



Advancing multi-use in offshore wind farms

Roadmap for the Dutch North Sea



This map represents the estimated future spatial use based on 'Programma Noordzee 2022-2027'. Please note that the space used by Oil & Gas infrastructure and cable routes is not shown. The map also does not include future uses that are still uncertain in their location, e.g. hydrogen infrastructure and aquaculture.

The Dutch North Sea: a small home to many transitions

The North Sea is playing a major role in transitioning towards a more sustainable European economy. Only within the Dutch EEZ, 70 GW of offshore wind are foreseen up to 2050 as an answer to climate change. The area required for this development is vast, but the available space is limited.

For one, offshore wind farm areas are competing for space with traditional fisheries, while options for transitioning partly towards different types of food production at sea are now being considered.

In addition, space is needed for future renewable energy infrastructure other than wind energy that will support the generation of solar and wave energy generation, as well as hydrogen production.

And all that in a degraded ecosystem that is also transitioning and needs to be protected and restored. Extracting sand to protect the coasts from rising sea levels, allowing space for safe navigation, as well as for defence and recreational activities complete the puzzle.

Multi-use: a solution to the “problem” of limited space?

Multi-use inside offshore wind farms is broadly recognised as a (partial) solution to this challenge and can be achieved by designing in such a way that co-use of space is facilitated, as opposed to exclusive use only for wind energy production.

While possible synergies between different uses promise a great future, there are a few technological, economic, ecological, and regulatory challenges that need to be overcome before a seamless symbiosis is achieved.

This project

The Road2SID project (Roadmap for technological advancements needed for Symbiosis-Inclusive Design in Offshore Wind) focuses on technological, regulatory, business case and ecological aspects of symbiosis in offshore wind farms.

The roadmap aims to:

- summarise available knowledge
- identify the various stakeholder perspectives
- and finally propose actions for advancing co-use in offshore wind farms.



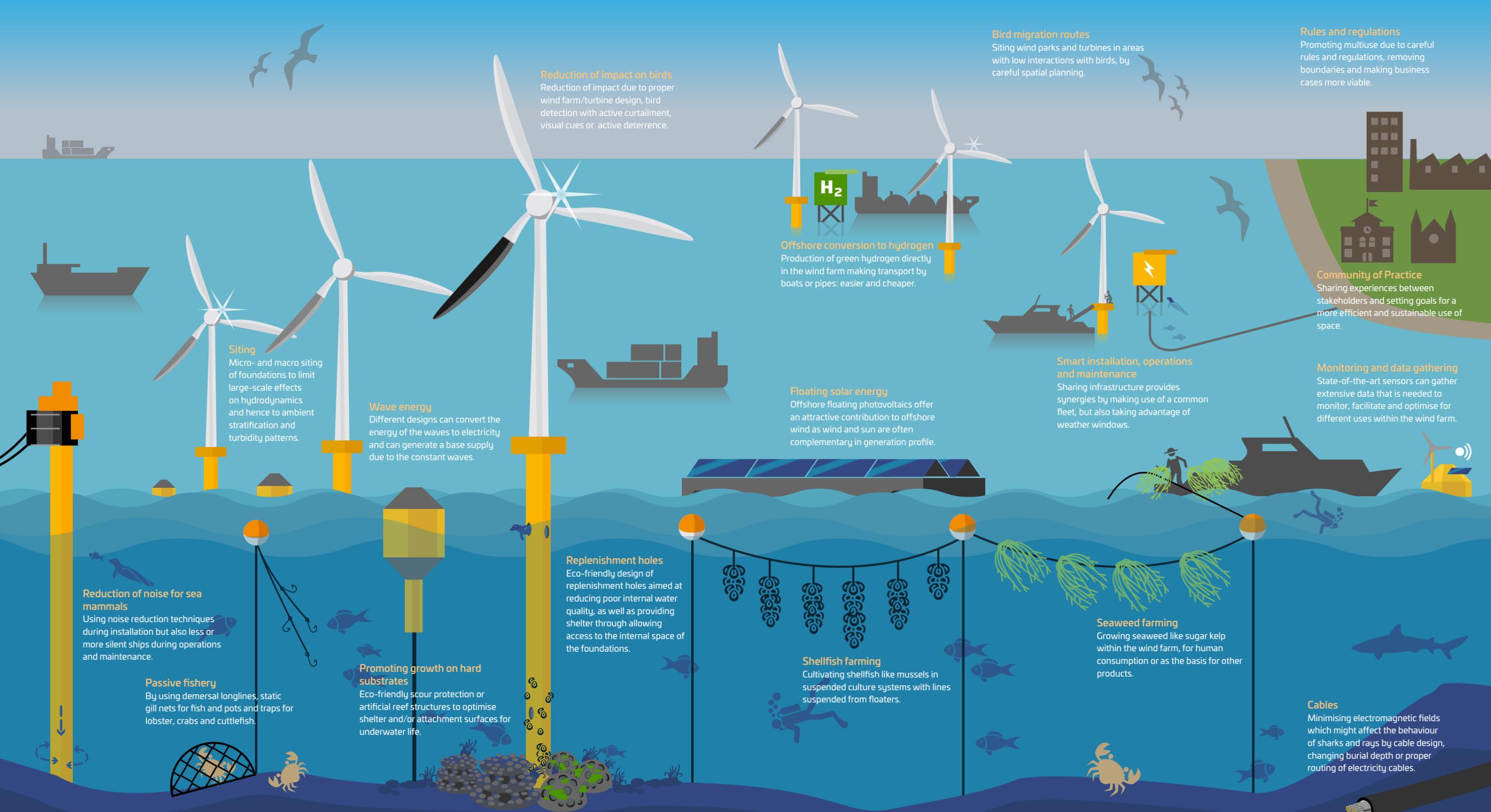
Road2SID Roadmap - read the full report

You can download the full report at grow-offshorewind.nl/project/road2sid



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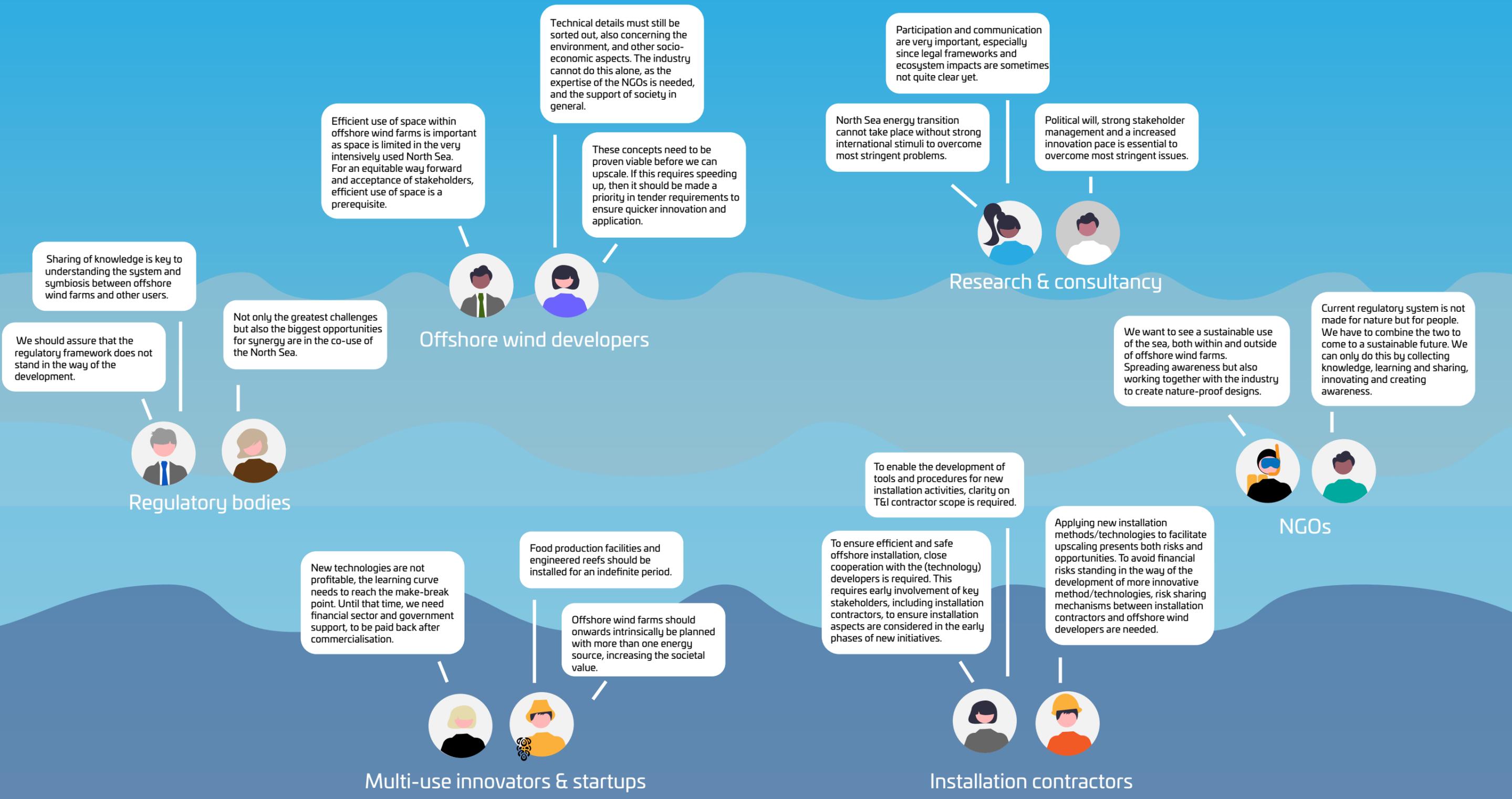
Available practices for the symbiosis of nature, energy and food production at sea

A visual overview of current knowledge and practice on multi-use in offshore wind farms is presented in the graphic above for the context of the Dutch North Sea. There are many developments underway in all three types of multi-use: nature restoration, food production

and alternative energy. Both policy and technology are developing fast, especially in the case of energy generation (technology) and nature restoration (policy).

The Netherlands is one of the leading countries on the topic of marine multi-use, primarily driven by the scarcity of space and long-term experience with the marine economy. However, the field of symbiosis between functions inside wind farms is relatively young, with many unknowns.

Symbiotic projects involve many stakeholders whose interests need to be aligned. The visual can inspire multi-use possibilities and be a starting point for further discussions or developments.



Exploring stakeholder perspectives on symbiosis; challenges and opportunities

Symbiotic projects involve many stakeholders whose interests need to be aligned. Therefore, we have asked the stakeholders about their perspectives on the individual themes Nature, Food and Energy and their feedback on the opportunities they see, the challenges they face, and the responsibilities they feel.

As such, we see that the stakeholders believe that combining offshore wind with nature, food or other energy aspects creates opportunities for utilising the marine space more efficiently. On a technical level, the stakeholders see opportunities in shared infrastructure, mooring and also operating the vessel fleet.

In terms of challenges, the stakeholders identify an unfavourable regulatory framework, for example concerning permitting and decommissioning. In terms of finance, they see that the costs of multi-use are high, with high insurance costs, high offshore operation costs and a lack of business case and/or track record of technologies.

Most stakeholders see it as their responsibility to advance innovation in the field of multi-use, both in terms of nature as well as energy. With respect to the former, the stakeholders saw a role for themselves in advancing stakeholder engagement, and awareness and they expect action from developers and even more from the government in terms of a regulatory framework.

Key actions to advance symbiosis towards 2030

Based on the literature review and stakeholder consultation, opportunities, risks and challenges are defined. Currently, these are separate for the three types of multi-use activities in wind farms: nature protection, food production and alternative energy generation. Specific actions are defined that have the potential to

accelerate the development of multi-use offshore wind farms and bring the three types further towards integration. The actions are presented below per type of multi-use.

The actions presented here share common timelines (up to 2030), topics (technological, regulatory, economical)

and to a large extent action owners. Balancing between realism and ambition, we suggest to initiate all these actions before 2030. The presented order is approximate, but in general, a vision is deemed necessary as a starting point. An integrated toolbox is presented in case study 3 that addresses symbiosis on the long term (e.g., 2030-2050). Most actions are defined in the governmental areas.

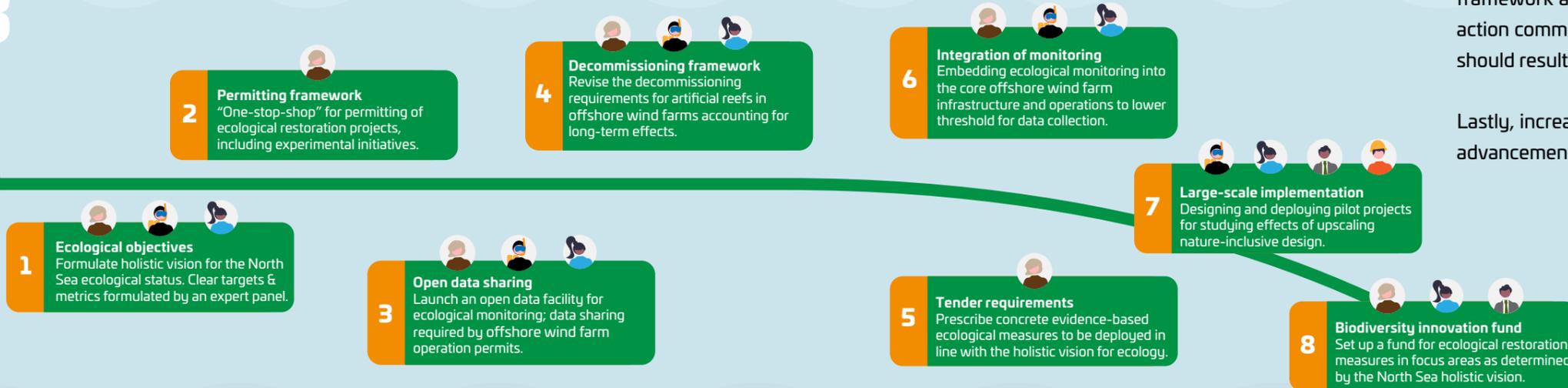
In terms of timeline, nature enhancement is the most advanced; several pilots have been performed already, whereas first pilots are on the list of actions for both food and energy production. Installing pilots is a common action between all three themes.

Next to the pilots, common actions are defined based on permitting all multi-users mentioned a clear permitting framework as an urgent action. Another governmental action commonly identified is an integrated vision which should result in tender requirements for multi-use.

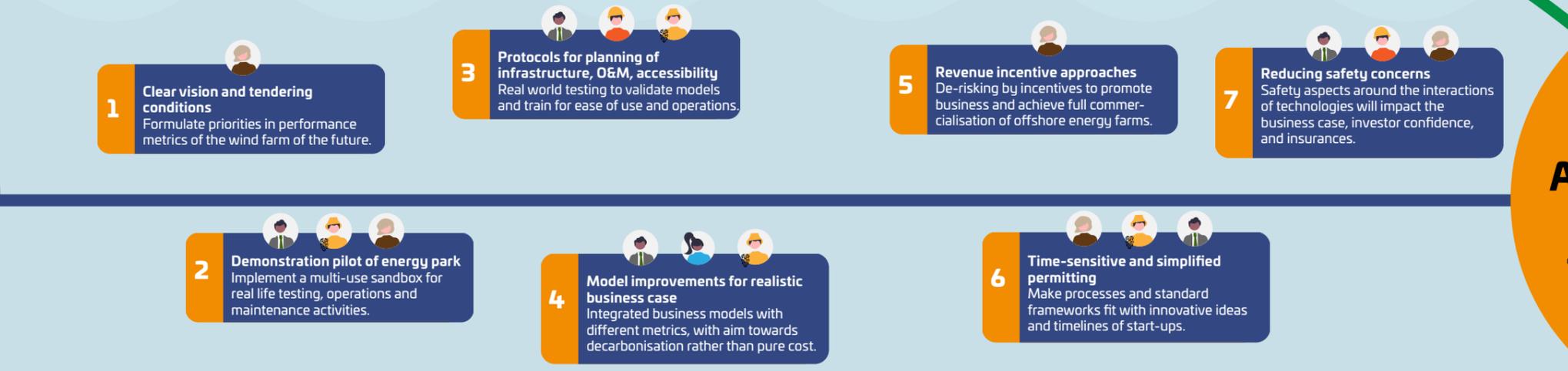
Lastly, increasing safety and business case by technical advancement is required for all themes.

2023

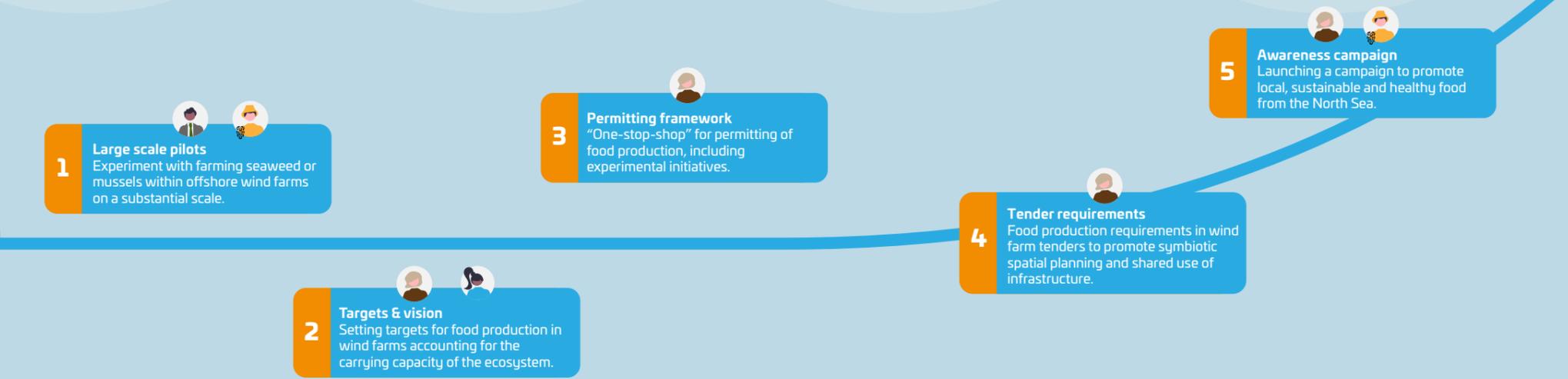
Nature



Energy



Food



2030

Advanced multi-use in offshore wind farms in the Dutch North Sea.

- MAIN ACTION OWNERS**
- Regulatory bodies
 - NGOs
 - Research & consultancy
 - Installation contractors
 - Offshore wind developers
 - Multi-use innovators & startups

Making information systems symbiotic

Many measurement, monitoring and information systems are in place in the North Sea and within wind farms. However, not all multi-use stakeholders have access to all relevant information. A holistic Operational Information System (OIS) is envisaged to enhance symbiosis and multi-use activities. The goal of the OIS is to make present and upcoming multi-use operations more efficient and safer by sharing information and thereby increasing multi-use business case potential.

The OIS is an open-access information system that provides metrics and Key Performance Indicators for decision-making.

Information consists of system performance data and operational information and can be retrieved on various time windows: long-term, near-term, real-time. The system allows to retrieve various types and depths of information depending on the interest of the specific users.

Types of information available provided through the OIS are:

- Yield and production: energy and food
- System integrity and performance (long-term): Wind turbine, floating photovoltaics or aquaculture structure
- Operational conditions, such as weather conditions (near-term; real-time)
- Safety and incident status (real-time).

There are several information systems available. The presence of these systems demonstrates the need for open-access information on biotic and abiotic metrics; the plurality of systems demonstrates the lack of one central system. In addition to monitoring KPIs for decision-making are required.

The blueprint, from a functionality perspective, of the Operational Information System is given below.



Open Information System

EXISTING SYSTEMS & ONSITE SENSING

Performance Monitoring
SCADA
Operational Systems of offshore wind farms
Digital Twins

Ecological Monitoring
Informatiehuis Marien (WOZEP, MONS)

Maritime Monitoring
DigiShape
Maritime Operations, Ship monitoring

Onsite Sensing
Mechanical Structural
Environmental Invasive
Energy Performance
Metocean conditions

OPEN ACCESS DATABASE

Information time scales
Real-time
Near-term
Long-term

System integrity & performance

Operational conditions
Metocean Conditions
Threats & Risks
Simultaneous Operations

KEY PERFORMANCE INDICATORS

- Hindcast Statistics*
- Nowcast Real Time*
- Forecast*

Abiotic & Biotic Indices
Biodiversity
Water Quality
Flow & Soil conditions

Yield & Production
Turbine (MWh)
Floating Photovoltaics (MWh)
H₂ (tonne)

Food Production
Catch Per Unit Effort
Shellfish, Fish, Seaweed (tonne)

COMMUNICATION & DECISIONS

Business Case

Optimal Operations

Ecological Evaluation

Safety

Best Practices

Capacity Sharing



Integrated vision for symbiosis in 2050

“By 2050, a revolutionary era of Dutch Offshore Wind Farms has emerged. Through harmonious integration, ecological measures, alternative forms of renewable energy generation and storage, as well as food production within offshore wind farms, have fully matured to the maximum of their potential and are the standard, ushering in a new era

of holistic, inclusive, and transboundary spatial planning that respects the carrying capacity of the North Sea. In this new era, symbiotic offshore wind farms act as the catalyst to achieve the climate and biodiversity targets set by the Dutch and European policymakers.”

With this case study, a fully symbiotic offshore wind production grid is envisioned. To establish this vision, a toolbox of ideal outcomes is summarised in the visual below. This visionary scenario for the implementation of sustainable integrated multi-use in offshore wind farms beyond 2050 highlights the importance of holistic international integration, data-driven decision-making, and

innovation. By adopting a unified approach, harnessing the power of data, and embracing innovative solutions, offshore wind farms of the future will not only contribute to global sustainability but also serve as harmonious (artificial) infrastructure ecosystems that thrive in symbiotic coexistence with nature.

Holistic international integration

Impact

O&M

By 2050, we have developed offshore wind farms where Energy, Nature and Food are optimally integrated, maximising benefit for society and the earth.

Ecology

Cost

Infrastructure

Data

Innovation

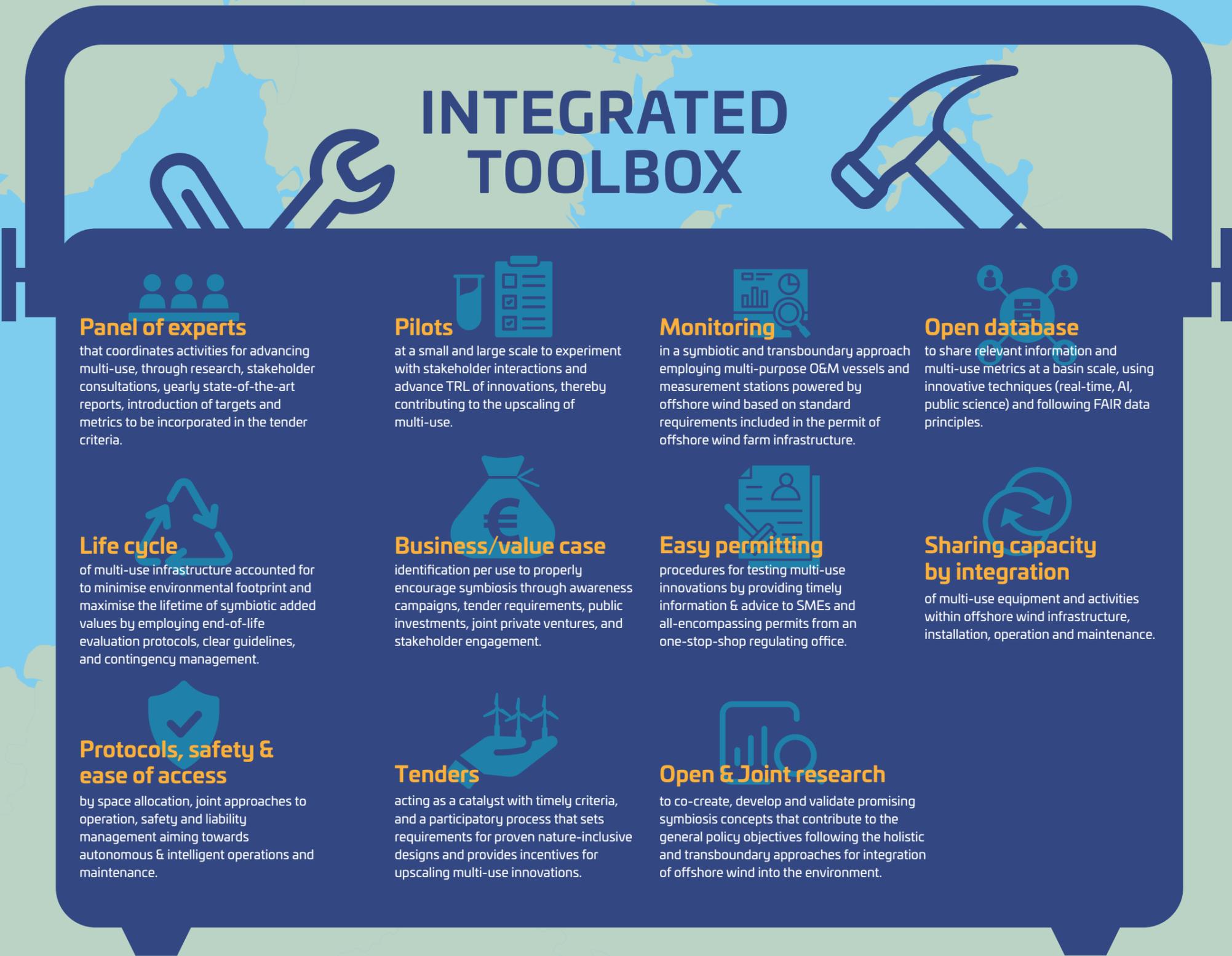
Space

Business case

Technology

Data

Governance



Partners

Deltares
MARIN
TNO
Boskalis
RWE
Seaway7
Shell
TenneT
Van Oord

Funding

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More information on the
GROW/Road2SID project webpage

grow-offshorewind.nl/project/road2sid

