Gigawatt Electrolyser Concept SI-50-07 (SI-20-07a+c)

Scientific and engineering part

January 2022

ISPT Hydrohub

Hans van 't Noordende

Peter Rapson

Institute for Sustainable Process Technology

Format final report (public part)

Project Number RVO and/or ISPT(-TKI)	SI-50-07A & SI-50-07 C
Project Title + Acronym	Gigawatt scale water electrolysis plant design: 2020-2030
Secretary (penvoerder)	ISPT
Name Cluster Director	Andreas ten Cate
Name project leaders	Hans van 't Noordende/Peter Ripson
PhD (name & title thesis)	
Funding	TKI E&I
TRL bij afsluiting	PEM Stacks TRL 3-7 depending on component AWE stacks TRL4-9 depending on component Other areas: TRL 7-9 depending on area/technology
Projectsucces	See our website with final public report and VR movie. Producing green hydrogen at industrial scale - ISPT
Vervolg	Approved projects: Safety project, Hyscaling, NL SOE Other projects in pipeline
Aantal gerealiseerde peer-reviewed publicaties	2
Verwachte gerealiseerde peer-reviewed publicaties	4
Niet peer-reviewed publicaties	Na
Aantal aangevraagde patenten	0
Aantal aangevraagde licenties	0
Aantal prototypes	0
Aantal demonstrators	0
Aantal spinn-offs/ spin-outs	0
Aantal nieuwe / verbeterde producten/ processen/ diensten geïntroduceerd	New PEM stacks with higher voltages/currents New Alkaline stacks with higher voltages/currents Improved compressor design Ready concept for heat integration Rectifiers based on IGBT Fewer transformer steps

	Larger modules
Impact	Total media reach in media of final report: **894.453** 8 articles in news media related to content final report A video was published on final results with **more than 2,5 K** Multiple follow-up projects have been defined based on the results of this project
Project start A	1-11-2018
Project original end date A	1-9-2021
Project start C	1-1-2020
Project original end date C	31-1-2021
Project final end date A	15-12-2021
Project final end date C	31-12-2021

1.Summary

Green hydrogen can replace natural gas as an energy carrier and industry feedstock to reduce CO_2 emissions. This transition requires economies of scale with the production of large volumes of green hydrogen in many large-scale water-electrolysis plants. These plants will be powered by large wind and solar parks that will have to be built within the next 10 years. The goals here are ambitious. The European Union (EU) aims to have 40-GW of electrolyzer capacity installed by 2030, while the ambition in the Netherlands is to have built green-hydrogen plants with a combined capacity of 3 to 4 GW by that date. The largest existing electrolyzers are at the 10-MW scale, whereas scaling up to GW scale is needed at acceptable cost levels. The aim of this work is to investigate innovative, technical and economical (mainly CAPEX) possibilities for making 1GW green hydrogen plant more cost-effective towards 2030.

First a baseline design for a 1-GW green hydrogen plant based on state-of-the-art (2020 level) technology was prepared as a reference. The total installed costs were estimated at 1400 €/kW for AWE technology, and 1800 €/kW for PEM technology. In a next step, the technical design and the associated total investment costs of a greenfield 1-GW green-hydrogen plant that would be built, and up and running, in a Dutch port area by 2030 has been prepared .It is shown that anticipated total investment cost levels of 730 €/kW or 1580 €/(kg/d) for AWE and 830 €/kW or 1770 €/(kg/d) for PEM are within reach. The CAPEX required will be about half of what would be required for the 2020 state-of-the-art design.

To come to this cost reduction, several innovations, optimizations and improvements have been made relative to the state-of-the-art 2020 design—see Figure 1. We incorporated innovations at the stack level, scaling up to larger stacks and modules, and came up with optimizations for, and other improvements to, the electrical installations, utilities, and balance of plants. See our website with final public report and VR movie. Producing green hydrogen at industrial scale - ISPT

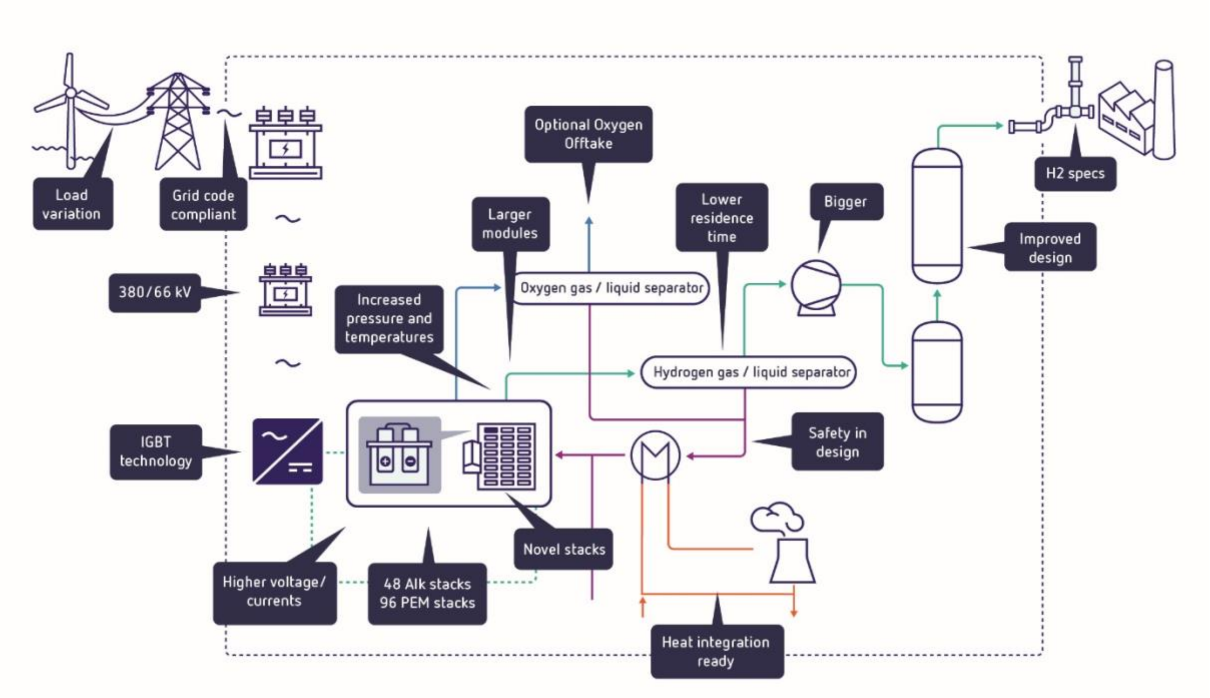

Figure 1: innovations, optimizations and improvements for an advanced 1-GW green hydrogen plant

The novel AWE electrolyzer stack is a large 20 MW stack with 335 cells. It operates at a high current density of 1.3 A cm^{-2}, and uses non-noble electrodes, at a temperature of 100° C. The novel PEM electrolyzer stack is a 10 MW stack with 310 cells. It has a current density of 3.5 A cm^{-2}, and uses improved membrane and electrode materials and low-iridium anodes. The stacks are electrically connected to rectifiers, and arranged in modules of 160 MW for AWE and 40MW for PEM, with improved gas-liquid separators. For AWE, the operating pressure is 5 Bara based on operational, safety, and economic considerations, and this requires mechanical compression to 30 Bara. As for the PEM technology, the hydrogen is already at 30 Bara, so no additional compression is needed. The efficiency of the system is thus slightly higher for PEM than for AWE, assuming 80% stack efficiency for both. The cooling water system design is heat recovery ready, meaning that large volumes of heat (> 130 MW at full load) can potentially be supplied to a district heating network. The plot size is about 10 ha for both technologies.

We showed that substantial cost reductions can be achieved by incorporating the anticipated technology improvements, which were thought of by our scientists. Efficient use of materials and pushing upscaling of components were key in this innovation quest. Many more R&D projects, pilots, and demonstration projects will be needed in order to make this happen. However, time is short. The required technologies must be commercially available in 2026 in order for a financial investment decision (FID) to be made in 2028 and for commercial operations to begin in 2030. This means that the development cycle that must bring the proposed innovations to a mature level is about 4 years.