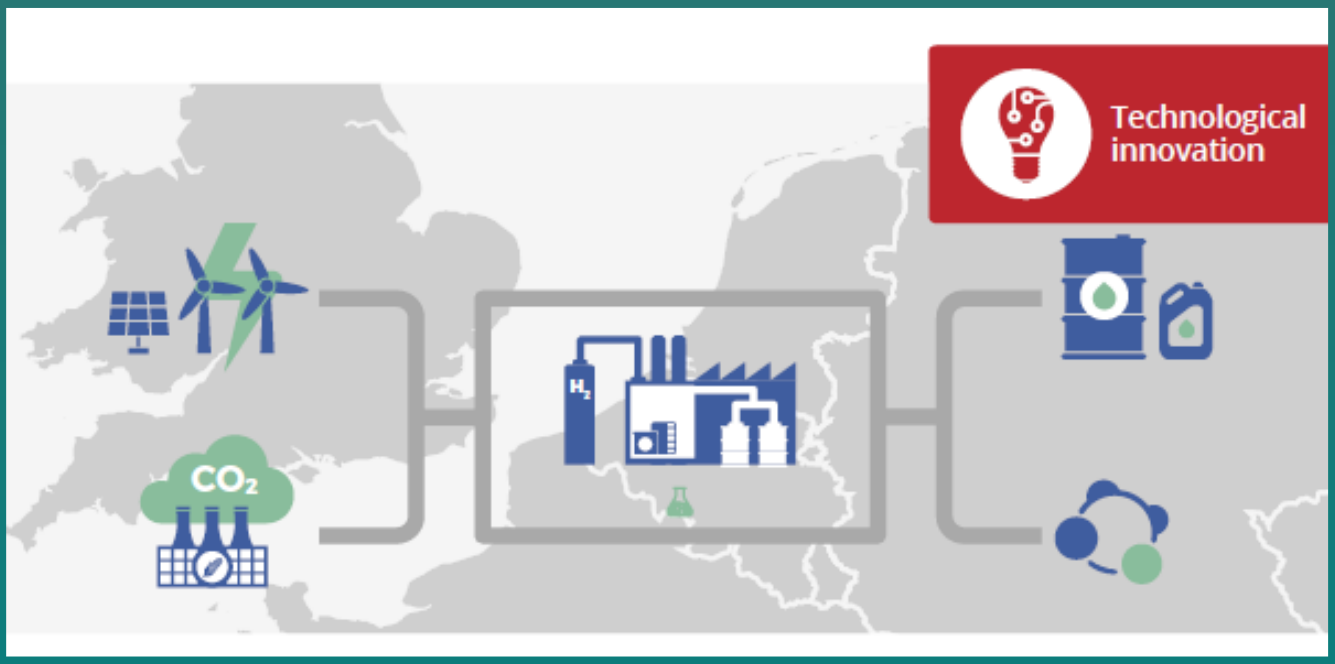

Project Output O1.1

Power-to-X highly flexible pilot demonstrator, available for crossborder testing and innovation (SEDMES pilot demonstrator)

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e2c

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1. Introduction

1.1 Project Background

The coastal areas of the 2 Seas region combine (future) availability of renewable energy with strong industrial activity. This leads to the common challenge of handling renewable energy surpluses, diversifying feedstocks in the chemical industry, reducing greenhouse gas emissions in energy intensive industry, and meeting societal and regulatory demands on advanced fuels and sustainable chemicals. "Power-to-X" concepts, using (renewable) electricity as a replacement for oil and gas energy sources in the production of chemical products, allow for the combination of a solution to these challenges with the creation of valuable products. However, several technical and economic hurdles still need to be overcome. These are related to the cost of renewable hydrogen, the technological immaturity of novel electrochemical processes, and the need for demonstrators and business case calculations to convince industry to invest in further development and implementation of these technologies.

1.2 E2C Project Scope and Deliverables

In order to achieve the above mentioned investment stimulation, the E2C project scope includes the design, construction and testing of two highly flexible Power-to-X pilot demonstrators, one for the indirect conversion of electricity to fuels and one for the direct conversion of electricity with CO_2 to platform chemicals. The former (O1.1) has been delivered at the end of 2021.

1.3 The SEDMES unit objectives: power-to-X highly flexible pilot demonstrator, available for crossborder testing and innovation

The indirect E2C pilot demonstrator aims at producing DME from green electricity through the integration of reaction and water sorption to overcome thermodynamic limitations. This process concept (namely SEDMES or Sorption Enhanced DME Synthesis) has been developed at TNO (Petten), throughout the Fledged and E2C project. The demonstrator unit has been designed with a capacity of 3 kg/hr and to be mobile (containerised) to enable future demonstrations of DME or other X chemicals production, boosting technology investments. The unit was built and constructed within the E2C project and is currently placed at TNO in Petten. The unit will be available for stakeholders from the 2 Seas region for further R&D activities.

1.4 Aim of the document

This document is intended to present and illustrate the specifications of the SEDMES pilot demonstrator. It is a highly flexible pilot demonstrator that can be used for testing adsorption based and power-to-X technologies in combination with a PEM electrolyser.

2. Specifications P2X SEDMES pilot demonstrator

The SEDMES pilot demonstrator unit is built within the E2C project to demonstrate the conversion of CO_2 and H_2 to Dimethyl Ether (DME), using Sorption Enhanced DME Synthesis (SEDMES), water electrolysis and (infrastructure) CO_2. It is designed for a production of 3 kg/hr of DME and to be transportable for on-site testing at industrial sites. This chapter contains information about the unit and its general requirements.

The P2X SEDMES process demonstrator currently consists of two pilot units:

- **Electrolyser unit**: water electrolyser for H_2 production (i.e. PEM).*
- **SEDMES unit**: Multi-column adsorption reactor for the continuous production of DME via reaction of H_2 and CO_2 combined with water removal by adsorption. Consists of 2 containers and a reactor skid. The unit is automated for unmanned operation and can be controlled remotely.

2.1 Specifications SEDMES unit

The SEDMES unit (Figure 2) is currently at TNO in Petten and completely designed for, but not connected to an electrolyser. The unit is designed for 3 kg/h production of DME, but this can vary depending on the conditions of operation.

Figure 1: *The SEDMES pilot unit as it currently is at TNO Petten.*

The required utilities for operating the SEDMES unit and the approximate layout are depicted below.

Specs required utilities:

	Flow [Nm^3/h]	Pressure [bara]	Comment
Water	-	-	Potentially demineralised water required for electrolyser
Instrument air	4.5	6	For pneumatic operation of instruments
CO_2	See below	55	
H_2	See below.	55	Either from electrolyser, infra or other. H2 is required for the process and catalyst activation. The purge step occurs at low pressure, while the repressurization must pressurize the reactor to the feed pressure.
N_2	Max. 12	50	Used for unit SAT, commissioning, start-up, shutdown, emergency shut-down (ESD) and for catalyst (de)activation.
Air	-	-	Required for catalyst passivation.
CH_4	-	-	For flare.
Analyser gases	-	-	Product analysis is probably performed by GC. In that case carrier gasses and support gasses are required.

Electricity:

System voltage	Low	Instrumentation
Normal voltage (+/-5%)	400/230 V	24 DC
Phases/wires	3/3	
Nominal frequency (+/-5%)	50 Hz	

Sizes:

Size stacked containers (infra):	6.06(l)x 2.44(w) x 5.2(h) m
Size reactor skid:	2,6 (l) x 2,5 (w) x 10.8 (h)

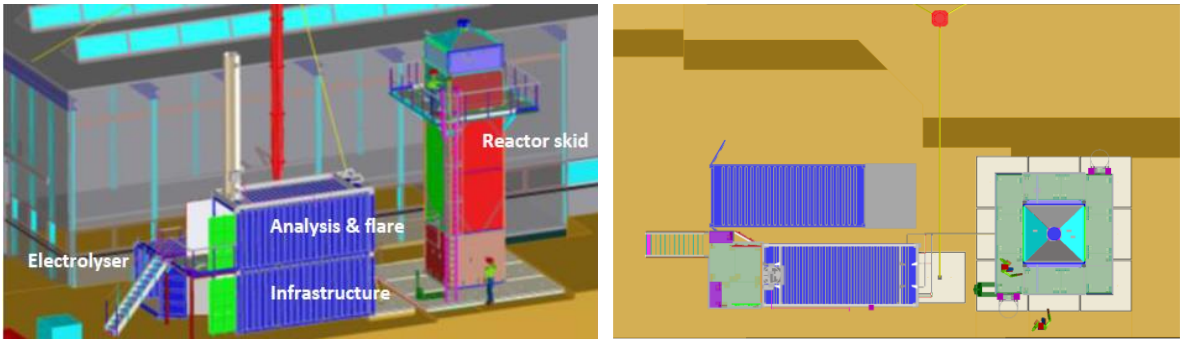

Figure 2: *Left the different containerized and reactor skid unit: 50 kW PEM water electrolyser (not connected to SEDMES and remaining in Petten). Analysis, gas mixing and flare in the top container. Bottom container mainly contains the oil heating system. Right: top view.*

2.2 Specifications P2X SEDMES pilot demonstrator in FLIE

The SEDMES pilot demonstator is planned to be moved to the Field :ab for Industrial Electrification (FLIE; https://flie.nl/en/) in Rotterdam. FLIE offers an open environment to demonstrate technologies amidst potential industrial end users, at an industrial relevant scale. Here, the full P2X SEDMES process will be demonstrated: 100 kW PEM electrolyser, a sorption enhanced DME synthesis (SEDMES) conversion unit and a purification column. Third parties can validate their technologies, by temporarily replacing or supplementing skids at FLIE (being the customer technology in Figure 3). Some testing and validation examples include new electrolyser concepts, production of synfuels using chemical or microbiological conversion units, efficiency of purification skids and compatibility with fluctuations in power supply or feedstock.

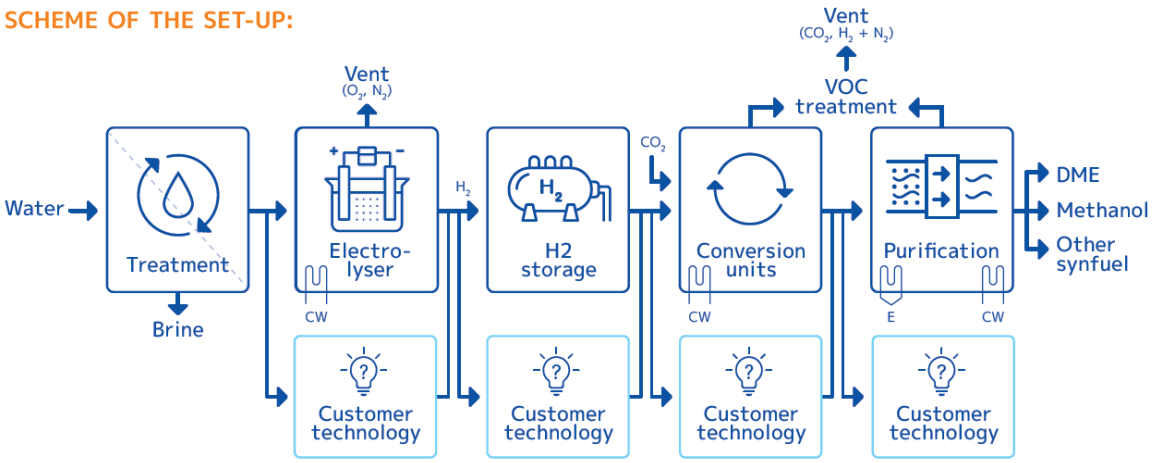

Figure 3: *Scheme of P2X process and the different unit at FLIE.*

Validating a technology within the FLIE helps third parties to mitigate (technical and financial) risks and make informed decisions on how to make industrial processes more sustainable and futureproof.