H2FUTURE
Green Hydrogen

Deliverable D2.3

Specifications of Pilot Test 3 / Use Case 3

V1.0

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Person Responsible for Document	Karl Zach – VERBUND
Author(s)	Karl Zach, Rudolf Zauner – VERBUND
Reviewers	Ronald Engelmair, Thomas Zöhrer - APG

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Revision History

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0.1	24/05/2017	K. Zach, R. Zauner	First draft version
1.0	09/06/2017	K. Zach	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 D2.3, details the specifications for use case / pilot test 3 - technical testing of the PEM-facility to meet the requirements of the grid services and power price opportunities. The aim of this use case is to validate the technical suitability and responsiveness of the electrolyser unit to participate in the (Austrian) power balancing/reserve markets. For this, three separate demonstrations / use cases are performed on providing Frequency Containment Reserve (FCR, primary control), automatic and manual Frequency Restoration Reserve (aFRR / mFRR; secondary and tertiary control).

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 templates for the three use case in pilot test 3, which contain the general narrative description, KPIs, sequence diagram, etc., can be found in chapter 3 - 5.

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 D2.3, details the specifications for use case / pilot test 3 - technical testing of the PEM-facility to meet the requirements of the grid services and power price opportunities. The aim of this use case is to validate the technical suitability and responsiveness of the electrolyser unit to participate in the (Austrian) power balancing/reserve markets.

For this, three separate demonstrations / use cases are performed on providing Frequency Containment Reserve (FCR, primary control), automatic and manual Frequency Restoration Reserve (aFRR / mFRR; secondary and tertiary control) to the Austrian transmission system operator (TSO) Austrian Power Grid (APG).

In chapter 2 of this document a brief introduction to the use case methodology and the use case template for WP2 is given. The three filled out use case templates for the different reserve market products are then provided in chapter 3 – 5.

1.3 Notations, Abbreviations and Acronyms

APG	Austrian Power Grid
EC	European Commission
EU	European Union
FCR	Frequency Containment Reserve (primary control)
aFRR	automatic Frequency Restoration Reserve (secondary control)
mFRR	manual Frequency Restoration Reserve (tertiary control)
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
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 cases developed within task WP2.3 of the H2FUTURE project are described in the following sections of the document.

3 Use Case / Pilot Test 3_1 – Provision of Primary Control / Frequency Containment Reserve

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**
UC3_1	Customer Premises / Process, Field, Station, Operation	Provision of Primary Control / Frequency Containment Reserve

1.2 Version management

Version management				
Version No.	**Date**	**Name of author(s)**	**Changes**	**Approval status**
0.1	23/02/2017	K. Zach	First draft	
0.2	28/03/2017	K. Zach	Second draft	
0.3	03/04/2017	R. Engelmair	Review of second draft	
0.4	04/04/2017	K. Zach	Third draft incl. comments	
0.5	11/04/2017	K. Zach	Forth draft	
0.6	15/05/2017	T. Zöhrer	Review of forth draft	
1.0	22/05/2017	K. Zach	Final version	

1.3 Scope and objectives of use case

Scope and objectives of use case	
Scope	Automatic provision of primary control/frequency containment reserve by changing the power consumption of the electrolyser based on local grid frequency measurements
Objective(s)	Prequalification for / provision of primary control/ frequency containment reserve to the Austrian TSO APG
Related business case(s)	Flexibility provision

1.4 Narrative of Use Case

Narrative of use case
Short description
This Use Case describes the provision of primary control/ frequency containment reserve which incorporates the periodic collection of frequency measurements from the grid and the corresponding commands sent from a SCADA application to change the power consumption of an electrolyser to counteract frequency deviations in the grid.
Complete description
This Use Case describes the provision of primary control / frequency containment reserve (FCR) by an electrolyser to the Austrian TSO APG. The use case has three different scenarios: the reservation of primary control power, the real-time control of the electrolyser and the real-time monitoring for APG. For the reservation of primary control power, APG reports the acceptance of bids of the weekly FCR tender to the network operation centre (NOC)/VERBUND. If a bid was accepted, the NOC calculates the needed FCR power that must be continuously reserved in the tender period by the electrolyser. For the real-time control of the electrolyser, an Intelligent Electronic Device (IED) periodically collects measurements indicating the current state of the frequency and power consumption in the local electricity grid. The IED communicates the current state of the frequency and power to the SCADA application which controls the electrolyser. When frequency measurements leave a predefined threshold area, the SCADA application calculates the needed change of power consumption of the electrolyser. Then the SCADA system sends the respective setpoint to the electrolyser with the aim of maintaining frequency within limits. Consequently, the following steps are required in this scenario: 1. IED obtains frequency and power consumption measurements from the local grid 2. IED sends measurement data to the SCADA application

3. In case it is necessary to change power consumption of the electrolyser to counteract the frequency change, the SCADA application sends the suitable commands accordingly. 4. The electrolyser changes its power consumption For the real-time monitoring for APG, the SCADA system periodically reports the current power consumption, frequency measurements etc. to a Remote Terminal Unit (RTU). The RTU forwards this parameters to the network operation centre (NOC) of VERBUND, which then sends the aggregated parameters of the pool for reporting to the Austrian TSO APG. The use case will be operated with different capacity bands for ancillary services: • +/- 1 MW at high partial load (e.g. at 5 MW) • +/- 1 MW at low partial load (e.g. at 2,5 MW) • Ancillary service over whole dynamic range of the electrolyser (i.e. between 20% and 100% of rated capacity which corresponds to 1,2 MW and 6 MW with a capacity band of +/- 2,4 MW)

1.5 Key performance indicators (KPI)

Key performance indicators			
ID	***Name***	***Description***	***Reference to mentioned use case objectives***
1	Linear activation	Droop of the system: $\sigma = \frac{\Delta f / f_n}{\Delta P / P_n}$ Δf … frequency deviation f_n … nominal frequency (50 Hz) ΔP … power change P_n … nominal power	
2	Activation speed	50% of dedicated/offered primary control power must be linearly activated within 15 s in case of a frequency deviation of +/- 100 mHz 100% of dedicated/offered primary control power must be linearly activated within 30 s in case of a frequency deviation of +/- 200 mHz	

1.6 Use case conditions

Use case conditions
Assumptions
Electrolyser is flexible and fast enough for primary control provision (see table of requirements)
Prerequisites
Electrolyser can be operated in the whole frequency range from 47,5 Hz to 51,5 Hz, i.e. there is no frequency-dependent separation from the grid
Data connection APG <-> NOC <-> RTU <-> SCADA is established
VERBUND's FCR pool offers sufficient backup capacity for the provision of FCR
The electrolyser system is successfully prequalified for the provision of FCR. The prequalification for the provision of FCR to APG involves a proof of the functional capability (measurement protocol – see section 8 Custom information), which is successfully passed.

1.7 Further information to the use case for classification / mapping

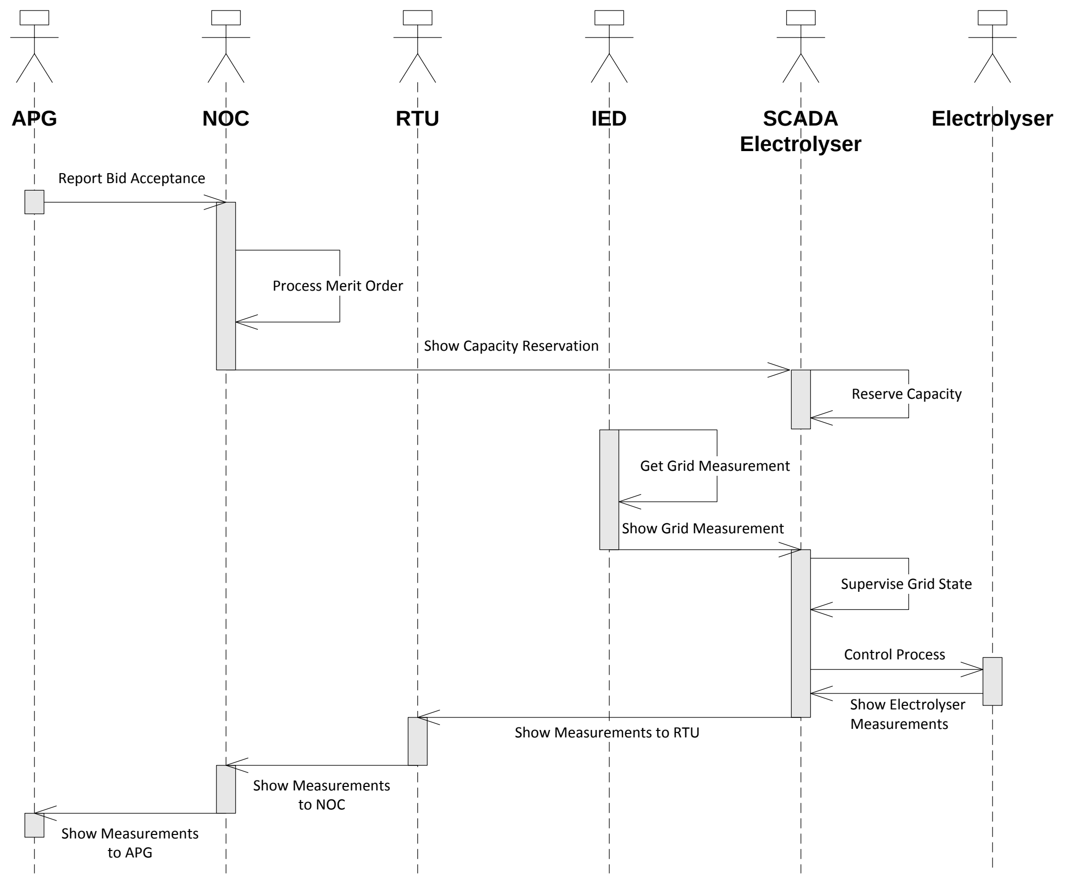
Classification information
Relation to other use cases
Use case of the WP2.3 of H2FUTURE
Level of depth
Individual Use Case
Prioritisation
Implemented in demo
Generic, regional or national relation
Austria
Nature of the use case
Technical
Further keywords for classification
Primary control, ancillary services

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***	
Process/Field/Station actors		Actors in Process, Field, Station levels	
Actor name	***Actor type***	***Actor description***	*Further information specific to this use case*
Austrian Power Grid (APG)	Role	APG operates the Austrian transmission grid and balancing markets and monitors the provision of the grid services	
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	In this use case the electrolyser is the technical unit which provides FCR
Intelligent Electronic Device (IED)	Component	Any device incorporating one or more processors with the capability to receive or send	In this Use Case, the IED collects frequency & power

		data/control from or to an external source (e.g., electronic multifunction meters, digital relays, controllers)	measurements from the grid, sends frequency changes to the SCADA
Network Operation Centre (NOC)	Application	A NOC or virtual power plant is an application that optimises the dispatch of technical units	
Remote Terminal Unit (RTU)	Component	A RTU is a microprocessor-controlled electronic device that interfaces objects in the physical world to a distributed control system or SCADA	In this Use Case, the RTU collects measurement data from the SCADA and sends them to the NOC
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 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	Capacity reservation	After bid acceptance by APG, the NOC informs the SCADA system about the needed capacity reservation for FCR	NOC	APG sends accepted bids to NOC/VERBUND (weekly)	VERBUND submitted bid(s) for the FCR tender to APG	
2	Control	SCADA sends control commands to the electrolyser in order to change its power consumption to counteract the frequency change	SCADA Electro-lyser	SCADA receives frequency deviations from IED which are out of the predefined area	All data communications are established. The electrolyser is up and running.	Electrolyser adapts its power consumption according to the control commands
3	Monitoring	SCADA reports the current power consumption, frequency etc. to the NOC	SCADA Electro-lyser	SCADA periodically sends the data to the RTU	All data communications are established. The RTU is up and running.	The NOC forwards this parameters to APG

4.2 Steps – Scenarios

Scenario								
Scenario name:	**No. 1 – Capacity reservation**							
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	Weekly	Report bid acceptance	APG publishes accepted bids of FCR tender	REPORT	APG	NOC		
2	NOC receives	Process	Based on the	INTERNAL	NOC	NOC	FCR	

	tender information	capacity reservation	accepted bids, NOC calculates needed capacity reservation by electrolyser	OPERATION				
3	NOC has determined FCR capacity reservation	Show capacity reservation	NOC sends the needed capacity reservation by electrolyser to the SCADA	SHOW	NOC	SCADA Electrolyser	FCR	
4	SCADA receives needed FCR capacity reservation	Reserve capacity	SCADA reserves needed FCR capacity of the electrolyser	INTERNAL OPERATION	SCADA Electrolyser	SCADA Electrolyser	FCR	
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	Get grid measurement	IED performs measurement	INTERNAL OPERATION	IED	IED	F_M PC_M	QoS_1 QoS_2 QoS_3
2	Periodically	Show grid measurement to SCADA	IED sends measurements to SCADA	SHOW	IED	SCADA Electrolyser	F_M PC_M	QoS_3
3	SCADA receives measurement data	Supervise grid state	SCADA supervises the current frequency state	INTERNAL OPERATION	SCADA Electrolyser	SCADA Electrolyser	F_M	
4	Frequency leaves predefined area	Control process	SCADA processes & sends out control commands	CHANGE	SCADA Electrolyser	Electrolyser	SP_V	QoS_4 QoS_5 QoS_6
Scenario name:	**No. 3 – 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	Show electrolyser measurement	Electrolyser sends measurements to SCADA	SHOW	Electrolyser	SCADA Electrolyser	PC_M OP_V	QoS_3 Conf_1
2	Periodically	Show measurement to RTU	SCADA sends measurements to RTU	SHOW	SCADA Electrolyser	RTU	PC_M OP_V	QoS_3 Conf_1
3	Periodically	Show measurement to NOC	RTU sends measurements to NOC	SHOW	RTU	NOC	PC_M OP_V	QoS_3 Conf_2 Conf_3
4	Periodically	Show measurement to APG	NOC sends measurements to APG	SHOW	NOC	RTU	PC_M OP_V	QoS_3 Conf_4

5 *Information exchanged*

Information exchanged			
Information exchanged, ID	***Name of information***	***Description of information exchanged***	***Requirement, R-IDs***
FCR	FCR Capacity Reservation	Needed capacity reservation of electrolyser for FCR for tendering period	
F_M	Frequency Measurement	Measurement indicating the frequency at the grid connection point.	QoS_1 QoS_3
PC_M	Power Consumption Measurement	Measurement indicating the power consumption of the electrolyser.	QoS_2 QoS_3
SP_V	Set-Point Value	Set-point for controlling of the electrolyser	
OP_V	Operating Point Value	Operating point of the electrolyser	QoS_3

6 Requirements (optional)

Requirements (optional)		
Categories ID	**Category name for requirements**	**Category description**
QoS	Quality of Service Issues	Requirements regarding the Quality of Service (e.g. availability of the system, acceptable downtime, etc.)
Requirement R-ID	**Requirement name**	**Requirement description**
QoS_1	Frequency measurement error	The error of the frequency measurements must not exceed +/- 5 mHz.
QoS_2	Power consumption measurement	The meter for measuring the power consumption must at least have an accuracy class 0,5.
QoS_3	Measurement interval	The measurement/data interval has to be 2 seconds (each full even second, GPS time).
QoS_4	Insensitivity range	Insensitivity range: 50 Hz +/- 10 mHz – in this range the electrolyser doesn't have to provide primary control
QoS_5	Activation speed	50% of dedicated/offered primary control power must be activated within 15 s in case for frequency deviations up to +/- 100 mHz 100% of dedicated/offered primary control power must be linearly activated within 30 s in case of a frequency deviation of +/- 200 mHz
QoS_6	Linear activation	Droop of the system: $\sigma = \frac{\Delta f / f_n}{\Delta P / P_n}$ Δf … frequency deviation f_n … nominal frequency (50 Hz) ΔP … power change P_n … nominal power
Categories ID	**Category name for requirements**	**Category description**
Conf	Configuration Issues	Requirements regarding communication configurations
Requirement R-ID	**Requirement name**	**Requirement description**
Conf_1	Communication protocol SCADA-RTU	Possible Communication protocol between SCADA <-> RTU: Modbus, Profibus
Conf _2	Communication protocol RTU-NOC	Possible Communication protocol between RTU <-> NOC: Modbus, IEC 60870-5-104
Conf_3	Encryption	Communication is encrypted via OpenVPN
Conf_4	Communication protocol APG-NOC	Communication protocol between APG <-> NOC: IEC 60870-5-101

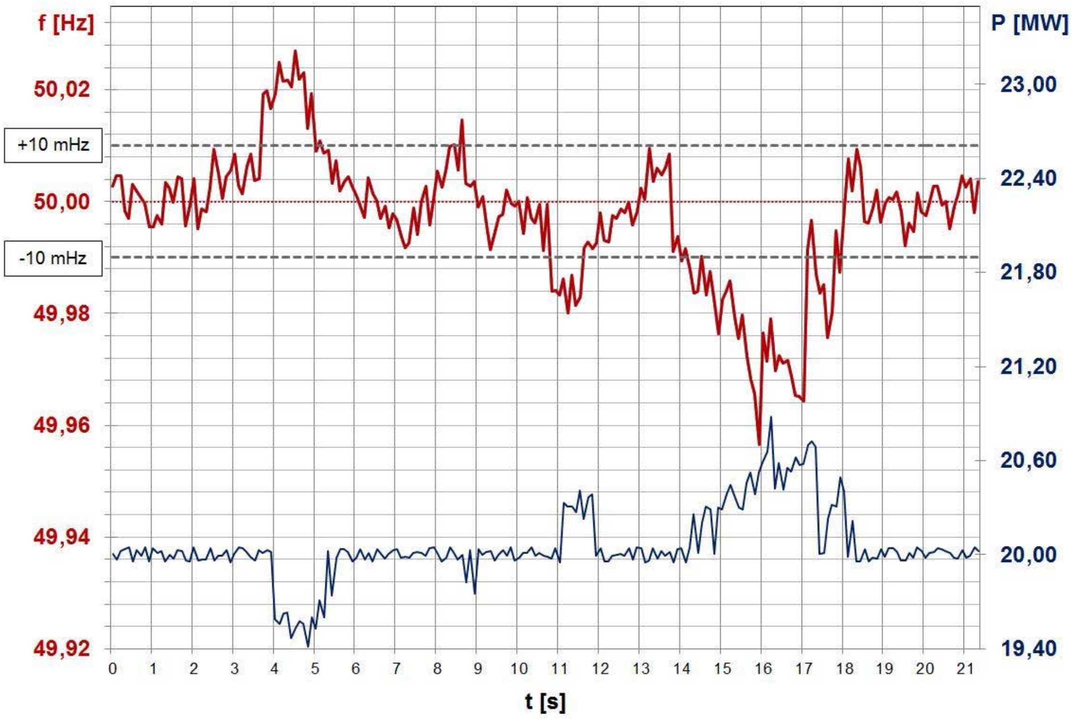
7 Common terms and definitions

Common terms and definitions	
Term	**Definition**
Primary Control / Frequency Containment Reserve (FCR)	FCR is generally provided by power plants and used to automatically compensate an imbalance between generation and consumption within a few seconds through corresponding activation (control) thus leading to the stabilisation of the frequency in the interconnected electricity grid. Activation is automatically triggered by frequency deviation from the target value (50 Hz), whereby the activated FCR increases proportionate to the magnitude of the deviation.

8 Custom information (optional)

Custom information (optional)
Examples of measuring protocols for the proof of the functional capability of a technical unit to provide FCR – activation speed (QoS_5) and insensitivity band (QoS_4):

Measurement plot for the reaction of the technical unit to a frequency jump of + 200 mHz



Measurement plot including an insensitivity range of +/- 10 mHz

4 Use Case / Pilot Test 3_2 – Provision of Secondary Control / automatic Frequency Restoration Reserve

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**
UC3_2	Customer Premises / Process, Field, Station, Operation	Provision of Secondary Control / autom. Frequency Restoration Reserve

1.2 Version management

Version management				
Version No.	**Date**	**Name of author(s)**	**Changes**	**Approval status**
0.1	12/04/2017	K. Zach	First draft	
0.2	16/05/2017	T. Zöhrer	Review of first draft	
1.0	22/05/2017	K. Zach	Final version	

1.3 Scope and objectives of use case

Scope and objectives of use case	
Scope	Provision of secondary control/frequency restoration reserve by changing the power consumption of the electrolyser based on online set point values
Objective(s)	Prequalification for / provision of secondary control/ autom. frequency restoration reserve to the Austrian TSO APG
Related business case(s)	Flexibility provision

1.4 Narrative of Use Case

Narrative of use case
Short description
This Use Case describes the provision of secondary control/ autom. frequency restoration reserve by an electrolyser which includes the adaption of the power consumption of the electrolyser to online control commands close to real time and the corresponding monitoring.
Complete description
This Use Case describes the provision of secondary control / automatic frequency restoration reserve (aFRR) by an electrolyser to the Austrian transmission system operator Austrian Power Grid (APG). The use case has three different scenarios: the reservation of secondary control power, the real-time control of the electrolyser and the real-time monitoring for APG. For the reservation of aFRR, APG reports the acceptance of bids of the aFRR tender to the network operation centre (NOC)/VERBUND. If a bid was accepted, the NOC calculates the needed aFRR power that must be continuously reserved in the tender period by the electrolyser. In case of an aFRR activation, APG sends the respective online set-point command to the NOC, which then calculates the online set-points for a selected set of the aggregated units in the pool (depending on the internal merit order). If the electrolyser is selected for an activation, the NOC forwards the calculated set-point to the Remote Terminal Unit (RTU). Then, the RTU forwards the set-point to the SCADA application of the electrolyser, which then calculates the needed change of power consumption of the electrolyser. Finally, the SCADA system sends the respective control commands to the electrolyser, which then adapts its power consumption. Consequently, the following steps are required in this scenario: 1. APG sends set-point command to the NOC 2. The NOC calculates the set-point of the electrolyser 3. The NOC sends the set-point to the RTU 4. The RTU sends the set-point to the SCADA application of the electrolyser 5. The SCADA system calculates the set-point of the electrolyser

6. The SCADA system sends the suitable commands to the electrolyser
7. The electrolyser changes its power consumption accordingly

For the real-time control of the electrolyser and the real-time monitoring for APG, an Intelligent Electronic Device (IED) periodically collects measurements indicating the current power consumption of the technical unit. The IED communicates the current power to the SCADA application of the electrolyser. The SCADA system periodically reports the current power consumption, etc. to the RTU. The RTU forwards this parameters to the NOC, which then sends the aggregated parameters of the pool for reporting to APG.

1.5 Key performance indicators (KPI)

Key performance indicators			
ID	***Name***	***Description***	***Reference to mentioned use case objectives***
1	Error margin of activation	The electrolyser adapts its power consumption according to the online set-point of the NOC. In case of over- or under-activation of the electrolyser the following error margin can be calculated: $(P_{act} - P_{set}) / P_{act}$ [%] P_{act} … actual power consumption P_{set} … target power consumption according to set-point	

1.6 Use case conditions

Use case conditions
Assumptions
Electrolyser is flexible and fast enough for secondary control provision (see table of requirements)
Prerequisites
Electrolyser can be operated in the whole frequency range from 47,5 Hz to 51,5 Hz, i.e. there is no frequency-dependent separation from the grid
Data connection APG <-> NOC <-> RTU <-> SCADA is established
The electrolyser system is successfully prequalified for the provision of aFRR. The prequalification for the provision of aFRR to APG involves a proof of the functional capability (measurement protocol – see section 8 Custom information).

1.7 Further information to the use case for classification / mapping

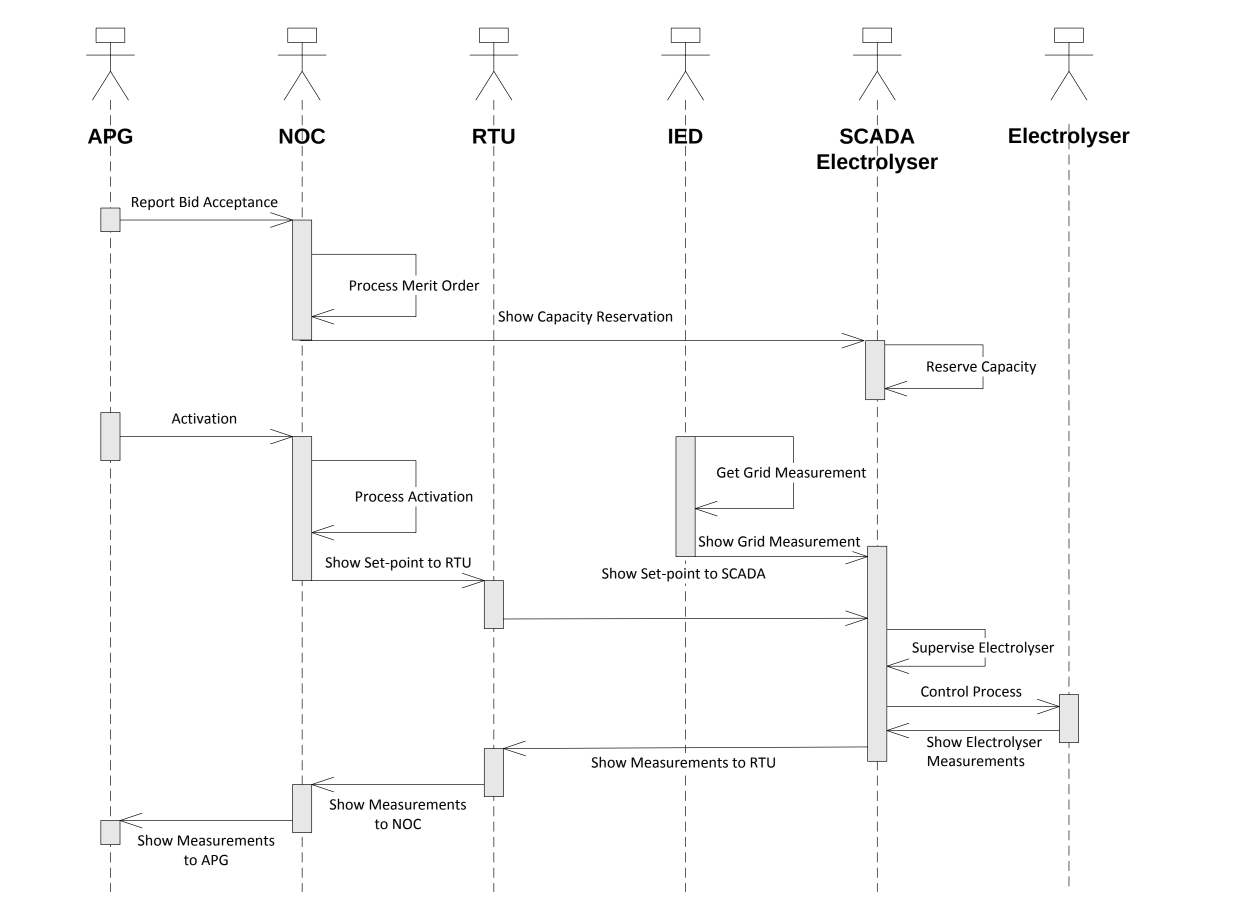
Classification information
Relation to other use cases
Use case of the WP2.3 of H2FUTURE
Level of depth
Individual Use Case
Prioritisation
Implemented in demo
Generic, regional or national relation
Austria
Nature of the use case
Technical
Further keywords for classification
Secondary control, frequency restoration reserve, ancillary services

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**	
Process/Field/Station actors		Actors in Process, Field, Station levels	
Actor name	**Actor type**	**Actor description**	*Further information specific to this use case*
Austrian Power Grid (APG)	Role	APG operates the Austrian grid balancing markets and monitors the provision of aFRR	
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	In this use case the electrolyser is the technical unit which provides aFRR
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 grid, sends frequency changes to the SCADA
Network Operation Centre (NOC)	Application	A NOC or virtual power plant is an application that optimises the	

		dispatch of technical units	
Remote Terminal Unit (RTU)	Component	A RTU is a microprocessor-controlled electronic device that interfaces objects in the physical world to a distributed control system or SCADA	In this Use Case, the RTU collects measurement data from the SCADA and sends them to the NOC
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 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	Capacity reservation	After bid acceptance by APG, the NOC reserves the capacity for aFRR	NOC	APG sends accepted bids to NOC/VERBUND (weekly)	VERBUND submitted bid(s) for the aFRR tender to APG	
2	Control	NOC calculates set-point based on APG input and forwards it to the SCADA which then controls the electrolyser in order to change its power consumption according to this set-point	SCADA Electro-lyser	NOC receives set-point from APG	All data communications are established. The electrolyser is up and running.	Electrolyser adapts its power consumption according to the control commands
3	Monitoring	SCADA reports the current power consumption, etc. to the NOC	SCADA Electro-lyser	SCADA periodically sends the data to the RTU	All data communications are established. The RTU is up and running.	The NOC forwards this parameters to APG

4.2 Steps – Scenarios

Scenario								
Scenario name:	**No. 1 – Capacity reservation**							
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	Weekly	Report bid acceptance	APG publishes accepted bids of aFRR tender	REPORT	APG	NOC		
2	NOC receives tender information	Process Merit Order	Based on the accepted bids, NOC calculates and reserves the needed capacity by electrolyser	INTERNAL OPERATION	NOC	NOC	aFRR	
3	NOC has	Show capacity	NOC sends the	SHOW	NOC	SCADA	aFRR	

	determined aFRR capacity reservation	reservation	needed capacity reservation by electrolyser to the SCADA			Electrolyser		
4	SCADA receives needed aFRR capacity reservation	Reserve capacity	SCADA reserves needed FCR capacity of the electrolyser	INTERNAL OPERATION	SCADA Electrolyser	SCADA Electrolyser	aFRR	
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)**	**Require ment, R-IDs**
1	Periodically	Activation	APG sends set-point to NOC	SHOW	APG	NOC	SP_V	QoS_2 Conf_4
2	NOC receives set-point	Process activation	Based on the received set-point, NOC calculates the set-point for the electrolyser	INTERNAL OPERATION	NOC	NOC		
3	Periodically	Show set-point to RTU	NOC sends set-point to RTU	SHOW	NOC	RTU	SP_V	QoS_2 Conf_2 Conf_3
4	Periodically	Show set-point to SCADA	RTU sends set-point to SCADA	SHOW	RTU	SCADA Electrolyser	SP_V	QoS_2 Conf_1
3	SCADA receives set-point	Supervise electrolyser	SCADA supervises the current electrolyser state based on the received set-point	INTERNAL OPERATION	SCADA Electrolyser	SCADA Electrolyser		
4	Periodically	Control process	SCADA processes & sends out control commands	CHANGE	SCADA Electrolyser	Electrolyser	SP_E	QoS_3 QoS_4
Scenario name:		**No. 3 – Monitoring**						
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 grid measurement	IED performs measurement	INTERNAL OPERATION	IED	IED	PC_M	QoS_1 QoS_2
2	Periodically	Show grid measurement	IED sends measurements to SCADA	SHOW	IED	SCADA Electrolyser	PC_M	QoS_2
3	Periodically	Show electrolyser measurement	Electrolyser sends measurements to SCADA	SHOW	Electrolyser	SCADA Electrolyser	PC_M	QoS_2
4	Periodically	Show measurement to RTU	SCADA sends electrolyser and grid measurements to RTU	SHOW	SCADA Electrolyser	RTU	PC_M OP_V	QoS_2 Conf_1
5	Periodically	Show measurement to NOC	RTU sends measurements to NOC	SHOW	RTU	NOC	PC_M OP_V	QoS_2 Conf_2 Conf_3
6	Periodically	Show measurement to APG	NOC sends measurements to APG	SHOW	NOC	RTU	PC_M OP_V	QoS_2 Conf_4

5 Information exchanged

Information exchanged			
Information exchanged, ID	**Name of information**	**Description of information exchanged**	**Requirement, R-IDs**
aFRR	aFRR Capacity Reservation	Needed capacity reservation of electrolyser for aFRR for tendering period	
PC_M	Power Consumption	Measurement indicating the power consumption of the electrolyser.	QoS_1 QoS_2

	Measurement		
SP_V	Set-point Value	Set-point data by APG and the NOC	QoS_2
SP_E	Set-point Electrolyser	Set-point for controlling of the electrolyser	
OP_V	Operating Point Value	Operating point of the electrolyser	QoS_3

6 *Requirements (optional)*

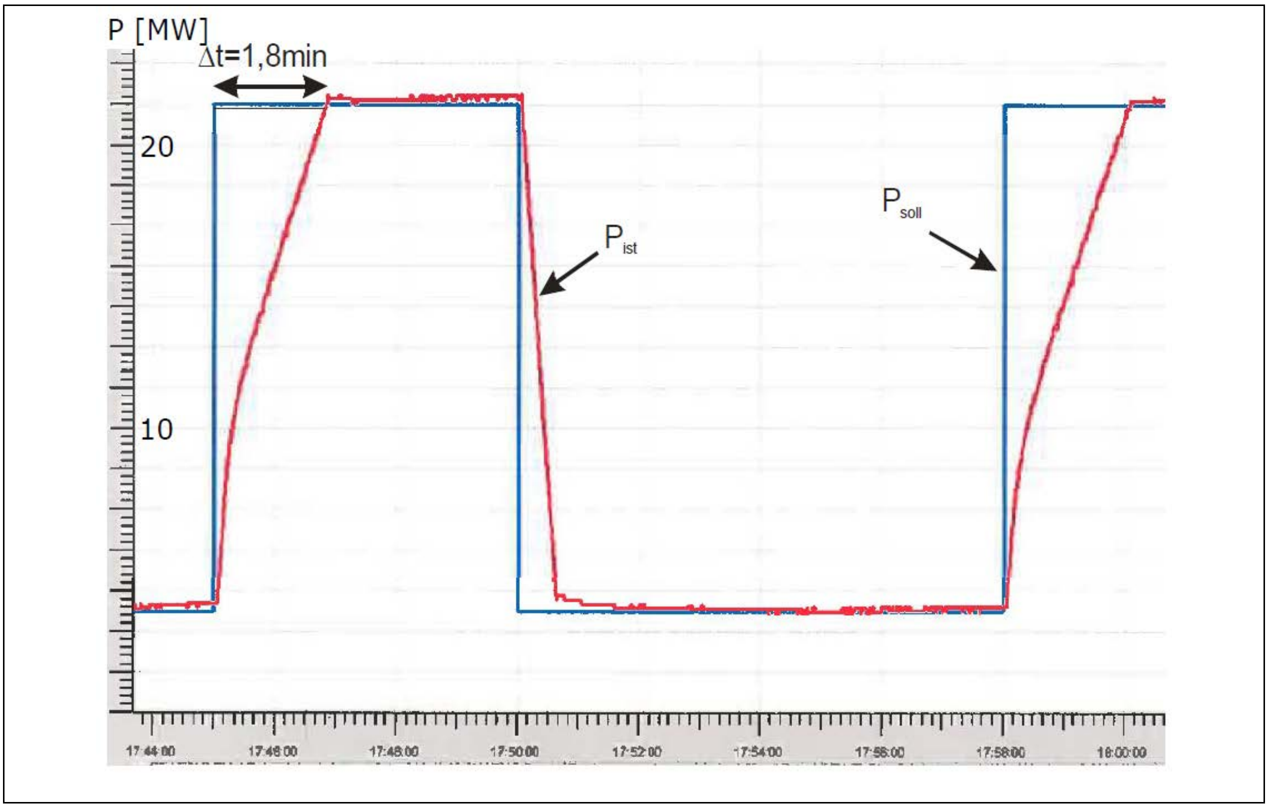
Requirements (optional)		
Categories ID	**Category name for requirements**	**Category description**
QoS	Quality of Service Issues	Requirements regarding the Quality of Service (e.g. availability of the system, acceptable downtime, etc.)
Requirement R-ID	**Requirement name**	**Requirement description**
QoS_1	Power consumption measurement	The meter for measuring the power consumption must at least have an accuracy class 0,5.
QoS_2	Data interval	The measurement/data interval has to be 2 seconds (each full even second, GPS time).
QoS_3	Error margin	Max. error of activation: -3% / +10%
QoS_4	Activation speed	100% of dedicated/offered aFRR power must be activated within 5 minutes; a reaction of the technical unit should be visible within seconds
Categories ID	**Category name for requirements**	**Category description**
Conf	Configuration Issues	Requirements regarding communication configurations
Requirement R-ID	**Requirement name**	**Requirement description**
Conf_1	Communication protocol SCADA-RTU	Possible communication protocol between SCADA <-> RTU: Modbus, Profibus
Conf _2	Communication protocol RTU-NOC	Possible communication protocol between RTU <-> NOC: Modbus, IEC 60870-5-104
Conf_3	Encryption	Communication is encrypted via OpenVPN
Conf_4	Communication protocol APG-NOC	Communication protocol between APG <-> NOC: IEC 60870-5-101

7 *Common terms and definitions*

Common terms and definitions	
Term	**Definition**
Secondary Control / automatic Frequency Restoration Reserve (aFRR)	Secondary control power / aFRR is used to restore the availability of the power bandwidth of the activated primary control power / frequency containment reserve (FCR). aFRR is automatically activated to relieve FCR so that it can resume its function of balancing the system.

8 *Custom information (optional)*

Custom information (optional)
Examples of measuring protocols for the proof of the functional capability of a technical unit to provide aFRR: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5 Use Case / Pilot Test 3_3 – Provision of Tertiary Control / manual Frequency Restoration Reserve

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**
UC3_3	Customer Premises / Process, Field, Station, Operation	Provision of Tertiary Control / man. Frequency Restoration Reserve

1.2 Version management

Version management				
Version No.	**Date**	**Name of author(s)**	**Changes**	**Approval status**
0.1	18/04/2017	K. Zach	First draft	
0.2	16/05/2017	T. Zöhrer	Review of first draft	
1.0	22/05/2017	K. Zach	Final version	

1.3 Scope and objectives of use case

Scope and objectives of use case	
Scope	Provision of tertiary control/frequency restoration reserve by changing the power consumption of the electrolyser based on set point values
Objective(s)	Prequalification for / provision of tertiary control/ man. Frequency restoration reserve to the Austrian TSO APG
Related business case(s)	Flexibility provision

1.4 Narrative of Use Case

Narrative of use case
Short description
This Use Case describes the provision of tertiary control/ man. Frequency restoration reserve by an electrolyser which includes the adaption of the power consumption of the electrolyser to online control commands close to real time and the corresponding monitoring.
Complete description
This Use Case describes the provision of tertiary control / manual frequency restoration reserve (mFRR) by an electrolyser to the Austrian transmission system operator Austrian Power Grid (APG). The use case has three different scenarios: the reservation of tertiary control power, the control of the electrolyser and the real-time monitoring for APG. For the reservation of mFRR, APG reports the acceptance of bids of the mFRR tender to the network operation centre (NOC)/VERBUND. If a bid was accepted, the NOC calculates the needed mFRR power that must be continuously reserved in the tender period by the electrolyser. In case of a mFRR activation, APG either sends the respective set-point command directly to the NOC or informs the operator of the NOC via telephone in advance. The NOC then calculates the set-points for a selected set of the aggregated units in the pool (depending on the internal merit order). If the electrolyser is selected for an activation, the NOC forwards the calculated set-point to the Remote Terminal Unit (RTU). Then, the RTU forwards the set-point to the SCADA application of the electrolyser, which then calculates the needed change of power consumption of the electrolyser. Finally, the SCADA system sends the respective control commands to the electrolyser, which then adapts its power consumption. Consequently, the following steps are required in this scenario: 1. APG sends set-point command to the NOC 2. The NOC calculates the set-point of the electrolyser 3. The NOC sends the set-point to the RTU 4. The RTU sends the set-point to the SCADA application of the electrolyser

5. The SCADA system calculates the set-point of the electrolyser 6. The SCADA system sends the suitable commands to the electrolyser 7. The electrolyser changes its power consumption accordingly For the real-time monitoring for APG, an Intelligent Electronic Device (IED) periodically collects measurements indicating the current power consumption of the technical unit. The IED communicates the current power to the SCADA application of the electrolyser. The SCADA system periodically reports the current power consumption, etc. to the RTU. The RTU forwards this parameters to the NOC, which then sends the aggregated parameters of the pool for reporting to APG.

1.5 Key performance indicators (KPI)

Key performance indicators			
ID	***Name***	***Description***	***Reference to mentioned use case objectives***
1	Error margin of activation	The electrolyser adapts its power consumption according to the online set-point of the NOC. In case of over- or under-activation of the electrolyser the following error margin can be calculated: $(P_{act} - P_{set}) / P_{act}$ [%] P_{act} … actual power consumption P_{set} … target power consumption according to set-point	

1.6 Use case conditions

Use case conditions
Assumptions
Electrolyser is flexible and fast enough for tertiary control provision (see table of requirements)
Prerequisites
Electrolyser can be operated in the whole frequency range from 47,5 Hz to 51,5 Hz, i.e. there is no frequency-dependent separation from the grid
Data connection APG <-> NOC <-> RTU <-> SCADA is established
The electrolyser system is successfully prequalified for the provision of mFRR. The prequalification for the provision of mFRR to APG involves a proof of the functional capability (measurement protocol – see section 8 Custom information).

1.7 Further information to the use case for classification / mapping

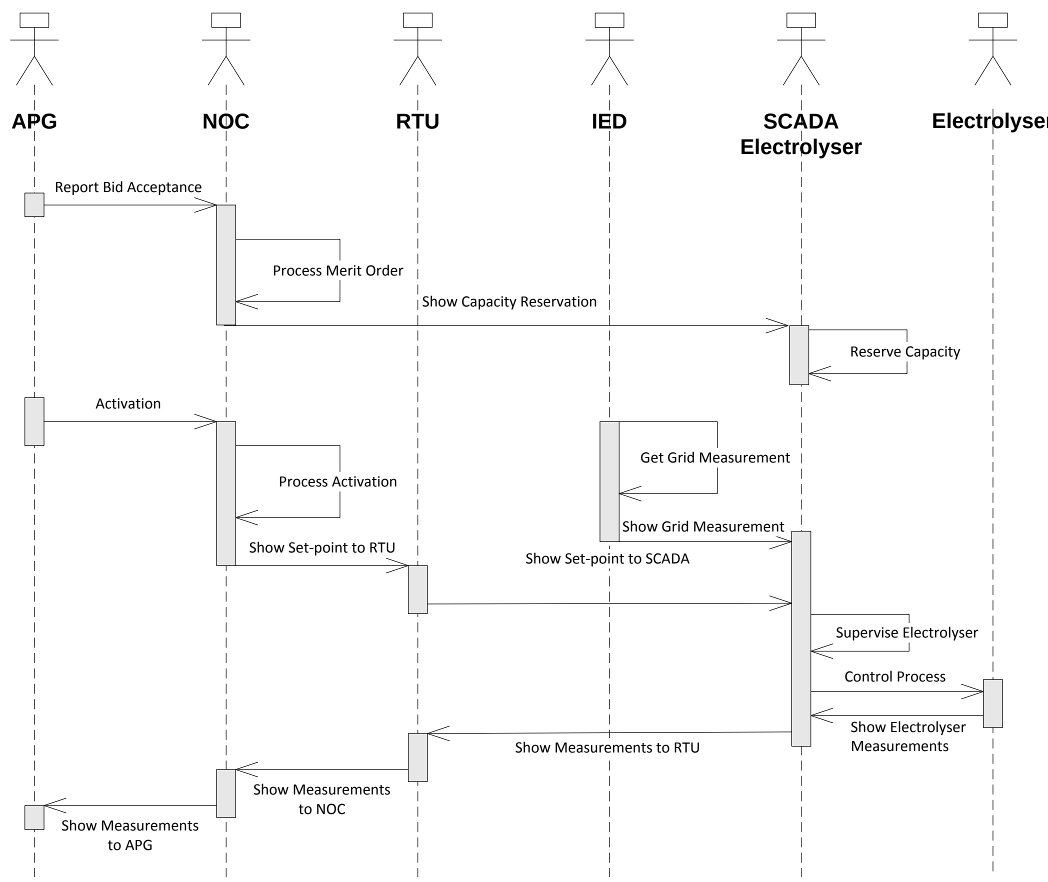
Classification information
Relation to other use cases
Use case of the WP2.3 of H2FUTURE
Level of depth
Individual Use Case
Prioritisation
Implemented in demo
Generic, regional or national relation
Austria
Nature of the use case
Technical
Further keywords for classification
Tertiary control, frequency restoration reserve, ancillary services

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**	
Process/Field/Station actors		Actors in Process, Field, Station levels	
Actor name	**Actor type**	**Actor description**	*Further information specific to this use case*
Austrian Power Grid (APG)	Role	APG operates the Austrian grid balancing markets and monitors the provision of FRR	
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	In this use case the electrolyser is the technical unit which provides mFRR
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 grid, sends frequency changes to the SCADA
Network Operation Centre (NOC)	Application	A NOC or virtual power plant is an application that optimises the	

		dispatch of technical units	
Remote Terminal Unit (RTU)	Component	A RTU is a microprocessor-controlled electronic device that interfaces objects in the physical world to a distributed control system or SCADA	In this Use Case, the RTU collects measurement data from the SCADA and sends them to the NOC
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 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	Capacity reservation	After bid acceptance by APG, the NOC reserves the capacity for mFRR	NOC	APG sends accepted bids to NOC/VERBUND (weekly)	VERBUND submitted bid(s) for the mFRR tender to APG	
2	Control	NOC calculates set-point based on APG input and forwards it to the SCADA which then controls the electrolyser in order to change its power consumption according to this set-point	SCADA Electro-lyser	NOC receives set-point from APG	All data communications are established. The electrolyser is up and running.	Electrolyser adepts its power consumption according to the control commands
3	Monitoring	SCADA reports the current power consumption, etc. to the NOC	SCADA Electro-lyser	SCADA periodically sends the data to the RTU	All data communications are established. The RTU is up and running.	The NOC forwards this parameters to APG

4.2 Steps – Scenarios

Scenario								
Scenario name:		**No. 1 – Capacity reservation**						
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	Report bid acceptance	APG publishes accepted bids of mFRR tender	REPORT	APG	NOC		
2	NOC receives tender information	Reserve capacity	Based on the accepted bids, NOC calculates and reserves the needed capacity by electrolyser	INTERNAL OPERATION	NOC	NOC	mFRR	
3	NOC has	Show capacity	NOC sends the	SHOW	NOC	SCADA	mFRR	

Step No.	Event	Name of process/ activity	Description of process/ activity	Service	Information producer (actor)	Information receiver (actor)	Information exchanged (IDs)	Requirement, R-IDs
	determined mFRR capacity reservation	reservation	needed capacity reservation by electrolyser to the SCADA			Electrolyser		
4	SCADA receives needed mFRR capacity reservation	Reserve capacity	SCADA reserves needed FCR capacity of the electrolyser	INTERNAL OPERATION	SCADA Electrolyser	SCADA Electrolyser	mFRR	
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	Start mFRR activation	Activation	APG sends set-point to NOC or informs NOC operator via telephone about activation	SHOW	APG	NOC	SP_V	
2	NOC receives set-point	Process activation	Based on the received set-point, NOC calculates the set-point for the electrolyser	INTERNAL OPERATION	NOC	NOC		
3	Periodically	Show set-point to RTU	NOC sends set-point to RTU	SHOW	NOC	RTU	SP_V	QoS_2 Conf_2 Conf_3
4	Periodically	Show set-point to SCADA	RTU sends set-point to SCADA	SHOW	RTU	SCADA Electrolyser	SP_V	QoS_2 Conf_1
3	SCADA receives set-point	Supervise electrolyser	SCADA supervises the current electrolyser state based on the received set-point	INTERNAL OPERATION	SCADA Electrolyser	SCADA Electrolyser		
4	Periodically	Control process	SCADA processes & sends out control commands	CHANGE	SCADA Electrolyser	Electrolyser	SP_E	QoS_3 QoS_4
Scenario name:		**No. 3 – 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	INTERNAL OPERATION	IED	IED	PC_M	QoS_1 QoS_2
2	Periodically	Show grid measurement	IED sends measurements to SCADA	SHOW	IED	SCADA Electrolyser	PC_M	QoS_2
3	Periodically	Show electrolyser measurement	Electrolyser sends measurements to SCADA	SHOW	Electrolyser	SCADA Electrolyser	PC_M	QoS_2
4	Periodically	Show measurement to RTU	SCADA sends electrolyser and grid measurements to RTU	SHOW	SCADA Electrolyser	RTU	PC_M OP_V	QoS_2 Conf_1
5	Periodically	Show measurement to NOC	RTU sends measurements to NOC	SHOW	RTU	NOC	PC_M OP_V	QoS_2 Conf_2 Conf_3
6	Periodically	Show measurement to APG	NOC sends measurements to APG	SHOW	NOC	RTU	PC_M OP_V	QoS_2 Conf_4

5 Information exchanged

Information exchanged			
Information exchanged, ID	***Name of information***	***Description of information exchanged***	***Requirement, R-IDs***
mFRR	mFRR Capacity Reservation	Needed capacity reservation of electrolyser for mFRR for tendering	

		period	
PC_M	Power Consumption Measurement	Measurement indicating the power consumption of the electrolyser.	QoS_1 QoS_2
SP_V	Set-point Value	Set-point data by APG and the NOC	QoS_2
SP_E	Set-point Electrolyser	Set-point for controlling of the electrolyser	
OP_V	Operating Point Value	Operating point of the electrolyser	QoS_3

6 Requirements (optional)

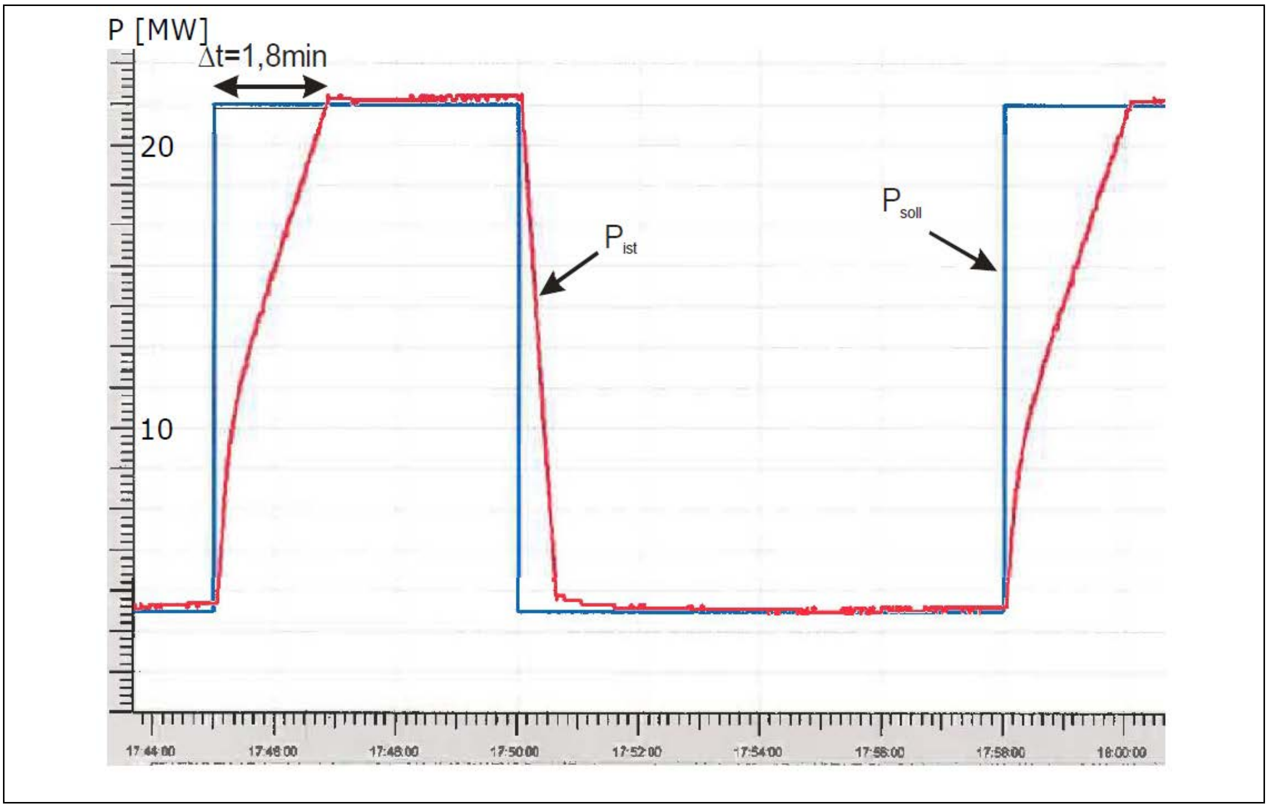
Requirements (optional)		
Categories ID	**Category name for requirements**	**Category description**
QoS	Quality of Service Issues	Requirements regarding the Quality of Service (e.g. availability of the system, acceptable downtime, etc.)
Requirement R-ID	**Requirement name**	**Requirement description**
QoS_1	Power consumption measurement	The meter for measuring the power consumption must at least have an accuracy class 0,5.
QoS_2	Data interval	The measurement/data interval has to be 2 seconds (each full even second, GPS time).
QoS_3	Error margin	Max. error of activation: -3%
QoS_4	Activation speed	100% of dedicated/offered mFRR power must be activated within 10 minutes
Categories ID	**Category name for requirements**	**Category description**
Conf	Configuration Issues	Requirements regarding communication configurations
Requirement R-ID	**Requirement name**	**Requirement description**
Conf_1	Communication protocol SCADA-RTU	Possible communication protocol between SCADA <-> RTU: Modbus, Profibus
Conf _2	Communication protocol RTU-NOC	Possible communication protocol between RTU <-> NOC: Modbus, IEC 60870-5-104
Conf_3	Encryption	Communication is encrypted via OpenVPN
Conf_4	Communication protocol APG-NOC	Communication protocol between APG <-> NOC: IEC 60870-5-101

7 Common terms and definitions

Common terms and definitions	
Term	**Definition**
Tertiary Control / manual Frequency Restoration Reserve (mFRR)	Tertiary control energy / manual Frequency Restoration Reserve (mFRR) is activated when the deviation in the control area lasts for longer than 15 minutes. mFRR is used to relieve secondary control / automatic Frequency Restoration Reserve (aFRR)

8 Custom information (optional)

Custom information (optional)
Examples of measuring protocols for the proof of the functional capability of a technical unit to provide mFRR: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17:58:00
18:00:00

6 References

6.1 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

6.2 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