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High Performance PEM Electrolyser for Cost-effective Grid Balancing Applications

HPEM2GAS - Deliverable report

D6.3 Physical integration of the electrolyser and customer site acceptance test

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Author(s)	G. Kielmann, A. Flat (SWE) B. Green (ITM Power)	2019-05-15
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Summary

The HPEM2GAS project aims to demonstrate an innovative PEM electrolyser at the Emden Council in Germany to assess the stack's and system's robustness to cope with dynamic situations under real-life operating conditions in a field test campaign. The produced hydrogen is fed into the local natural gas grid. For the start of the field testing activity site preparation and connections between the electrolyser and the electricity and gas grids had to be made in Emden. Before the electrolyzer was delivered to Emden, Germany, all necessary measures were taken in this regard and discussed in this deliverable.

For the integration of the electrolyser, a control station was positioned before feeding the hydrogen it into the natural gas network. This runs through the control station to the mixer in the gas transfer station. Several safety-relevant elements are installed along the route. All installed elements were approved by a German Association of Gas and Water (DVGW) expert.

Before the start of the field test, an inspection by a TÜV inspector also had to be carried out. Only after the approval by these two organisations is was legally permitted to put the electrolyzer into operation.

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1 Introduction

The HPEM2GAS project aims to demonstrate an innovative PEM electrolyser at the Emden Council in Germany to assess the stack's and system's robustness to cope with dynamic situations under real-life operating conditions in a field test campaign. The objective is to feed the produced hydrogen into the local natural gas grid. For the start of the field testing activity site preparation and connections between the electrolyser and the electricity and gas grids had to be made in Emden. Before the electrolyzer was delivered to Emden, Germany, all necessary measures were taken in this regard and discussed in this deliverable. The electrolysis system characteristics, construction of pipe bridges and material conducts for system connection to the gas and electricity grids were discussed in previous deliverables.
This deliverables focuses on the last steps needed for the physical integration of the electrolyser at the field testing site in Emden and for achieving the TÜV approval before injection of the produced hydrogen in the gas grid in Emden.

2 Physical integration of the electrolyser at the field testing site in Emden

The ITM hydrogen electrolyser design was based on one PEM electrolyser stack packaged in a 16 foot ISO container with a ground mounted refrigerant chiller. The plant required just mains electricity and tap water to generate self-pressurized hydrogen on site. Apart from the produced hydrogen, the only outputs of the plant are heat rejected during the water and hydrogen purification processes and venting of oxygen, vapour water and small amounts of hydrogen gas (to safe location). Hydrogen from the electrolyzer is transferred to the natural gas takeover station from SWE which is just a few meters away from the location. Hydrogen is thus injected into the natural gas grid operated by SWE.

Regarding the integration of system into control centre of SWE, the plant control system is located in the main control panel, formed by two 2200 (H) x 600 (W) x 600 (D) mm panels bayed together. Panels are divided into PLC, incomer, essential and non-essential compartments. The control panel is bayed with the PSU in the control compartment. The plant control software operates on an S7-1500 failsafe Programmable Logic Controller (PLC). Safety-critical and process instrumentation is interfaced the PLC IO modules in the control panel.
A touch screen, Human Machine Interface (HMI) was provided for plant visualisation and control. The

HMI is mounted upon the front of the main control panel. Password protection is used to ensure only users with sufficient privileges can stop/start the plant. The plant is operated remotely, by a Distributed Control System (DCS) of SWE.

Corresponding specifications for the integration of the electrolyzer into the SWE control system have been finalized. For compliance reasons, it has been decided to install a separate control system for the electrolyzer in the SWE control room. The unit can be controlled by the operator here. The SWE control centre is located about 6 km from the electrolyzer's location. In addition, remote access by ITM is planned. In addition, there is the possibility of intervention directly on site.

3 Regulatory framework for the electrolysis plant

In Germany, the approval of a plant is essentially regulated by the Federal Immission Control Act. This determines the procedure and the necessary steps for approval. The authority responsible for the approval is the trade supervisory office. This decides on the approval for building and operation. A TÜV (Technischer Überwachungsverein), certification was strictly needed for this plant before that a continuous injection of the hydrogen produced by the electrolyser into the gas grid was carried out. The official request was made to this agency after the positive SAT (site acceptance test). This step was preceded by the authorisation DVGW - German Association of Gas and Water Industries about the stability, leaks and connections of pipelines.

3.1 Immission control

The construction and operation of the new plant for the electrolytic production of hydrogen requires a permit pursuant to § 4 para. 1, § 6 para. 1, § 10 of the Federal Immission Control Act (Bundesimmissionsschutzgesetz - BImSchG) in conjunction with §§ 1 and 2 of the 4th Ordinance on the Federal Immission Control Act (4th BImSchV), No. 4.1.12 of the Annex to the 4th BImSchV.

For an operating time less than 12 months, no approval is required.

A licensing procedure in accordance with § 10 BImSchG (with public participation) must be carried out.

The project is a plant pursuant to Art. 10 of Directive 2010/75/EU.

When the plant produces less than 250 Nm3/h, no public participation is necessary.

3.2 Necessary arrangements for P2G field testing

The necessary requirements are discussed in the following.

1. Explosion protection document

As part of a risk assessment, an explosion protection document must be drawn up in accordance with § 6 of the Hazardous Substances Ordinance.

2. Lightning protection

The lightning protection must be implemented according to the lightning protection document of Vektor Plan dated 30.07.2017.

3. Expansion lines

Gases released into the atmosphere from expansion and relief lines, in particular from safety valves, shall be safely discharged.

4. Pipelines

The pipelines must at least be technically tight in accordance with TRBS 2141 Part 3 2.4.

5. Declaration of Conformity/CE marking

The companies involved must have a CE marking and an EC declaration of conformity for all system components covered by one or more harmonization directives.

6. Instruction

Employees must be instructed in accordance with the operating instructions.

Inspections are carried out first by the DVGW - German Association of Gas and Water Industries and deal with stability and leak tests. A second inspection is made in accordance with the TÜV- Technical Inspection Association and it deals with **a**cceptance of the plant in accordance with the "Ordinance on Pressure Vessels, Pressurized Gas Vessels and Filling Plants (Druckbehälterverordnung - DruckbehV)".

This includes a classification into test groups

The pressure vessels are divided into the following groups according to the permissible operating overpressure p in bar, the volume of the pressure chamber I in litres and the pressure content product p*I - in the case of several pressure chambers separated from each other, the product is determined separately for each pressure chamber:

Pressure vessels in which the pressure is exerted by gases or vapours, by liquids or solids with gas or vapour cushions or by liquids whose temperature exceeds the boiling temperature at atmospheric pressure:

Group I:

Pressure vessels intended for the carriage of cryogenic liquefied gases with a maximum allowable working pressure p of more than 0,01 bar and not more than 0,1 bar;

Pressure vessels with a working gauge pressure p of not more than 25 bar and a pressure content product p*I of not more than 200; pressure vessels as pipe assemblies consisting solely of pipes with a clear cross-section of not more than 100 cm^2 , if the product of the working gauge pressure in bar and the clear diameter d in millimetres does not exceed 2000.

Group II:

Pressure vessels with a working gauge pressure p of more than 25 bar and a pressure content product p*I of not more than 200;

Pressure vessels with an allowable working pressure p of not more than 1 bar and an allowable pressure content product p*I of more than 200; The HPEM2GAS electrolyser falls under this directive (group II; 29 l and 35 bar).

Regarding hydrogen injection into the gas grid in Emden, the following considerations are made: currently, less than 5 % hydrogen may be fed into the natural gas grid in Germany, there is no clear legal framework. In Emden at *Pfälzer Straße*, a maximum of 2 % H2 may be fed into the natural gas network, the reason being a natural gas filling station in the immediate vicinity. To do this, the quality of the natural gas must be guaranteed in order to rule out possible damage to the refuelled cars.

For Emden, with the growing construction of wind power plants and solar power plants, it is important to store excess electricity in the form of hydrogen.

4 Integration of the plant and related requirements.

4.1 Lightning protection system and explosion protection document

For commissioning, the ex-zone (area of ignitable concentration of flammable gases) for the control station had to be determined and the ex-zone document of the electrolyzer had to be provided. After the analysis of the two documents, the existing lightning protection system was not sufficient. A new lightning protection system was installed for the field test

The newly calculated explosion protection document states that for hydrogen an ex-zone 2 with a radius of 16.5 metres around the vent pipe must be observed. The inspection report showed that the newly installed system meets the requirements of the Guideline and thus ensures the avoidance of ignition sequences due to electrostatic charges.

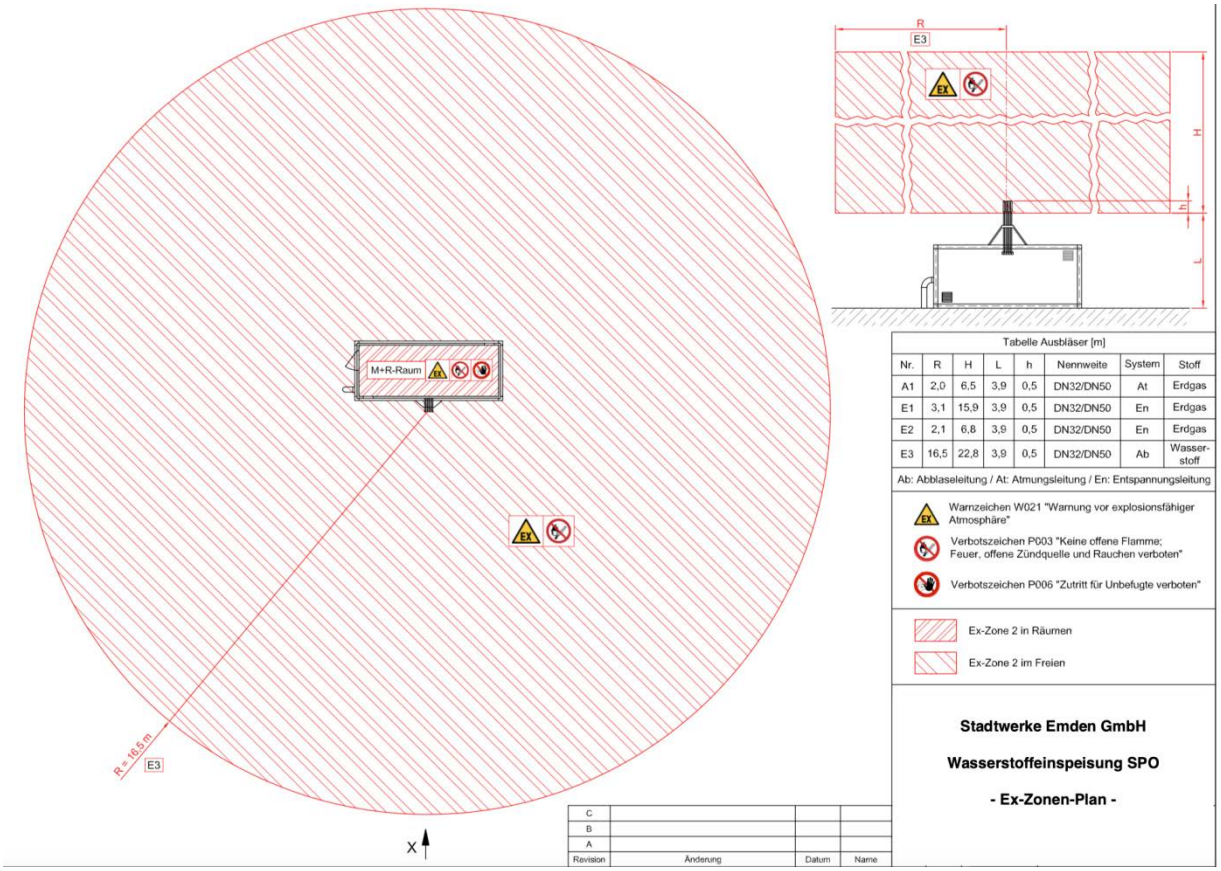

Figure 1: Ex-zone for the control station

Figure 2: New lightning protection system

4.2 Installation of a pressure relief valve (SPV) - Setting to 11 bar

For safety reasons, a safety relief valve was installed in the control station after consultation with the DVGW expert. In case of problem, the hydrogen leaves the electrolyser at a pressure of 10 bar. The SPV is set to a pressure of 11 bar, so that if the pressure rises above 11 bar, the SPV intervenes and prevents feeding into the gas grid.

Figure 3: Pressure relief valve (SPV) - setting to 11 bar

4.3 Inspection of the system by the German Gas and Water Association (DVGW) expert

Acceptance of the control station and the lines to the electrolyzer

Based on the test regarding tightness and strength and the presence of the necessary safety devices as well as the interactions with connected pipelines, it was determined that the conditions for commissioning specified in §6 paragraph 1 of the Ordinance on High Pressure Gas Pipelines were fulfilled.

Therefore, there are no safety concerns against the commissioning of the natural gas, pressure control and measuring system.

Test limits:

The entire newly installed moulding includes its flange connections (DN200), as well as the H_2 inoculation line (seamless steel pipe DN12) drawn from the outside into the natural gas, pressure control and measuring system from the first detachable connection outside the station building to the connection sleeve of the inoculation nozzle projecting into the moulding.

Tests performed:

Stability and leak testing

The newly installed moulded part (injection point) within the natural gas, pressure control and measuring system "Pfälzer Straße, Emden, Germany" for the injection of hydrogen together with the supply line from outside was tested for strength and tightness.

All welded joints within the above test limits were included in the leak test. The connection of the electrolyser to the control station or the gas transfer station was made by a DIN 12 mm pipe.

The maximum permissible operating pressure (MOPd) of this line is 16.0 bar. The operating pressure of this line is currently set to OPd = 10.0 bar.

Safety devices

The necessary safety equipment in accordance with § 3 Paragraph 4 No. 1 is available.

Interactions

Interactions with other lines, including interactions with connected lines, have been tested.

4.4 TÜV acceptance of the electrolyzer

Acceptance of the plant in accordance with the "Ordinance on Pressure Vessels, Pressurized Gas Vessels and Filling Plants (Druckbehälterverordnung - DruckbehV)".

§8 - Classification into test groups

The pressure vessels are determined separately for each pressure chamber according to the permissible operating overpressure p in bar, the volume of the pressure chamber L in litres and the pressure content product p*L - in the case of several separate pressure chambers the product is determined separately for each pressure chamber - here it is divided into groups I - VII:

For the electrolyser used in the project, a TÜV approval according to Group II is required, as the pressure vessels have a volume of 20 to 29 L and a pressure of 35 bar.

Group II:

Pressure vessels with a permissible operating overpressure p of more than 25 bar and a pressure content product p*L of not more than 200;

Pressure vessels with a maximum allowable working pressure p of not more than 1 bar and a maximum allowable pressure content product p*L of more than 200;

Documents provided by ITM for the TÜV approval were:
D964-0002-01 - HPEM2GAS HGas - User manual
D964-1002-05 HPEM2GAS P&ID
D964-3004-01 - HPEM2GAS HGas - PED Safety Case
A908-0620 REV F - General Arrangement and Hazardous Area Drawing

TÜV certification was achieved and hydrogen injection into the gas grid in accordance to the planned field testing activity.

Figure 4: Complete system ready for operation

4.5 Training of operators on PEM-system

Three engineers from ITM were present in Emden to support the system installation especially to install the pressure reduction equipment. The ITM engineer who carried out the initial SAT work (Paul Bennet) was staying for a week to test the system, run the plant and make sure everything was in place for the TUV. The main responsible of system development at ITM (Ben Green) was present for the TUV visit and to allow a training in the successive days. Remote support from ITM is provided during the field testing activity in Emden.

5 CONCLUSIONS

The aim of WP6 is to assess a grid-connected advanced PEM electrolysis system to address a dynamic power profile and to demonstrate achievement of TRL6 for the developed electrolysis device in a field test campaign. For the electrolyser, assessment the gas takeover station of SWE at Pfälzer-Straße was chosen as field testing site. Here, the hydrogen gas can be injected directly into the natural gas grid. The PEM electrolyser unit after completing the build phase at ITM in Sheffield and the factory acceptance testing has been transported to Emden where it has been integrated into the whole plant for power to gas assessment. The unit has been commissioned, tested and subjected to TUV approval prior handover to SWE and commencement of the field trial.