Demonstration projects offshore hydrogen: what should be learned? (November 2023)

Inventarisation of current learnings by Ministry of Economic Affairs and Climate Policy, together with Gasunie, TenneT and stakeholders

In order to enable safe and cost-efficient large scale offshore hydrogen production in wind farms in the North Sea, timely demonstration is needed. Demonstration is expected to shape the conditions and create confidence among all relevant parties in the large-scale roll-out of offshore hydrogen production in future wind farms in the North Sea. Therefore, the Ministry of Economic Affairs and Climate Policy has announced two demonstration projects.

Within these projects, learnings will be obtained in order to be able to have sufficient knowledge, insights and experience to scale up the technology towards commercial GW-scale projects. In this overview the preconditions, overarching drives and learnings are described. The learnings are based on current insights and might change as the projects are further developed. The learnings give direction to the project developments and will help design them, for example in decision making. The list below does not represent tender criteria.

Preconditions

As there is no track record for offshore hydrogen projects, it is important that certain preconditions are in place in time for the successful realisation of projects. The preconditions below are relevant for both demonstration projects as well as for follow-up projects (after demonstration). Some should be in place already for the demonstration projects, whereas others will be fed by insights from these projects, preparing for the projects to follow.

Preconditions	Description	Who?
Governance & market regulation	Determine roles, ownership and responsibilities of market parties, TSOs and government	Government
Permits & regulatory framework	Prepare permits for demonstration within existing regulatory framework, while adjusting where needed for future projects	Government
Financing	Organise financial resources for demonstration in a way that matches financial feasibility of projects	Government
Tender	Find suitable tender procedure and scope demarcation for projects containing offshore hydrogen	Government
Transport	Have the necessary transport routes and landfall in place in time	Government and TSOs
Off-takers	Have market conditions for off-takers in place in time	All

Overarching drivers

The objective of the demonstration projects is to enable timely and responsible scale up and commercialisation of offshore hydrogen production suitable for application in North Sea based energy hub(s). The overarching drivers for the demonstration project are:

Driver	Description	Who?

Develop trust	Risk reduction, gain trust for all market parties, financing parties and TSOs	Government
Speed up learnings	Speed up learning curve and market developments (e.g. through knowledge dissemination and facilitation of valuable iterations)	All
Activate and prepare supply chain	Involve and activate supply chain, prepare necessary certification	All
Activate and prepare off-takers	Prepare off-take market for offshore hydrogen	All
Engage stakeholders	Involve and inform stakeholders and create support	All

Specific learning objectives

- The learning objectives below focus on learnings for market parties (e.g., developers, electrolysis manufacturers, contractors but also knowledge institutions), TSOs and government (Ministries, executing agencies, regulatory agency).
- The learnings are related to different themes (technique, transport, financial, environment, regulation) and phases (pre-project, project (technical), project (financial, environmental impact)).
- The learning objectives are based on current knowledge and expectations, and by definition are not limitative. Learning objectives will be added or adapted because of new or changed insights. Some learning objectives might also be influenced by decisions on longer term offshore hydrogen policy.

Themes

Throughout the projects there will be a few focus themes for learning. Learning about the focus themes is essential to be able to scale up the technique safely and responsibly after demonstration. The overarching focus themes are:

Technical	Insights in all technical aspects of hydrogen production in offshore conditions that are needed for scale up
Financial	Insights in financial aspects of offshore hydrogen projects to enable commercial future projects
Transport	Insights in transport specifications of hydrogen offshore
Environment	Insights in the environmental impact, including safety, of offshore hydrogen production to guarantee safe and responsible (future) projects
Regulation	Insights in required additional or adjusted regulation

Learnings per phase

During the different phases of the projects there will be project learnings relevant for scaling up. The learnings are divided into three project phases: pre-project (phase in which permits are being prepared), project (technical) (all technical learnings of different project phases) and project (financial and environmental) (all learnings that are not directly technical but crucial for further development, such as financial and environmental).

1. **Pre-project:** In the pre-project phase learnings will be obtained through research and by learnings from existing projects. The learnings in this phase are needed for permitting.

Pre-project (research)	Learning objective	Who?
Ecology	Obtain necessary information on ecological impact and required measures or regulation to grant permits for the (demonstration) projects	Government
Safety	Obtain necessary information on safety impact to develop regulation for permitting (demonstration) projects	Government

2. **Project (technical):** Within the preparation and execution of the projects, there are learnings within the phases of design and technology, transport, installation, operation and maintenance and decommissioning.

Project (technical)	Learning objective	Who?
Design & technology	Integration of electrolyser with the wind farm, grid and infrastructure and preferred location electrolyser and compression	Market parties, TSOs
	Hybrid and/or off-grid production in wind farms (electrons/hydrogen)	All
	Offshore hydrogen compression (technology, vibration management)	*TBD*
	Determine the key concepts, design choices and parameters to design modular offshore hydrogen production	All
	Gain expertise (e.g. costs, efficiency, maintenance, operability) on different configurations (e.g. central and decentral), sub-configurations and design choices	Market parties
	Preferred electrolyser related design choices (technology selection, efficiency, operating ranges, operating modes, efficiency tradeoffs, etc.)	Market parties
	Preferred system integration w.r.t safety, development of oversight, safety standards & regulation	All
	Stability and grid quality control of AC grid/electrical interfaces	TSOs
Installation	Engineering and construction method, construction locations, etc.	Market parties
Transport	Configuration pipeline transport and landfall	TSOs
Operation & maintenance	System operations (who controls which equipment, where are the exact interfaces and what agreements/contracts need to be in place)	Market parties, TSOs
	Experience with unmanned and remote operation and maintenance, manning, logistics management, optimising availability/reliability	Market parties
	Accessibility requirements of activities	All
	Set up maintenance regime in offshore conditions and obtain insight in costs	Market parties
	Experience with commissioning and start-up (especially around interfaces)	All
	Operation, maintenance, interface, reliability and availability management of compressor station	Market parties, TSOs

	Electrolyser operations, maintenance, lifetime and replacement logistics under real operating conditions (partload, on/off, stand-by mode operation)	Market parties
Decommissioning	End-of-life and safe and responsible decommissioning planning	All

3. **Project (financial and environmental):** Besides the technical engineering learnings, there are also other project learnings relevant for upscaling, such as the financial and environmental aspects of the projects.

Project (financial and environmental)	Learning objective	Who?
Financial		
	Determine factors that have a large impact on the business case, that can be addressed by design, government or collaboration between industries	All
	Determine the main financial risks and how they can be mitigated or managed	Market parties
	Determine costs (investment and operational) and revenues of different design layouts (centralised and decentralised production)	Market parties
	Insights into factors determining revenues and LCOH	All
	Develop and test market designs and connection agreements power and hydrogen export and import	All
Environmental		
Ecology	Assess the ecological impact of the emissions of substances, heat and brine of the demonstration projects and provide a first extrapolation of these findings to offshore hydrogen production on GW-scale	All
	Assess the ecological impact of oxygen and hydrogen venting, flaring and leakage	All
Safety	Asses the safety impact of offshore operation on shipping and broader environment (windfarm, other users) to ensure safety regulation	All