H2FUTURE

Green Hydrogen

Deliverable D2.1

Specifications of Pilot Test 1 / Use Case 1

v1.0

Funded by

Document Information

Deliverable Title	Specifications of Pilot Test 1 / Use Case 1
Number of the Deliverable	D2.1
WP/Task related	WP2 / T2.1
Distribution/Confidentiality	PU Public
Date of Delivery	2017-05-26
Status and Version	Final Version 1.0
Number of Pages	17 pages
Person Responsible for Document	Klaus Scheffer – Siemens AG
Author(s)	Klaus Scheffer – Siemens AG Hagen Hertsch – Siemens AG
Reviewers	Karl Zach – VERBUND Thomas Wasser – Siemens AG

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking under grant agreement No 735503. This Joint Undertaking receives support from the European Union's Horizon 2020 research and innovation programme and Hydrogen Europe and N.ERGHY.

Revision History

Version	Date	Author / Reviewer	Notes
0.4	2017-04-03	K. Scheffer H. Hertsch	Initial draft
0.6	2017-04-11	K. Scheffer	KPIs 1-5 added in articles 3.1.4 and 3.1.5; minor modifications in KPI descriptions; modification of use case diagram (DC current measuring added)
0.8	2017-05-03	H. Hertsch	3.2. updated Diagram of use case 3.3.1 updated 3.4.1 updated 3.4.2 and 3.5 added
0.9	2017-05-19	K. Scheffer	Adapted to Delivery document format. Energy consumption in KPIs now referring to Electrolyser Plant consumption instead of Elektrolyser System Remarks to definition of Efficiency added in section “3 / 1.8 General Remarks”
0.91	2017-05-22	K. Scheffer	Consideration of Karl Zach’s comments on formal structure
0.92	2017-05-26	K. Scheffer	Consideration of Thomas Wasser’s comment on adding information when the pilot test is scheduled (section 1.2)
1.0	2017-06-23	K. Scheffer	Consideration of Karl Zach’s comments on V0.92 Alignment of KPI definitions to the wording agreed upon in Deliverable D2.8

Executive Summary

Work Package 2 (WP2) of the H2FUTURE project has the objective to detail the aims and execution of the individual use cases / pilot tests and the quasi-commercial operation phase, which are performed in WP8 at a later stage of the project.

This document, deliverable D2.1, details the specifications for use case / pilot test 1 – "Stress test". This basic use case is a pilot test addressing the behaviour of the system during start and stop sequences and under partial and full load operational conditions. The pilot test forms the baseline for the following use cases.

In order to facilitate the development of the use case / pilot test specifications a common methodology based on the use case collection method (cf. Smart Grid Coordination Group at EC level) has been used, which is briefly introduced in chapter 2.

The filled-out use case template for use case / pilot test 2, which contains the general narrative description, KPIs, sequence diagram, etc., can be found in chapter 3.

Table of Contents

1 Introduction

1.1 The H2FUTURE Project

As part of the H2FUTURE project a 6 MW polymer electrolyte membrane (PEM) electrolysis system will be installed at a steelworks in Linz, Austria. After the pilot plant has been commissioned, the electrolyser is operated for a 26-month demonstration period, which is split into five pilot tests and quasi-commercial operation. The aim of the demonstration is to show that the PEM electrolyser is able to produce green hydrogen from renewable electricity while using timely power price opportunities and to provide grid services (i.e. ancillary services) in order to attract additional revenue.

Subsequently, replicability of the experimental results on a larger scale in EU28 for the steel industry and other hydrogen-intensive industries is studied during the project. Finally, policy and regulatory recommendations are made in order to facilitate deployment in the steel and fertilizer industry, with low CO_2 hydrogen streams also being provided by electrolysing units using renewable electricity.

1.2 Scope of the Document

Work Package 2 (WP2) of the H2FUTURE project has the objective to detail the aims and execution of the individual use cases / pilot tests and the quasi-commercial operation phase, which are performed in WP8 at a later stage of the project. Further on, in order to validate the commercial exploitation of the PEM electrolyser, to analyse the operational impacts and the deployment conditions of the resulting innovations, key performance indicators (KPIs), which are monitored during the demonstration, are also detailed in WP2. For each use case / pilot test specification (D2.1 – D2.5), for the specification of the quasi-commercial operation (D2.6), for the final technical review (D2.7) and for the monitored KPIs separate documents will be created in WP2.

This document, deliverable D2.1, details the specifications for use case / pilot test 1 – “Stress test”. This basic use case is a pilot test addressing the behaviour of the system during start and stop sequences and under partial and full load operational conditions. It includes an in-depth analysis of:

- the interactions and interplay of each of the single subsystems as an integrated plant
- power consumption of the electrolyser system and its auxiliaries in hot and cold stand-by mode with analysis of the start-up time from these energy saving states to operation at full electrical load.
- the effect of full load and part load situations on the local grid. The effect on the power factor and harmonic distortions are examined in detail under various load situations.

Together with the use case / pilot test 2 – Continuous Operation 24/7 with maximized hydrogen production – this pilot test 1 determines the technical abilities and behaviour of the electrolyser system. They serve as basis for the following use cases, which are related to business opportunities and commercial operation.

This pilot test is scheduled to be performed starting March 2019 – this is the first task of work package 8.

In chapter 2 of this document a brief introduction to the use case methodology and the use case template for WP2 is given. The filled out use case template is then provided in chapter 3.

1.3 Notations, Abbreviations and Acronyms

AC	Alternating Current
DC	Direct Current
EC	European Commission
EU	European Union
IEC	International Electrotechnical Commission
IED	Intelligent Electronic Device
KPI	Key Performance Indicator
LV	Low Voltage
MV	Medium Voltage
PEM	Polymer Electrolyte Membrane / Proton Exchange Membrane
THD	Total Harmonic Distortion
TSO	Transmission System Operator
WP	Work Package

Table 1: Acronyms list

2 Use Case Methodology

2.1 Introduction to Use Cases

In order to facilitate the development of the use case / pilot test specifications a common methodology based on the use case collection method (cf. Smart Grid Coordination Group at EC level) has been used.

Use cases were initially developed and used within the scope of software engineering, and their application has been gradually extended to cover business process modelling. This methodology has extensively been used within the power supply industry for smart grid standardisation purposes by international and European standardisation organisations and projects, such as International Electrotechnical Commission (IEC), M/490 Smart Grid Coordination Group, EPRI Electricity Power Research Institute and National Institute of Standards and Technology (NIST).

In general, use cases describe in textual format how several actors interact within a given system to achieve goals, and the associated requirements. IEC 62559-2 defines a use case as "*a specification of a set of actions performed by a system which yields an observable result that is of value for one or more actors or other stakeholders of the system*". Use cases must capture all of the functional requirements of a given system (business process or function), and part of its non-functional requirements (performance, security, or interoperability for instance), not based on specific technologies, products or solutions.

The targets of actors can be of different levels, i.e. business or functional, and use cases can be of different levels of detail (very high-level or very specific, related to the task the user of a system may perform) accordingly. Business processes and the related requirements can be described in business use cases, while functions or sub-functions supporting the business processes and their associated requirements can be detailed in system use cases.

2.2 Use Case Template

For the H2FUTURE use cases a template based on the IEC 62559-2 (IEC, 2015) and the DISCERN project (OFFIS, 2013) has been used. This structured format for use case descriptions helps to describe, compare and administer use cases in a consistent way.

The use case template contains the following main information, structured in separate sections and tables:

- Administrative information (version management)
- Description of the use case (general narrative description, KPIs, use case conditions, etc.)
- Diagram(s) of the use case (e.g. sequence diagram)
- Technical details (actor description, references, etc.)
- Step-by-step analysis of the use case
- Information exchanged and requirements

The system use case developed within task WP2.1 of the H2FUTURE project is described in the following section of the document.

3 Use Case / Pilot Test 1

1. Description of the use case

1.1 Name of use case

Use case identification		
ID	***Area / Domain(s)/ Zone(s)***	***Name of use case***
UC1_1	Customer Premises / Process, Field, Station, Operation	Stress Test

1.2 Version management

Version management				
Version No.	***Date***	***Name of author(s)***	***Changes***	***Approval status***
0.4	2017-04-03	K. Scheffer H. Hertsch	Initial draft	n.a.
0.6	2017-04-11	K. Scheffer	KPIs 1-5 added in articles 1.4 and 1.5; minor modifications in KPI descriptions; modification of use case diagram (DC current measuring added)	n.a.
0.8	2017-05-03	H. Hertsch	2. updated Diagram of use case 3.1 updated 4.1 updated 4.2 and 5. added	n.a.
0.9	2017-05-22	K. Scheffer	Definition of energy consumption of electrolyser plant added (1.8)	n.a

1.3 Scope and objectives of use case

Scope and objectives of use case	
Scope	Stress tests including ramp-up and partial-load testing
Objective(s)	Proof of successful commissioning of the electrolyser subsystem; Qualification baseline for further pilot tests.
Related business case(s)	Base for any related business case

1.4 Narrative of Use Case

Narrative of use case
Short description
This basic use case is a pilot test addressing the behaviour of the system during start and stop sequences and under partial and full load operational conditions. The use case forms the baseline for the following pilot tests.
Complete description
In-depth analysis of: - the interactions and interplay of each of the single subsystems as an integrated plant - power consumption of the electrolyser system and its auxiliaries in hot and cold stand-by mode with analysis of the start-up time from these energy saving states to operation at full electrical load. - the effect of full load and part load situations on the local grid. The effect on the power factor and harmonic distortions are examined in detail under various load situations.

1.5 Key performance indicators (KPI)

Key performance indicators			
ID	***Name***	***Description***	***Reference to mentioned use case objectives***
1	Start-up time from cold stand-by to nominal capacity	Cold stand-by is considered as the most energy-saving stand-by state of the electrolyser system. All auxiliaries (pumps, vents etc.) as well as the AC/DC power conversion system (Transformer-Rectifier system) are switched off. Active components are limited to the process control system and to units related to safety issues. The electrolyser starts from ambient temperature and has not been operated for at least 24 hours. This KPI is the time from receipt of the START command, starting the auxiliaries, activating the transformer-rectifier system and ramping up the electrical load from 0% to 100% of nominal production. [KPI unit]: s	
2	Energy consumption in cold stand-by	Total energy consumption of the electrolyser plant from medium voltage grid connection (no-load losses of transformer) down to auxiliaries consumption on low voltage level, measured when the electrolyser system is in cold stand-by mode. [KPI unit]: kW	

3	Start-up time from hot stand-by to minimum partial load	In contrast to cold stand-by, hot stand-by is considered as an energy state of the electrolyser which allows rapid start-up with reasonable low energy consumption in the stand-by mode. In hot stand-by mode, auxiliaries which significantly influence the start-up time may be kept active. The electrolyser may start from a temperature close to the normal operating temperature but has not been operated for at least 1 hour. This KPI is the time from receipt of the START command, starting the auxiliaries, activating the transformer-rectifier system and ramping up the electrical load from 0% to minimum partial load. [KPI unit]: s	
4	Start-up time from hot stand-by to nominal capacity	See KPI #3 for definition of hot stand-by. This KPI is the time from receipt of the START command, starting the auxiliaries, activating the transformer-rectifier system and ramping up the electrical load from 0% to 100% of nominal production. [KPI unit]: s	
5	Energy consumption in hot stand-by	Total energy consumption of the electrolyser plant from medium voltage grid connection (no-load losses of transformer) down to auxiliaries consumption on low voltage level, measured when the electrolyser system is in hot stand-by mode. [KPI unit]: kW	
6	Ramp-up speed	Averaged speed for ramping up the electrical load from 30% to 100% of nominal production at nominal operating temperature. [KPI unit]: %/s	
7	Ramp-down speed	Averaged speed for ramping down the electrical load from 100% to 30% of nominal production production at nominal operating temperature. [KPI unit]: %/s	
8	Power factor	Minimum of observed power factor (cos phi, averaged over a 60s measuring period) at the MV feeder to the transformer-rectifier system when operating the electrolyser system at partial loads between minimum partial load and 100% of nominal production. [KPI unit]: ./.	

9	Harmonic distortions	Maximum of observed harmonic current distortions (THD_I, averaged over a 60s measuring period) at the MV feeder to the transformer-rectifier system when operating the electrolyser system at partial loads between minimum partial load and 100% of nominal production. [KPI unit]: ./.	
10	Stability	Number of required manual interventions during a 100h stability test when operating the electrolyser system at random loads between minimum partial load and 100% of nominal production (load changes every 15 minutes) [KPI unit]: 1/h	

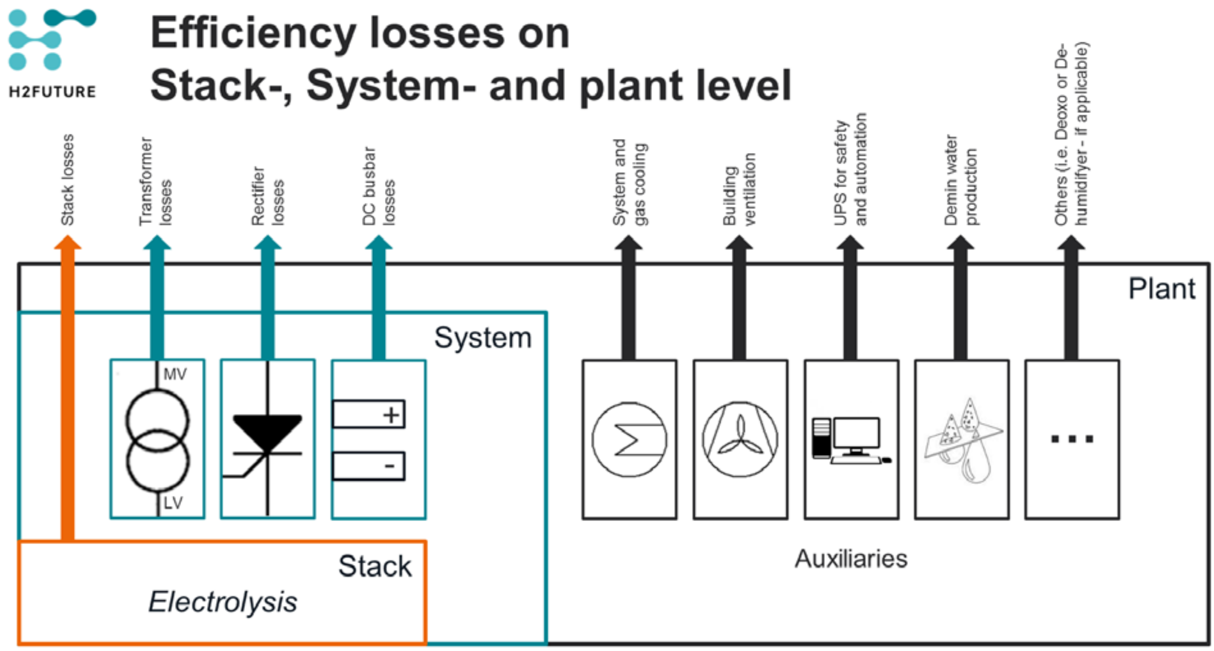
1.6 Use case conditions

Use case conditions
Assumptions
./.
Prerequisites
Electrolyser and infrastructure components are installed, commissioned and ready for operation
Permission to operate the electrolyser has been granted
Electrical energy is available with required amount

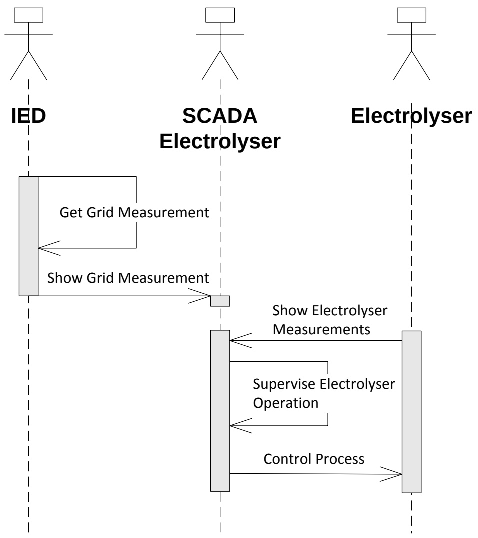
1.7 Further information to the use case for classification / mapping

Classification information
Relation to other use cases
None (qualification for further pilot tests)
Level of depth
Individual Use Case
Prioritisation
Mandatory / implemented in demonstration
Generic, regional or national relation
Generic
Nature of the use case
Technical
Further keywords for classification
Dynamic test; SAT

1.8 General remarks

General remarks
The definition of energy consumption of the electrolyser plant as it is used for calculation of KPIs 2) and 5) is derived from the projects document “H2F_WP3.1_AOP526_ Efficiency at Stack-, System- and Plant Level”. Following graphic is an excerpt of this document:  The definition of electrolyser plant as shown in the graphic above includes any and all components which are directly or indirectly connected to the electrolyser and which consume (additional) energy due to the existence of the electrolyser.

2. Diagrams of use case

Diagram(s) of use case


3. Technical details

3.1 Actors

Actors			
Grouping		***Group description***	
Process/Field/Station actors		Actors in Process, Field, Station levels	
Actor name	***Actor type***	***Actor description***	*Further information specific to this use case*
Electrolyser	Component	An electrolyser is a technology allowing to convert electricity into hydrogen (and oxygen). It consists of electrolyser stacks (several electrolyser cells stacked to a larger unit) and the transformer rectifier system providing the electrical power	
Intelligent Electronic Device (IED)	Component	Any device incorporating one or more processors with the capability to receive or send data/control from or to an external source (e.g., electronic multifunction meters, digital relays, controllers)	In this Use Case, the IED collects power measurements from the AC grid and sends them to the SCADA of the electrolyser
SCADA Electrolyser	Application	Supervisory control and data acquisition – an industrial control system to control and monitor a process and to gather process data. A SCADA consists of programmable logic controllers and human-machine interface computers with SCADA software. The SCADA system directly interacts with devices such as valves, pumps, sensors, actors and so on	In this use case the SCADA controls the electrolyser process and sets the DC power input for the electrolyser stack

3.2 References

References						
No.	***References Type***	***Reference***	***Status***	***Impact on use case***	***Originator / organisation***	***Link***

4. Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
1	Monitoring	IED measures the output power, power factor and harmonic current distortions of the electrolyzer system.	IED	periodically	SCADA is running and data connection is established	
2	Control	SCADA sends control commands to the electrolyser in order to change its power consumption	SCADA Electro-lyser	periodically	SCADA is running and the electrolyser system is running or ready to start.	Electrolyser adepts its power consumption according to the control commands

4.2 Steps – Scenarios

Scenario								
Scenario name:	**No. 1 – Monitoring**							
Step No.	***Event***	***Name of process/ activity***	***Description of process/ activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***
1	Periodically	Get grid measurement	IED performs measurement of local grid	INTERNAL OPERATION	IED	IED	G_M	
2	Periodically	Show grid measurement to SCADA	IED sends measurements to SCADA	SHOW	IED	SCADA Electrolyser	G_M	
Scenario name:	**No. 2 – Control**							
Step No.	***Event***	***Name of process/ activity***	***Description of process/ activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***
1	Periodically	Show electrolyser measurement to SCADA	Electrolyser sends measurements to SCADA	SHOW	Electrolyser	SCADA Electrolyser	E_M	
2	Periodically	Supervise electrolyser operation	SCADA keeps electrolyser consumption at constant level (rated power)	INTERNAL OPERATION	SCADA Electrolyser	SCADA Electrolyser		
3	Periodically	Control process	SCADA sends set point to the electrolyser system	CHANGE	SCADA Electrolyser	Electrolyser	SP_V	

5. *Information exchanged*

Information exchanged			
Information exchanged, ID	***Name of information***	***Description of information exchanged***	***Requirement, R-IDs***
G_M	Grid Measurement	Measurement of the power consumed by the transformer-rectifier system of the electrolyser	
E_M	Electrolyser Measurement	Measurement indicating the DC current consumption of the electrolyser which is then used to calculate the hydrogen production	
SP_V	Set-Point Value	Set-point for controlling the hydrogen production of the electrolyser	

6. *Requirements (optional)*

Requirements (optional)		
Categories ID	**Category name for requirements**	**Category description**
Requirement R-ID	**Requirement name**	**Requirement description**
Categories ID	**Category name for requirements**	**Category description**
Requirement R-ID	**Requirement name**	**Requirement description**

7. *Common terms and definitions*

Common terms and definitions	
Term	**Definition**

8. *Custom information (optional)*

Custom information (optional)		
Key	***Value***	***Refers to section***

4 References

4.1 Project Documents of H2FUTURE

- D2.2 Specifications of Pilot Test 2 / Use Case 2
- D2.3 Specifications of Pilot Test 3 / Use Case 3
- D2.4 Specifications of Pilot Test 4 / Use Case 4
- D2.5 Specifications of Pilot Test 5 / Use Case 5
- D2.6 Specifications of quasi-commercial Operation
- D2.7 Specifications of Final Tests
- D2.8 KPIs to monitor the Demonstrations and perform the Exploitation Tasks
- H2F_WP3.1_AOP526_Efficiency at Stack-, System- and Plant Level (internal deliverable)

4.2 External Documents

- International Electrotechnical Commission (IEC) (2015): IEC 62559-2 "Use case methodology – Part 2: Definition of the templates for use cases, actor list and requirements list", 2015
- OFFIS (2013): “Architecture templates and guidelines”, deliverable D1.3 of the DISCERN project, available at https://www.discern.eu/project_output/deliverables.html, 2013