Ministry of Foreign Affairs

Navigating U.S. Offshore Wind R&D: strategic opportunities for the Netherlands

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REPORT

Navigating U.S. Offshore Wind R&D: strategic opportunities for the Netherlands

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DISCLAIMER

This study was commissioned by the Climate and Energy Response Facility (CERF), a programme of the Netherlands Enterprise Agency. CERF collaborates with Dutch diplomatic missions in nearly 40 countries to ensure a just and inclusive green energy transition. Through CERF, the Netherlands Enterprise Agency contributes to decreasing greenhouse gas emissions worldwide and mitigating climate change on behalf of the Netherlands Ministry of Foreign Affairs.

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The Carbon Trust and Marin wrote this report based on an impartial analysis of primary and secondary sources including expert interviews.

Who we are

This report is the result of a collaboration between MARIN and Carbon Trust.

Carbon Trust's mission is to accelerate the move to a decarbonised future. We have been climate pioneers for more than 20 years, partnering with leading businesses, governments and financial institutions globally. We are one global network of 400 experts with offices in the UK, the Netherlands, South Africa, China, Singapore and Mexico.

MARIN is a globally recognised top institute for maritime research. Our mission is 'Better Ships, Blue Oceans': we stand for clean, smart and safe shipping and sustainable use of the sea. We do this as an independent knowledge partner for the maritime sector, government and society.

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Contents

Figures

Tables

Abbreviations

BOEM	Bureau of Ocean Energy Management
DOE	Department of Energy
EIA	Environmental Impact Assessment
FOW	Floating offshore wind
FTE	Full-time equivalent
GW	Gigawatts
IRA	Inflation Reduction Act
LCOE	Levelized Cost of Electricity
MW	Megawatt
NOWRDC	National Offshore Wind Research and Development Consortium
NREL	National Renewable Energy Laboratory
O&M	Operations and Maintenance
OSW	Offshore wind
PIB	Partners for International Business Program
RVO	Netherlands Enterprise Agency
TSO	Transmission System Operator
TUD	Technical University of Delft
WETO	Wind Energy Technologies Office
WTIV	Wind turbine installation vessels

1. Executive summary

The Netherlands is recognized as a global leader in offshore wind, offering extensive expertise and opportunities for collaboration that could help meet the ambitious targets for offshore wind deployment in the United States (U.S.). This report analyzes the priority research areas in the Unites States and the Netherlands to identify eight overlapping thematic areas, combining U.S. challenges and Dutch capabilities. Three thematic areas emerge as having the most extensive collaboration potential: transmission solutions, floating wind commercialization, and turbine scale-up and standardization.

The report provides detailed insights into eight thematic areas, highlighting current U.S. and Dutch research activities and potential timelines for partnership opportunities. These areas include supply chain industrialization, turbine scale up and standardization, installation and operations and maintenance (O&M), minimizing ecological impact, offshore wind resource and site characterization, transmission solutions, floating offshore wind commercialization and integrated offshore energy systems. Additionally, an assessment of current and historic funding opportunities in the U.S. provides tangible options for collaboration for Dutch and U.S. research collaborations.

This report identifies numerous opportunities for Dutch and U.S. partnerships across the eight thematic areas. However, significant barriers currently hinder these potential collaborations. To ensure successful partnerships, it is recommended to address these barriers through strategic networking, capacity building, formal partnerships, and targeted R&D funding.

Figure 1: Vineyard Wind Farm, Massachusetts. Courtesy of Iberdrola.

2. Introduction

The United States has ambitious goals to reach 30 gigawatts (GW) offshore wind by 2030. This target is backed by strong state and federal policies, resulting in a current offshore wind pipeline of 52 GW.[1] Currently, only 174 megawatts (MW) is commissioned and 804 MW is under construction so significant development is needed to meet targets. Recent legislation, including the Bipartisan Infrastructure Law and the Inflation Reduction Act (IRA) of 2022, aims to support the long-term development of the offshore wind supply chain in the United States. However, to meet the target of 30 GW by 2030, short-term action is also required and there are opportunities to seek input from international offshore wind markets to share knowledge and technology innovations.

The Netherlands is recognized as a global leader in offshore wind energy, with offshore wind playing a crucial role in the country's transition to a sustainable energy system. The first offshore wind turbines in the Netherlands were installed in 2007 and there is currently about 5GW of installed capacity. Most of this capacity has been installed in the past 5 years, with ever-increasing turbine sizes. Until 2020, the largest turbines were 4MW, while the newer turbines are between 8MW and 12MW. These larger turbines became feasible with the construction of larger installation vessels, foundation innovations and port facility upgrades. This has made the levelized cost of energy competitive in the local market, further developing the supply chain. The Dutch offshore wind sector holds significant expertise and has the opportunity to partner, operate and share this knowledge with developing markets, including the United States.

There is already ongoing collaboration between the Netherlands and the United States, in the form of an information exchange. In 2019 the Bureau of Ocean Energy Management (BOEM) and the Netherlands Government (RVO) signed a Memorandum of Understanding to create a platform for knowledge exchange of policy, risk management, environmental and ecological impact, stakeholder management and cost reduction.[2] Subsequently, the Partners for International Business Program (PIB) was formed to provide a platform to strengthen the relationship between Dutch businesses and relevant stakeholders in the U.S.

However, with ambitious targets and a large pipeline of offshore wind in the U.S., there is an opportunity to further strengthen the partnership between the Netherlands and the United States by exploring potential innovation partnerships to address shared U.S. and Netherlands bottleneck challenges.

[1] U.S. Department of Energy, Offshore Wind Market Report: 2023 Edition, Link

[2] Wind and Water Works, PIB United States. Link

3. Identification of thematic areas

An evaluation of overlapping priority research areas and potential opportunities was carried out to highlight the opportunities for collaboration between Dutch companies and companies or projects in the United States. The methodology used in this report is illustrated in **Figure 2**, below.

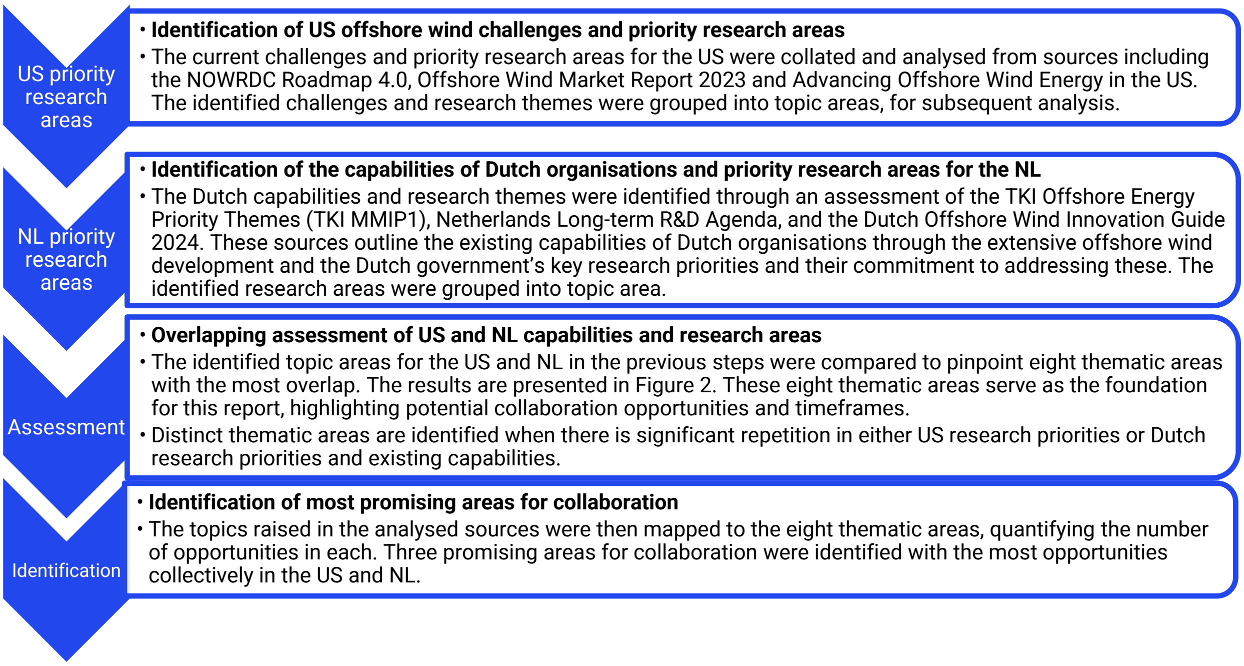

Figure 2: Process flow methodology to identify promising collaboration opportunities between the U.S. and the Netherlands.[3]

The sources for analysis were identified through an online literature review, focusing on those with Government input or alignment.

As a mature offshore wind market, the Netherlands' R&D landscape has adapted over the past two decades, with research currently focused on innovative future technologies. The U.S. market is developing quickly, with ample R&D opportunities to help accelerate the installation of offshore wind technology, but as it is still in its infancy, it is expected that new challenges and priorities will emerge as the market develops. This presents an opportunity for international collaboration to accelerate R&D efforts in the U.S. An example of this is ecological impacts and challenges which are not discussed in detail in the analyzed reports for the U.S., however, it is expected that this area will become a greater

[3] References include:
NOWRDC, Research and Development Roadmap 4.0, 2023, Link
U.S. Department of Energy, Offshore Wind Market Report: 2023 Edition, Link
U.S. Department of Energy, Advancing Offshore Wind Energy in the United States: Highlights, 2023, Link
TKI Wind Op Zee, Herijking MMIP1 2022, 2023, Link
TKI Wind Op Zee, The Netherlands' Long-Term Offshore Wind R&D Agenda, 2019, Link
Wind & Water Works, 2023. Dutch Offshore Wind Innovation Guide. Link

consideration in the future based on the European experience and changes observed in the U.S. Ecological challenges including co-existence and ecology are being explored in current Dutch offshore wind projects, presenting an opportunity for Dutch organizations to collaborate with U.S. projects.

The identified topic areas were compared resulting in a selection of eight distinct thematic areas which reflect U.S. challenges and research areas, and Dutch capabilities and research areas. Figure 3 presents the mapped topics from the literature sources onto the eight thematic areas. The number of mapped topics is displayed on either side of the thematic areas in the Figure.

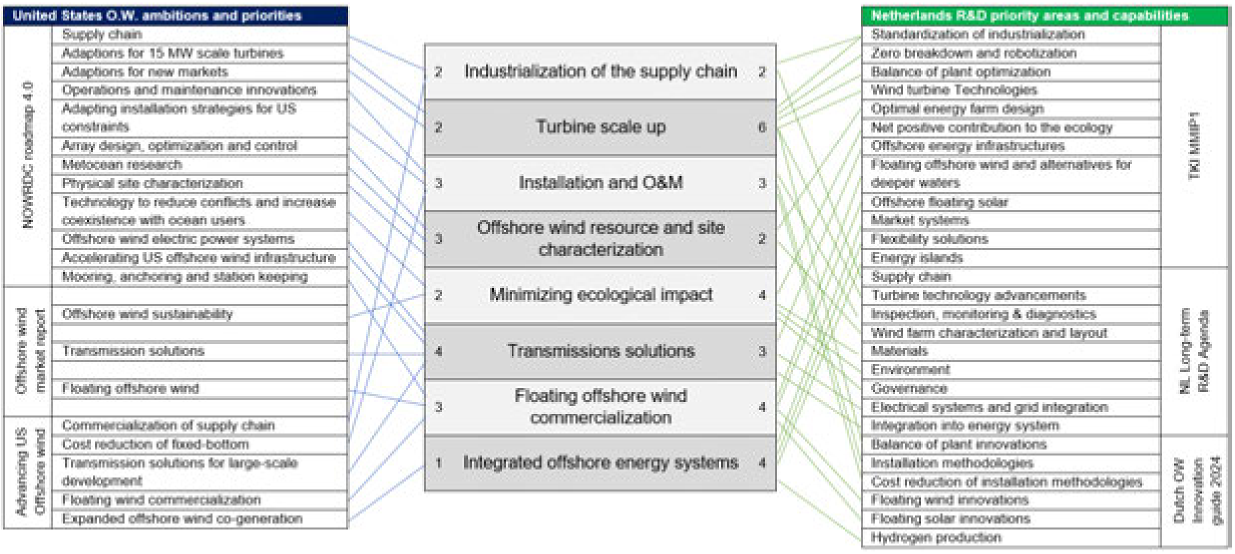

Figure 3: Priority matching of the U.S. market priorities and Netherlands priorities and capabilities. Analysis conducted by Carbon Trust.

A prioritization exercise was subsequently conducted to highlight the most promising areas for collaboration, as shown in Table 1 below. The number of mapped topics from both sides of the ocean are multiplied to rank the collaboration potential. The three areas with most extensive collaboration potential were identified as transmission solutions, floating wind commercialization and turbine scale-up and standardization.

Table 1: Opportunities assessment within the NL and U.S.

Thematic area	U.S. opportunities	NL opportunities	U.S. * NL	Collaboration potential
Transmission solutions	**4**	**3**	**12**	**Extensive**
Floating wind commercialization	**3**	**4**	**12**	**Extensive**
Turbine scale-up and standardization	**2**	**6**	**12**	**Extensive**
Installation and O&M	3	3	9	Moderate
Minimizing ecological impact	2	4	8	Moderate
Wind resource and site characterization	3	2	6	Moderate
Integrating offshore energy systems	1	4	4	Targeted
Industrialization of the supply chain	2	2	4	Targeted

This report considers challenges and opportunities in all eight of the thematic areas identified in Figure 3. The figure shows the largest number of research activities in the Netherlands on the turbine scale up and standardization area. This thematic area has been the catalyst for successful offshore wind development in the Netherlands as shown in Figure 4. It requires advanced knowledge of the turbine design, foundation design and a well-developed infrastructure of port facilities, installation vessels and maintenance vessels. All areas in which partnership between Dutch design firms and research centers and U.S. regulators, developers and investors can prove beneficial for the installation targets in the Netherlands and in the U.S.

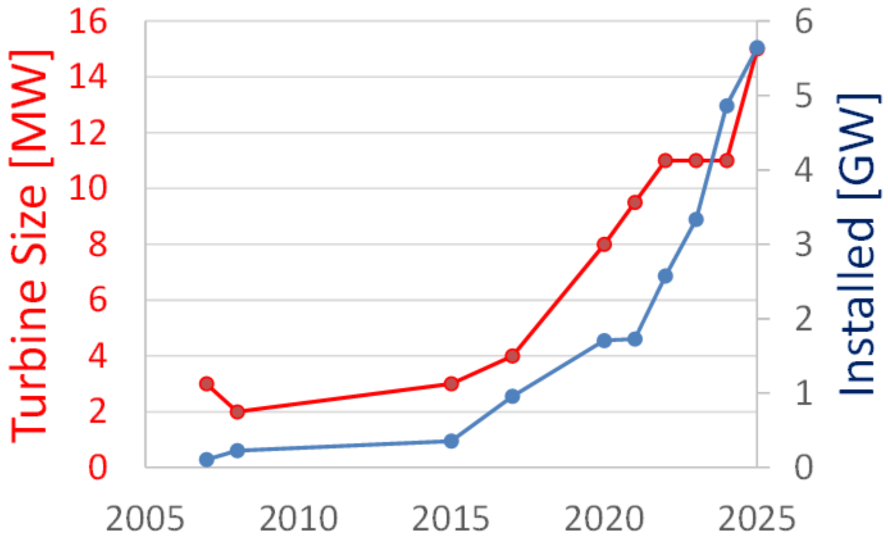

Figure 4: Installed offshore wind capacity and turbine size in the Netherlands.[4]

[4] Voogt, A., Marin. 2024. Maritime Research Accelerating Offshore Wind Energy Deployment. Global Insights Stage, IPF 2024

4. Collaboration opportunities

This section analyzes each of the eight thematic areas in more detail, highlighting existing capabilities and research activities within the United States and the Netherlands. This has been informed by publicly available information and interviews with Dutch entities working in this research space. Several Dutch organizations that operate within each of the eight thematic areas have been identified in Appendix 1, highlighting potential collaboration partners for U.S. entities. Analysis of each thematic area determines the likely timelines for collaboration opportunities in the U.S. market, ranging from short-term (2024-2029) opportunities to long-term (2035-2040+) opportunities, as illustrated in Figure 5.

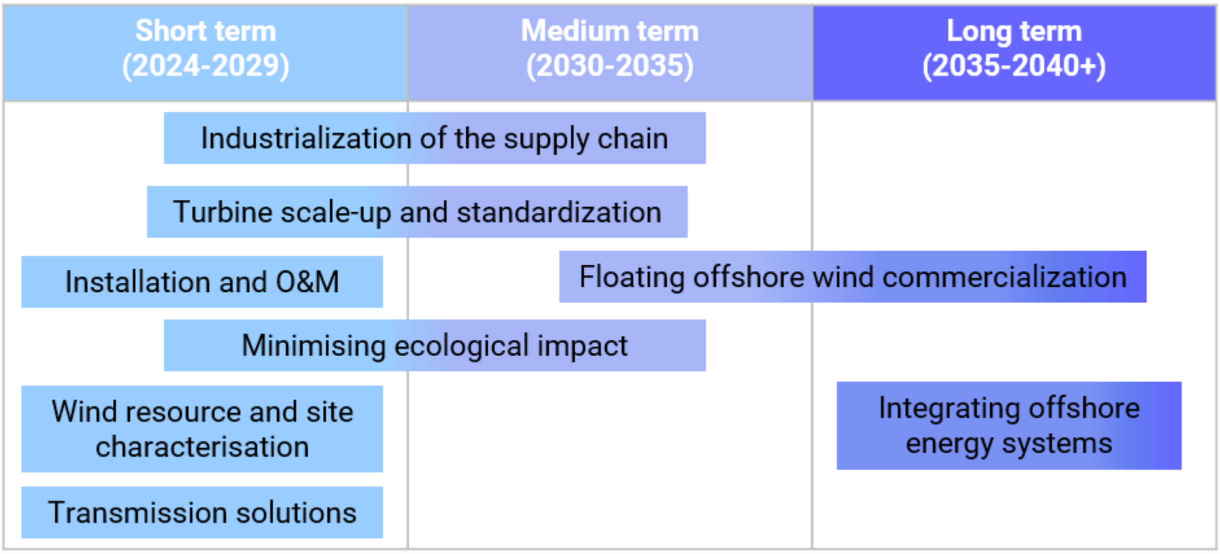

Figure 5: Capabilities of Dutch entities in engaging with the U.S. offshore wind market.

To achieve the U.S. national target of 30 GW by 2030 and 39 GW by 2040, many challenges will need to be addressed which collaboration and partnership opportunities can help accelerate. The mature Dutch offshore wind market is supported by an ecosystem containing many established organizations in addition to innovators with a good understanding of how to address industry challenges globally. This means Dutch entities are well-placed to partner with U.S. organizations to accelerate offshore wind.

However, there are barriers to collaboration including market uncertainty, exacerbated by the cancellation of recent projects and economic uncertainty. Navigating this uncertainty, while adhering to specific U.S. rules and regulations, makes market engagement challenging for Dutch organizations. Additionally, there is a lack of expertise regarding specific U.S. metocean conditions, such as the large Atlantic swell waves on the East Coast and deep waters on the West Coast, which are not as prevalent in European waters. Combining the expertise of Dutch and U.S. entities could help to overcome U.S. market challenges.

4.1. Industrialization of the supply chain

The U.S. supply chain needs significant support to attempt to deliver the 30 GW by 2030 national target.[5] Within the next 5 years, the U.S. needs to continue construction whilst upskilling and training the workforce. The wind industry employs over 126,000 people with 20,000 manufacturing roles in onshore and offshore wind.[6] Making domestically assembled components cost-competitive is possible but will heavily rely on international imports to meet the 2030 capacity targets. Research, conducted by NREL, shows that the development of a domestic supply chain could create up to 10,000 full-time equivalent (FTE) jobs by 2030 in component manufacturing with other opportunities across supplier roles.[7] This will require investment and innovation into the supply chain, to ensure sufficient capacity to deliver national targets. The NOWRDC Roadmap 4.0 states that innovations are required in adapting or converting existing manufacturing facilities to have offshore wind capabilities.

The Dutch offshore wind supply chain has evolved from a long-standing industry of oil and gas and maritime manufacturing and servicing. As there is significant overlap with the offshore wind industry (subsea cables, substations, foundations, and shipbuilding), there has been a transition to manufacturing for offshore wind. Sif, a Dutch monopile manufacturer recently opened its latest monopile factory in Rotterdam to help meet the growing demands for offshore wind (OSW) and is now the largest monopile factory in the world.[8]

Robotization is another part of innovation that can help meet the growing demands for OSW and help reduce costs during manufacturing and during Operations and Maintenance (O&M). The Dutch Organization for Applied Scientific Research known as TNO is researching the robotization of maintenance to reduce and replace hazardous work in maintenance and reducing maintenance costs.[9]

Opportunity landscape:	Short term (2024-2029)	Medium term (2030-2035)	Collaboration potential:	Targeted

In the short to medium term, large investments in staging ports in the Northeast create opportunities for Dutch companies with extensive expertise in port design and dredging. Lessons learned from the development of the Maasvlakte can help develop these projects in the safest (minimum risk for navigation), most economic (less future dredge maintenance) and minimum ecologic impact possible. Applying the storm surge models developed in the Netherlands can further help design these ports with the lowest risk of impact from hurricane activity.

U.S. investors have also taken notice of the vessels developed specifically for offshore wind installation. Different U.S. companies are currently building cable laying vessels, a scour protection vessel and wind turbine installation vessels designed by Dutch companies. Once these vessels are in operation, the success of these purpose-built vessels might result in further orders for vessels and component designs to industrialize the supply chain.

[5] U.S Department of Energy, Advancing Offshore Wind Energy in the United States. Link
[6] American Clean Power. Link
[7] NREL, Supply Chain Road Map for Offshore Wind Energy in the United States. Link
[8] offshoreWIND.biz, 2024. First Production Line at 'World's Largest Monopile Factory' to Go Live in July. Link
[9] TNO, New wind energy technology. Link

Industrialization of the supply chain also opens opportunities to increase efficiencies with digitization and automation. Heavy-lift cargo drones were recently deployed at a Dutch wind park (Borssele 1) to improve schedule and reduce costs while improving operational safety and efficiency. Autonomous underwater vehicles bring similar benefits to seabed surveys and even installation procedures are continuously improved by walk-to-work systems and motion compensation. Combined with a strong track record of U.S. companies increasing efficiencies, these innovations will continue to benefit the U.S. Offshore wind development.

Dutch investors could also partner up with U.S. companies or open fabrication facilities in the U.S., but given the large global demand for wind turbine installations and the specific regulatory, environmental and technical challenges in the U.S. waters, this might be more of a targeted opportunity.

4.2. Turbine scale-up and standardization

Offshore wind turbine size has been increasing over the past decade and 15 MW capacity turbines are becoming more commonplace. An increase in turbine size results in a cascade of additional requirements or adaptations to other aspects of the wind farm. The increase in turbine size increases loads on the components, affecting the structural integrity of the turbine, blades and foundations, which require further assessment and innovations, along with requirements for larger installation vessels and port facility upgrades to accommodate taller lifts.

Since the U.S. market is in the early stages of development, 15 MW turbines can be implemented sooner than seen in Europe with the supply chain built with consideration of larger turbines from the start. This is already being seen with 15MW turbines being chosen at the Empire Wind sites in New York. [10] These turbines and their foundations have largely undergone development with European metocean conditions, and there is the potential for innovation and adaptation to the turbines to understand performance in the U.S. conditions. Turbine innovations including durability could lead to cost reduction through increased efficiency and extended lifetime, reducing lifetime costs. The increase in turbine size to 15 MW turbines and above necessitates adjustments or innovations to ensure proper functionality and compatibility across all components and services, specifically for the U.S. physical and market conditions.

The TKI MMIP1 specifically identifies Wind Turbine Technologies and Standardization and Industrialization as a pillar focus area, with Medium and High commitment to address the area. This demonstrates the Dutch commitment to understanding these topics more readily and the existing capabilities of adapting to 15MW turbine sizes and advancements, opening opportunities for collaboration in the U.S. market.

Extensive research is being conducted on turbine advancements and extending the life of components in the Netherlands. The Technical University of Delft (TUD) researches new materials for OSW and novel concepts that can ultimately reduce loads on supports. The WMC Technology Centre is involved in the design and testing of new wind turbine blades. Other Dutch research centers like MARIN and TNO are involved in R&D around wind turbines and their loads on foundations and in the field of installation, operation, and decommissioning.

[10] offshoreWIND.biz, 2021. BP and Equinor Pick Vestas 15 MW turbines for US Offshore Wind Projects. Link

Opportunity landscape: | Short term (2024-2029) | Medium term (2030-2035) | **Collaboration potential:** **Extensive**

R&D centers in the Netherlands are interested in collaborating with U.S. Offshore wind partners to support existing suppliers in upgrading their equipment for the U.S. market. Dutch research centers can also support local developers on the specifics of project development including installation and operation in an efficient way, based on the knowledge gained in the last 20 years with the North Sea projects.

In the medium term, the turbine scale-up also creates opportunities to upgrade existing wind farms based on advanced knowledge of blade (tip) design and control systems with digital twin technologies to further increase power production and increase the life expectancy of the turbines.

4.3. Installation and O&M

The Merchant Act of 1920 (the Jones Act) prevents foreign-flagged vessels from coastal trade across ports in the U.S., which directly impacts OSW farms. Projections from the National Renewable Energy Laboratory (NREL) have signaled that to meet the 2030 OSW targets, between 4 and 6 wind turbine installation vessels (WTIVs) are needed in the U.S.[11] With a limited number of WTIVs in operation, this is expected to be the bottleneck for offshore wind farm construction to meet 2030 targets. Whilst there are methods of working around the Jones Act, these are costly. Given that installation constitutes a significant portion of capital costs, even without taking the Jones Act into consideration, significant innovation and cost reductions are needed.

The Netherlands has extensive offshore installation capabilities originating with the oil and gas industry and has numerous bespoke vessels capable of heavy lift operations. Innovations have contributed to the cost reduction of monopile installation, with innovative methods being used to reduce the reliance on slip joints and bolts, potentially saving millions.[12] The extensive pipeline of offshore wind in the U.S. will require an increase in relevant vessels and innovative installation and O&M methods. There is an opportunity to collaborate and share Dutch expertise, particularly in heavy lift vessels, to be compliant with U.S. regulations (the Jones Act) and specific to the U.S. market.

Opportunity landscape: | Short term (2024-2029) | **Collaboration potential:** **Targeted**

There are several large Dutch vessels capable of heavy lift operations, which are providing services for foundation installation. There is a significant opportunity for the Dutch service operators and owners to share expertise and advance the construction of Jones Act-compliant vessels, easing the bottleneck. Dutch knowledge of underwater noise mitigation is used to limit disturbance and complex motion compensation systems are used to increase operability.

These and other technological advancements are needed to install turbines in the more challenging Atlantic waters within the framework of the U.S. industry. Dutch companies with innovative ideas have opportunities in this area but might not have the experience record to show for it. To overcome

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[11] NREL, Supply Chain Road Map for Offshore Wind Energy in the United States. Link

[12] Wind & Water Works, 2023. Dutch Offshore Wind Innovation Guide. Link

resistance against scheduling uncertainties, they need to demonstrate how their innovation accelerates the U.S. offshore wind development through pilot projects and risk assessments. The U.S. government (with the IRA and other means) would like to stimulate offshore wind development but will not do this with active subsidies to individual companies. Instead, they provide incentives to develop new solutions and sponsor research through entities such as DOE, NOWRDC and NREL to benefit the whole industry. Chapter 5 provides some examples of previous innovation calls where these topics have been addressed through available funding.

4.4. Minimizing ecological impact

Greater consideration of ecology and wildlife (both negative and positive impacts) as part of the offshore wind decision-making process is becoming more prominent, especially as the cumulative impact of offshore wind projects grows. There is existing research taking place on these topics and in the U.S. all federal agencies have responsibility for environmental impact assessments (EIA) and mitigating the impacts of OSW per the National Environmental Policy Act.[13] Net-positive ecology is a research area for the U.S. Department of Energy's (DOE) Wind Energy Technologies Office (WETO), which is collaborating with researchers across the DOE's national laboratories to investigate wind blade recycling as a part of the circular economy objectives. An example of work on circularity and raw materials is the research collaborations between Oak Ridge National Laboratory and the NREL in producing blades and generators with fewer materials.[14]

During installation and O&M there can be direct and indirect ecological impacts varying across species within the wider ecosystem with some species being impacted by noise effects, water quality or potential collision risks all of which can be minimized through risk mitigation. Environmental impact assessments form the foundation for understanding the ecological impact, which needs to be complemented with long-term ecological data monitoring. RVO introduced a pioneering policy which requires the curtailment of turbines at Dutch offshore wind farms to allow for bird migration. The policy has been possible due to the sufficient and valuable data collection of bird migration patterns over time, with an understanding of the interaction with turbine blades. This is an example of how monitoring systems can be used to reduce ecological impacts for long-term offshore wind developments.

The Netherlands has been supportive of research contributing to reducing ecological impacts, resulting in expertise across many sectors of offshore ecology managers or marine biodiversity specialists, which has now developed a self-sufficient industry with expertise. Nature-inclusive design and coexistence feature heavily across recent Dutch projects, resulting in an increase in expertise on these topics.

Research is taking place in the Netherlands related to minimizing ecological impacts including organizations such as GROW. The Dutch multi-year research program WOZEP also focuses on the ecological impact of offshore wind, which creates another opportunity for cooperation between both sides of the Atlantic. With the pipeline of projects in the U.S., the cumulative impact of installing foundations will soon become a prominent challenge and Dutch expertise could be utilized.

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[13] Congressional Research Service, 2024. Potential Impacts of Offshore Wind on the Marine Ecosystem and Associated Species: Background and Issues for Congress. Link

[14] Wind Energy Technologies Office, 2021. No Time To Waste: A Circular Economy Strategy for Wind Energy. Link

Opportunity landscape: Short term (2024-2029) | Medium term (2030-2035) **Collaboration potential:** **Moderate**

Based on the feedback from the initial projects and with the developing regulatory framework in the U.S., it is expected that ecological challenges will need to be addressed more thoroughly in the near future. Both the U.S. and the Netherlands have strong research capabilities, and as addressing ecological and wildlife impacts requires these skills, this area is well suited to international cooperation.

4.5. Offshore wind resource and site characterization

The second pillar of the NOWRDC Roadmap 4.0 is dedicated to improving data collection and validation for offshore wind resources and site characterization in the U.S.[15] Resource evaluation is key during the planning phase of OSW projects and to do so assessments rely on atmospheric models, metocean data and in-situ measurements for model validation. Due to the risk of hurricanes and seismic activity, there is a significant amount of research taking place in the U.S. to study the impacts of extreme weather on turbines.[16] Data collection in harsh conditions is challenging and often models are reliant on publicly available buoys at heights significantly lower than a hub height greatly increasing data uncertainty. There have been activities in U.S. waters for metocean data collection, but there are varying degrees of accessibility of this data and data gaps. Data accessibility will facilitate quicker design and development of offshore wind sites and research is being conducted with organizations such as NERACOOS and NOAA to investigate the feasibility of collecting and reporting specific metocean data.

In Europe, public data sets provide high-quality metocean data that is available to the public and benefits academia and developers. In the Netherlands, RVO has launched a data portal with published site characterizations.[17] The capabilities lie in the Netherlands to assist in increasing the data availability for OSW however further collaboration would be required with U.S. departments and developers that are the present data owners.

Opportunity landscape: Short term (2024-2029) **Collaboration potential:** **Moderate**

For site characterization, Dutch research vessels and autonomous underwater vehicles are mapping the seabed to determine soil conditions and water depth for underwater cables. Autonomous vessels and robotics facilitate long-term environmental data collection reducing the need for personnel offshore in harsh weather conditions. Further, capabilities in robotics technology are being used to perform environmental characterization, habitat mapping and baseline surveys remotely. For extreme wind conditions and hurricane modelling, a Dutch research institute participates in a large research project under the flagship of the U.S. National Oceanographic Partnership Program on Hurricane Coastal Impacts, consisting of 30 academic, government and industry partners to investigate how to best model these phenomena. [18] These models include the entire U.S. East Coast and the Gulf of Mexico coast.

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[15] National Offshore Wind, 2023. Research and Development Roadmap 4.0. Link

[16] Office of Energy Efficiency and Renewable Energy, 2018. Wind Turbines in Extreme Weather: Solutions for Hurricane Resiliency. Link

[17] Windpowernl, 2023. New data portal makes Dutch offshore wind site data more accessible. Link

[18] Forecasting hurricanes on US Coast Link

4.6. Transmission solutions

Across the U.S., there are OSW integration issues regarding the grid and significant transmission updates are needed to meet the ambitious 2030 target. The DOE published a "Building a Better Grid Initiative" to identify upgrades in high-priority areas.[19] Transmission is not standardized but rather responsibilities lie with the individual developers. With limited interconnection points along coastlines remaining there is a risk of interconnection queues as the grid may not have the required capacity in time for the new developments.

Several aspects contribute to successful transmission infrastructure, stretching across both onshore and offshore site locations. Innovative design solutions, including HVDC transmission, development of subsea cables, installation strategies and vessels capable of installing the subsea cables, substructure manufacturing and innovative electrical equipment including reactive compensation systems, all contribute to the transmission solution.

The transmission system for offshore wind connection is coordinated by the Transmission System Operator (TSO), TenneT, in the Netherlands. TenneT is responsible for the design and buildout of the infrastructure, streamlining the grid connection to match the estimated construction time for OSW projects. TenneT develops the grid infrastructure holistically, with foreplaning, allowing for standardization of design. The Netherlands experiences benefits from this model including cost savings due to economies of scale of infrastructure as well as more strategic benefits such as national security.[12]

The transmission model in the U.S. is currently different from the Netherlands, with the offshore wind developer taking responsibility for the transmission infrastructure buildout, rather than TenneT. Although the same model is unlikely to be adopted, to enable complete standardization of the offshore transmission system, there are still numerous opportunities to implement innovative technology aspects relating to subsea cables, substations and substation platforms, monitoring systems and transmission installation solutions within U.S. wind farm developments.

Opportunity landscape:	Short term (2024-2029)	Collaboration potential:	Extensive

For transmission solutions, Dutch companies provide cable laying solutions and innovative standardized connectors and substations for subsea infrastructure. Offshore wind parks include many cable terminations for all inter-array cables and it is therefore important to prevent downtime and reduce (failure) cost by increasing robustness. Based on experience in the North Sea, several Dutch companies are researching cable improvements and are interested in sharing their lessons learned with partners in the United States to cooperate to design failproof solutions for cables, connectors and substations.

4.7. Floating offshore wind commercialization

With an estimated two-thirds of potential offshore wind in deeper waters, floating technology will be required to meet the full potential of offshore wind in the United States. Floating offshore wind (FOW) is an emerging industry globally, but the U.S. government is providing support for the development

[19] Department of Energy, Building Better Grid Initiative, 2022, Link

including the launch of the Floating Offshore Wind Energy shot in 2022, which aims to reduce costs of FOW by up to 70% by 2035.[21] A recent development in the U.S. FOW market is the announcement that the Humboldt district in California will receive over $400 million in grants to construct a modern terminal for preassembly and launch of FOW.[20]

The U.S. currently leads with the number of patents registered for floating foundations,[21] though to harness the full potential of FOW it is noted that standardization is required across manufacturing and installation processes, and standardization more specifically across components. [22] As the U.S. is starting to develop its FOW capabilities it presents an opportunity for an early streamlining of platform types and standardization across the manufacturing which has the potential to lead to accelerated economies of scale. In the Netherlands, Dutch foundation designer SBM Offshore and French Technip Energies have created a joint venture entity to combine the design expertise of their foundation designs, to improve compatibility, benefiting the industry as a whole. [23]

The deeper waters of FOW sites are typically further from shore, encountering harsher metocean conditions, which poses challenges during installation and O&M. The typical vessels used for fixed-bottom installations cannot be used interchangeably. To overcome these challenges innovative installation methods along with stabilization techniques to enhance crew safety will be required; this creates an opportunity for existing Dutch installation companies. Research is being conducted in the Netherlands into floating solar technology, by a number of research organizations, SMEs and private developers including the Solar@Sea, Crosswind Hollandse Kust and SolarDuck offshore prototype projects.[24] Floating solar can be used in tandem with FOW to maximize energy production with the space between turbines. Floating solar panels require mooring, similar to floating offshore turbine platforms, opening up the opportunity for collaboration on mooring techniques for floating offshore wind in the U.S., which has a high capacity potential due to deep waters. In the future, once floating solar projects have been successfully demonstrated in the Netherlands, there will be the opportunity to collaborate with U.S. projects, increasing the electricity yield in a single space. As floating solar is still at a low technology readiness level, the opportunities for this are long-term.

Opportunity landscape:	Medium term (2030-2035)	Long term (2035-2040+)	**Collaboration potential:**	**Extensive**

Commercialization of floating offshore wind is still on the horizon, but Dutch design companies with extensive experience in the O&G industry could play an important role in this market. Floating offshore wind designs will have to focus on constructability and bankability and might involve alternative turbine designs which are better able to benefit from the floater motions. With demonstration projects underway in Europe and Asia, the U.S. is not expected to be the first market to commercialize floating wind, but incentives in California will allow for major port development in the medium term. Dutch expertise from the expansion of the Maasvlakte and innovations about the floating ports of the future may contribute to this focus area.

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[20] offshoreWIND.biz, 2024. Californian Port to Get USD 400+ Million for Floating Wind Terminal. Link
[21] IRENA, 2024. Floating offshore wind outlook. International Renewable Energy Agency. Link
[22] Engineering and Technology, 2024. New floating offshore wind survey reveals the major hurdles and risks facing the sector. Link
[23] SWZ Maritime, 2024. SBM and Technip form floating wind joint venture. Link
[24] Floating Solar Panels, TNO, Link

4.8. Integrated offshore energy systems

Flexibility solutions and co-generation technologies will be essential for transitioning to an integrated offshore energy system. Whilst research is ongoing, for example with NREL, there are no demonstrator sites for integrated energy systems, presenting an opportunity for collaboration. The U.S. Government supports this transition through the implementation of measures such as the TRANSFORM initiative of the Advancing Offshore Wind Energy in the U.S. (2023) report and the Inflation Reduction Act which will provide tax incentives to support hydrogen co-generation, wind-to-X technologies, storage solutions and energy hubs.[25] However, the introduction of these measures is a way off, with the IRA tax credits scheduled to be launched after 2030, providing an opportunity to collaborate with Dutch entities who are researching integrated offshore energy systems.

Significant technology development is taking place with Dutch organizations within the energy storage space, including organizations such as Giga Storage and Lion Storage. Additionally, Green hydrogen expertise is progressing in the Netherlands, with projects such as NortH2 and H2opZee demonstrating the conversion of offshore wind power to green hydrogen at the offshore platform. As these projects progress over the next decade, the expertise of green hydrogen production and offshore electrolysis will continue to grow, with an opportunity to share learnings in international markets such as the U.S.

Opportunity landscape:	Long term (2035-2040+)	Collaboration potential:	Targeted

Another topic area of interest for the long term is the integration of offshore energy systems. Cost reduction in floating wind enabled by deployment at scale will produce abundant power making the viability of green hydrogen production. Several Dutch players with experience in floating production vessels are studying the opportunity to harvest this energy and Dutch research institutes are studying the best ways to generate, transport and use hydrogen. Solar wind development within offshore wind parks in Europe will also improve the understanding of integrated energy systems.

Eneco and OCI N.V have collaborated on NortH2 which is an OSW to hydrogen project being developed in Eemshaven and by 2040 the project is predicted to produce 1 million tons of green hydrogen a year.[12] Another hydrogen project of note is the H2opZee demonstration project being developed in the Dutch part of the North Sea by RWE and Neptune Energy to build electrolyzes with a capacity of up to 500 MW to produce hydrogen.[26]

[25] U.S Department of Energy, Advancing Offshore Wind Energy in the United States. Link

[26] RWE, H2opZee. Link

5. Open innovation calls and accelerators

There are several funding opportunities for research and development projects which will address challenges specific to the U.S. offshore wind market. The opportunities differ in their focus areas, with some providing broad focus areas and others specific and narrow focus areas. A list of recent funding calls and solicitations is provided in Table 2 below, with state specific funding calls identified in Table 3.

Table 2: Recent or open innovation calls in the United States, with a partnering country (where applicable).

#	Country	Funding Partners	Years Active	Focus	Objective	Research Areas
1	**United States and Denmark**	**Innovation Fund Denmark and the U.S. Department of Energy**[27] Announced a $4.2 million innovation opportunity. Funding applications are yet to open, expected to be released in Spring 2024.	2024	Floating offshore wind	To advance floating offshore wind energy systems towards cost-effective commercialization and wide-scale deployment	Focused specifically on **mooring innovations**: • Compatibility strategies for mooring, cabling and coexistence; • Mass-producible, high-reliability moorings; • Novel station-keeping systems and components; • Monitoring and inspection technologies for moorings; • Open topic addressing mooring technologies
2	**United States and UK**	**Innovate UK and NOWRDC**[28] Innovate UK is funding £2 million into the UK innovator. Innovators must partner with a U.S. entity that receives separate funding through NOWRDC.	2024-2026	Cost reduction	Reduce cost and risk of offshore wind development projects throughout the U.S.	• Solutions to facilitate offshore wind resiliency and transmission coordination • Operations and maintenance systems development • Innovation to facilitate ocean area coexistence • Sub-categories provide specific details of the technologies/projects which are eligible.

[27] Wind Energy Technologies Office, 2024. DOE and Innovation Fund Denmark Announce Upcoming $4 Million Opportunity to Advance Floating Offshore Wind. Link
[28] Innovate UK, UK-US Offshore Wind Collaborative R&D. Link

3	**United States**	**United States Department of Energy**[29] U.S. DoE announced a notice of intent for a $48 million funding opportunity.	2025-Project end	Floating platforms, foundations and monitoring	Accelerate wind power off U.S. coasts and contribute to a robust U.S. clean energy economy driven by a carbon-free power sector.	Six key topic areas: • Floating offshore wind platform research and development • Innovation for fixed-bottom offshore wind foundation types and supporting infrastructure • Technology advancement for bird and bat research office • Development of a manufacturing and supply chain offshore wind consortium in the Great Lakes region • Floating offshore wind center of excellence • Protecting the future offshore wind fleet against lightning
4	**United States**	**Wind Energy Technology**[30] **Office** Regularly funds research and development across competitive solicitations.	2008 - Present day	Innovations in OSW	Addressing various technical innovations and providing various funding mechanisms.	Open solicitations in 2024: • Fluid Dynamics • Improving the aerodynamic performance of OSW turbines • Ocean Energy Safety Institute RFP on OSW Energy
5	**United States**	**NOWRDC Solicitation rounds 1-4**[31] **Round 4:** Funding pool of $10.6 million supported by NYSERDA, CEC, MassCEC and BOEM.	2021 - Present day	Innovations in floating OSW	Address various floating technological, environmental, and cost barriers to help accelerate the deployment of FOW.	Round 4 focuses on key areas for floating offshore wind including: • Innovations in Ports and Vessels; • Transmission Technology Advancement; • Uncrewed Underwater Vehicles for Environmental Monitoring.

[29] Wind Energy Technologies Office, Funding Notice: Nearly $50 Million Funding Opportunity for Offshore Wind National and Regional Research and Development. Link
[30] Wind Energy Technologies Office. Link
[31] National Offshore Wind Research & Development Consortium, Solicitation 4.0 – Innovations in Floating Offshore Wind. Link

Previous funding calls at a state level that may be relevant for future tenders are displayed in Table 3. Outputs from state level funding calls will still be relevant more widely for U.S. OSW developments.

Table 3: Recent innovation calls at a state level.

Name of Funding		Description of work and previous examples
6	**Maine OSW Research Consortium**[32]	The consortium focuses on the challenges of floating OSW in Maine, minimizing environmental impact and methods of improving cost efficiency. An ongoing project is researching and delivering the collection of seabed data to map 840 square nautical miles of the seabed.
7	**California Energy Commission**[33]	A newly established Wind Waterfront Facility Improvement Grant Program aims to support retrofitting, engineering studies and environmental reviews. The Funding opportunities are currently pending.
8	**NYSERDA**[34]	The 2024 solicitation is the 5th solicitation NYSERDA has launched. ORECRFP24-1 covers commitments to environmental and fisheries plans, stakeholder engagement and requirements to make environmental data publicly available.
9	**New Jersey Economic Development Authority**[35]	The Wind Institute for Innovation & Training coordinates workforce development and R&D to support New Jersey's 2040 OSW target. In 2023 there was a request for expressions of interest for the creation of a wind innovation center.

The examples listed in Table 2 and Table 3 above provide a non-exhaustive list of some of the historic and existing opportunities for funding research and innovation projects in the U.S. Many of these innovation calls require applicants to have a specific presence in the U.S. market, creating specific partnership opportunities leveraging local U.S. knowledge and Dutch research expertise.

Of the previously identified thematic areas for Dutch collaboration in the United States, we have identified the historical and current opportunities, showing support within this research topic. The areas with extensive collaboration potential have the following opportunities:

1. **Transmission solutions**: This topic has been specifically addressed within funding calls [2] and [5] which focus on resiliency, transmission coordination innovations and transmission technology advancements. Additionally, funding call [3] focuses on a specific transmission issue by examining the interaction of lighting with offshore wind farms, inherently addressing system protection and its impact on broader transmission. As more offshore wind farms connect to the grid, transmission challenges will increasingly compound, impacting the connection and transmission of future OSW farms. The significance of this challenge is reflected in the available funding opportunities.
2. **Floating wind commercialization:** This topic has been addressed through funding call [1], which focuses entirely on mooring innovations and funding call [3] which offers substantial funding

[32] State of Maine Governor's Energy Office. Maine Offshore Wind Research Consortium. Link
[33] California Energy Commission, Offshore Wind Waterfront Facility Improvement Program. Link
[34] New York State, Offshore Wind - Requests for Proposals. Link
[35] NJEDA, Wind Institute for Innovation and Training. Link

specifically for floating offshore wind platform research and development. Additionally, the Maine OSW Research Consortium [6] continues to highlight floating wind challenges in Maine, with broader applicability. A large amount of the OSW potential in the U.S. is located in deeper, more challenging waters. To be able to fully exploit the offshore resources, floating OSW will be necessarily, reflected in the number of dedicated research opportunities.

3. **Turbine scale-up and standardization:** This topic has been specifically addressed through funding call [3] which focuses on innovation for fixed-bottom OSW foundation types and supporting infrastructure. Additionally, funding call [4] looks to address improvements of the aerodynamic performance of OSW turbines. As the installation pipeline continues to grow, this topic will become more important, to capitalize on economies of scale and efficiency.

The areas with moderate collaboration potential:

4. **Installation and O&M:** This topic has been addressed specifically through [2], which directly focuses on the development of O&M systems. It is also indirectly covered in [3] and [5], which addresses supply chain capabilities within the Great Lakes Region and innovations in ports and vessels research area. Installation and O&M remain significant, present challenges in the U.S. market and the numerous funding opportunities have been reflective of this urgent need to overcome the challenge.
5. **Minimizing ecological impact:** This topic has been explicitly addressed in funding call [3] which focuses on ornithological research to better understand the specific risks to U.S. offshore wind projects. It is also implicitly covered under the ocean area coexistence topic in funding call [2]. As the cumulative impacts of OSW installation become more significant, additional funding opportunities are expected to emerge in this area, aligning with research trends in Europe. This is evidenced by the 5th NYSERDA solicitation which includes a specific focus area on environmental and fisheries plans.
6. **Wind resource and site characterization:** So far, funding opportunities within the topic area have been localized. The Maine OSW Research Consortium [6] is currently focusing on collecting seabed data within the State boundary and this will likely continue to be a localized effort, due to the extensive seabed area available in the U.S. Consequently, collaboration opportunities may be limited to specific states.

The areas with targeted collaboration potential:

7. **Integrating offshore energy systems:** To date, none of the identified funding opportunities focused on the topic of integrating offshore energy systems. The challenge of integrated offshore energy systems, such as power-to-X or energy hubs and storage co-generation, is a longer-term challenge in the U.S., with more immediate challenges taking precedence. Research is being conducted in the Netherlands in this space, and will continue to be addressed over the next few years, to explore collaboration opportunities in the future.
8. **Industrialization of the supply chain:** Funding call [3] addresses this topic through the research area on supply chain and manufacturing in the Great Lakes region, leveraging existing capabilities and addressing future challenges with locational proximity to offshore wind projects. The Netherlands has a strong offshore wind supply chain, specialized in areas outlined in Chapter 4. However, collaboration opportunities are more nuanced, requiring careful consideration of factors such as location, commercial state, local workforce and technological capabilities to ensure successful partnerships on a case-by-case basis.

6. Conclusion

This report outlines several key challenges facing the U.S. market over the next decade. The U.S. coastline offers significant opportunity for offshore wind development, with a resource potential of over 5,000 GW.[36] With a national target of 30 GW by 2030, there are significant opportunities for companies to support research and development aimed at addressing the key challenges facing the U.S. market and to accelerate deployment.

The experienced offshore wind industry in the Netherlands has generated extensive expertise in various fields as outlined in Chapter 4 of this report. While there are numerous opportunities for collaboration between Dutch and U.S. entities in these research areas, there are also significant barriers that must be overcome to ensure successful partnerships.

Current barriers facing Dutch entities on collaboration opportunities were explored throughout this report, including a potential lack of expertise or experience in U.S. regulation, commercial environment and environmental conditions. Operating without a local physical presence can limit relationship building and the ability to apply for funding. Logistically, the time and geographical differences can make partnership opportunities more difficult to establish and maintain.

To successfully enable partnerships and collaboration between Dutch and U.S. entities, there are several recommendations for businesses, governments and knowledge institutes to address the existing barriers:

- **Promote networking platforms.** Platforms that foster collaboration are essential for creating partnerships between Dutch and U.S. organizations. The PIB has been effective in establishing such connections, but the platform is nearing its end. Continued funding of such opportunities would not only facilitate networking and organically grow partnerships but also provide a means for capacity building and research sharing. Government funding for these platforms, combined with private sector investment into specific capacity building events or knowledge institutes, would lead to successful outcomes.
- **Capacity building events and knowledge institutes.** Capacity building events should include knowledge exchange of Dutch research and existing capabilities and U.S. expertise of specific market constraints and commercial status, specifically in the three areas identified in this report as having extensive collaboration potential. Additionally, it has been highlighted through this report that the localized nature of data collection can pose significant challenges for global players seeking collaboration. It would be beneficial for government organizations, to facilitate discussions with relevant U.S. entities on mitigating barriers to collaborating in specific areas.
- **Explore formal partnership opportunities.** Capacity building and networking events will form the foundation of new partnerships, but to take the partnership to the next level, it is the responsibility of the individual organizations to solidify these collaborations. Existing private and public resources such as the Netherlands Enterprise Agency in the Netherlands and the

[36] USA_Offshore-Wind-Technical-Potential_GWEC-OREAC.pdf

Dutch economic network in the United States, can be utilized to find connection opportunities. The Dutch economic network in the US consists of the Netherlands Embassy in Washington D.C., Consulate Generals in five major cities and several Netherlands Business Support Offices where there is no diplomatic representation. In Boston the Netherlands Innovation Network is present to help innovators connect to the local ecosystem.

- **Identify R&D funding opportunities.** Chapter 5 of this report identifies many R&D funding opportunities which are ongoing in the United States. It is recommended that readers of this report, with aspirations to accelerate the research and development landscape in the U.S. should familiarize themselves with the available funding streams. Resources will be available through the sources in the information box below, to assist with information.
- **Disseminate activities and capabilities.** To ensure successful collaboration opportunities are capitalized, it is important to disseminate activities and research regarding the areas outlined in this report. Organizations are encouraged to reach out and make connections and disseminate capabilities.

In summary, addressing current barriers through strategic networking, capacity building, formal partnerships, and targeted R&D funding will be crucial for fostering successful partnerships between Dutch and U.S. entities in the offshore wind sector.

FOR MORE INFORMATION

To find out more information on the expertise of the Dutch industry, please refer to:

- Offshore wind energy | Renewable energy | Government.nl (rvo.nl)
- **Climate and Energy Response Facility - CERF (rvo.nl)**
- **Dutch Offshore Wind Innovation Guide 2024 (rvo.nl)**
- **The Dutch in the U.S. wind market (windandwaterworks.nl)**

Or please contact Was-ia@minbuza.nl , nin@nost-boston.org and nyc-ea@minbuza.nl.

Appendix 1: Repository of Dutch innovators

Company name	Thematic area	Details
VDL Klima BV	Transmission solutions	Design, manufacture, and installation of heat exchange and air treatment systems
Interdam	Transmission solutions	Design, manufacture, and installation of lightweight substation fire and blast-resistant wall systems
TKF	Transmission solutions	Design and manufacture of submersed power cables
Ocean Grazer	Transmission solutions	Utility scale offshore energy storage
Reynard	Transmission solutions	High voltage technicians
GustoMSC	Floating wind commercialization	Design and engineering of advanced vessels like WTIVs, Jackup and Semi-Submersibles
Bluewater	Floating wind commercialization	Design and engineering of floating wind foundations, dynamic cables and mooring systems
SBM	Floating wind commercialization	Design and development of floating wind platforms and moorings
Lankhorst	Floating wind commercialization	Design and manufacture of synthetic ropes for mooring systems
Vrijhof-Delmar	Floating wind commercialization	Design, manufacture and installation of drag anchors
MARIN	Floating wind commercialization	Development, testing, and optimization of offshore wind solutions
Royal IHC	Turbine scale-up	Engineering and manufacturing of specialized vessels and tools
Damen	Turbine scale-up	Design and construction of SOVs and CTVs
Huisman	Turbine scale-up	Design and manufacturing of heavy lift & advanced handling systems
Trelleborg	Turbine scale-up	Design and construction of seals and bearings
C-Job	Turbine scale-up	Design of vessels and offshore structures
Vuyk	Turbine scale-up	Maritime engineering support
RoyalHaskoning	Turbine scale-up	Offshore renewable energy consultancy
WE4CE:	Turbine scale-up	wind turbine rotor blade specialists

CAPE Holland	Installation and O&M	Vibro Lifting Tool which requires no supplemental noise mitigation techniques when pile driving, reducing installation costs through a combined technique.
Van Oord	Installation and O&M	VanOord, foundation installations, cable installation, dredging
Heerema Marine Contractors	Installation and O&M	Tasked with transporting and installing the 64 XL monopiles for the first designed 15 MW turbine.[1]
SPT Offshore	Installation and O&M	Subsea foundation installations
DEME	Installation and O&M	Turbine installation with WTIVs
Boskalis	Installation and O&M	Foundation installations, cable laying, heavy transport ships
Mammoet	Installation and O&M	Heavy transport and lifting
Seaway7	Installation and O&M	EPCI services for installation and services
Seaquilize	Installation and O&M	Innovative motion compensation machine to increase the operating envelope of cranes
Bargemaster	Installation and O&M	Gangway and motion compensation platforms for heavy lift operations
Ampelmann	Installation and O&M	Gangway systems
Enduro	Installation and O&M	Softslings to counteract the effect of wave-induced motion, enabling precise handling of equipment
Ulstein Design & Solutions BV	Installation and O&M	Exploring autonomous vessel technology, which could play a role in the future of offshore wind operations, particularly in maintenance and monitoring tasks.
Oyster Heaven	Minimizing ecological challenges	Ecological Restoration
TNO	Minimizing ecological challenges	Research on the environmental impact of offshore wind farms, including studies on marine life and ecosystems.
Wageningen Marine Research (WUR)	Minimizing ecological challenges	The institute focuses on marine ecology and the impact of offshore wind farms on marine environments.
Deltares	Minimizing ecological challenges	Environmental impact assessment, coastal management
Arcadis	Wind resource and site characterization	Environmental impact assessments and site surveys for offshore wind projects

Bosch Rexroth	Wind resource and site characterization	Specialized offshore services, including surveying equipment and technology for precise geotechnical and geophysical data collection
Lobster Robotics	Wind resource and site characterization	Develops robotic technology which can be used to perform environmental characterization, habitat mapping and remote baseline surveys.
Fugro	Wind resource and site characterization	Geotechnical site investigations
SwitcH2 BV	Integrating Offshore Energy Systems	SwitcH2 designs floating production units for green hydrogen and green ammonia, harnessing wind, solar, and wave energy.
SolarDuck	Integrating Offshore Energy Systems	Utility scale offshore floating solar energy
IQIP	Industrialization of the supply chain	Manufacturing and supply of hydraulic hammers
Smulders	Industrialization of the supply chain	Manufacturing foundation, transition pieces and substations
SIF	Industrialization of the supply chain	Monopile construction
Cape Holland Venterra	Industrialization of the supply chain	Vibro-Lifting tools and jacket foundations
iPS Powerful People LLC	Industrialization of the supply chain	Offshore staffing
Holmatro Industrial Equipment	Industrialization of the supply chain	Hydraulic solutions to level wind turbine foundations (TP levelling)

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