H2FUTURE
Green Hydrogen

Deliverable D2.5

Specifications of Pilot Test 5 / Use Case 5

v1.0

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Revision History

Version	Date	Author / Reviewer	Notes
0.1	28/03/2017	S. Engleder	First draft
0.2	21/04/2017	S. Engleder	clarification KPI, raw analog data of electrolyser power from voestalpine, not calculated by Siemens
0.3	22/05/2017	S. Engleder	Update diagram of use cases, definition of KPI (THDI, cosf) new formal structure connection SCADA_voestalpine- DCS added Revision of points 3 to 6
0.4	02/06/2017	S. Engleder	Correction of KPI: removal of : ..reporting of standard deviation…
0.5	20/06/2017	K.Zach	General remarks, update diagram of use cases
1.0	29/06/2017	S. Engleder	Final Version

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 D2.5, describes the trend curve of the active power of the electrolyser to minimize the deviations of the active power curve of the steel plant. The power curve, which is applied in this case, is the measured curve of the whole energy consumption of the steel plant from the external 110 kV grid.

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 5, 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 D2.5, details the specifications for use case / pilot test 5 - Integration in state-of-art steel plant.

The aim of this use case is to quantify the trend curve of the active power of the electrolyser to minimise the deviations of the active power consumption of the steel plant from the public 110kV grid.

Following key performance indicators are examined:

- Load smoothing factor
- Power quality factors

1.3 Notations, Abbreviations and Acronyms

AC	Alternate Current
EC	European Commission
EU	European Union
IEC	International Electrotechnical Commission
IED	Intelligent Electronic Device
KPI	Key Performance Indicator
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 WP2.5 of the H2FUTURE project is described in the following section of the document.

3 Use Case / Pilot Test 5 - Integration in state-of-art Steel Plant

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**
UC5	Customer Premises / Process, Field, Station, Operation	Integration in state-of-art steel plant

1.2 Version management

Version management				
Version No.	**Date**	**Name of author(s)**	**Changes**	**Approval status**
0.1	28/03/2017	S. Engleder	First draft	
0.2	21/04/17	S. Engleder	clarification KPI, raw analog data of electrolyser power from voestalpine, not calculated by Siemens	
0.3	22/05/2017	S. Engleder	Update diagram of use cases, definition of KPI (THDI, cosf) new formal structure connection SCADA_voestalpine- DCS added Revision of points 3 to 6	
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0.5	20.6.17	K. Zach	General remarks, update diagram of use cases	

1.3 Scope and objectives of use case

Scope and objectives of use case	
Scope	Technical validation of the electrolyser pilot plant to smooth the deviations of the electrical power demand of the steel plant from the public 110kV grid, also depending on the predicted demand
Objective(s)	The highly dynamic operational mode will be tested with a focus on reliability and fast response
Related business case(s)	Minimization of deviations in the predicted electric power consumption from the external grid

1.4 Narrative of Use Case

Narrative of use case
Short description
This use case describes the trend curve of the active power of the electrolyser to minimize the deviations of the active power curve of the steel plant
Complete description
This use case describes the trend curve of the active power of the electrolyser to minimize the deviations of the active power curve of the steel plant voestalpine in Linz. The power curve, which is applied in this case, is the measured curve of the whole energy consumption of the steel plant from the external 110 kV grid. The current active power value of the energy consumption and the predicted power by the end of quarter of an hour for voestalpine is available in the SCADA system of the voestalpine net. The equivalent power of the electrolyser is

calculated in the SCADA of voestalpine in real-time and then sent via an analog signal to the electrolyser.

The nominal power of the installed electrolyser is very much smaller than the total power of the steel plant which is consumed from the grid. For this reason, the calculated power / set point of the electrolyser has to be accordingly scaled to the nominal power of the electrolyser (i.e. 6 MW).

1.5 Key performance indicators (KPI)

Key performance indicators			
ID	***Name***	***Description***	***Reference to mentioned use case objectives***
1	Load smoothing factor	The quality of the total power (load and electrolyser) in terms of constant power consumption measured in different periods (30sec, 1 min, 5min, 15 min, 1h, ..); observation period= 30 days $DEV_{Sum\_30s} = \frac{1}{86400} * \sum_{1}^{864000} \left\| \frac{P_{mittel-electrolyser\_30s} - P_{mittel\_30s}}{P_{mittel\_30s}} \right\|$ $DEV_{Sum\_1min} = \frac{1}{43200} * \sum_{1}^{43200} \left\| \frac{P_{mittel-electrolyser\_1min} - P_{mittel\_1min}}{P_{mittel\_1min}} \right\|$ $DEV_{Sum\_5min} = \frac{1}{8640} * \sum_{1}^{8640} \left\| \frac{P_{mittel-electrolyser_{5min}} - P_{mittel\_5min}}{P_{mittel\_5min}} \right\|$ $DEV_{Sum\_15min} = \frac{1}{2880} * \sum_{1}^{2880} \left\| \frac{P_{mittel-electrolyser\_15min} - P_{mittel\_15min}}{P_{mittel15min}} \right\|$ $DEV_{Sum\_1h} = \frac{1}{720} * \sum_{1}^{720} \left\| \frac{P_{mittel-electrolyser\_1h} - P_{mittel\_1h}}{P_{mittel\_1h}} \right\|$ $MAX\_DEV_{Sum\_30s} = MAX\left(\frac{P_{mittel-electrolyser\_30s} - P_{mittel\_30s}}{P_{mittel\_30s}}\right)$ $95\%MAX_{DEV_{Sum_{30s}}} = 95\%\ value\_MAX\left(\frac{P_{mittel-electrolyser\_30s} - P_{mittel\_30s}}{P_{mittel\_30s}}\right)$ $MAX\_DEV_{Sum\_1min} = MAX\left(\frac{P_{mittel-electrolyser\_1min} - P_{mittel\_1min}}{P_{mittel\_1min}}\right)$ $95\%MAX_{DEV_{Sum_{1min}}} = 95\%\ valueMAX\left(\frac{P_{mittel-electrolyser\_1min} - P_{mittel-EAF\_1min}}{P_{mitt\_1min}}\right)$ $MAX\_DEV_{Sum\_5min} = MAX\left(\frac{P_{mittel-electrolyser\_5min} - P_{mittelF\_5min}}{P_{mittel\_1min}}\right)$ $95\%MAX_{DEV_{Sum_{5min}}} = 95\%\ valueMAX\left(\frac{P_{mittel-electrolyser\_5min} - P_{mittel\_5min}}{P_{mittel\_5min}}\right)$ $MAX\_DEV_{Sum\_15min} = MAX\left(\frac{P_{mittel-electrolyser\_15min} - P_{mittel\_15mins}}{P_{mittel\_15min}}\right)$ $95\%MAX_{DEV_{Sum_{15min}}} = 95\%\ valueMAX\left(\frac{P_{mittel-electrolyser\_15min} - P_{mittel\_15min}}{P_{mittel\_15min}}\right)$ $MAX\_DEV_{Sum\_1h} = MAX\left(\frac{P_{mittel-electrolyser\_1h} - P_{mittel\_1h}}{P_{mittel\_1h}}\right)$ $95\%MAX_{DEV_{Sum_{1h}}} = 95\%\ valueMAX\left(\frac{P_{mittel-electrolyser\_1h} - P_{mittel\_1h}}{P_{mittel\_1h}}\right)$	

2	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]: ./.	
3	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]: ./.	

1.6 Use case conditions

Use case conditions
Assumptions
The electrolyser system can follow given power gradients of the power consumption of the steel plant
Prerequisites
Data exchange from the voestalpine process control units to the electrolyser and vice versa operates faultless
High power gradients can be repeated without loss of performance during the concrete use case

1.7 Further information to the use case for classification / mapping

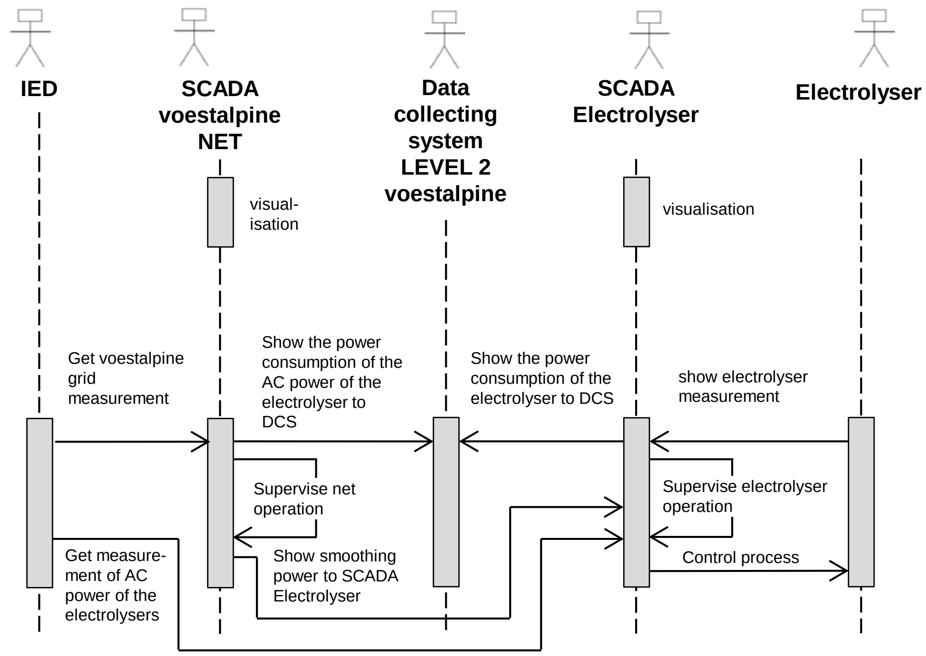
Classification information
Relation to other use cases
Use case of the WP2.5 of H2FUTURE
Level of depth
Individual use case
Prioritisation
Implemented in demo
Generic, regional or national relation
Austria
Nature of the use case
Technical
Further keywords for classification
Power curve compensation, electric demand

1.8 General remarks

General remarks

2 Diagrams of use case

Diagram(s) of use case



3 Technical details

3.1 Actors

Actors			
Grouping		***Group description***	
Actor name	***Actor type***	***Actor description***	*Further information specific to this use case*
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 measurements of active power from the voestalpine internal grid
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	
SCADA_voestalpine	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	SCADA voestalpine controls and monitors the voestalpine internal distribution net and the connection to the external 110kV grid
SCADA_ Electrolyser	Application		In this use case the SCADA controls the electrolyser process and sets the DC power for the electrolyser stack

Data Collecting System (DCS)	Application	A DCS is a computer application that facilitates the process of data collection, allowing specific, structured information to be gathered in a systematic fashion, subsequently enabling data analysis to be performed on the information	The DCS (level 2 system) collects and stores data of variable processes and process control units in voestalpine

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	Measuring	IED measures the AC power consumption of the electrolyser	IED	periodically		
2	Control	SCADA_Electrolyser sends control commands to the electrolyser in order to change its power consumption	SCADA_ electrolyser	SCADA_Electrolyser gets information of the requested AC power of the electrolyser directly via analog signal from the SCADA_voestalpine; the requested AC power of the electrolyser is calculated in the SCADA-voestalpine	Communications from SCADA_Electrolyser to the electrolyser can be established. The electrolyser is up and running.	Electrolyser adopts its power consumptio n according to the control commands
3	Monitoring	SCADA_voestalpine reports the chosen data to the DCS	SCADA_ voestalpine	SCADA_voestalpine periodically sends the data to the DCS	Communications from SCADA_voestalpine application to DCS must be established.	

4.2 Steps – Scenarios

Scenario								
Scenario name:		**No. 1 – Measuring**						
Step No.	***Event***	***Name of process/ activity***	***Description of process/ activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Require ment, R-IDs***
1	Periodically	Get voestalpine-grid measurements	IED performs measurement	INTERNAL OPER-ATION	IED	IED	PC_M	
2	Periodically	Show grid measurements	IED shows grid measurements to SCADA voestalpine	SHOW	IED	SCADA voestalpine	PC_M	
3	Periodically	Get measurement of AC power of the electrolysers	IED performs measurement	INTERNAL OPER-ATION	IED	IED	PC_M	

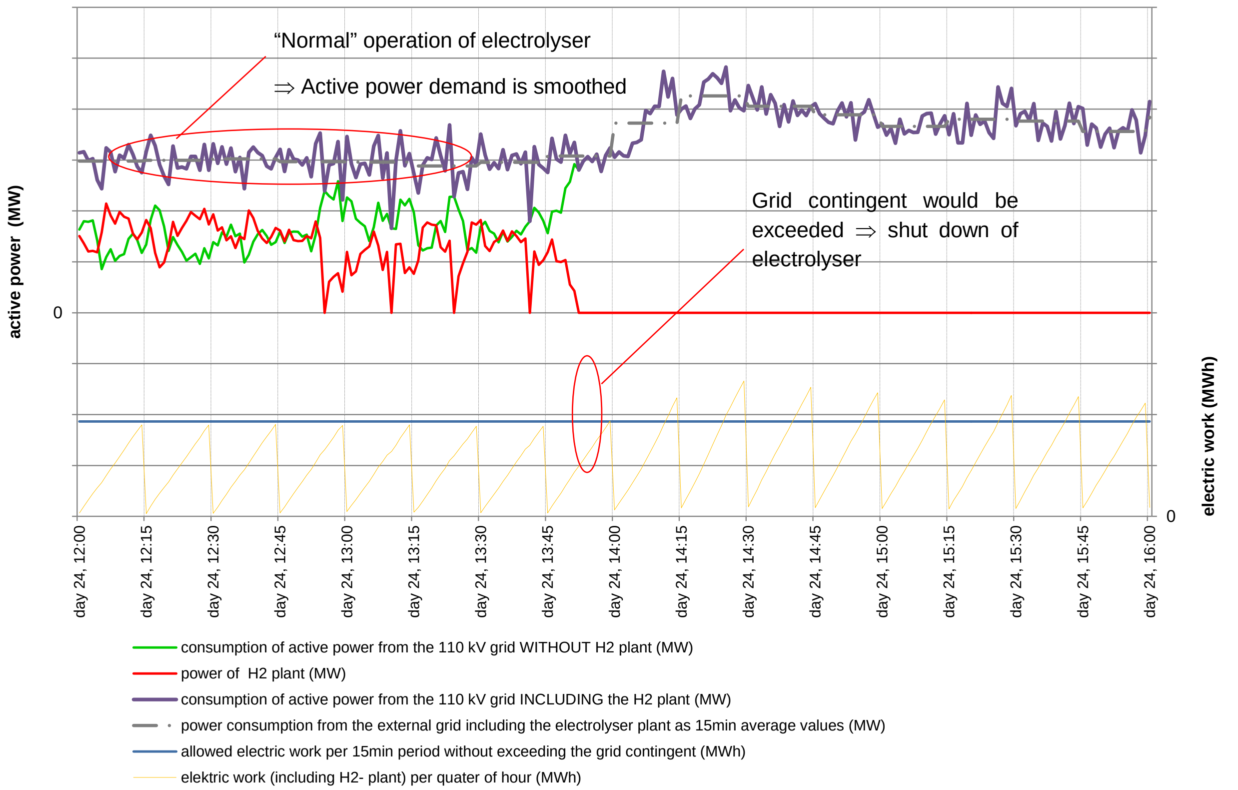


Figure 2: Detail of consumption of active power from the 110 kV grid with and without H2 plant (1 min average values, nominal power of electrolyser with a synthetic value of the max. power demand of approx. 150 MW)

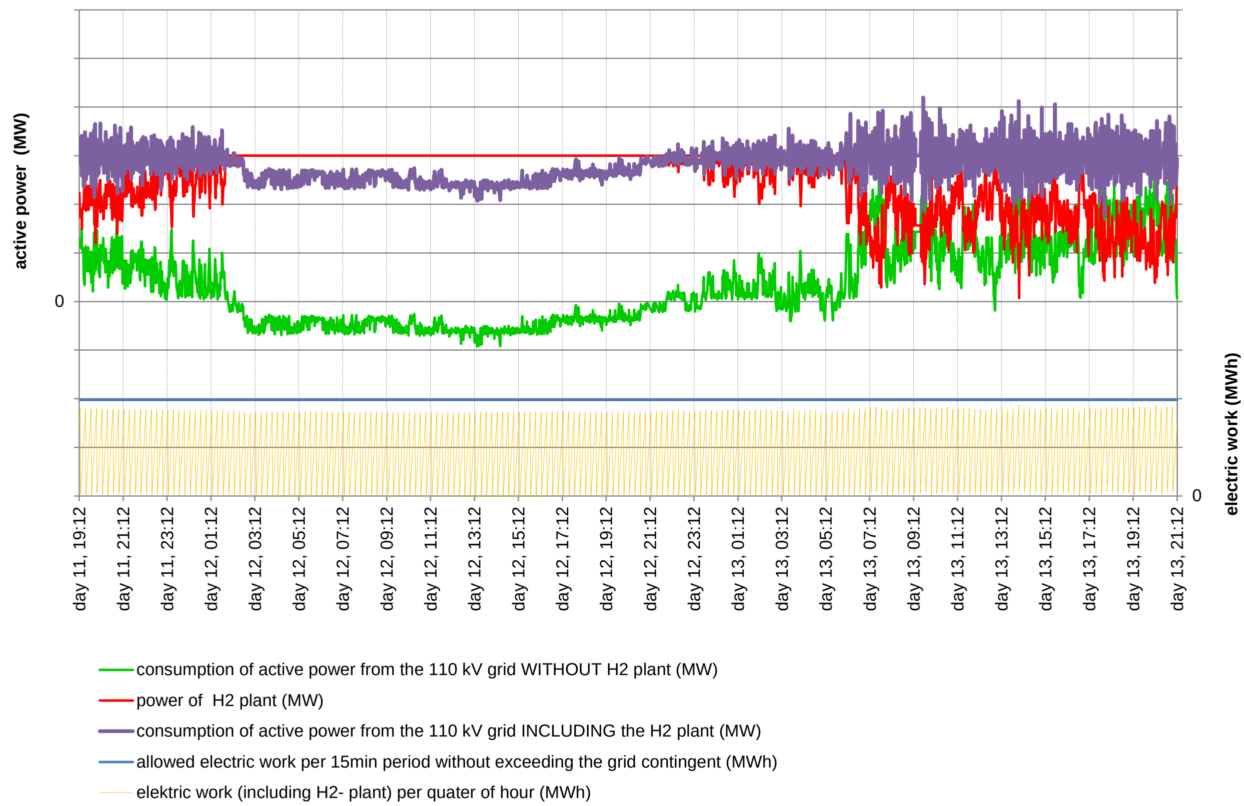


Figure 3: Detail of consumption of active power from the 110 kV grid with and without H2 plant (1 min average values, nominal power of electrolyser with a synthetic value of the max. power demand of approx. 150 MW)

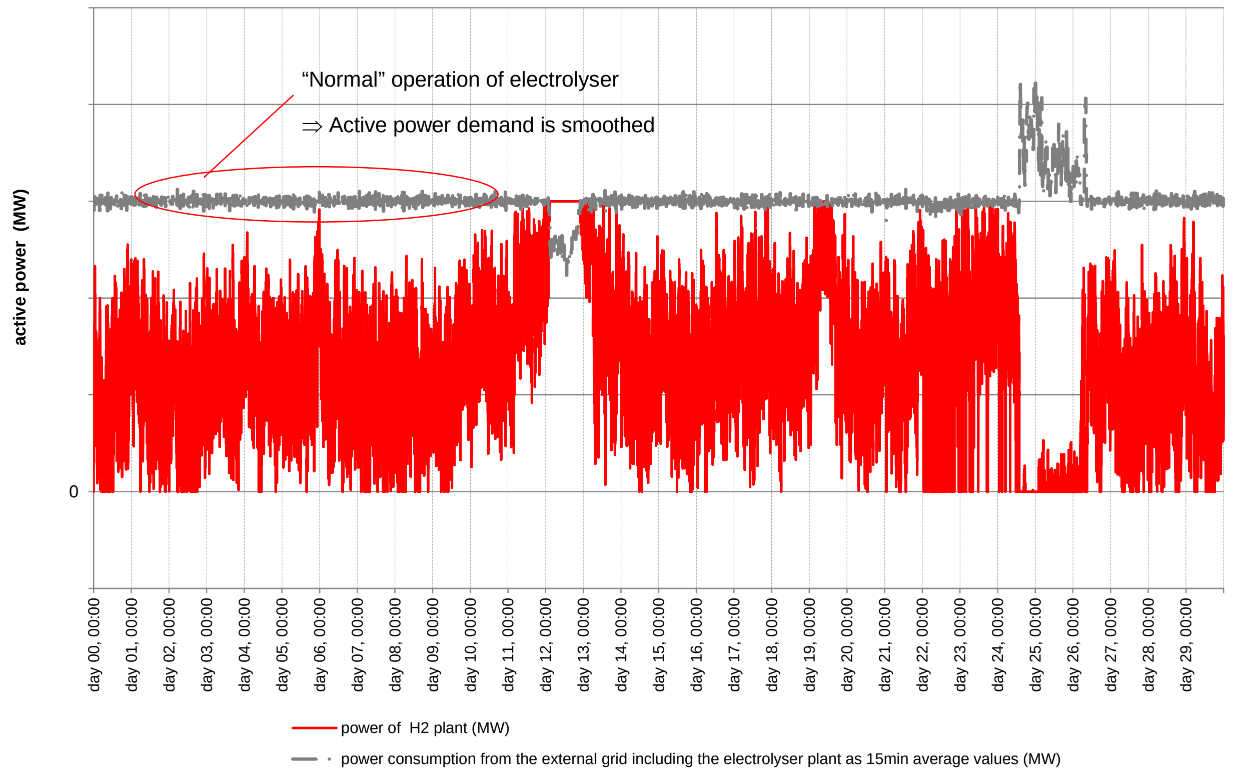


Figure 4: expected synthetic power curve of H2 plant (with a nominal power of 150 MW) for the time span of 30 days and (1min average values) and total consumption of the 110 kV grid as 150 min average values

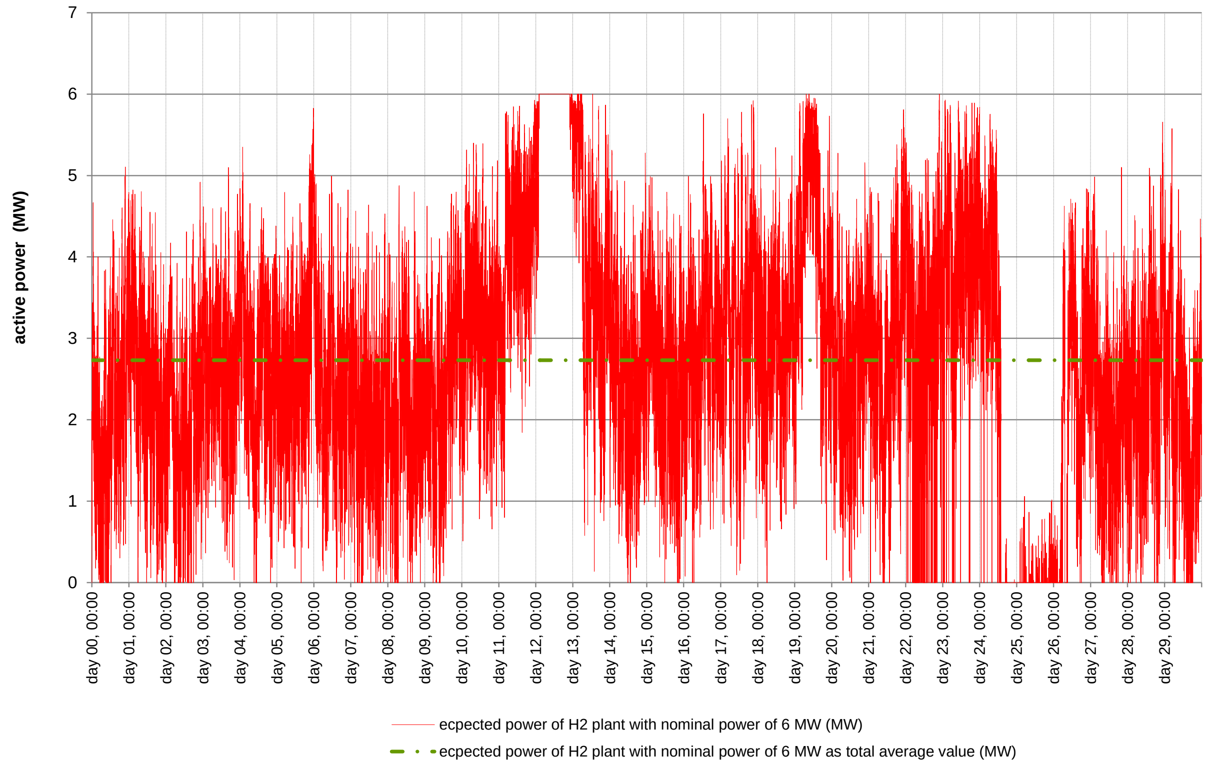


Figure 5: expected power curve of H2 plant (with a nominal power of 6 MW) for the period of 30 days (1min average values) and average power of the electrolyser

4 References

4.1 Project Documents of H2FUTURE

D2.1 Specifications of Pilot Test 1 / Use Case 1

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

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