Project Number	TEWZ11925JCU
Project Title	HybridEnerSeaHub JIP
Applicant	Stichting Maritiem Research Instituut Nederland
Additional applicant	TNO, TNO, RHDHV, Offshore Service Facilities BV (OSF), WMR Next to that also DEME has joined the JIP
Project Period	01-10-2019 to 30-06-2022
RVO Tender	Wind op Zee R&D tender 2019
Date of this report	November 2022
Type of report	Public report
Publication date report	30-6-2022

1. Summary of principles, objective's and project partners

The energy transition on the North Sea is ongoing. In the next decades the O&G infrastructure will to a certain extent be replaced by and transformed into assets that produce, store and transport renewable energies. The need for this renewable energy relates to the need for lower (CO2) emissions and to finally reduce the effect of global warming. This is enforced by the Paris agreement and finds a strong support in the public opinion in Europe and other parts of the world. Authorities, users and energy producing companies are working together to adjust the infrastructure to the energy mix of the future. On the energy demand side the speed of electrification of our society will partly determine the pace of the energy transition. On the other hand power to gas (hydrogen) solutions also provide a promising scenario, for example for zero emission shipping using fuel cells or hydrogen cars. To support cost effective renewable energy production far out at sea there is a need for O&M support, efficient and safe energy conversion, transport and storage of renewable energy during peak production. This project aims to fulfil those needs with a comprehensive design of a partially floating energy hub.

Figure 1-1: Example of an energy island with its different functions.

The idea for an energy island hub has been proposed before by different countries (Netherlands, Belgium, UK and Denmark). Studies have been performed to develop a reclaimed island on the North Sea. With the volatile production and demand for energy the need for interconnecting electricity grids across the North Sea and for local energy storage is becoming larger. The present electricity grid is not yet designed to accommodate the variability in the supply of electricity if the offshore wind capacity in the North Sea is increased to an estimated total of ~120 GW in the next 30 years. An international high voltage connection may facilitate the distribution of the maximum production of wind generated electricity.

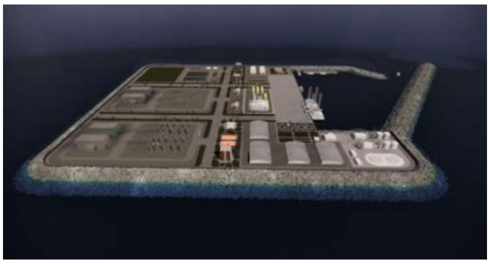
Although local storage of the energy into hydrogen (H2) and ammonia (NH3) will come at the cost of efficiency losses, the stored energy may be used directly as a fuel for ships or (when transported to shore) for cars, heating, cooling and future airplanes. It may also be exported trough the existing gas pipe network if this is modified for Hydrogen transport.

New installation methods and O&M strategies may require different support functionalities of the island. Assembly yards and storage of parts may be part of the functionality of the islands. Furthermore, an island may provide shelter to smaller O&M vessels in harsh weather conditions. As the sailing distance from the island to remote wind farms is smaller, the island contributes to improving the weather window and could have a positive effect on the overall O&M cost and exhaust emissions. At this moment, there is a fair amount of uncertainty in how the installation, O&M and energy storage scenarios will develop.

There are a number of international consortiums investigating the possibility of an (energy) island in the North Sea, like the North Sea Wind Power Hub and IJVER (see
Figure 1-2). All the consortiums have the same goal, creating cost effective workspace offshore.

Besides governmental regulations and environmental impact, one of their main challenges is finding a good balance between planned activities on the island, and possible addition users in the future. When designing an island only for the planned activities, it will be relatively small resulting in higher prices per M^2, and no possibilities to adept to future users. But when building a large island the M^2 will be lower, but the total investment costs will be higher and there is a risk that the additional space on the island is not needed in the future. Therefore, we believe that an adaptive concept for an energy island will be more successful on the longer term.

North Sea Wind Power Hub
https://northseawindpowerhub.eu



IJVER
https://offshoreservicefacilities.nl/

Figure 1-2: International consortiums investigating the possibility of an (energy) island in the North Sea.

In this project the possibility of using floating modules has investigated to support the energy island functionality in every stage of its life-cycle. This modular approach will make the island more adaptive to future activities in the different stages of the offshore developments. This is an advantage since investments only need to be made when needed. Furthermore, a partially floating island may have a smaller impact on the sea life and surroundings then a large permanent reclaimed island. On the other hand motion requirements and mooring loads set a practical limitation for a fully floating island on the North Sea. Therefore, a combination of floating modules connected to a reclaimed island has been investigated. This project performed an early design and feasibility study for a hybrid island at a 40m water depth representative for the North Sea. An example is showing in below Figure 1-3.

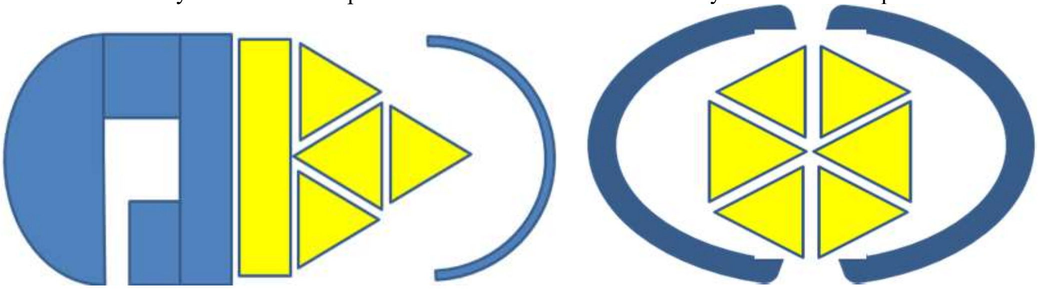


Figure 1-3: Different examples of a Hybrid island combining floating island modules (yellow) in combination with a reclaimed part (blue) provide flexibility and shelter.

In 2019, in an attempt to design a (partly) floating maintenance and energy storage island and to investigate the feasibility in the North Sea, a Joint Industry Project (JIP) was launched by five entities; TNO, RHDHV, Offshore Service Facilities BV (OSF), WMR and MARIN, furthermore DEME joined the JIP ones started.

The main objective of the HybridEnerSeaHub JIP is:

To ***develop an initial design*** *of a* ***(partly) floating maintenance and energy storage island*** *and to investigate the* ***feasibility in the North Sea****.*

The work plan consists of five technical work packages (WP).

- WP 1: Design Basis; functional requirements during the life-cycle phases of the island
- WP 2: Fixed/Floating Hybrid Design Concept
- WP 3: Environmental impact evaluation
- WP 4: Performance evaluation of the Hybrid Design Concept
- WP 5: Business case evaluation
- WP 6: Project coordination

The WPs were assigned to the project partners respectively. However, as it is a Joint Industry Project it was expected that all parties involved regularly gave constructive feedback to each other.
The deliverable of the project will be improved and validated engineering knowledge including environmental impact study for a hybrid energy island. The recorded data has been made available to the project partners along with the final reports. Further development of the technology for hybrid energy islands towards a higher TRL will be facilitated by the results presented in the final reports and the validated numerical simulation software

2. Description of the results achieved, the bottlenecks and the perspective for application

The objective of the HybridEnerSeaHub JIP was to support elements of the energy transition that are located further away from the coast with a cost-effective and flexible offshore island design. The objective of the HybridEnerSeaHub project was:

*To **develop an initial design** of a **partly floating maintenance and energy storage island** and to investigate the **feasibility in the North Sea***

The following sub objective were defined and reached as follows:

- What part of the energy hub should be fixed or floating; This objective was reached as part of the deliverables of WP 1, in which a large part of the island consisted of floating modules, increase the islands flexibility in future functions.
- What is the optimum layout for the fixed part to give best shelter to the floating parts; This objective was reached by the island concept designed as part of this project and extensively tested in the basin at Deltares
- What motions levels are acceptable for a floating energy hub; This objective was reached by the work performed 1.2, in which the most important conclusion is that all floating modules are bound by human working related motion criteria.
- How can motions be reduced; The most realistic way of reducing the motions of the floating modules was to apply a breakwater protecting the floating modules from the environmental conditions.
- What size should the island be for certain functionalities; This objective was reached by the outcome of WP 1.1, in which each functionality had a defined required space.
- How large are the forces in the floating structure, mooring and couplings; This objective followed form the extensive model tests and simulations performed by MARIN, Deltares and TNO, and showed the floating island would be feasible to build despite the large loads.
- How can we design the platform, couplings and moorings that can sustain these forces over its lifetime; It was concluded that the preferred mooring solution for a hybrid island is the use of piles fixed in the soil (in between floaters) combined with mooring lines. This solution prevents excessive excursions within the limited space in the basin, allows vertical motions due to water level variations and long waves and has a minimum footprint, which ensures sufficient manoeuvrability.
- Which energy storage methods are available; This objective was reached as part of WP 1.2 and 2.1 and accommodated 2GW of power to gas on this islands design.
- What is the impact on the LCOE of offshore wind; The expectation is that an island would have a positive impact on the cost of offshore wind.

The design of the partly floating maintenance and energy storage island was investigated in the model basin of Deltares in North Sea conditions as shown in below figure:

Figure 2-1: HybridEnerSeaHub JIP consortium with the final concept design of the island being tested at Deltares.

3. Description of the contribution of the project to the objectives of the tender (sustainable energy management, strengthening of the knowledge position)

Offshore wind has enormous potential: globally, in Europe and in the Netherlands. Large-scale application of offshore wind for the production of electricity can make an important contribution to the far-reaching reduction of CO_2 emissions and to increasing security of supply.

Thanks to the HybridEnerSeaHub JIP project, improved knowledge in the field of island design is generated. With this knowledge, the project partners can support the government and industry with future energy hubs in the North Sea, which are part of the 2040-2050 vision of the Dutch government.

4. Spin off inside and outside the sector

Within the offshore wind industry, the spin-off is clear. The knowledge developed will provide more efficient and improved knowledge in the field of island design consisting of floating and fixed modules. The size of the consortium, will ensure a good dissemination of the developed knowledge in new offshore wind projects. The results of the HybridEnerSeaHub JIP can also be used in other sectors such as the Civil and offshore Oil & Gas industry, and for future islands for other applications (transport, living, industry,…).

5. Overview of public publications about the project and where to find or obtain them

The following articles have been published about the project:

1. Article in the TO2 magazine: Wind en Water bundelen krachten
2. RVO.NL – PRAKTIJKVERHALEN THEMA DUURZAAM
3. MARIN website: https://www.marin.nl/en/jips/hybridhub including a summary video of the JIP

6. More copies of this report

More copies of this report can be obtained digitally from the contact listed below.

7. Contact for more information.

More information about this project can be obtained from:

- Erik-Jan de Ridder, MARIN, e.d.ridder@marin.nl

8. Subsidy

The project was carried out with a subsidy from the Ministry of Economic Affairs, for the TKI WIND OP ZEE R&D tender conducted by RVO.