H2FUTURE
Green Hydrogen

Deliverable D2.7

Specifications of Final Tests

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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 D2.7, details the specifications for the final technical review. The aim of this final technical review is to detect facility aging issues of the electrolyser and its components in the final phase of the demonstration.

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 common mapping of the architecture of the demonstration and its use cases, which are different operation modes in the pilot tests and quasi-commercial operation, using the Smart Grid Architecture Model (SGAM) layer representation is also included in chapter 2 of this document.

Further on, chapter 3 provides details on the overall schedule of the two-year demonstration in WP8. In general, every pilot test is scheduled to be in execution for about one month in total before the start of the quasi-commercial operation.

After 26 months of operation of the pilot plant as specified in WP2.1 to WP2.6 there will be a final technical evaluation / test of the electrolyser system and its sub units. This test involves an assessment of the reliability and availability of the facility, of its operational capabilities and any evolution from the key performance indicators of the facility as determined in the previous operation modes (e.g. electrical energy input and electric efficiency, system efficiency, expected lifetime, performance, start-up time, etc.).

If deemed necessary for the performance evaluation in the final tests, the use cases / pilot tests as specified in WP2.1 to WP2.5 can be repeated in WP8.8.

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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 execution and aims 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 are established in WP2.

This document, deliverable D2.7, details the specifications for the final technical review. The aim of this final technical review is to detect operational and facility aging issues of the electrolyser and its components in the final phase of the demonstration.

Since this is the final specification document in WP2, the common mapping of the architecture of the demonstration and its use cases, which are different operation modes in the pilot tests and quasi-commercial operation, using the Smart Grid Architecture Model (SGAM) layer representation is included in this document.

1.3 Notations, Abbreviations and Acronyms

EC	European Commission
EU	European Union
DCS	Data Collecting System
DER	Distributed Energy Resources
IEC	International Electrotechnical Commission
IED	Intelligent Electronic Device
KPI	Key Performance Indicator
NOC	Network Operation Centre
PEM	Polymer Electrolyte Membrane / Proton Exchange Membrane
RTU	Remote Terminal Unit
SGAM	Smart Grid Architecture Model
SGCG	Smart Grid Coordination Group
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 individual system use cases developed within WP2 of the H2FUTURE project are described in the deliverables D2.1 to D2.6.

2.3 Smart Grid Architecture Model (SGAM)

The Smart Grid Architecture Model (SGAM) was introduced by the CEN-CENELEC-ETSI Smart Grid Coordination Group in 2012 (SGCG, 2012) and it focuses on a structured description of a distributed smart grid system with the aim to identify standardization gaps.

Figure 1 shows the general structure of the SGAM, which consists of three dimensions: Interoperability layers, domains and zones.

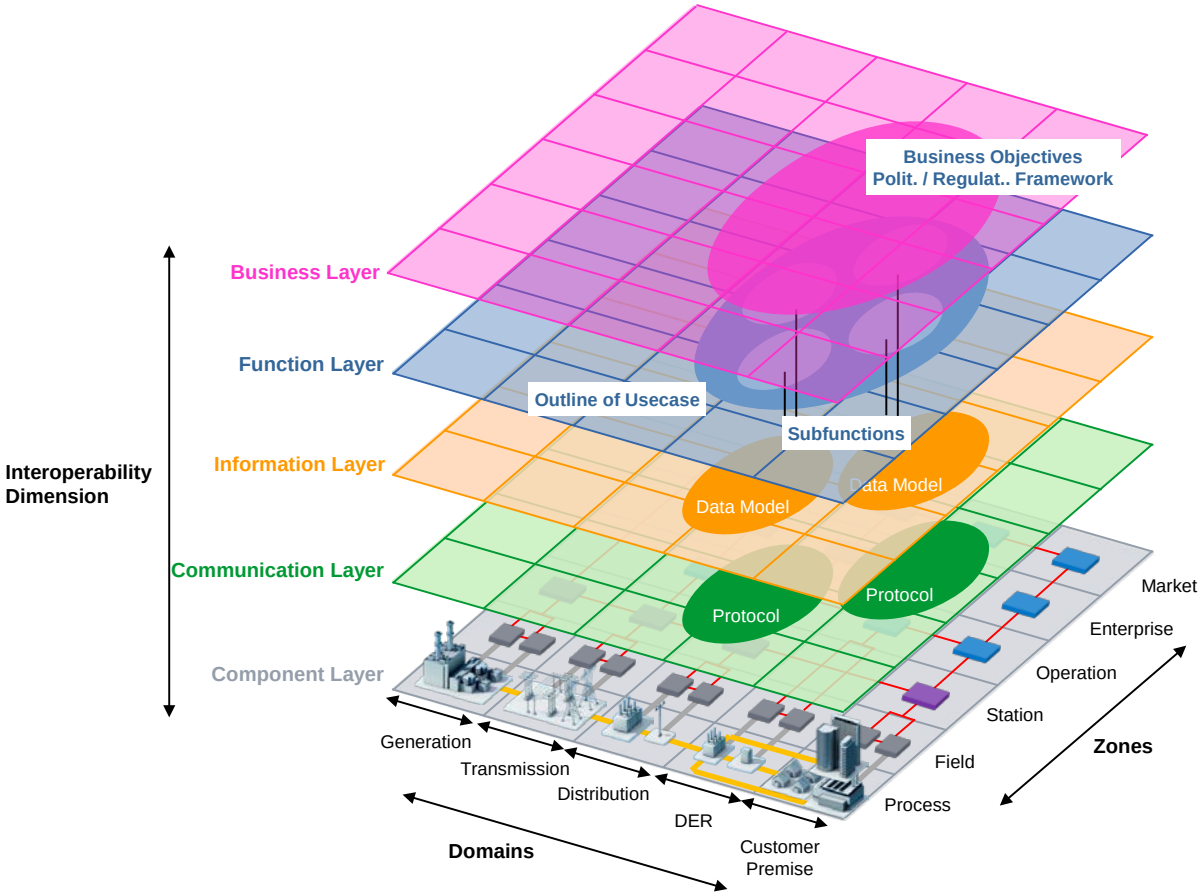

Figure 1: The Smart Grid Architecture Model

The SGAM consists of five *interoperability layers*, which refer to the categories that need to be covered to realize an interoperable smart grid solution. They are representing business objectives and processes, functions, information models, communication protocols and components. Each layer covers the two-dimensional smart grid plane, which is spanned by smart *grid domains* and *zones*. The smart grid domains are directly related to the electricity system (generation, transmission, distribution, distributed energy resources (DER) and customer premises) and are arranged according to the electrical energy conversion chain. The zones represent the hierarchical levels (or zones) of the management of the power system ranging from:

- *Process*: Including the physical, chemical or spatial transformations of energy (electricity, solar, heat, water, wind, etc.) and the physical equipment directly involved (e.g. generators,

transformers, circuit breakers, overhead lines, cables, electrical loads, any kind of sensors and actuators, which are part or directly connected to the process, etc.)

- *Field*: Including equipment to protect, control and monitor the process of the power system (e.g. protection relays, bay controller, any kind of intelligent electronic devices which acquire and use process data from the power system)
- *Station*: Representing the areal aggregation level for field level (e.g. for data concentration, functional aggregation, substation automation, local SCADA systems, plant supervision)
- *Operation*: Hosting power system control operation in the respective domain (e.g. grid management systems, energy management systems, virtual power plant management systems, etc.)
- *Enterprise*: Includes commercial and organizational processes, services and infrastructures for enterprises (e.g. asset management, logistics, work force management, staff training, customer relation management, billing and procurement, etc.)
- *Market*: Reflecting the market operations possible along the energy conversion chain (e.g. energy trading, mass market, retail market)

2.4 SGAM of H2FUTURE

The architecture of the H2FUTURE project and its use cases has been mapped into the three dimensional model defined within the scope of the SGAM.

The five pilot test and the quasi-commercial operation within the H2FUTURE project are different in terms of complexity and actors involved. They are ranging from the "*simple*" pilot test in WP2.1 and WP2.2, in which the technical functionalities of the electrolyser system are tested and only a small few actors are involved, to the more complex pilot tests of e.g. grid services (WP2.3) and the quasi-commercial operation, where many different actors/systems are included. However, as they are built on one another, a general and common representation of the overall system has been carried out instead of a pilot-specific mapping.

The SGAM component layer of the H2FUTURE project is shown in Figure 2 below. The following devices have been mapped:

- Electrolyser system is mapped in the Customer Premises domain and in the Process area
- The SCADA of the electrolyser and the remote terminal unit (RTU) are mapped in the Customer Premises domain and in the Field area
- The SCADA of voestalpine and the data collecting system (DCS) are mapped in the Customer Premises domain and in the Station area
- The network operation centre (NOC) of VERBUND is mapped in the DER domain and in the Operation area
- The intelligent electronic device (IED) (i.e. power/energy meter) is mapped in the Distribution domain and in the Field area

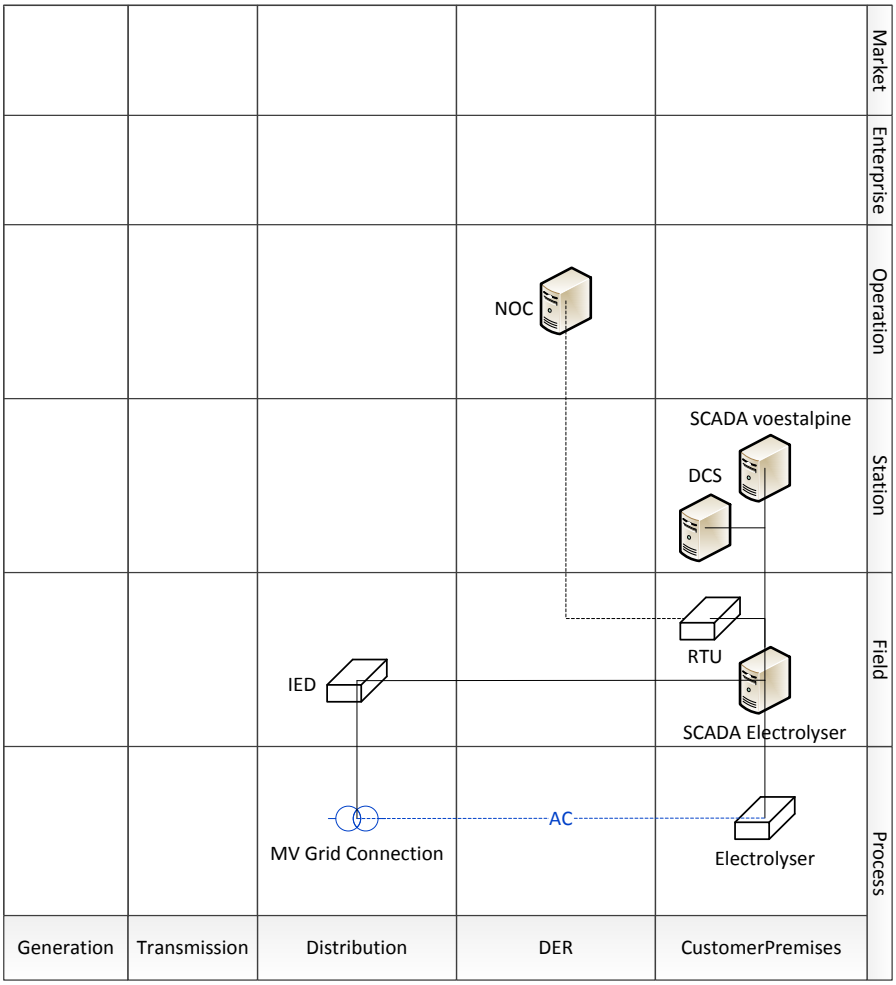

Figure 2: SGAM component layer of the H2FUTURE project

The SGAM communication, information and function layers of the H2FUTURE project are shown in Figure 3, in Figure 4 and Figure 5 respectively.

For the mapping of the H2FUTURE project in SGAM the Microsoft Visio templates developed in the project DISCERN have been used (see https://www.discern.eu/project_output/tools.html).

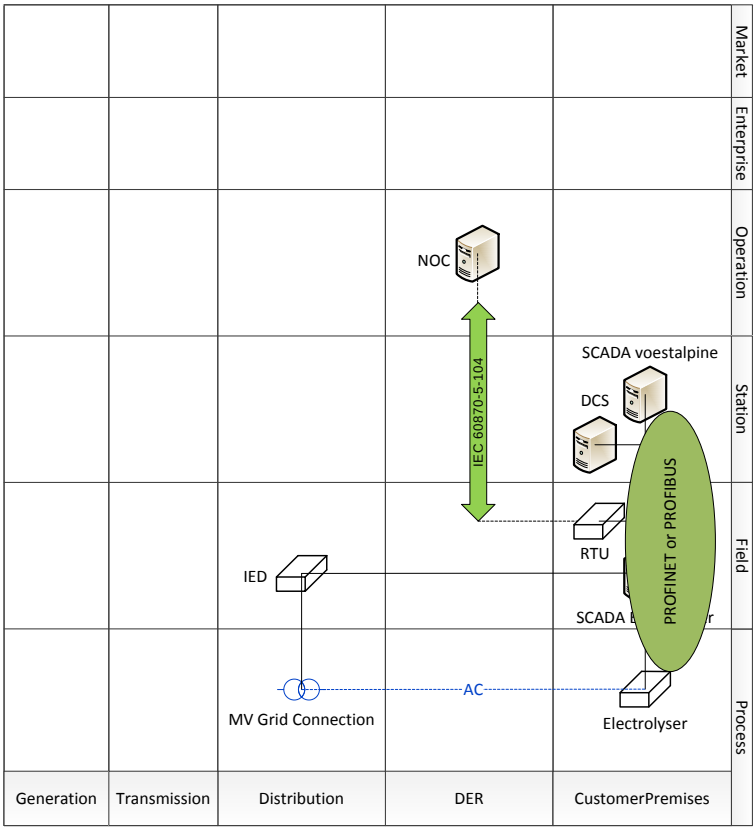

Figure 3: SGAM communication layer of the H2FUTURE project

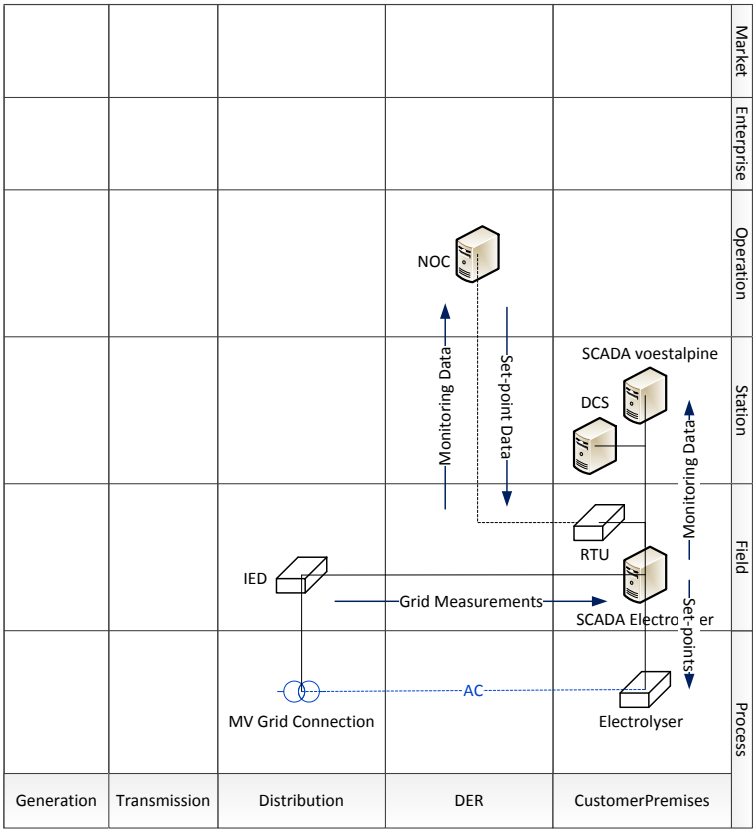

Figure 4: SGAM information layer of the H2FUTURE project

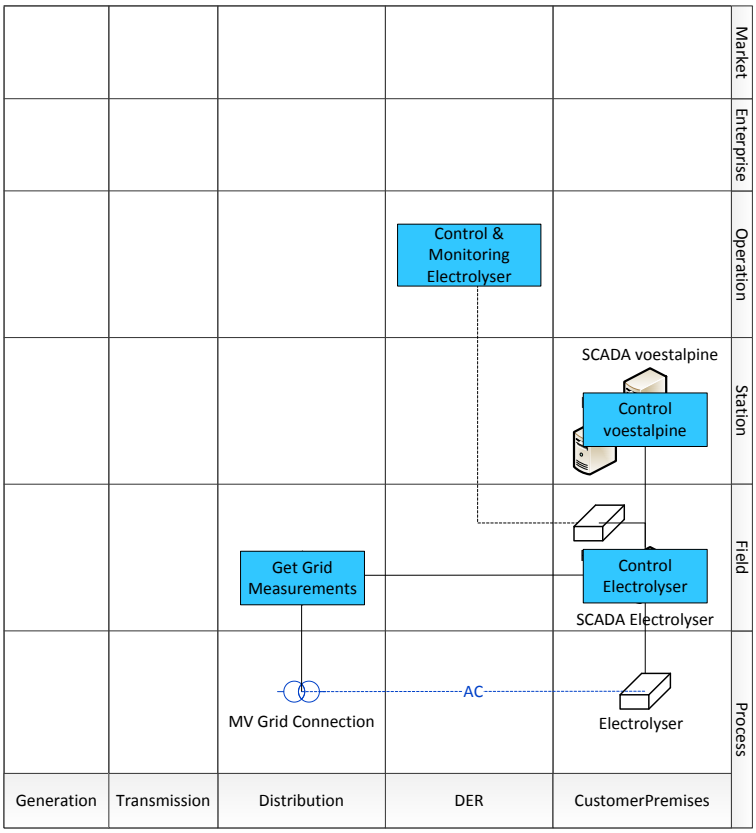

Figure 5: SGAM function layer of the H2FUTURE project

3 Specifications of Final Tests

The overall schedule of the two-year demonstration in WP8 is shown in Figure 6 below. The pilot tests will start in month 27 of the H2FUTURE project (i.e. in March 2019) and should be completed until month 32 (i.e. August 2019) when milestone 11 is due. Therefore, each pilot test is scheduled to be in execution for about one month in total.

Upon completion of the commissioning of the electrolyser pilot plant (WP8.6) in month 33, the quasi-commercial operation (WP8.7) will start.

Task	WORKPACKAGE DESCRIPTIONS	YEAR 3												YEAR 4												YEAR 5					
		25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
WP8	Two Year Demonstration																														
WP8.1	Pilot test 1 –Stress tests								◆																						
WP8.2	Pilot test 2 - Continuous operation								◆																						
WP8.3	Pilot test 3 – Grid services										◆																				
WP8.4	Pilot test 4 –Integration in future Low Carbon Steel Plant												◆																		
WP8.5	Pilot test 5 - Integration in current Steel Plant												◆																		
WP8.6	Commissioning of the electrolyser pilot plant												◆																		
WP8.7	Quasi-commercial operation for 18 months																													◆	
WP8.8	Final technical review																													◆	
WP8.9	Raw KPIs gathered during the demonstrations																														
WP8.10	Service of electrolyser system																													◆	
WP8.11	Operation (contact person on site)																														

Figure 6: Schedule of WP8

After 26 months of operation of the pilot plant as specified in WP2.1 to WP2.6 there will be a final technical evaluation / test of the electrolyser system and its sub units. This test involves an assessment of:

- The reliability and availability of the facility and any evolution of the key performance indicators of the facility as determined in WP8.1 to WP8.5 e.g.: electrical energy input and electric efficiency, system efficiency, expected lifetime, system costs, operational costs, performance, start-up time, etc.
- Any feed-back of the past use cases on the overall performance of the system
- If deemed necessary for the performance evaluation in the final tests, for examples if inconsistent or implausible results were obtained or the calculations performed in WP9 give inconsistent results, individual use cases / pilot tests as specified in WP2.1 to WP2.5 can be repeated in WP8.8. In this way not only more consistent results could be obtained but also the repeatability of the KPIs could be confirmed. The repeated tests shall not be as extensive as the initial pilot operation but shall consist of short and well defined tests.
- If the KPIs obtained in the additional tests differ significantly from the KPIs obtained in WP8.1 to WP8.5, the reason for this shall be analysed and the more plausible KPIs shall be reported and further used.
- The electrolyser system and its periphery will be checked for leaks, flaws or other deficiencies which have to be remedied.
- All emergency and safety procedures, automatic shutdown modes and safety devices will be checked and tested.
- The documentation such as operating manuals, design drawings etc. will be checked on consistency and completeness.

- The operation log book will be reviewed.
- The software will be - if necessary - updated and tested.
- If deemed necessary a third party such as an independent expert can be called in for expert opinion.

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

CEN-CENELEC-ETSI Smart Grid Coordination Group (SGCG) (2012): “Smart Grid Reference Architecture”, November 2012