a senior energy infrastructure expert.



Graph 9: planned investments in decommissioning in the Netherlands for 2024-2033 [18]

Based on these investment variations, human capital demands are expected to vary as well. The average workforce estimation is 360 FTE/year. The total workforce for 10 years is estimated at 3.600 FTE.

[18] Nexstep - Re-use & Decommissioning report, 2024

4.4 Carbon Capture and Storage

Background

For Carbon capture and Storage (CCS) two projects are running in the Netherlands: Porthos and Aramis. Porthos is currently being build and is expected to operate in 2026, currently the infrastructure is under construction. Aramis is expected to operate in 2029. For this study the scope for CCS will be on the offshore requirements of human capital.

The two CCS installations require onshore transport pipelines from the industrial cluster in the Port of Rotterdam to the compression station on the Maasvlakte. From the compression station, subsea pipelines lead towards an offshore platform where the CO_2 is injected in an empty gas field. Operations and maintenance of the installation will require an onsite crew at the Maasvlakte.

Besides these two pipeline projects, a non-pipeline CO_2 transport option is being investigated. The Carbon Collectors are developing an initiative that aims to transport CO_2 with ships. In this way, they can serve the hinterland and industrial clusters that are more inland. In their business plan, FTE numbers are estimated as well.

Results

Based on the interviews, the FTE numbers for the offshore parts of a CCS facility is estimated to be very low compared to offshore wind and hydrogen. Therefore, the model does not include employment that will arise from CCS. This has been verified by an expert on certification and testing of offshore infrastructure.

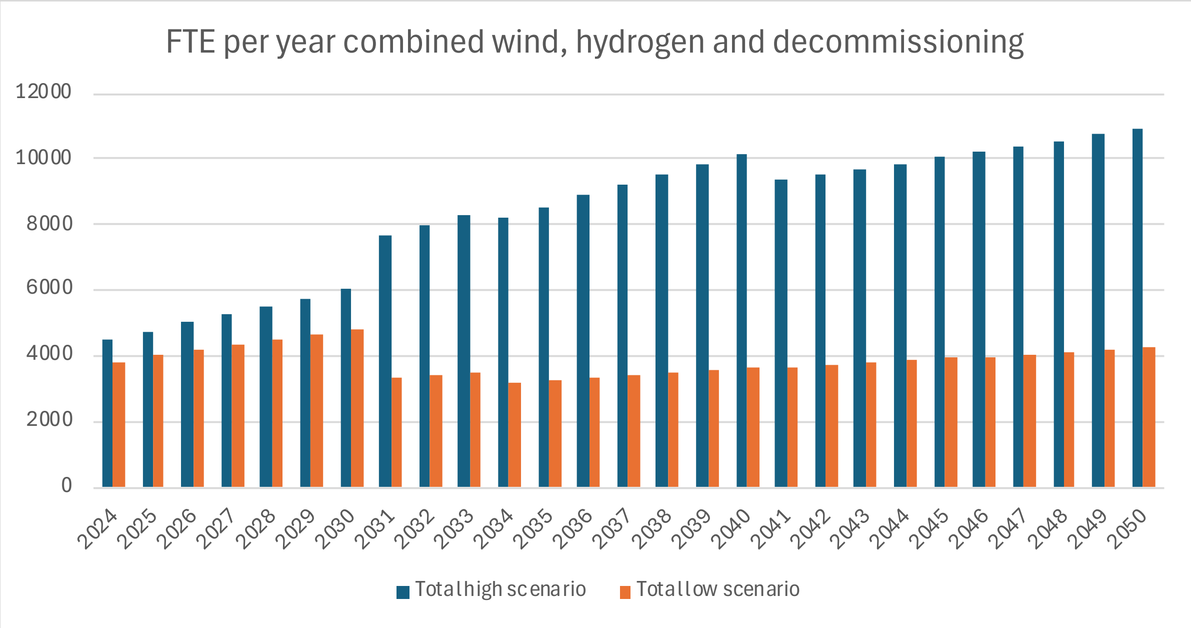
Other projects in Europe

The Acorn CCS project in the UK estimated that 45 full-time equivalent positions for the operations are estimated and there is a support team of 23 full-time equivalents [19].

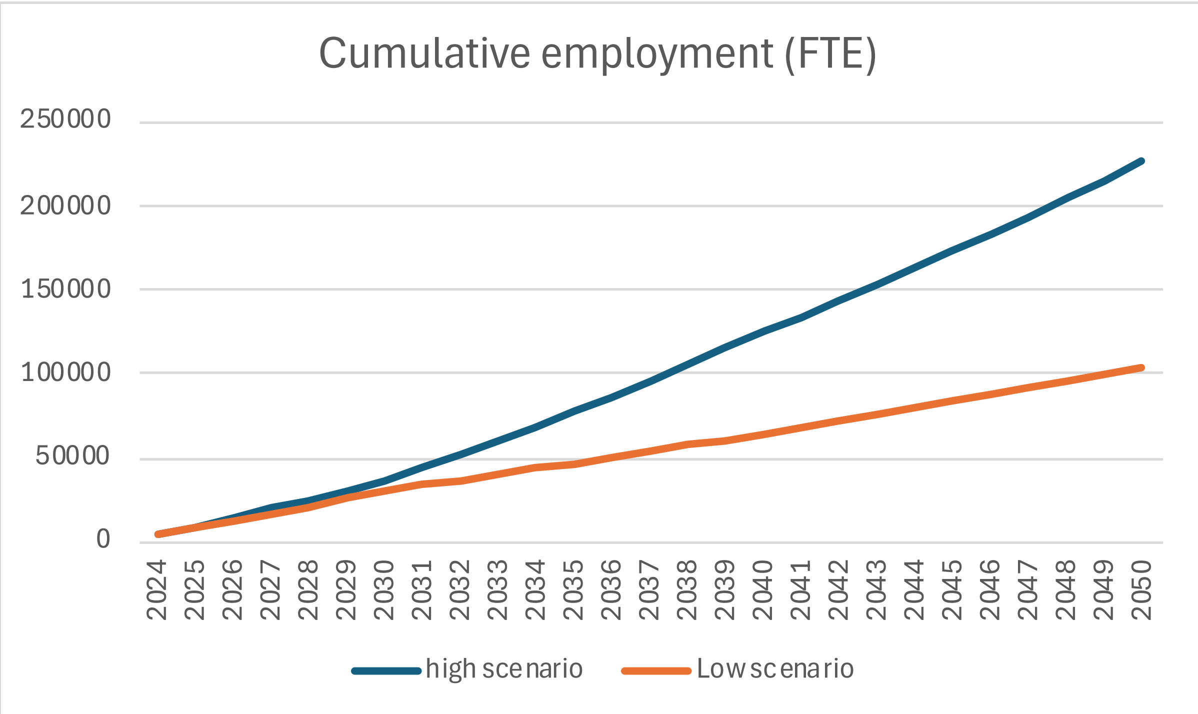
[19] Accorn CCS Project – operations and maintenance philosophy 2021 https://assets.publishing.service.gov.uk/media/6219ede58fa8f549142bf3a2/A01_KKD7_D08_Ops_and_Maintenance.pdf [accessed 29th of October 2024]

4.5 Overview of all (three) technology areas

Results



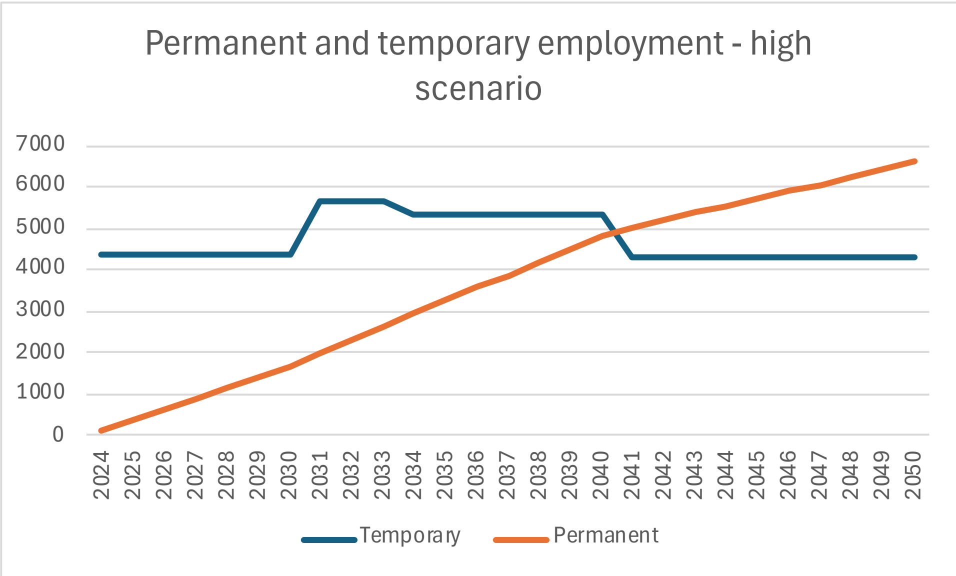
Graph 10: Estimation of total employment per year in FTE for two NSE scenarios



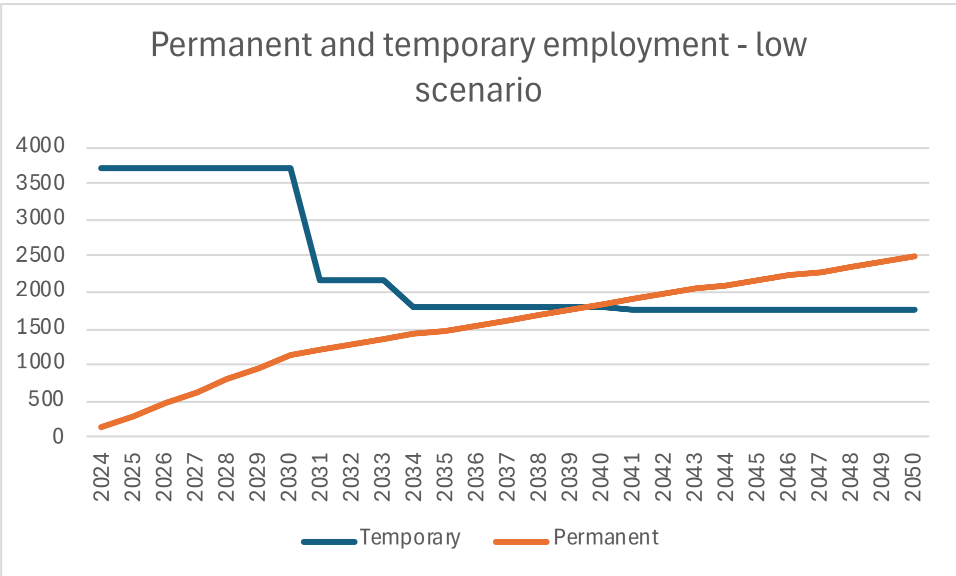
Graph 11: Cumulative employment in FTE for the two NSE scenarios for the period 2024-2050

The two lines show the range of required FTEs over the years. A cumulative employment of 104.000-226.000 FTE is expected between 2024 and 2050.

Temporary vs permanent employment
An important difference exists between the temporary jobs in construction and the permanent jobs in the operations and maintenance phase. Temporary jobs are mainly filled by marine contractors which are active internationally and hire local contractors to support the construction. The permanent jobs remain after the infrastructure has been built and will merely require a local workforce.



Graph 12: Estimation of employment per year in temporary and permanent jobs – high NSE scenario

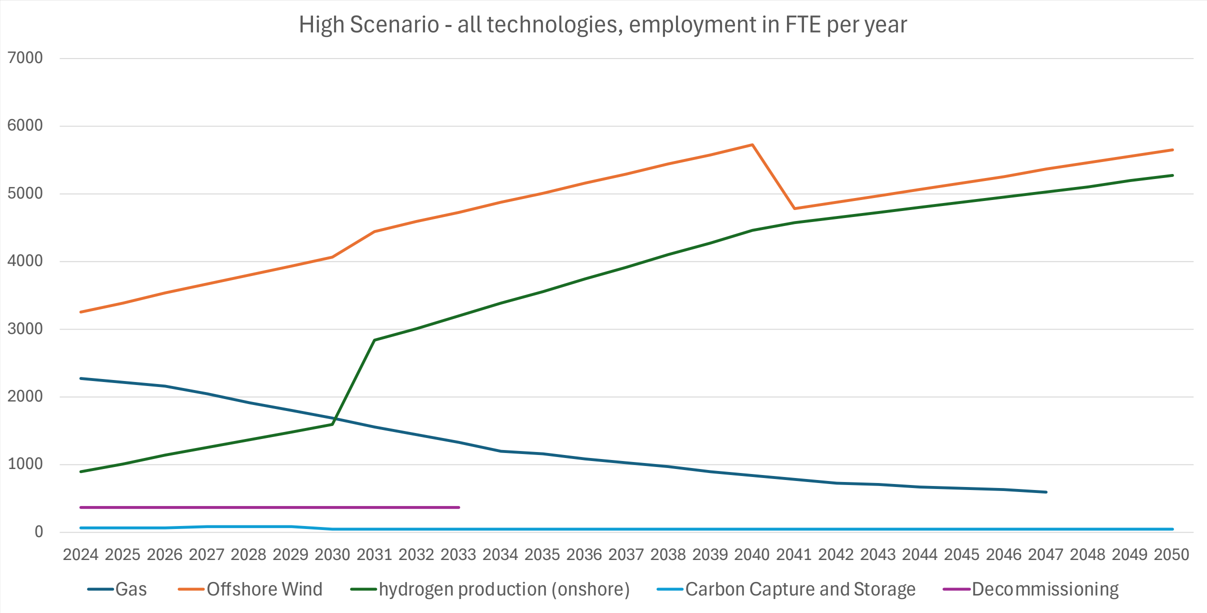


Graph 13: Estimation of employment per year in temporary and permanent jobs – low NSE scenario

Over time the permanent jobs outmatch the temporary jobs. The tipping point is around 2040. From 2040 onwards the number of permanent jobs in operations and maintenance will be higher than the number of temporary jobs in manufacturing and installation.

Cumulatively, 81.000-147.000 FTE temporary jobs will be needed, and 42.000 – 98.000 FTE permanent jobs for the period 2024-2050.

For the high NSE scenario, employment for all 3 energy technologies is represented in the graph below. As a reference the effect of declining oil and gas activities, is illustrated as well.

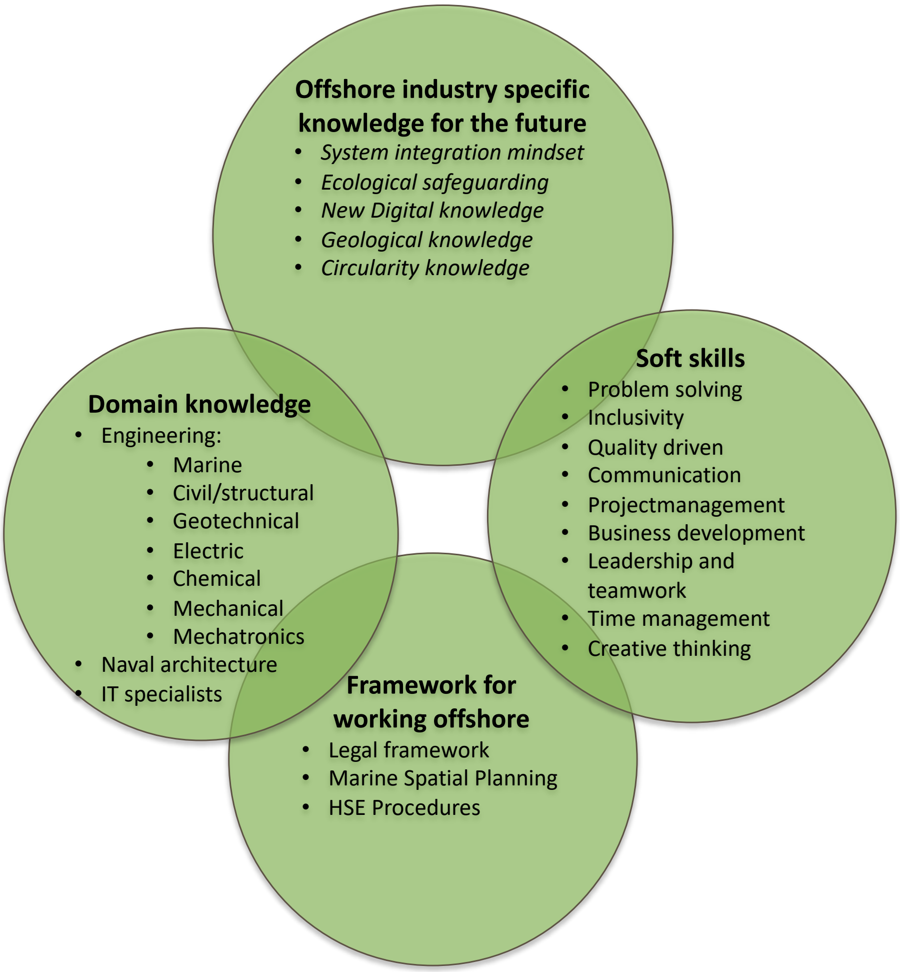


Graph 14: total employment per year for all technologies, high NSE scenario

5 Skills, education levels and jobs

5.1 Skill overview

The image below gives an overview of relevant knowledge areas and skills regarding system integration on the North Sea. Based upon stakeholder interviews and existing programs on offshore energy human capital, the image was created. This image is not complete and is made to provide a starting point to work on strategies regarding skill development of offshore personnel. In the upper circle, knowledge areas are represented that require industry-specific knowledge. In Section 5.2. these specific skills are worked out further.



5.2 Detailed skills description

System integration mindset

Strengthening the system integration mindset in both companies and knowledge institutes with students is essential for a successful energy transition in the North Sea. The energy transition is not something you do alone as a company, but as part of the chain that can only manifest change through collaboration. This requires a mindset that is open to thinking in terms of complex systems, other forms of collaboration, and expertise development outside your own field. Having a broad overview of the energy system can contribute to a better system integration mindset. An energy “skills passport” could contribute to a multiskilled workforce.

Digital skills and data science

Digitalization and data management skills are becoming more and more important. A parallel can be drawn with the automotive industry, which has become much more digitalized over the last decades. Technicians who handle electric cars must be able to understand data, whereas in the past, the focus of work was on mechanical tinkering and inspection.

For offshore energy, there is a similar shift visible from marine engineering to more digital engineering. Many operational processes are monitored (temperature, pressure, weight) and inspections are done with drones. Increasingly, work can be done remotely with digital twins. Therefore, more people can work on land instead of at the North Sea. More work can be done with fewer people. Digitalization can make work in the offshore sector more attractive to a new target group and possibly be a solution for manpower shortages. This provides opportunities to improve the image by explaining the digital aspects to the potential workforce

Important to note is that digital tools are facilitating work, but human know-how on physical infrastructures and properties remains important. Regulation may form barriers for automation and robotization. Vessels, for example, still need to be manned. Capacity is another important barrier; drones and vessels can only carry up to a certain weight and not a few tons of material. To integrate them into logistics protocols is difficult and requires new regulations.

SEO researched the impacts of labour-saving innovations for offshore wind and concludes that innovation policies can contribute to lowering the labour demand in the energy transition[20]. In Q2 2025 there will be a new publication on labour-saving technologies of the offshore industry.

Circularity skills

Circular skills are required for more circularity in the offshore sector. In the future, many of the materials could be reused. Attention increases for materials passports of large infrastructures. In the long term, wind turbines will (have to) become fully circular. The current infrastructure clearly is not. A solution will have to be found to build, maintain, and remove the turbines and windfarm infrastructure in an environmentally friendly way. In all phases of the lifespan of a wind turbine, from construction to decommissioning, a new type of engineering is needed that takes these impacts into account. Circularity requires a supply chain to be developed. For the circularity of offshore infrastructures companies that can process concrete, steel and different materials are needed.

Geological knowledge

In the Netherlands, a lot of geological knowledge is available on the subsurface. TNO and oil and gas operators know a lot about the subsurface and have bundled the knowledge on the platform NLOG . This knowledge could become relevant again for storage in empty gas fields

[20] Justus van Kesteren & Iris Klinker Arbeidsbesparende innovaties in de offshore windsector 2024. SEO on behalf of topsector energiehttps://www.seo.nl/wp-content/uploads/2024/05/2024-48-Arbeidsbesparende-innovaties-in-de-offshore-windsector.pdf [accessed 29th of October 2024]

or in salt caverns under the seabed. This knowledge can also be applied in the storage of heat on land, geothermal energy and in compressed air storage. Besides the knowledge, the oil and gas sector are sharing their standards to assure other sectors can work safely and efficiently in the subsurface.

Ecological skills

The North Sea Energy program has a dedicated work package focused on ecology, which provides an ecology-friendly design for one of the energy hubs. Ecology had a two-sided impact on work and skills: for marine contractors and for monitoring institutions.

Marine contractors

Attention for potential negative ecological impacts of the infrastructure in the North Sea is growing and in the Dutch tender procedures for wind farms, the weight of ecological aspects has been steadily increased. For marine contractors, ecology has a clear impact on the work. For example, bubble screens are now being used when installing monopiles to reduce noise. This is done especially to protect harbour porpoises and other marine mammals that are particularly affected by this noise. Wind farms must be developed with as little negative impact on ecology as possible and preferably with a positive impact on ecology. Therefore, ecological skills are becoming increasingly important for marine contractors. Currently, several pilots have been done on nature-friendly installation techniques, nature-strengthening materials, and on improved and lower-cost monitoring methods. Contractors can have in-house marine biologists.

During the design phase, the ecological impact, as well as the life cycle of materials (circularity) and design should be considered. For example, marine contractors can make use of an eco-friendly scour protection on which oyster reefs can grow. For other parts of a structure, e.g. the blades of wind turbines and the steel of monopiles and platforms, it is especially important to think about how they can be designed in a way that makes it easy to remove them without damaging the surrounding ecosystem at the end of their lifetime.

Monitoring institutions

Monitoring of sites is important to improve our understanding of the ecological characteristics of the infrastructure over time. During the phase of decommissioning, it will be a challenge to protect the ecological diversity that has emerged on the (nature-enhancing) structures. Currently, national regulations generally prescribe that everything has to be removed at the end of a wind farms lifetime, but this policy may be revised in the coming years as it obviously clashes with the demand for nature-enhancing measures in tender procedures.

The WOZEP program[21] (Wind Op Zee Ecologisch Programma) is a program by Rijkswaterstaat on behalf of the Dutch Ministry of Climate Policy and Green Growth that monitors and assesses the ecological effects of offshore wind farms. The WOZEP studies provide important insights into the impacts of offshore wind farms on birds, bats and marine mammals and provides a basis for the development of effective mitigation measures.

[21] Wind op Zee Ecologisch Programma Available from: https://www.noordzeeloket.nl/functies-gebruik/windenergie/ecologie/wind-zee-ecologisch-programma-wozep/ [Accessed 29th of October 2024]

The MONS program (Nature Strengthening and Species Protection Monitoring Survey, Monitoring-Onderzoek-Natuurversterking-Soortbescherming in Dutch) aims to answer whether and how the changing use of the North Sea fits within the ecological carrying capacity of the North Sea. A healthy North Sea is important to everyone. The marine ecosystem already requires protection and restoration based on existing use. The changing use (in form and intensity) must fit within the ecological carrying capacity of the North Sea.

De Rijke Noordzee has a toolbox that includes design options for nature enhancement in offshore wind farms.

For safeguarding ecological values in the offshore environment, the Best Available Techniques study was conducted on behalf of the Noordzeeoverleg in 2024[22]. This includes an assessment framework for the nature enhancing and nature protective measures that are taken during design and construction of new energy infrastructure in the North Sea.

5.3 Education levels and jobs

Current information on educational levels of employees and on job types can be found in the table below, for the oil and gas sector and for Topsector Energie.

Sector	Production of oil and gas (SBI06)	Topsector Energie
Employees	2.400	206.000
Education level		
Hbo-, wo-master, doctor	36%	17%
Hbo-, wo-bachelor	36%	25%
Mbo or other	29%	58%
Jobs		
Technical jobs	60%	56%
Non technical jobs	40%	44%

Table 11: Employee characteristics for the Oil and gas sector and for Topsector Energie[23]

The (offshore) energy sector is characterized by a high percentage of technical employees. The education level for employees in the oil and gas industry is relatively high: 72% of the employees has at least a Bachelor degree. This is clearly higher than the average for Topsector Energie as a whole.

[22] Hermans en Schilt et al 2024 of Hermans, A. en Schilt, B., van der Endt, J.J., Smit, M. en Dusseljee, D. Witteveen+Bos op opdracht van het Noordzeeoverleg (2024). Onderzoek naar natuurbeschermende en natuurversterkende maatregelen voor energiesystemen op de Noordzee. Available from: https://www.noordzeeoverleg.nl/nieuws/2679673.aspx [Accessed 29th of October 2024]

[23] Arbeidsmarkt monitor topsectoren 2024 https://sbi.topsectorenarbeidsmarktmonitor.nl/arbeidsmarktvolume/sbi-indeling?sector-indeling=SBI-indeling&sector=06%20|%20Winning%20van%20aardolie%20en%20aardgas# [accessed 29th of October 2024]

6 Human capital Framework for NSE towards 2050

6.1 Methodology

In Sprint 3, a human capital “Framework” was created as a final deliverable for NSE-5. The Framework is meant to recognize and facilitate management of human capital transitions that are needed for NSE for the period 2025-2030. The Framework is built around three human capital themes:

1. Human capital capacity up to 2050.
2. Workforce skills and standards for 2030-2050
3. Human capital offshore data monitoring to 2030/2040/2050

From those three themes, in total 10 “human capital issues” were deducted:

THEME 1

- Issue 1: Availability of technical personnel
- Issue 2: Contractor capacity
- Issue 3: Image of the offshore energy sector
- Issue 4: Ageing of the offshore Workforce
- Issue 5: International Workforce
- Issue 6: Labor productivity

THEME 2

- Issue 7: Certifications
- Issue 8: New skills adoption
- Issue 9: Re-training and reskilling

THEME 3

- Issue 10: Human capital monitoring

Each human capital issue was mapped along the following seven criteria:

- Opportunities
- Bottlenecks
- Interventions
- Impact of interventions
- Current development programs
- Stakeholders and ownership
- Topic for NSE-6 to work out further (Y/N)

During a human capital working session with 10 HCA experts, originating from the NSE-5 community, the validity of the Framework was confirmed (March 10, 2025).

6.2 Descriptors of all 10 Human Capital Issues

HCA THEME 1: Human Capital Capacity up to 2025

ISSUE 1. Availability of technical personnel

Bottleneck: Shortages of technical educational graduates in the labour market
Severe shortages occur in the labour market for technical professionals. For the offshore energy sector especially, the influx of students from the vocational (MBO) domain is a bottleneck. This shortage may also affect the realisation of offshore energy ambitions or slow the pace of installation down.

Opportunity: Intensify the relationship between Industry and education institutes/ private recruitment agencies and make use of the Existing workforce (maritime, energy, process industry).
The existing workforce from other technical sectors can also be used in the offshore energy sector. Think of onshore employees who work in adjacent sectors such as the process industry and the energy industry on land.

Actions/Interventions:

- Develop a strategy for retention, attraction, and lateral entry for the offshore energy industry
- Start creating interest in the North Sea at a young age

Existing Programs: Techniekpact, HR platforms in ports, learning communities

Impact: High

Impact qualitatively: Stronger collaboration between education and the offshore energy industry

Parties/Owners: Topsector Energie, TKI Offshore Energy, Element NL, NedZero, IRO, AYOP, NNOW

Role foreseen for NSE-6? NO

ISSUE 2. Contractor capacity

Bottleneck: Limited capacity at contractors
Marine contractors are limited in their capacity to deliver people to do the offshore work. Often, they must work together in joint ventures on new projects. Operations and maintenance can be organized more efficiently when there is more collaboration and more multi-skilledness.
Companies are not likely to share their human resources since there are issues regarding the insurance of the offshore energy infrastructure assets. The projects are often manned with manning agents that deliver a temporary workforce for construction or decommissioning.

Opportunity: Organizing contractor capacity more efficiently and effectively, and more data sharing between Manufacturers of turbines and asset owners for optimisation of O&M (logistics)

Workforce sharing between offshore companies
Sharing workforce is an uncommon practice on the North Sea, however, it makes sense to do this from a cost, emissions, and an optimisation point of view. There are already initiatives and organizations that work on shared operations and maintenance to do it cost-effectively. Usually, this is outsourced to 1 facilitating partner that does the work for multiple operators.

For instance, the Southern North Sea Pool (SNS Pool) is an integrated fourth party logistics concept (4-PL) where nine Operators outsourced their combined marine requirements and their helicopter requirements to one logistics facilitator.

Data sharing between asset owners for optimisation of O&M (logistics)
Asset owners can share data of their assets to start a more efficient and optimized maintenance campaign. This information is also relevant for warehousing in ports.

Actions/Interventions:

- Platform for data sharing and logistics (requires willingness to share data)
- Improve workforce sharing by outsourcing O&M to independent parties
- Provide insight into the value of data sharing

Existing Programs:

- Southern North Sea Pool – Peterson and operators
- Onshore/regional initiatives

Impact: medium

Impact qualitatively: More efficient logistics and O&M, less costs, less emissions and less human capital required

Parties/Owners: NSE partners

Role foreseen for NSE-6? NO

ISSUE 3. Image of the offshore energy sector

Bottleneck: The image of the offshore energy sector is not appealing to the younger generation
The image of the offshore energy sector is a concern that was mentioned by many of the stakeholders. Working in the offshore energy sector doesn't seem appealing to (especially) young people due to the unfavourable work-life balance conditions.

Opportunity: Improve collaboration with knowledge institutes to make offshore "hip and happening" for young students, e.g., through Learning Communities
Learning communities can make an important contribution to the "look and-feel-experience" of students and young professionals. Strengthening and expanding the current network of (local) learning communities on (development of) offshore technologies, therefore, seems a good idea. Preferably, this should be done close to ports of the Northsea, where the supply chain and the construction chain of offshore technologies are already located. In Learning communities, practical experiences can be gained in the area of new offshore technologies, which can inspire students to choose an offshore career.

Actions/Interventions:

- Regional hotspots to make (young) people more familiar with working offshore
- Use workers as ambassadors and create videos to increase interest

Existing Programs:

- Learning communities TKI offshore energy

Impact: medium

Impact qualitatively: Visibility of working in offshore energies increases

Parties/Owners:

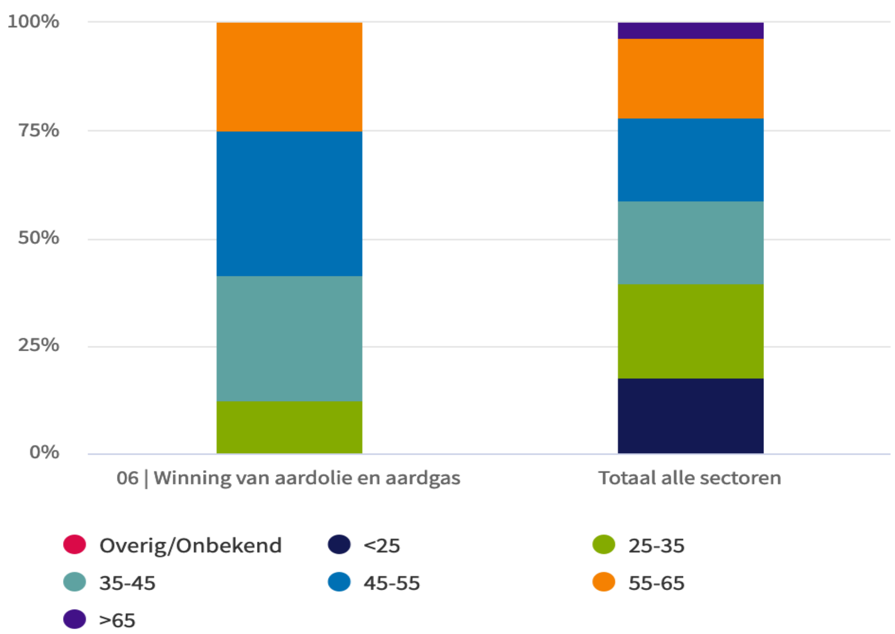
- Topsector energy/TKI offshore energy
- (Young) IRO / NMT
- Per region: Ports network organisations and PPP's AYOP and NNOW

Role foreseen for NSE-6? NO

ISSUE 4. Ageing of offshore Workforce

Bottleneck: The Dutch oil and gas sector has an ageing workforce compared to all sectors

The age distribution of the Dutch oil and gas sector is shown in the graph below. In the next 20 years, more than half of the working population will reach the retirement age. This may lead to lower productivity and loss of process knowledge.



Graph 15: age distribution of the oil and gas sector compared to the national average (sbi 06; arbeidsmarkt monitor topsectoren)

Opportunities: Use older workers for training of younger workers. Keep older workers fit through "Sustainable employability" programs ("Duurzame inzetbaarheid")

Actions/Interventions:

- Make use of new means for (Tacit) Knowledge transfer via Techbinder
- Use of older/experienced employees in a different way/part-time

Existing Programs:

- New Energy Coalition (Academy with short courses)
- MDIEU regeling (Duurzame Inzetbaarheid Eerder Uittreden). This translates to "Sustainable Employability Early Retirement Scheme"

Impact: High

Impact qualitatively: The older generation can be of value for the younger generation

Parties/Owners: NSE partners

Role foreseen for NSE-6? NO

ISSUE 5. international Workforce

Bottleneck: The Capacity of International crews is limited and subject to competition between countries and companies
The offshore energy sector relies on foreign experience and expat workers; without them, there wouldn't be an energy system. International workers are drawn to countries where offshore energy projects are most viable. Sufficient international workers, therefore, are not always available for the Netherlands. Differences exist between national legislations and guidelines. This makes it difficult to send people offshore to multiple countries.

Opportunity: International workers provide a “flexible” workforce for dedicated jobs in the North Sea
The labour market is highly international: the countries sharing the North Sea all have multinational companies that are active in the development of offshore energies. Many skilled workers come from abroad, and many international graduates in technical studies stay after graduation. European countries can install policies that make it easier to work across borders and together they can play a role in planning.

Actions/Interventions:

- Human Resource management planning of the offshore energy industry

Existing Programs: No programs running on a national level. EU regulations for working abroad could be harmonized

Impact: medium

Impact qualitatively: International workers provide a “flexible” workforce for dedicated jobs at the North Sea

Parties/Owners: Flexible workforce contributions

Role foreseen for NSE-6? NO

ISSUE 6. Labor productivity

Bottleneck: Limited potential for automation in certain North Sea activities and low adoption of new tech
The use of digital means and automation changes the way of working and will lower the amount of human capital. Digital twins are created for new projects, but some activities remain very labour-intensive and still require investment in heavy lifting equipment, involving many man-hours.

Opportunity: Labor-reducing technologies: Digitalization, automation and AI, and a North Sea Standard for wind turbines
The expectation is that labour-reducing technologies will play a big role in the operations and maintenance phase. Much of the processes can be measured and controlled remotely. Automation and remote control require a thorough design of control loops and systems. For offshore wind, various applications in the engineering phases can be automated and remotely monitored.

For example:

- Remotely Operated Vehicles (ROV's)
- Autonomous Underwater Vehicles (AUV's)
- Unmanned Aerial Systems (UAS's)
- Optimisation models for logistics with AI
- Digital twins of assets
- Augmented Reality and virtual reality training opportunities
- Predictive maintenance with AI

Actions/Interventions:

- Increased use of automation and digital means
- Action plan for labour-reducing technologies and share the learnings

Existing Programs:

- TNO studies
- NedZero Topsector Energy program 2024-2025
- MMIP's TKI's
- Learning Communities

Impact: medium

Impact qualitatively: Access and use of these technologies lower amount of required human capital

Party/owner/further research:

- North Sea Standard for wind turbines
- NSE partners + external parties
- TKI offshore energy, network organisations AYOP and NNOW and sector organisations

Role foreseen for NSE-6? NO

HCA THEME 2: Workforce skills and standards for 2030-2050

ISSUE 7. Certifications

Bottleneck: Certifications for offshore work are not aligned
OPITO and GWO, the international branch organisations of gas and wind, have their own certifications for working offshore. These are required to work in each part of the offshore energy.

Opportunity: Skill harmonization/certification
Currently, it is not easy to switch between parts of the offshore energy sector. Different certificates exist for offshore employees. Also, based on expert judgements, there appears to be room for further standardization. This will save time and costs. Skill harmonization can contribute to a smoother transfer of human resources to a different part of the offshore energy sector.

Actions/Interventions: Convenant for skills harmonization between parties of the offshore energy sector on selected parts of certification

Existing Programs:

- NedZero and ElementNL.
- OPITO/GWO (international branche organisations gas and wind)

Impact: Low

Impact qualitatively: Smoother certification procedures and less admin

Parties/Owners: NedZero and ElementNL

Role foreseen for NSE-6? NO

ISSUE 8. New skills adoption

Bottleneck: Availability of (education for) new skills for the Offshore Energy industry

Opportunity: Improve collaboration with knowledge institutes
Knowledge institutes and industry both work on developing new skillsets for (future) employees. Exchange of experiences would speed up the adoption of new skills. Companies that are active in Offshore energy can strengthen their relationship with knowledge institutes by offering (more) internships and formulating research questions and challenges.

Actions/Interventions: An agenda/platform on new skills for the offshore energy. Modular education based on needs of the industry

Existing Programs:

- NEC
- T-shore program

Impact: medium

Impact qualitatively: A knowledge platform for energy system integration, ecology, digitalization and circularity

Parties/Owners:

- Learning communities
- T-shore / affiliated institutes for Wind
- NEC or groenvermogenNL for hydrogen
- NexStep for decomissioning
- CATO community for CCS

Role foreseen for NSE-6? NO

ISSUE 9. Re-training and reskilling

Bottleneck: Skill gaps in the current workforce for reskilling and upskilling the existing workforce

Specific skill gaps were identified that are likely to persist for offshore energy. These include:

- A lack of digital skills among employees
- System integration mindset (social and ecological aspects)
- Shift from vocational workers towards a highly educated/multiskilled workforce among the marine contractors

Opportunity: Skills transfer between knowledge domains and Life Long Learning via LLO-katalysator

Actions/Interventions: Identify skill gaps and check with LLO katalysator program

Existing Programs:

- LLO-katalysator.

Impact: high

Impact qualitatively: Better use of LLO (Life Long Learning) support schemes in the offshore energy industry

Parties/Owners:

- Educational institutes, ports and industry
- LLO-katalysator
- Public private partnerships
- Network organisations in the ports (AYOP and NNOW)

Role foreseen for NSE-6? NO

HCA THEME 3: Human capital offshore data monitoring to 2030/2040/2050

ISSUE 10. Human Capital Modelling

Bottleneck: Lack of insights into the workforce required for system integration related to human capital

Opportunity: Extension of the current human capital model for NSE-5 and linkage with other models/ calculations that have recently become available

Actions/Interventions: Create a more detailed human capital model for estimation of the origin of future offshore workforce (students, lateral entries, influx of human capital from abroad), including system skillset analysis and integration scenarios

Existing Programs:

- CE Delft, NEC, MSG. ECHT report

Impact: medium/high

Impact qualitatively: a monitoring for working offshore (NSE6) and system integration

Parties/Owners: NSE6 + new partners for each topic

Role foreseen for NSE-6? YES

6.3 Human Capital Management Framework

The table below provides a representation of the proposed Human Capital Framework for NSE, for all 3 Human capital themes and all 10 HCA issues, comprising actions/ interventions, impacts and ownerships

HCA issue	Action/intervention	Impact	Ownership
THEME: Human capital capacity up to 2050.			
1. Availability of technical people	Develop a strategy for retention, attraction, and lateral entry for the offshore energy industry Start creating interest in the North Sea at a young age	Stronger collaboration between education and the offshore energy industry	Top sector energie TKI offshore energy Element NL NedZero IRO AYOP NNOW
2. Contractor capacity	Platform for data sharing and logistics (requires willingsness to share data) Improve workforce sharing by outsourcing O&M to independent party's	Provide insight in the value of data sharing More efficient logistics and O&M, less costs, less emissions and less human capital required.	NSE partners and external parties
3. Image of the offshore energy sector	Regional hotspots to make (young) people more familiar on working offshore Use workers as ambassadors and create videos to increase interest	Visibility of working in offshore energies increases	Topsector energy/TKI offshore energy (Young) IRO / NMT Per region: Ports networkorganisations and PPP's AYOP and NNOW.
4. Ageing of offshore Workforce	Make use of new means for (Tacit) Knowledge transfer via Techbinder. Use of older/experienced employees in different way/parttime	The older generation can be of value for the younger generation	NSE partners
5. International Workforce	Human Resource management plannings of companies	Flexible workforce contributions	NSE partners and external parties
6. Labor productivity	Increased use of automation and digital means. Action plan for labour reducing technologies and share the learnings	Access and use of these technologies lower amount of required human capital	NSE partners + external TKI offshore energy learning communities, network organisations AYOP and NNOW and branche organisations

THEME: Workforce skills and standards for 2030-2050			
7. Certifications	Convenant for skills harmonisation between parts of the offshore energy sector on selected parts of certification	Smoother certification procedures and less admin	NedZero and ElementNL.
8. New skills adoption	An agenda/ platform on new skills for the offshore energy industry Modular education based on needs of the industry	A knowledge platform for energy system integration, ecology, digitalization, and circularity	Learning communities T-shore / affiliated institutes for Wind NEC or groenvermogenNL for hydrogen NexStep for decomissioning CATO community for CCS and in Public Private partnerships
9. Re-training and reskilling	Identify skill gaps and check with LLO- katalysator	Better use of LLO (Life Long Learning) support schemes in the offshore energy industry	LLO-katalysator. Educational institutes PPP's Network organisations
THEME: Human capital offshore data monitoring			
10. Human Capital modelling	Create a more detailed human capital model for estimation of the origin of offshore workforce (students, lateral entries, influx of human capital from abroad)	Facilitation of management of human capital transitions for NSE	NSE 6

7 Conclusions

In this report, results are presented on the following three human capital research questions:

- Research question 1: **What workforce is needed for future offshore activities for NSE between now and 2050?**

A quantitative spreadsheet model was constructed to calculate offshore human capital requirements up to 2050. For the total of the most human capital-intensive technology areas (wind, hydrogen, decommissioning), around 104.000 FTE will be needed to enable the low wind/low hydrogen production scenario of NSE-5 until 2050. Around 226.000 FTE are needed to enable the high wind/high hydrogen production scenario. The yearly (additional) human capital demand will be around 4.000-10.000 FTE/ year. Although these latter numbers do not seem exorbitant, realization of these figures will still be a challenge, since they come on top of existing labour market requirements for the growing onshore Energy sector in the Netherlands.

- Research question 2: **Which bottlenecks and opportunities need to be addressed in a human capital agenda for NSE-5?**

Workforce requirements
Workforce bottlenecks and opportunities were identified during interviews, desk research and further discussed during a human capital stakeholder workshop. Based on this workshop, actions and interventions were defined for 10 Human capital issues that need to be considered towards 2050. For 9 out of 10 human capital issues, it was confirmed that ownership of actions and interventions already lies within the group of NSE stakeholders and does not require a specific role for the North Sea Energy program. However, for NSE-6, a deepening of the human capital model calculations is proposed.

Skills, education levels, and jobs
A first mapping was done on skill sets, education levels, and job types for the offshore energy sector. For successful system integration on the North Sea, the following technical knowledge & skills areas need upgrading for offshore professionals: system integration, digital and data science, circularity, geology and ecology. Education levels and job types have been mapped for the offshore sector but need to be worked out further in relation to these skill areas.

- Research question 3: **How can human capital interventions be aligned with existing organizations and programs?**

In Sprint 3, bottlenecks and opportunities for 10 human capital issues were translated to actions and interventions. Connects were made with existing human capital programs during an online workshop with HCA stakeholders in the offshore energy field. Visualization of these connections was done by means of a “Human Capital Framework”. For nine out of ten human capital issues, it could be established that “ownership” lies with one or more of the current NSE partners, in relation to existing human capital roadmaps or programs. Only for the tenth issue, “system integrated” human capital monitoring, a role is foreseen for further development activities in NSE-6.

8 Human Capital recommendation for NSE-6

For the next NSE program, NSE-6 it is recommended to organize a follow-up on human capital development also.

Based upon the results of NSE-5 it is recommended to focus on Human Capital issue 10 of the Human Capital Framework (see paragraph 6.3), which is about improved modelling of future workforce requirements.

Terms of Reference for such an improved monitoring tool need to be determined but will be related to:

- Job developments in the 4 technology areas
- Levels and types of education needed
- Graduate numbers from schools/ knowledge institutes
- Lateral entry potential from other sectors
- Foreign employees

A second role that is proposed for human capital in NSE-6 is monitoring of the progress of the other 9 Human capital issues of the Human Capital Framework and updating the Human Capital Framework, when appropriate.

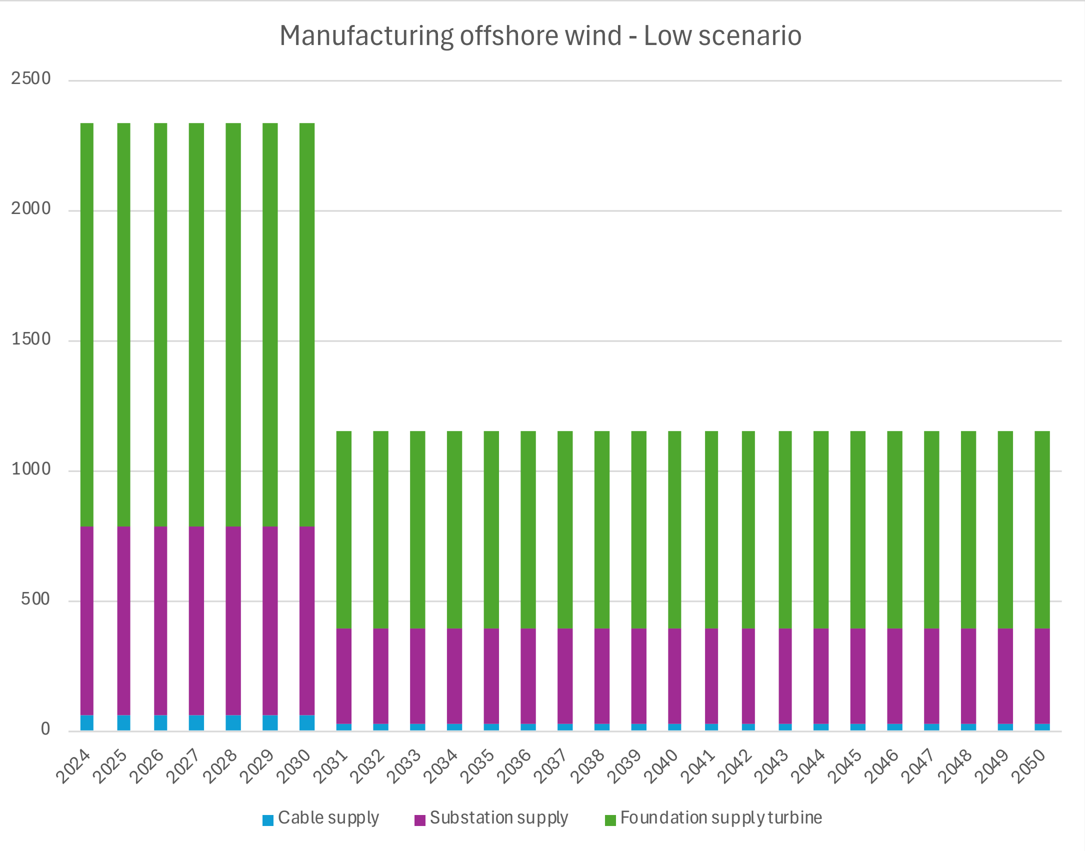
Appendices

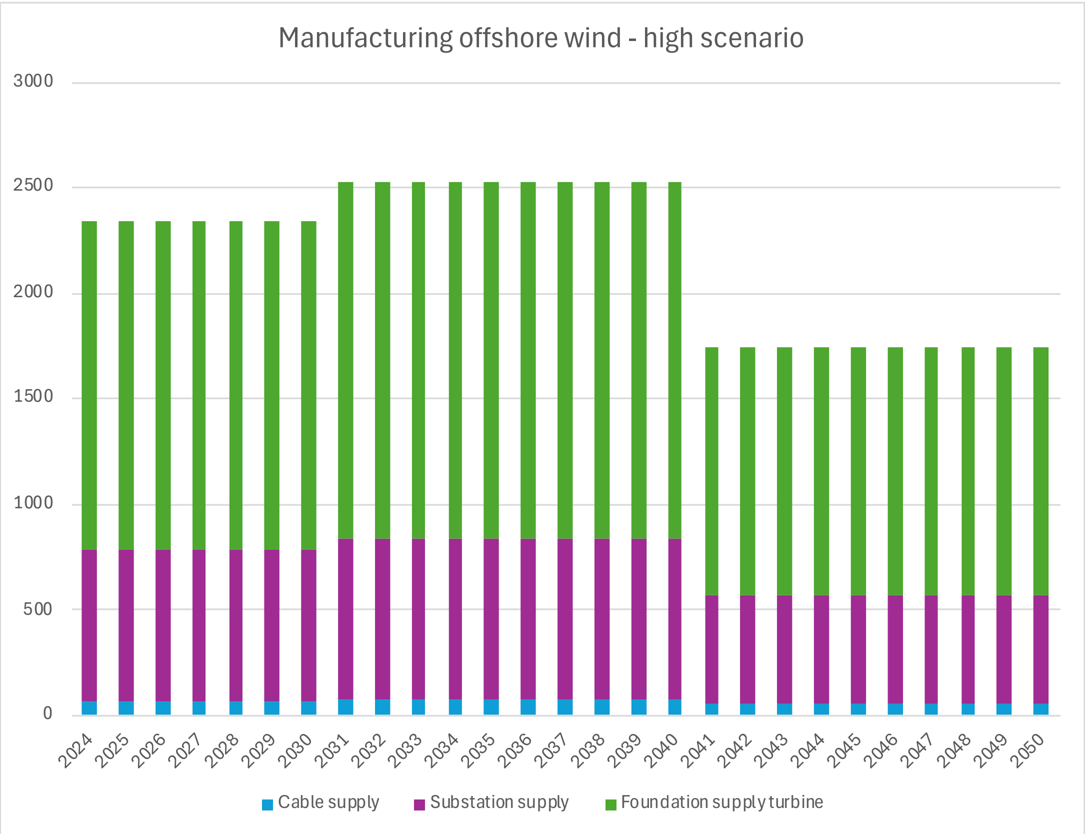
A.1 Interviews

	Oil & Gas	Wind	Hydrogen production	CCS	Decommissioning	System integration	Human Capital / Trends in labour market
ELEMENTNL + 6 operators	x	x	x	x	x	x	x
DEME group		x			x	x	x
van Oord		x	x	x		x	x
TKI Offshore Energy		x	x		x	x	x
Shell		x	x	x	x	x	x
EBN				x		x	x
CATO community				x		x	x
VNO-NCW	x	x					x
TenneT		x	x			x	x
NWEA		x	x		x	x	x
Carbon collectors				x		x	X
Peterson	x	x			x	x	X
IRO	x	x	x	x	x	x	x
TNO experts / other WPs (5 interviews)		x	x	x	x	x	x
Groningen Seaports		x	x		x		x
Nexstep					x		x
Shell			x				X

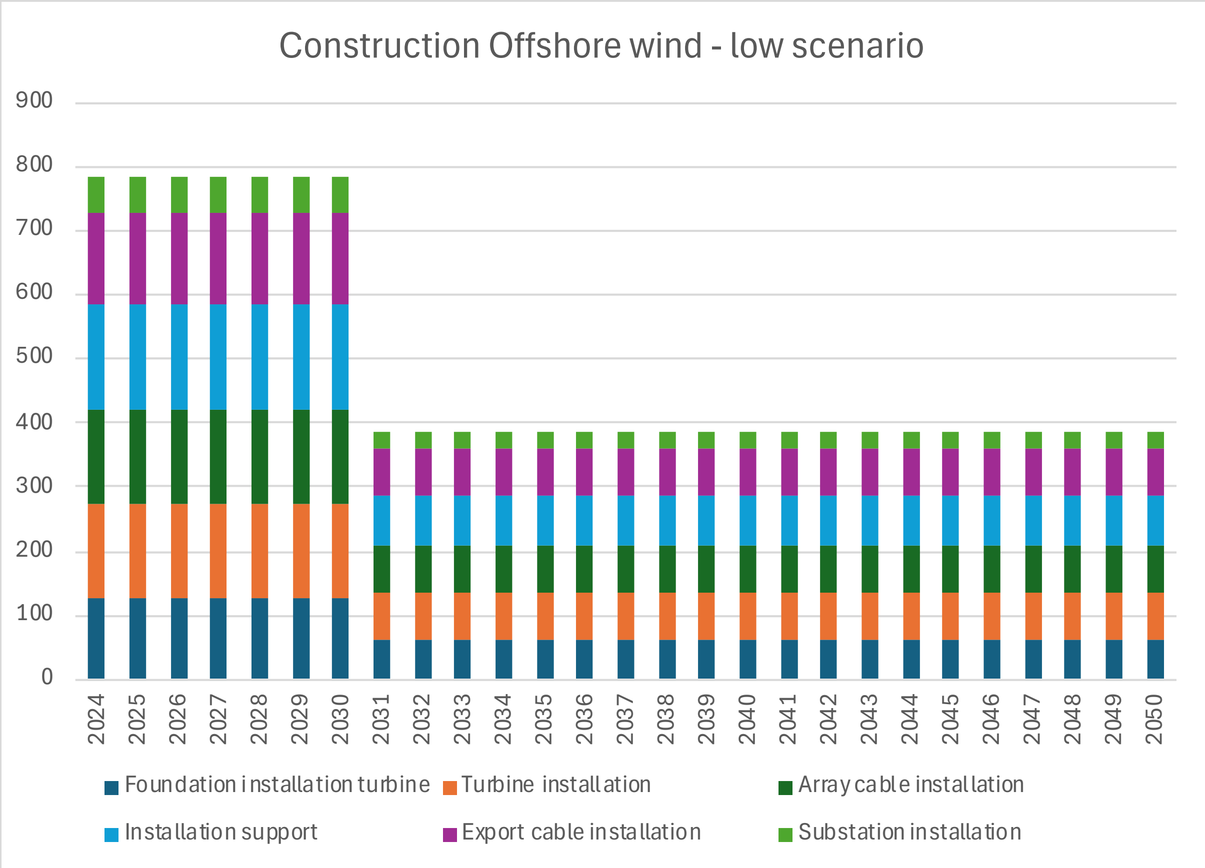
A.2 Graphs for employment Offshore Wind in detail

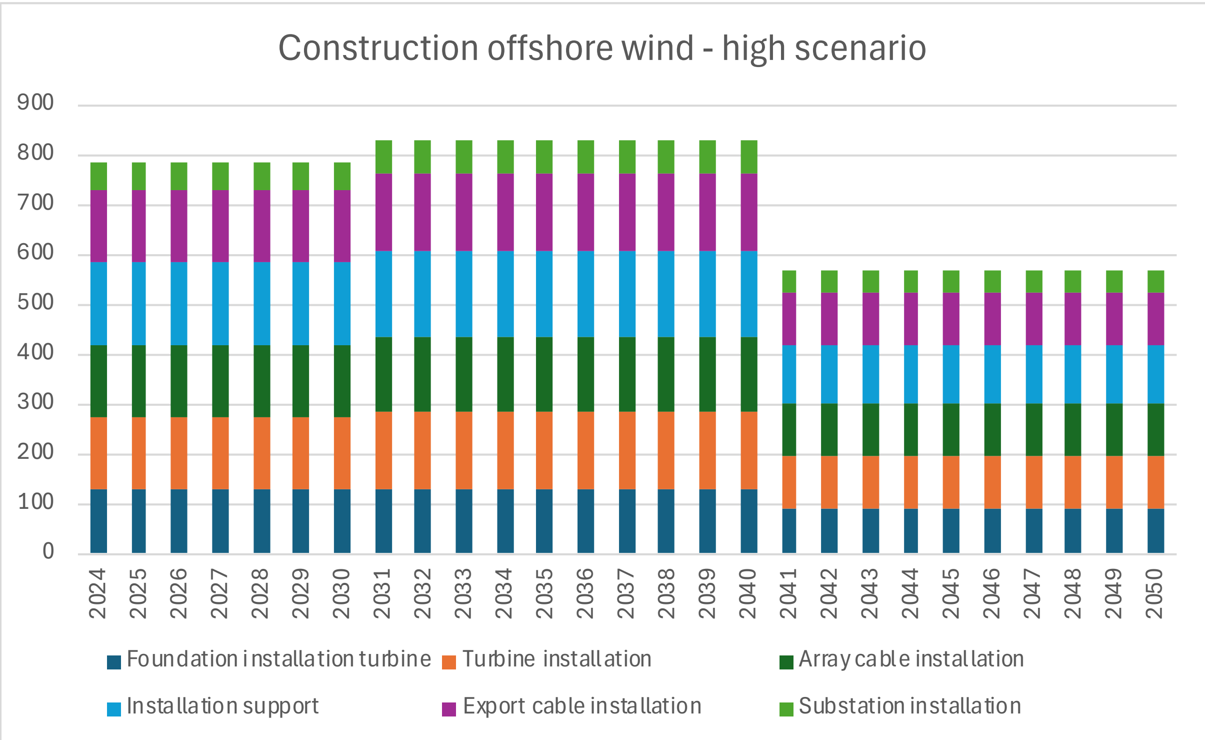
Manufacturing (FTE/jaar):



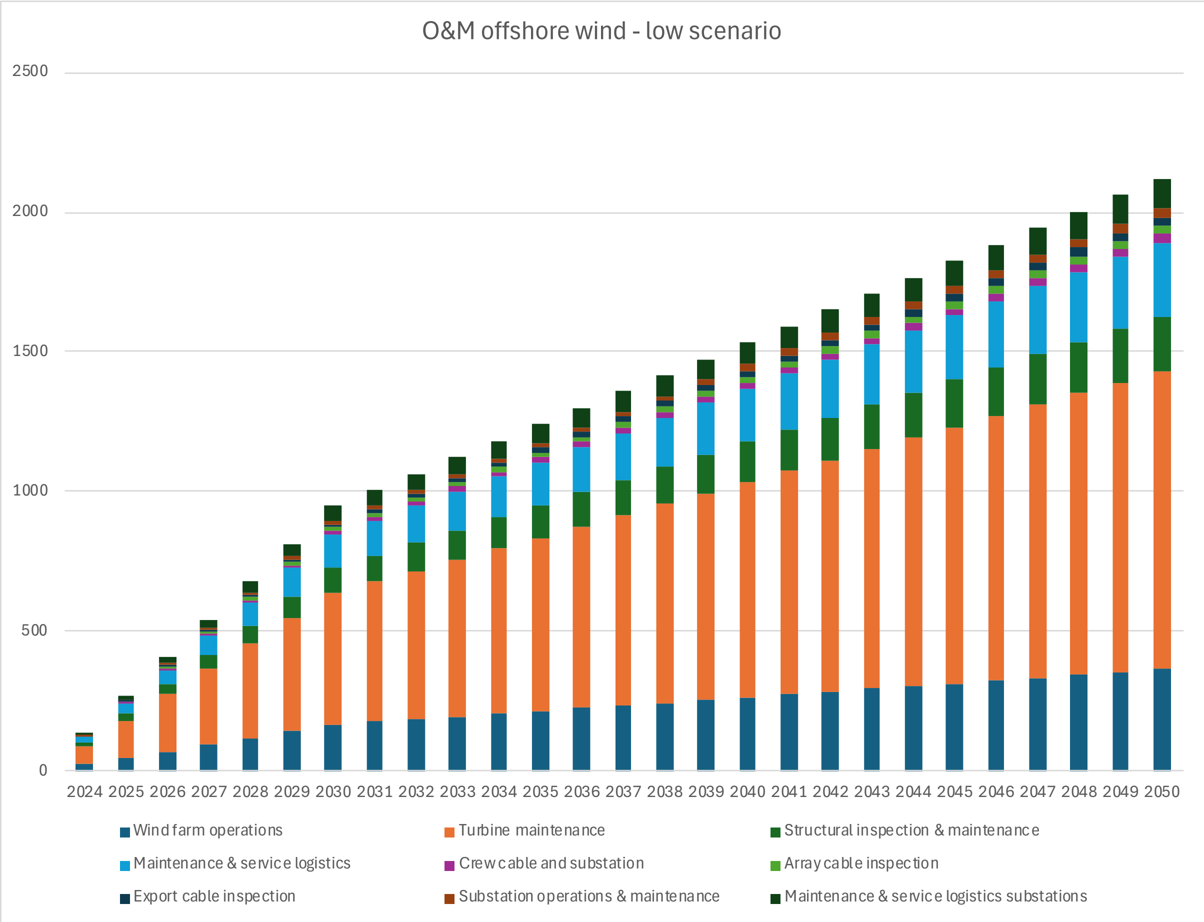


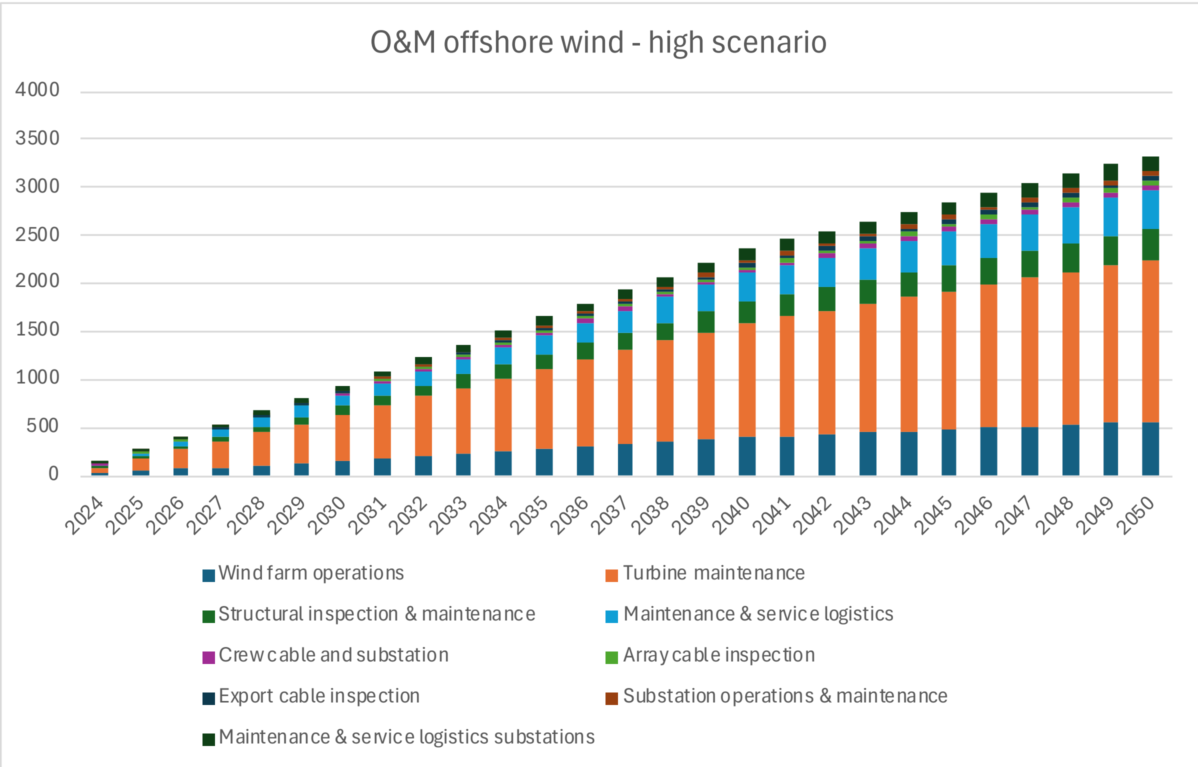
Wind farm construction (FTE/jaar)





Operations and maintenance (FTE/jaar):





North Sea Energy offshore system integration

In collaboration and appreciation to

Consortium members
TNO
Bureau Veritas
Total E&P Nederland
Shell Nederland
NAM
EBN
Nederlandse Gasunie
ONE-Dyas
DEME Dredging
Neptune Energy Netherlands (after ENI)
HINT Global
Noordgastransport
NOGAT
Peterson Offshore Group
Port of Den Helder
Port of Amsterdam
Groningen Seaports
Equinor Energy
ElementNL
Port of Rotterdam
SmartPort
Net Zero Technology Centre
Stichting Dutch Marine Energy Centre
BP Offshore Renewables
RWE Offshore Wind
Wintershall Carbon Management Solutions (WDCMS)
Arcadis Nederland
Van Oord Offshore
Norce Norwegian Research Center
H2Sea
Aquaventus
MSG Sustainable Strategies
Stichting New Energy Coalition
TU Eindhoven
Deltares
Taqa Energy
Subsea7

Sounding Board members
Bluespring (Dutch Energy from Water Association)
Energy Innovation NL – Topsector Energie
Branche Organisatie Zeehavens
ECHT regie in tranisitie
IRO – The Association of Dutch Suppliers in the Offshore Energy Industry
Jonge Klimaatbeweging
Ministerie Klimaat Groene Groei (KGG)
Nexstep
NLHydrogen
Noordzeeoverleg
De Nederlandse WindEnergie Associatie (NWEA)
Stichting Natuur & Milieu
Stichting De Noordzee
Tennet TSO

North Sea Energy

offshore system integration