H2FUTURE
Green Hydrogen

# Deliverable D2.6

Specifications for Quasi-Commercial Operation

v1.0

Funded by FCH Fuel Cells and Hydrogen Joint Undertaking

# Document Information

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# Revision History

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| 0.1 | 22/05/2017 | B. Forster, A. Eichhorn, K. Zach | First draft version |
| 0.2 | 30/05/2017 | B. Forster, A. Eichhorn | Review |
| 0.3 | 07/06/2017 | K. Zach | Clean version for review process |
| 1.0 | 26/06/2017 | 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 D2.6, details the specifications for the quasi-commercial operation phase. As for the pilot tests in the other tasks of WP2 (see D2.1 – D2.5 of H2FUTURE), also for the quasi-commercial operation the specifications are described by using the common methodology based on the use case collection method (cf. Smart Grid Coordination Group at EC level), which is briefly introduced in chapter 2.

The aim of this use case for the quasi-commercial operation is to quantify key performance indicators (KPIs) related to the economic feasibility of the electrolyser in commercial operation.

The filled-out use case template for the quasi-commercial operation, which contains the general narrative description, KPIs, sequence diagram, etc., can be found in chapter 3.

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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 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 D2.6, details the specifications for the quasi-commercial operation phase. The aim of this use case is to quantify key performance indicators (KPIs) related to the economic feasibility of the electrolyser in a commercial operation, trying to show that the PEM electrolyser is able to use timely power price opportunities (in order to provide affordable hydrogen for current uses of the steel making processes), and to attract extra revenues from grid services.

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

| | |
|---|---|
| aFRR | Automatic Frequency Restoration Reserve |
| EC | European Commission |

| | |
|---|---|
| ECFOH | Economic Feasible Operating Hours per year |
| ECOH | Economic Operating Hours per year |
| EU | European Union |
| FCR | Frequency Containment Response |
| IEC | International Electrotechnical Commission |
| IED | Intelligent Electronic Device |
| KPI | Key Performance Indicator |
| mFRR | Manual Frequency Restoration Reserve |
| 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 case developed within task WP2.6 of the H2FUTURE project is described in the following section of the document.

# 3 Use Case for Quasi-Commercial Operation

***Description of the use case***

### *1.1 Name of use case*

| Use case identification | | |
|---|---|---|
| ***ID*** | ***Area / Domain(s)/ Zone(s)*** | ***Name of use case*** |
| UC6 | Customer Premises / Process, Field, Station, Operation | Quasi-Commercial Operation |

### *1.2 Version management*

| Version management | | | | |
|---|---|---|---|---|
| ***Version No.*** | ***Date*** | ***Name of author(s)*** | ***Changes*** | ***Approval status*** |
| 0.1 | 29/03/2017 | B. Forster | First Draft | |
| 0.2 | 30/03/2017 | P. Pedronetto | Draft | |
| 0.3 | 05/04/2017 | B. Forster | Review | |
| 0.4 | 05/04/2017 | A. Eichhorn | First Draft in another document | |
| 0.5 | 04/05/2017 | B. Forster | Merge of Documents, Review | |
| 0.6 | 09/05/2017 | K. Zach | Draft of sections 2 to 7 | |
| 0.7 | 17/05/2017 | A. Eichhorn | Graphic + Review | |
| 1.0 | 26/06/2017 | K. Zach | Final version | |

### *1.3 Scope and objectives of use case*

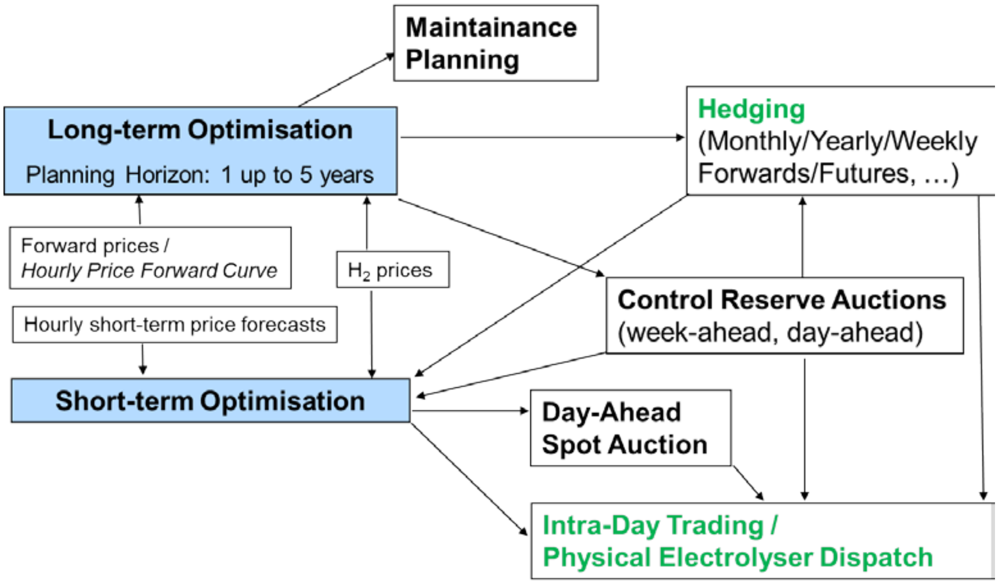
| Scope and objectives of use case | |
|---|---|
| *Scope* | **Hedging and Short-term Optimization**<br><br>**Hedging**<br>Medium-/long-term procurement of electricity on the forward and futures market for the electrolyser, based on long-term optimization results taking into account obligations from already contracted ancillary services (e.g. auction results for primary control reserve on a week-ahead basis) such that remaining spot market positions are reduced.<br><br>**Short-term Optimization: Day-Ahead and Intraday Optimization**<br>Short term and Intraday optimization of the electrolyser's production schedule via day-ahead markets taking into account already contracted ancillary services obligations and technical constraints. Scheduling of electrolyser. |
| ***Objective(s)*** | Set up a stable optimization environment for long-term optimization (within physical constraints) and guidelines and/or a partly automatized process for hedging (i.e. buying and selling of electricity forwards and futures) based on long-term optimization result and obligations from already contracted ancillary services.<br><br>Set up a stable optimization environment for short term optimization within physical constraints, ancillary services constraints and optimum commercialisation on Spot and Intraday markets. |
| ***Related business case(s)*** | Flexibility provision |

### *1.4 Narrative of Use Case*

| Narrative of use case |
|---|
| ***Short description*** |
| The electrolyser shall be operated and optimized on the basis of (hydrogen demand/prices and) hourly and quarter-hourly electricity spot market prices (day-ahead and intra-day) as well as ancillary services. The real short-term and a forecasted long-term power schedule shall be calculated by an optimization tool taking into account these prices as well as physical constraints; the short-term schedule shall be |

purchased at the respective spot markets/auctions. The long-term schedule serves, together with already contracted ancillary services, shall serve as a quantitative basis for hedging (i.e. purchasing electricity block products such as week-ahead, month-ahead, or year-ahead forwards/futures in order to reduce spot price risk exposure) and will be updated periodically (e.g., daily).

***Complete description***




**HEDGING**

Hedging positions for the expected electricity demand of the electrolyser, i.e. positions of electricity forwards and/or futures for various delivery periods in the future (weeks, months, quarters, years; for base and peak, respectively) shall be built up continuously according to availability and market liquidities. Existing hedging positions shall be constantly adapted to updates of the expectation of the electrolyser's future electricity demand.
Hedging is useful because

- it reduces the uncertainty of the financial result of the electrolyser substantially
- in the long run it possibly yields some small additional revenues by making use of the optional character of the electrolyser.

The electrolyser's electricity demand in the future depends on various factors such as electricity prices, prices for grid services, hydrogen and oxygen, etc.; many of these factors and, thus, electrolyser's electricity demand are uncertain at the time of hedging; therefore the hedge amount is derived from a long-term optimization model; the latter is set up in a stochastic framework; it shall resemble and anticipate the short-term optimization process and the real dispatch of the electrolyser in an hourly (or, if necessary, quarter-hourly) time discretization. The optimization horizon (planning period) shall be one or two years, starting at the present. Due to the resulting high number of steps (at least 8760 for one year in hourly discretization) some simplifications may have to be made, but the model has to be consistent with the short-term model; in particular, the following aspects have to be taken into account:

- technical characteristics of the electrolyser such as efficiency curves, ramp rates etc.
- scenarios for electricity prices, prices for grid services, hydrogen and oxygen
- obligations from already contracted grid services
- constraints from the refinery process

The result of the long-term optimization model are (quarter-)hourly scenarios for the electrolyser electricity demand; these scenarios shall be aggregated (in time according to the delivery periods of the available hedging products, and statistically across the scenarios); based on these aggregated results the hedging is carried out; to this end additional determinations have to be set up:

- hedge ratios (target hedging position = percentage * expected electricity demand
- time limits (which forwards/futures should be trades at which time periods)
- price and/or liquidity limits for the respective forwards/futures

**DAY-AHEAD OPTIMIZATION**

The day-ahead commercialization of the electrolysers available power consumption capacity with dependence on technical constraints, reserved capacity and the operating point for fulfilment of contracted ancillary services obligations is part of the short-term optimization and scheduling process.

Various options to buy and sell electricity on different markets with regard to the day-ahead optimization exist. Important restrictions for trading on a specific market are the following: Bidding zone and border capacities, liquidity, gate-closure time for placing orders, possibilities of congestion management and the necessity to exchange trading and production schedules in time.
In the following the status-quo of the common bidding zone of Austria and Germany is assumed as there is no congestion management on this border at the moment, whereas an analogous process can be conducted in case of a split of the bidding zone and a possible resulting market coupling process.

The day-ahead optimization shall be carried out automatically by an optimization tool, e.g. the one used for short term optimization of hydro and thermal power plants at VERBUND.

By the strict definition of operational parameters of the electrolyser as well as a defined optimization strategy it is possible to highly automatize the optimization process and create a resulting bidding matrix for the day-ahead-market auction(s).

In case of unforeseen restrictions or conditions which are not implemented in the optimization tool, a backup method for the automated day-ahead process is provided by the day-ahead planning team of VERBUND (manual process). The day-ahead-planning team may also market individual block-orders or market a distinct consumption profile if necessary.

To elaborate a reasonable day-ahead-optimization the optimization tool has to be updated continuously with technical and operational parameters of the electrolyser, as well with price information and details regarding already contracted ancillary reserve obligations:

Technical / operational parameters

- Minimum consumption (static and time dependent, if applicable)
- Maximum consumption (static and time dependent, if applicable)
- Derated maximum consumption in case of providing ancillary services (if applicable)
- Increased minimum consumption in case of providing ancillary services (if applicable)
- Maintenance schedule
- Ramp rate up (MW/min)
- Ramp rate down (MW/min)
- Maximum primary reserve contribution (up and down) in MW
- Maximum secondary reserve contribution (up and down) in MW
- Operational costs of the electrolyser per operational hour or per MWh consumption
- Start costs
- Minimum uptime (if relevant)
- Minimum downtime (if relevant)
    - In case minimum uptime and minimum downtime must not be neglected:
        - Last synctime provided by SCADA or at least metered consumption values
        - Last de-synctime provided by SCADA or at least metered consumption values

Ancillary services obligations data
Already contracted ancillary services need to be taken into account by the optimization tool

- Type of ancillary service(s)
- Direction
- Time definition / validity
- Contracted capacity

Price forecasts and price information

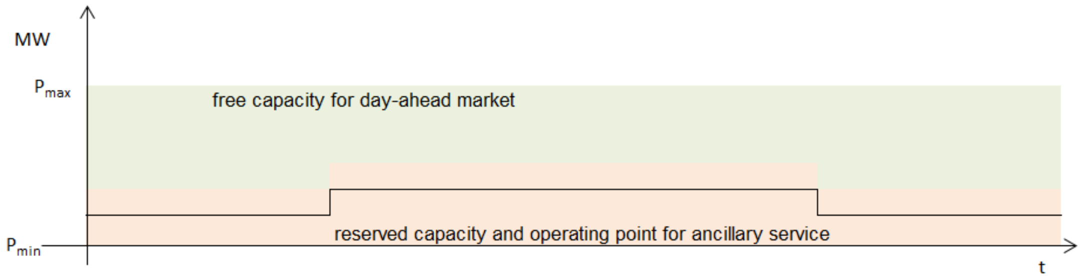
- Value of hydrogen or equivalent gas price forecast
- Value of oxygen (if applicable)
- Electricity price forecast
- Any certificate prices (if applicable)

To enable an automated optimization any dynamic input parameter shall be transmitted to the optimization tool via well-defined and automated interfaces.

- Interface to a price data base
- Interface to an ancillary services data base
- Interface to the NOCs information system, indirectly connected to the SCADA system
- …

Use case example:
The optimization tool obtains all relevant dynamic information by interfaces and runs a day-ahead optimization accurately timed before the day-ahead-auctions take place.

Free capacity - not already occupied by ancillary services – may be used for increased hydrogen production, if economically feasible. Electricity bought on the day-ahead-market results in an increased consumption of the electrolyser which increases the hydrogen production.




The optimization results enter into a day-ahead bidding process. Previously hedged electricity products needs to be netted with any spot market (limit) orders.
The hedging process has no impact on the day-ahead optimization itself, but may stabilize the financial result of the commercialisation of the electrolyser.

Possible products to be taken into account for optimization are quarter-hourly orders, hourly orders, block orders and smart block orders (linked/exclusive blocks).

Auctions:

- Austrian EXAA Day-Ahead Auction (1/4h, 1h, Block orders)
- Germany/Austria Bidding Zone: EPEX SPOT Day-Ahead Auction (1h, Block Orders, Smart Blocks)

The auction results finally determine the day ahead schedule of the electrolyser.
Any trading results are imported into the VERBUND Trading System to incorporate the deals for scheduling. The confirmed deals are aggregated and scheduled automatically in the scheduling system, so that any necessary nominations[1], in particular cross-border schedules, are carried out in time. The aggregation of the trading deals closed for the electrolyser leads to a set-point for the electrolysers consumption for each quarter-hour which will be transmitted by an interface from the NOC to the SCADA system, so that it follows the scheduled electricity consumption.

**INTRADAY OPTIMIZATION**

The Intraday process is similar to the day-ahead process. A semi-automated commercialization of the available capacity of the electrolyser on the continuous intraday trading markets in Austria and Germany shall be conducted, whereas the opportunity to optimize the electrolyser via over-the-counter trading (OTC) should be viable optionally.

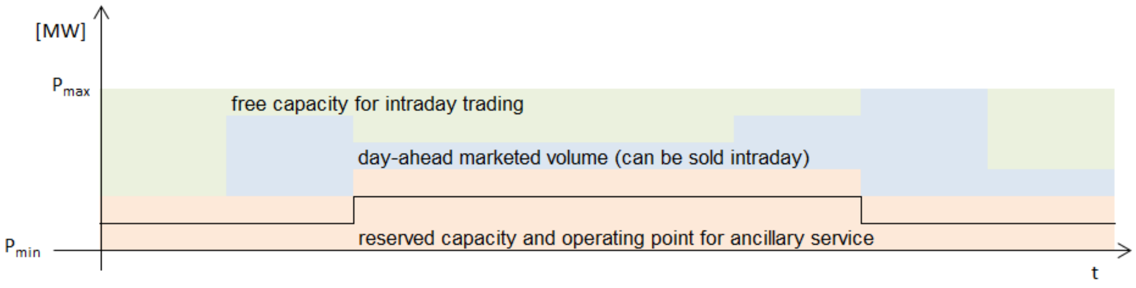
Important Products: Quarterly hour product, hourly product, block hour product, individual contract.

The Intraday commercialization of the available power consumption capacity with dependence on contracted hedging contracts, reserved capacity, technical restraints and operating point for fulfilment of contracted ancillary services takes place 24/7.

Intraday trading in the bidding zone AT/DE starts at 15:00pm for the next day.
From 4.00 pm it is possible to trade on the EPEX continuous intraday-trading platform for the next day.

[1] Consumptions schedules do not need to be transmitted to the TSO, besides ex-post nominations in case of occurred ancillary services calls.

The trading-strategy parameters for semi-automated trading are configured by the Intraday trading team.




In case of technical problems the Intraday trading may alternatively conduct a manual back-up process.

After trading and scheduling a new set-point for production and consumption is calculated. This set-point has to be transmitted to the control unit of the electrolyser in time. The set-point indicates the amount of energy which has to be consumed for an quarter hour besides ancillary services.

### *1.5 Key performance indicators (KPI)*

| ***ID*** | ***Name*** | ***Description*** | ***Reference to mentioned use case objectives*** |
|---|---|---|---|
| 1 | Actual economical operating hours per year (ECOH) | Number of hours in a year in which the electrolyser was running due to economical reason by contributing a margin | |
| 2 | Economical feasible operating hours per year (ECFOH) | Theoretical maximum number of hours in a year in which the electrolyser could have contributed a margin (ex-post) | |
| 3 | Utilization of economical feasible operating hours | ECOH / ECFOH in % | |
| 4 | Contracted hours of ancillary services | Number of hours in which ancillary services bids were accepted and to be provided by the electrolyser | |
| 5 | Contracted hours of FCR | Number of hours in which FCR bids were accepted and to be provided by the electrolyser | |
| 6 | Contracted hours of aFRR | Number of hours in which aFRR bids (secondary control) were accepted and to be provided by the electrolyser | |
| 7 | Contracted hours of mFRR | Number of hours in which mFRR bids (tertiary reserve) were accepted and to be provided by the electrolyser | |
| 8 | Average provision of FCR | Average power of provision of FCR per year in MW | |
| 9 | Average provision of aFRR | Average power of provision of aFRR per year in MW | |
| 10 | Average provision of mFRR | Average power of provision of mFRR per year in MW | |
| 11 | Overall margin in a year, after operating expenses | Overall margin in a year, after operating expenses, including all costs for operating, the electrolyser (except initial recognition costs or equivalent depreciations) | |
| 12 | Ancillary services provision per year | Average provision of ancillary services per year in MW | |
| 13 | Quantity of hydrogen produced | Quantity of hydrogen produced in the reporting period (year) in t | |
| 14 | Energy volume turnover per year | Electric energy volume turnover per year on the day-ahead market in MWh (gross and | |

| | | | |
|---|---|---|---|
| | on the day ahead market | net) | |
| 15 | Energy volume turnover per year on the intraday market | Electric energy volume turnover per year on the intraday market in MWh (gross and net) | |
| 16 | Hedged quantities per year | Hedged quantities per year for any future product in MWh (gross and net) | |
| 17 | Average price of electricity consumption | Average price of consumed electricity in €/MWh per year after deduction of ancillary services market returns | |
| 18 | Cost of hydrogen produced | Average cost of produced hydrogen in €/kg | |

Additionally, all KPIs as described in UC 2 - Continuous Operation 24/7 with maximized Hydrogen Production could be applied in this use case (see Deliverable D2.2 of H2FUTURE).

### *1.6 Use case conditions*

| ***Use case conditions*** |
|---|
| ***Assumptions*** |
| Electrolyser is capable of fulfilling quarter hourly consumption profiles |
| ***Prerequisites*** |
| Electrolysers consumptions follows a set-point given by a schedule or signal to consume the specified amount of electricity for an quarter hour. |
| The amount of electricity which has to be consumed by the electrolyser is activated upon previous request by VERBUND. |
| Necessary information for a proper optimization of the electrolyser is available (e.g. availability, technical restraint,…) |

### *1.7 Further information to the use case for classification / mapping*

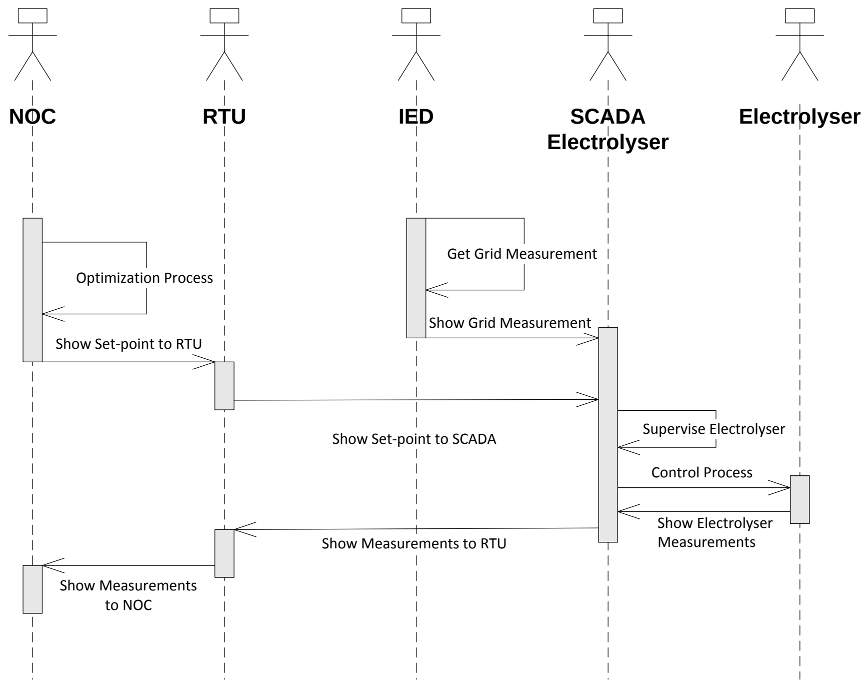
| ***Classification information*** |
|---|
| ***Relation to other use cases*** |
| Use case of the WP2.6 of H2FUTURE |
| ***Level of depth*** |
| Individual Use Case |
| ***Prioritisation*** |
| Full implementation quasi-commercial phase |
| ***Generic, regional or national relation*** |
| Austria |
| ***Nature of the use case*** |
| Technical |
| ***Further keywords for classification*** |
| Energy market, day-ahead, spot optimization, intraday optimization, hedging |

### *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* |
| 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 for which the optimization is performed |
| 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 and sends them to the SCADA |
| Network Operation Centre (NOC) | Application | A NOC or virtual power plant is an application that optimises the dispatch of technical units | In this use case the NOC also incorporates the short- and long-term optimization tools of VERBUND |
| 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 | The RTU sends measurement data from the SCADA to the NOC for monitoring and sends control commands |

| | | | |
|---|---|---|---|
| | | | from the NOC to the SCADA |
| 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 | Optimization | The NOC performs the short- and long-term optimization for the operation of the electrolyser system | NOC | Periodically | Optimization tools are running and parametrized | Set-point schedule of electrolyser is available in NOC |
| 2 | Control | SCADA sends control commands to the electrolyser in order to change its power consumption | SCADA | SCADA receives set-point from NOC / RTU | Communications from SCADA to the electrolyser can be 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 to the RTU / NOC | SCADA | SCADA periodically sends the data to the RTU | Communications from SCADA application to the RTU can be established. The RTU is up and running. | The RTU forwards these parameters to the NOC |

### 4.2 Steps – Scenarios

| Scenario | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Scenario name:** | **No. 1 – Optimization** | | | | | | | |
| **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 | Optimization process | NOC performs optimization process for electrolyser operation | INTERNAL OPERATION | NOC | NOC | | |
| **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 set-point to RTU | NOC sends set-point to RTU | SHOW | NOC | RTU | SP_V | QoS_2<br>Conf_2<br>Conf_3 |
| 2 | Periodically | Show set-point to SCADA | RTU sends set-point to SCADA | SHOW | RTU | SCADA Electrolyser | SP_V | QoS_2<br>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 | |
| ***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 OPERATIO N | 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 | QoS_2 Conf_1 |
| 5 | Periodically | Show measurement to NOC | RTU sends measurements to NOC | SHOW | RTU | NOC | PC_M | QoS_2 Conf_2 Conf_3 |

## 5 Information exchanged

| ***Information exchanged*** | | | |
|---|---|---|---|
| ***Information exchanged, ID*** | ***Name of information*** | ***Description of information exchanged*** | ***Requirement, R-IDs*** |
| 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 | |

## 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). |
| **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 | Possible Communication protocol between SCADA <-> RTU: |

| | | |
|---|---|---|
| | protocol 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 |

## 7 Common terms and definitions

| **Common terms and definitions** | |
|---|---|
| **Term** | **Definition** |
| | |

## 8 Custom information (optional)

| ***Custom information (optional)*** |
|---|
| |

# 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