TKI Wind op Zee

Program 2018-2019

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1. Introduction

Offshore wind energy is an essential part of a successful energy transition in the Netherlands. To support this process, TKI Wind op Zee (Offshore Wind) facilitates research, development, demonstrations, valorisation, knowledge transfer, (international) cooperation, training and market development, which reduces the costs and increases the economic value of offshore wind.

TKI Wind op Zee is centered around the societal challenge of *Energy & CO_2*. The offshore wind energy sector could deliver 50% of the electricity supply by 2030, even if there is a considerable increase in the demand for electricity. As such, offshore wind energy will contribute to a sustainable, reliable and affordable energy supply.

Necessary conditions to generate offshore wind energy on a large scale are a continuation of declining costs, excellent spatial planning, and integration within the energy system. By fulfilling these requirements, offshore wind energy will not only supply the necessary sustainable energy, but it also increase revenues and employment levels for the Dutch industrial sector.

By promoting collaboration on research, development and demonstrations, the TKI Wind op Zee innovation programme strives to:

- Support offshore wind energy to make a bigger contribution to the energy transition by reducing costs and initiating optimisation of processes, improving integration within the energy system and establishing appropriate spatial planning;
- Increase the contribution of the Dutch offshore wind energy sector to the implementation of offshore wind in the Netherlands, and;
- Strengthen the competitiveness of these companies on the international export market.

The TKI Wind op Zee Research, Development & Demonstration (RD&D) programme consists of a number of themes that focus on the development of technology, cooperation on the North Sea, and integration within the energy system, including large-scale offshore energy storage and conversion systems. Since these topics are also of relevance for other energy production methods, such as onshore wind energy and wave and tidal energy, the programme will also address these methods.

In addition to this innovation programme, TKI Wind op Zee is also committed to the Human Capital Agenda (HCA), Socially Responsible Innovation (SRI), SME support and internationalisation. TKI Wind op Zee initiates partnerships such as the mission driven RD&D programme GROW, the HCA partnership CAREER (training and applied research), SME support with Offshore Wind Innovators and the SRI North Sea Energy Lab. Moreover, TKI Wind op Zee is currently developing offshore demonstration facilities such as the “Borssele V innovation site” in collaboration with the Ministry of Economic Affairs and Climate and the Netherlands Enterprise Agency (RVO.nl).

2. Topics highlighted in the TKI Wind op Zee programme

The energy transition focuses on the societal challenge of Energy & CO_2: in other words, the transition to a ***low-carbon***, ***reliable*** and ***affordable*** energy supply. The TKI Wind op Zee innovation programme contributes to tackling this challenge:

Affordable energy requires a reduction in costs and optimisation:
Despite the recent fall in costs for offshore wind, it remains essential that through innovation costs continue to decline in order to reduce the societal costs, new locations and the risks of external factors. Moreover, integration within the energy system (for example, energy storage) will also entail extra costs. Innovation is not just about optimisation and acceleration, but also focuses on new technologies and materials.

Reliable energy requires integration within the energy system:
Generating offshore wind power on a large scale means that integration within the energy system is becoming increasingly important. Issues such as chain coordination, forecasting, balancing, storage and conversion, interconnection, the offshore grid and grid support services (ancillary services) are of importance.

Low-carbon energy requires consideration of environmental impacts:
The energy transition relies upon a major contribution from offshore wind energy. This has both a limiting and strengthening effect on the ecology and use of space at sea. Collaboration with other users and research into the interaction between technology and ecology are subject of research and innovation.

The programme comprises a balanced portfolio of activities and topics, each of which contributes to one or more phases of the innovation chain: discovery, development, demonstration and/or deployment . For some of the activities, a testing ground or a demonstration facility is essential to actually bring the innovations to fruition. That is why demonstration facilities are addressed separately in this innovation programme.

There are various (subsidy) instruments available for the various themes within the innovation chain or Technology Readiness Levels (TRLs) to support projects, each with their own possibilities and requirements.

THEME 1 Cost reduction and optimisation

The objective here is to reduce the costs, both the Levelised Cost of Energy (LCoE) and the societal costs. The basis is the cost level as stipulated in the Energy Agreement, but also taking into account the 10 to 20 GW anticipated growth between 2020 and 2030. This will require new locations to be determined, which will also influence the costs.

In the short term it concerns the optimisation of current technology, and for the medium term the development of new technology (TRL 4-9 including offshore demonstration). For the long term radical new innovations might become of interest (TRL 2-6 including pilots).

Fundamental research is necessary for accumulating knowledge of wind climate and turbulence, subsoil, aerodynamics and hydrodynamics, control systems, conversion of electricity, ecology, societal aspects, modelling of uncertainty, and developing new materials. In this regard, the innovation programme aligns with the 'NWA Route Energietransitie'.[1]

The R&D topics for cost reduction and optimisation are:
- Support systems
- Wind turbines and the wind farm
- Internal electrical network and the grid connection
- Transport, installation and logistics
- Operations and maintenance

These R&D topics are discussed further below.

Support systems
- Improvements in location research and modelling of location data, such as wind, waves, tides and soil that lead to improvements in the design.
- Improvements in (integrated) design methods, tools and standardisation, including modelling, validation and certification.
- Further development of monopile technology for the next generation wind turbines in deeper waters, cost reduction of floating foundations, also for shallow water.
- New and more efficient foundation concepts and improved connection techniques between the tower, transition piece and foundation.
- Application of new materials such as corrosion resistant and fatigue resistant materials.

[1] See https://www.nera.nl/wp-content/uploads/2016/06/NWA-Energietransitie-routebeschrijving.pdf

- Life cycle design: optimisation of design and products regarding manufacturing, transport and installation, maintenance or end-of-life aspects (lifetime extension, repowering, decommissioning and recycling).
- Knowledge development regarding degradation processes (such as corrosion) and development of efficient protection systems in which environmental aspects also play a role.

Wind turbines and the wind farm

- Knowledge improvement of the wind climate and wake effects through measurements and modelling, including research into the effects of wind farms on the wind climate.
- Multidisciplinary analysis and optimisation of the design of individual wind turbines, wind farms and larger wind areas or zones (e.g. aerodynamics, materials and controls).
- Innovation of wind turbine components and production techniques for larger wind turbines and higher capacities (e.g. blades, bearings, transmission systems, generators) to improve service life, reliability, yields and maintenance, both for onshore and offshore applications.
- Development and demonstration of the next generation wind turbine technology, for example, wind turbines with alternative energy conversion systems which improve energy transport and storage, multi-rotor turbines, vertical axis or airborne wind energy, provided this technology is beyond the proof-of-concept phase (TRL 3).

Internal electrical network and the grid connection

- Increasing the availability and capacity of the local loop consisting of an inter-array network, transformer, converter stations and export cables. Increasing the availability of the wind farm as a whole by improving the interaction between the wind farm and the local loop.
- Research into life cycle aspects of the local loop such as degradation models and monitoring, lifetime extension, reuse and recycling.
- Reducing the cost of grid connections through standardisation processes and grid code compliance (including harmonic resonance).
- Development and demonstration of smart command and control options for the wind turbine, wind farm and substation.
- The deployment of wind turbines and wind farms for the provision of ancillary services.
- The development of data communication options in the wind farm (above and below water) that contribute to the optimisation of activities during construction and exploitation through digitisation, such as the collection and processing of data and the use of (autonomous) robot technology.

Transport, installation and logistics

- Development of new specialised vessels and tools for installation, maintenance and removal of foundations, cables, scour protection and wind turbines that speed up the process, reduce costs or improve workability. Development of single lift installation methods.
- Optimisation of the installation process by improving instrumentation and monitoring, and the application of artificial intelligence and big data analytics.
- New installation methods for the next generation wind turbines to reduce costs, improve safety and contribute positively to the environment.

- Development of improved decommissioning methods to reduce costs and make a positive contribution to the environment.
- Research into optimising the infrastructure (e.g. ports and offshore facilities) and the logistics chain, in particular for rolling out on a larger scale and constructing further away from the coast.

Operations and maintenance

- Development of new methods and equipment for maintenance that speed up the process, reduce costs or improve workability.
- Improving safety and crew performance (such as human factors), partly due to improved training and instruction.
- Improvements in sensor technology and instrumentation, monitoring and SCADA/CMS systems of both environmental parameters and components (e.g. foundation, cables, wind turbine components). Application of artificial intelligence and big data analytics for benchmarking, predictive maintenance, performance optimisation and determining the remaining service life.
- Development and demonstration of (autonomous) robot technology to carry out inspections and repairs.
- Optimisation of maintenance logistics both onshore and offshore, in particular for large scale remote wind farms.

THEME 2 Integration in the energy system

The objective of this part of the innovation programme is to facilitate the integration of very large quantities of offshore wind energy in the energy system. For this, both transport and matching supply and demand play a role. Additionally, smart transmission technology is essential to integrate offshore wind energy into the energy system.

Large scale smart transmission systems

- Improving the balance in the energy system by monitoring and predicting supply and demand.
- Application of ICT for the provision of ancillary services and demand side management and transaction processing through the chain (e.g. block chain).
- Economic studies into market mechanisms for developing the energy system and integrating offshore wind power effectively.

The offshore grid

- Development and demonstration of the necessary technology for combining international interconnections, the grid connection of offshore wind farms and other users of an offshore grid (such as the electrification of gas platforms, other energy generation methods or CO_2 storage facilities).
- Demonstrating the application of the aforementioned combination of international interconnections, the grid connection of offshore wind farms and other users of an offshore grid.
- Research into optimising the connection to the onshore grid and consumption centres.

Conversion and storage

- Design, development and demonstration of offshore energy storage technology (such as batteries, pumped hydro, power-to-gas systems), both stand-alone and integrated in new wind turbine technology.
- Design, development and demonstration of offshore conversion technology with associated transport networks and storage systems, both stand-alone and integrated in new wind turbine technology.
- Development of integrated energy island concepts for offshore storage and conversion technology (including electrical conversion for the offshore grid), possibly combined with logistics functions.

THEME 3 Offshore wind and the environment

The energy transition process requires a major contribution from offshore wind energy. This has an impact on the ecology and use of space at sea. The choice of location for offshore wind farms is also a factor which affects the costs. This part of the innovation programme focuses on the efficient integration of offshore wind by cooperating with other users and enhancing the ecology.

Multiple use of offshore wind farms

- Development of cooperation models between offshore wind farms and other users of the North Sea to optimise the use of space. Examples include fishing, sea farming (shellfish, fish, seaweed, algae), tourism, oil & gas and shipping.
- Research into the technical and economic potential, the risks and the necessary organisational and technical integration processes.
- Execution of offshore pilots (field labs) in which the aforementioned cooperation can be shown and where ocean energy technology such as wave and tidal energy can also be tested.

Improving the ecological value of offshore wind farms

- Research into, and development and demonstration of, methods and technology for the mitigation of negative and the strengthening of positive interaction between offshore wind farms and ecology (e.g. bats, birds and marine mammals), such as observation systems for the behaviour of birds and bats near wind turbines and bird or bat deterrent systems to limit collisions and casualties.
- Development and demonstration of foundation methods (including scour protection) that improve biodiversity and reduce underwater noise, including the reuse of foundations and scour protection for other purposes such as nature, mariculture and fishing at the end of the wind farm’s service life.
- Reducing the carbon footprint of offshore wind farms caused during its transportation, installation, operation and disposal.

THEME 4 Research, testing and demonstration facilities

The possibility to research innovations in a lab environment and to test and demonstrate those innovations is essential for validating the results of R&D projects, encouraging competition by opening doors for new players on the market, testing and certifying market ready developments and trying out system innovations for the first time. With the funding available for demonstrations, these activities can be supported as much as possible alongside existing developments and construction projects.

There are many types of research, testing and demonstration facilities at Dutch knowledge institutions, with facilities such as the Deltares delta flume, ECN’s wind turbine test park in Wieringermeer (EWTW), MARIN’s offshore basin, WMC’s blade test facilities, TNO’s structural dynamics lab or the wind tunnel at TU Delft, to name but a few.

To carry out offshore demonstrations, TKI Wind op Zee is currently developing an innovation site in Borssele (site V) in collaboration with the Ministry of Economic Affairs and Climate Policy and Rijkswaterstaat. This innovation site provides the necessary space and a grid connection, entirely separate from the regular wind farms, for demonstrating offshore wind technology. By providing an innovation site in the Hollandse Kust (North) Wind Farm Zone, it is possible to scale up this project to include other aspects, such as cooperation on the North Sea and system integration. Various stakeholders are involved with this development.

In addition to space for offshore demonstrations, there is also a need for a more robust research infrastructure for researching wind turbines, test facilities for blades and components, and offshore foundation technology. TKI Wind op Zee is collaborating with knowledge institutions to develop these necessary facilities.

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