QualyGridS

Standardized qualifying tests of electrolysers for grid services

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State Secretariat for Education, Research and Innovation SERI

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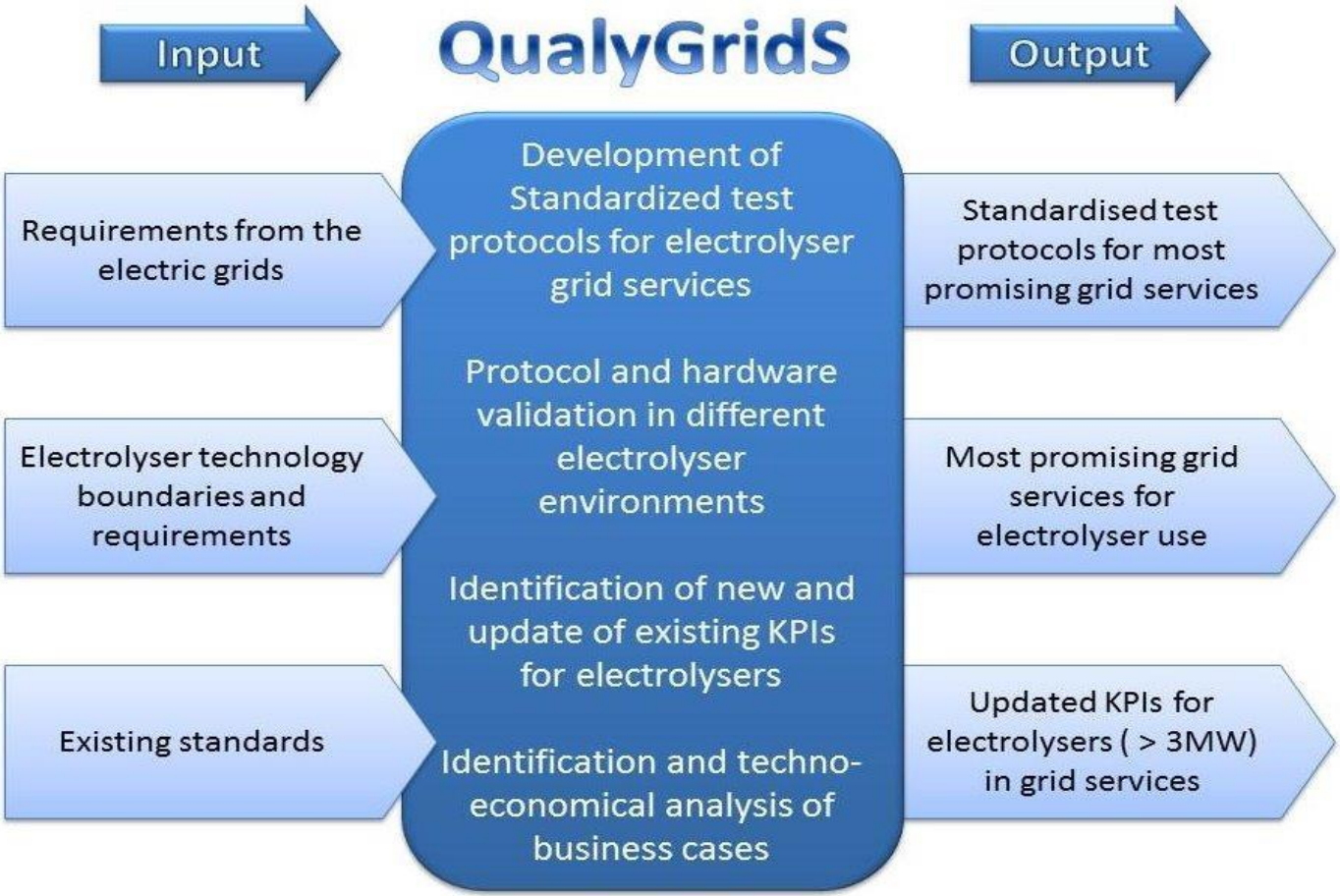
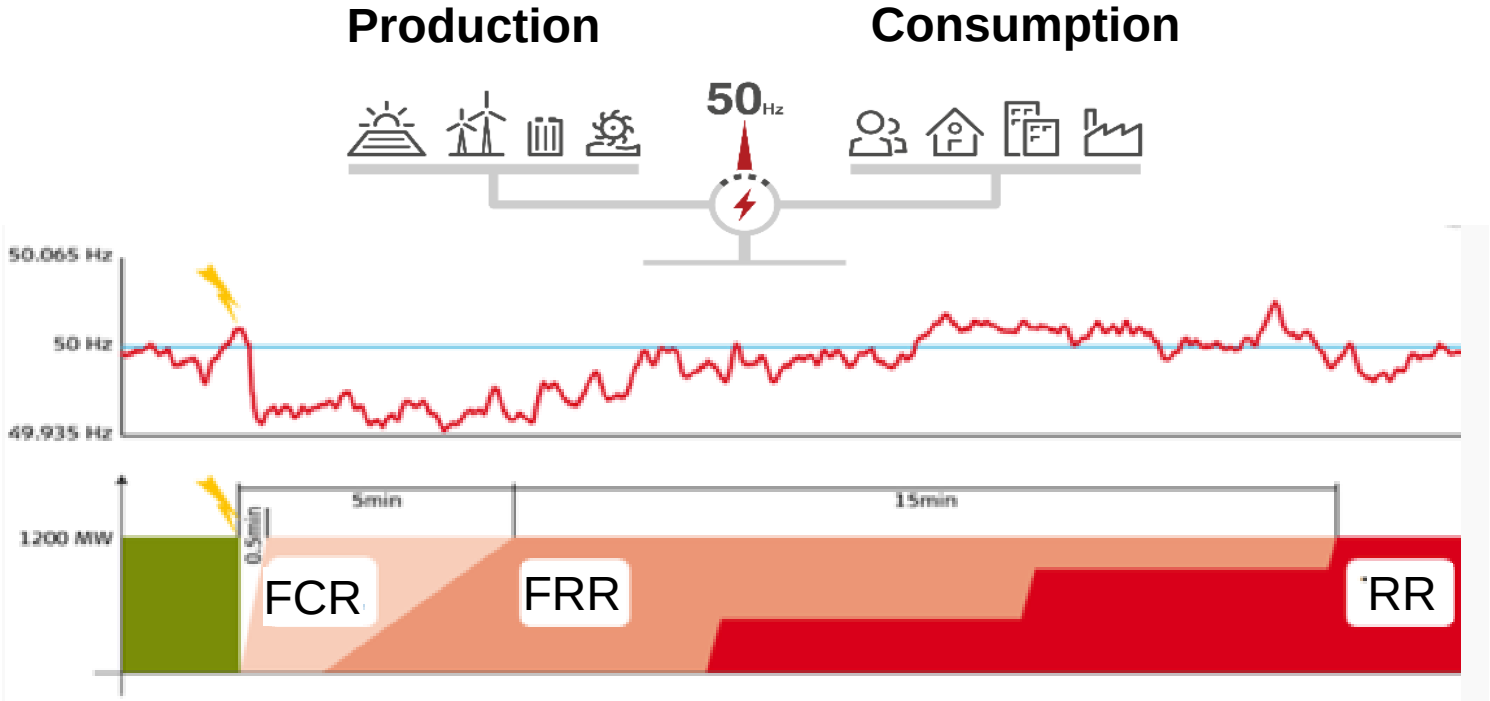
Rationale

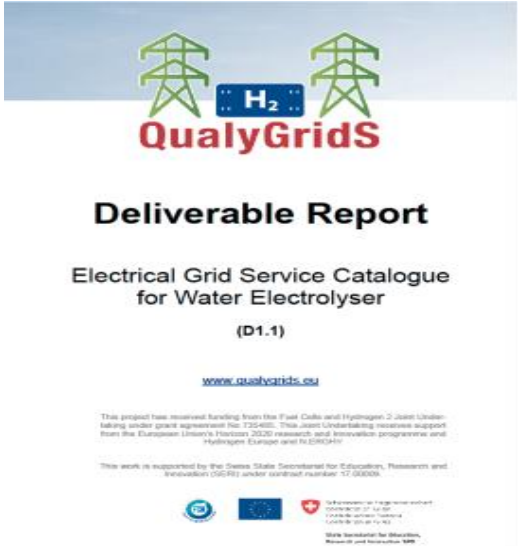
- Strong market entry of electrolysers today still limited by costs
- Hydrogen from electrolyers using renewable energy for mobility, energy storage, feed in gas grid, industrial use → link between the sectors, decarbonisation
- Performing electricity grid services → improved revenues for electrolysers
- Approved and standardised electrolysers tests to verify which service an electrolyser can perform → help OEMs and customers

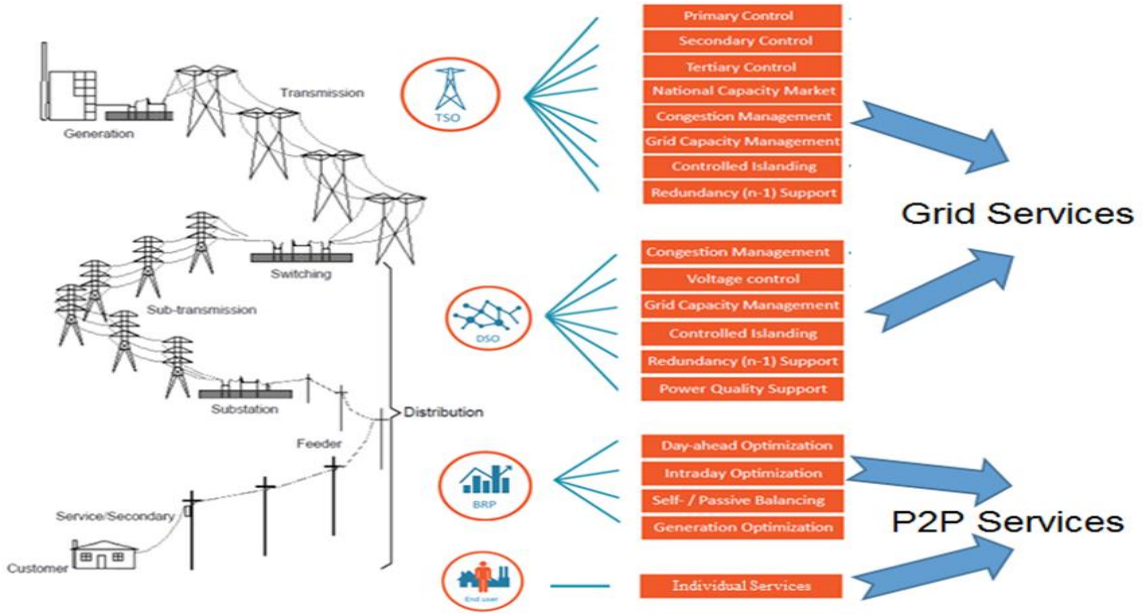

Input
QualyGridS
Output
Requirements from the electric grids
Electrolyser technology boundaries and requirements
Existing standards
Development of Standardized test protocols for electrolyser grid services
Protocol and hardware validation in different electrolyser environments
Identification of new and update of existing KPIs for electrolysers
Identification and techno-economical analysis of business cases
Standardised test protocols for most promising grid services
Most promising grid services for electrolyser use
Updated KPIs for electrolysers (> 3MW) in grid services

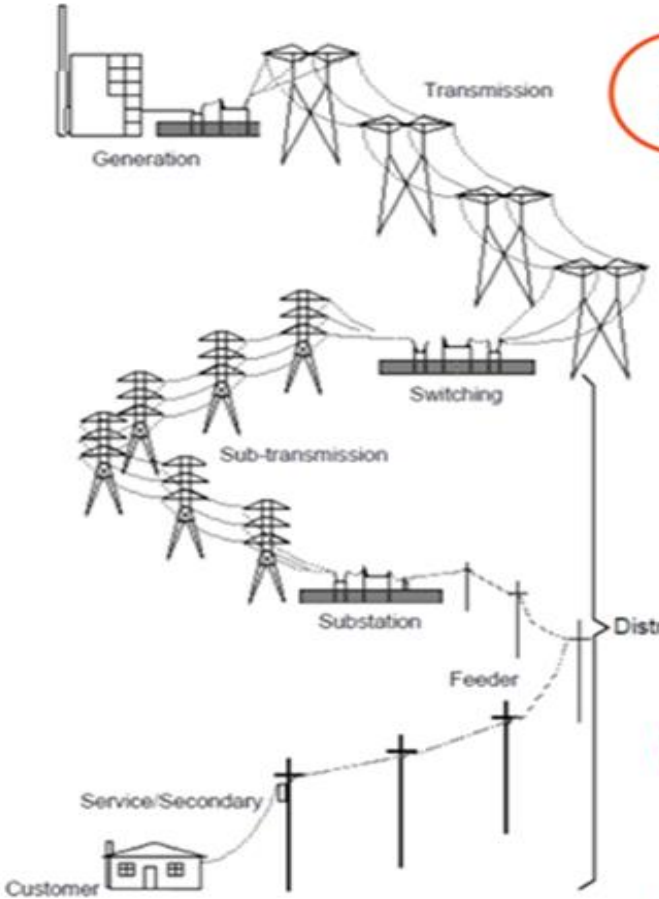
Review of electrical grid service requirements Europe



Review of electrical grid service requirements Europe







TSO

- Primary Control
- Secondary Control
- Tertiary Control
- National Capacity Market
- Congestion Management
- Grid Capacity Management
- Controlled Islanding
- Redundancy (n-1) Support

DSO

- Congestion Management
- Voltage control
- Grid Capacity Management
- Controlled Islanding
- Redundancy (n-1) Support
- Power Quality Support

Grid Services

BRP

- Day-ahead Optimization
- Intraday Optimization
- Self- / Passive Balancing
- Generation Optimization

End user

- Individual Services

P2P Services

Basic characterisation (grid-relevant) and Performance Indicators

5.13 Performance tests

The tests 5.13.1, 5.13.2, 5.13.3, 5.13.4, 5.13.5 and 5.13.6 are independent of each other. Users of this technical specification may selectively execute test items suitable for their purposes from those described in this technical specification.

5.13.1 Basic characterisation of electrolyser system for grid-service relevant parameters

5.13.1.2.1.1 *Protocol for determination of Cold Start Time to Nominal Power*

5.13.1.2.1.1.1 Protocol for determination of start-up time from standby mode

5.13.1.2.1.2 *Protocol for Identification of available range*

5.13.1.2.1.3 *Protocol for Determination of Minimum-Maximum-Dynamics*

5.13.1.2.1.4 *Protocol for Determination of Nominal-Maximum-Dynamics*

5.13.1.2.1.5 *Protocol for determination of power down to standby time*

Basic characterisation (grid-relevant) and Performance Indicators

5.13 Performance tests

The tests 5.13.1, 5.13.2, 5.13.3, 5.13.4, 5.13.5 a
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**5.13.1 Basic characterisation o
relevant parameters**

5.13.1.2.1.1 *Protocol for determina*

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5.13.1.2.1.3 *Protocol for Determinatio*

5.13.1.2.1.4 *Protocol for Determinatio*

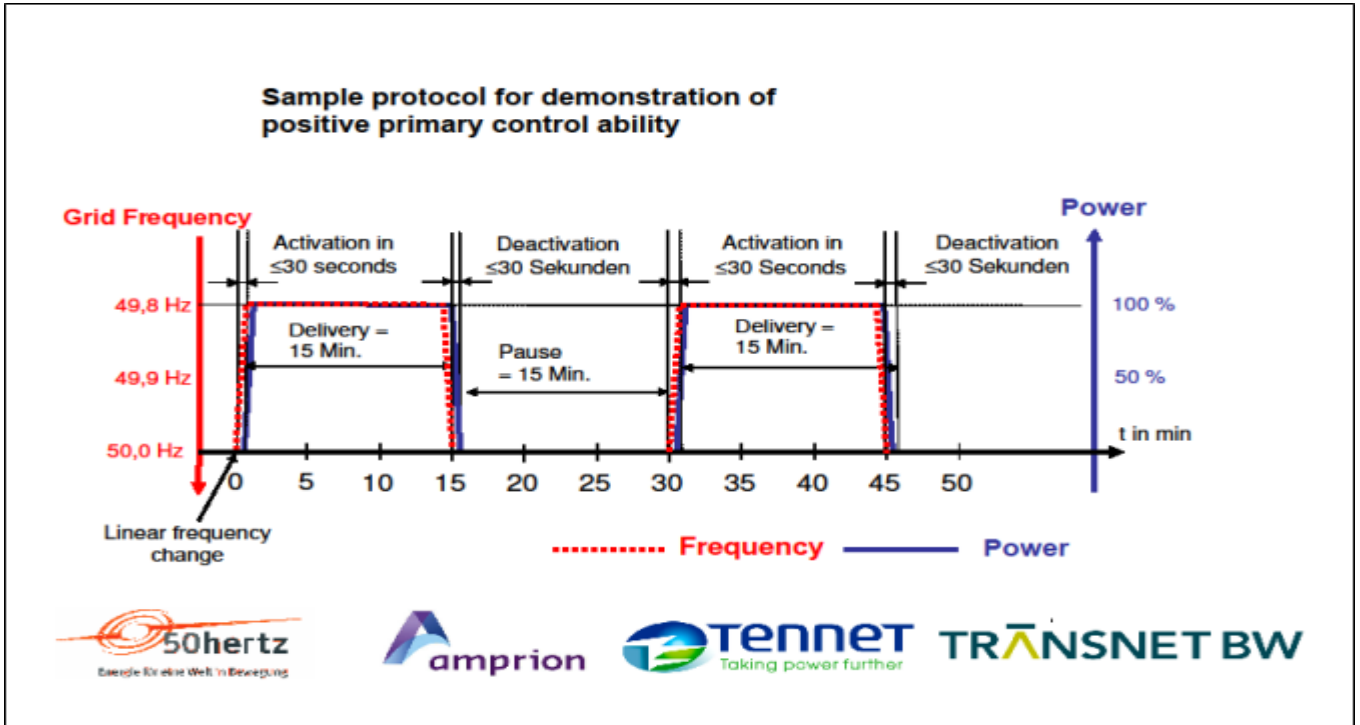
5.13.1.2.1.5 *Protocol for determinatio*

- Available Power Range ΔP
- Time to power up t_{up}
- Time to power down t_{down}
- Power stablity
- Characteristic time t_m and t_{full} for steps up and steps down / ramp duration
- Initial response time
- The Total Response Time Maximum Power to Minimum Power $t_{max->min}$
- Time from nominal to standby state: $t_{down\_to\_standy}$

→to be exp. verified and relevance determined

Collecting Electricity Grid Services and Prequalification Procedures

Example primary control (FCR=Frequency Containment Reserve) Germany

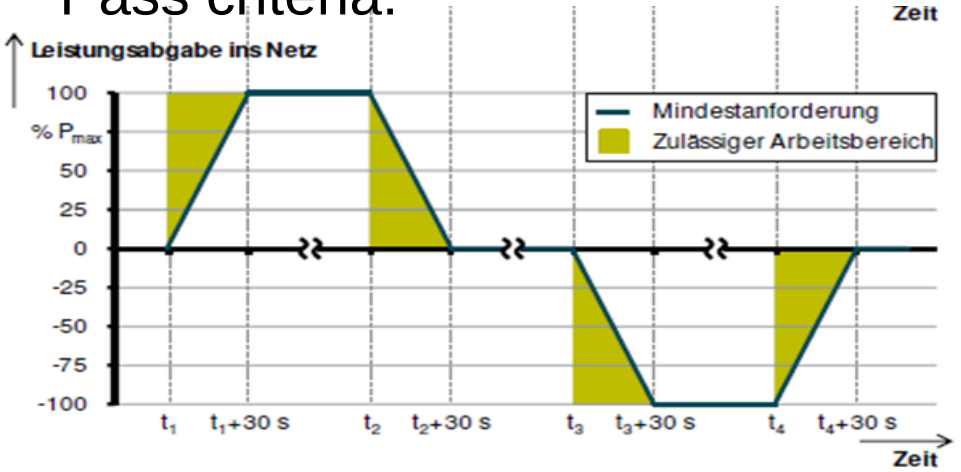


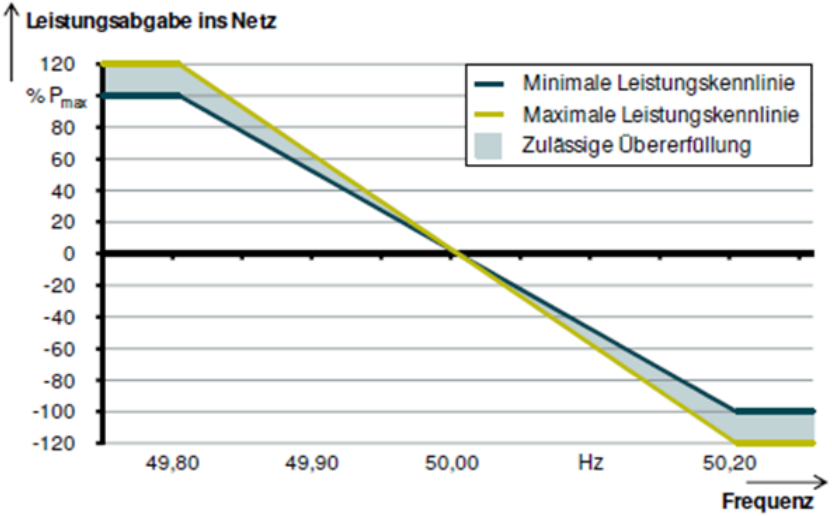
Collecting Electricity Grid Services and Prequalification Procedures

QualyGridS

Example primary control (FCR=Frequency Control Reserve) Germany

Pass criteria:





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Collecting Electricity Grid Services and Prequalification Procedures

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Example primary control (FCR=Frequency Control reserve) France and several other, smaller steps

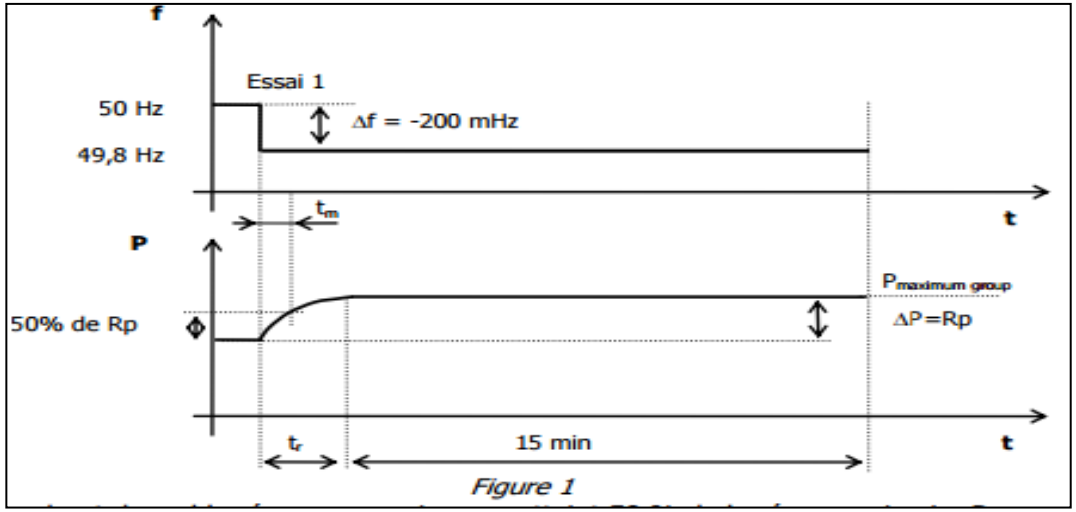

Figure 1

Pass criteria:

- Non oscillating waveform response
- Time t_r < 30 sec
- Time t_m < 10 sec
- The variation $\Delta P = R_p$ maintained for 15 min (after t_r)

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Collecting Electricity Grid Services and Prequalification Procedures

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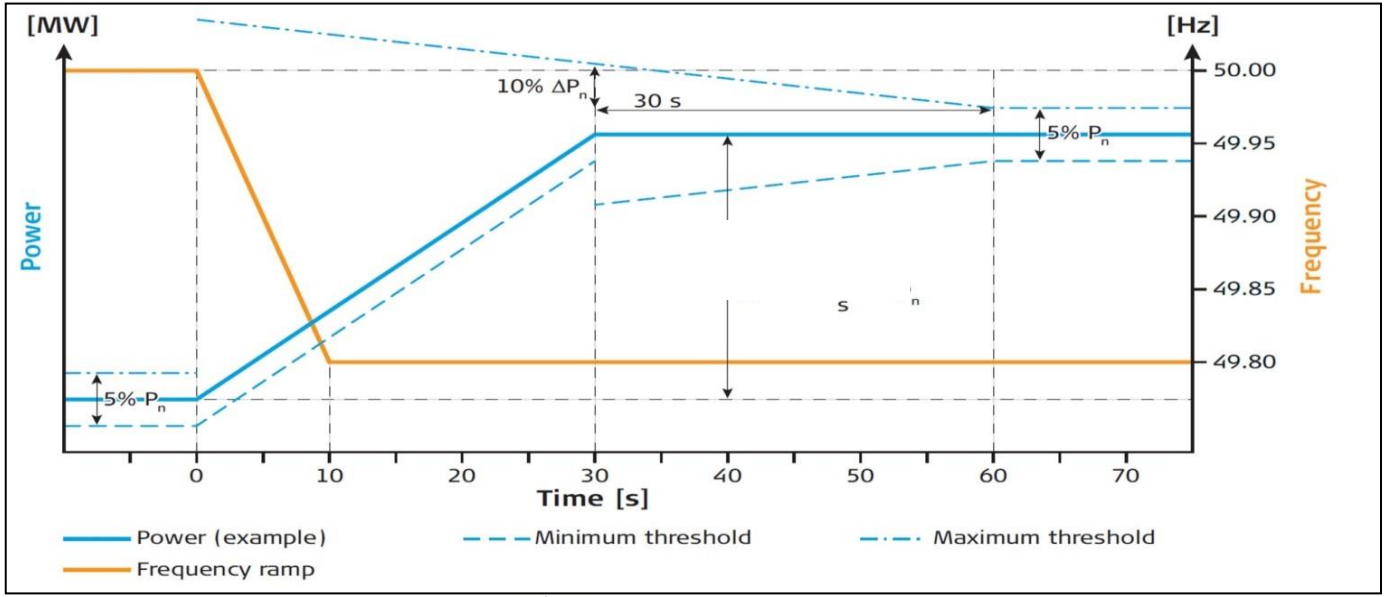
Example primary control (FCR=Frequency Control reserve) Switzerland



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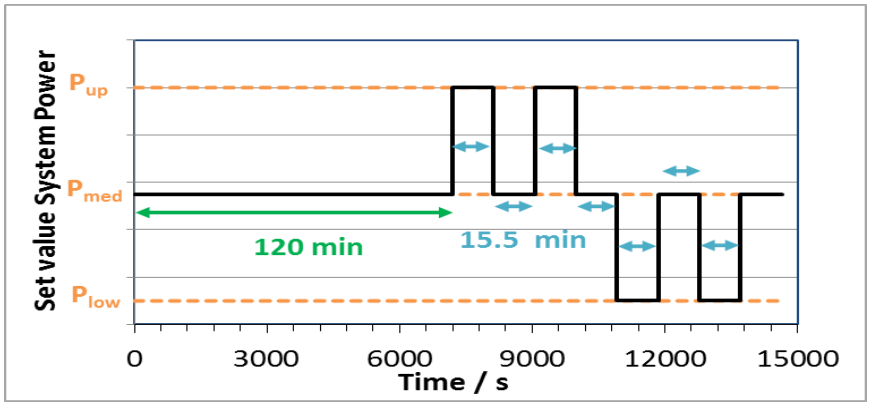
Test protocols for electricity grid services

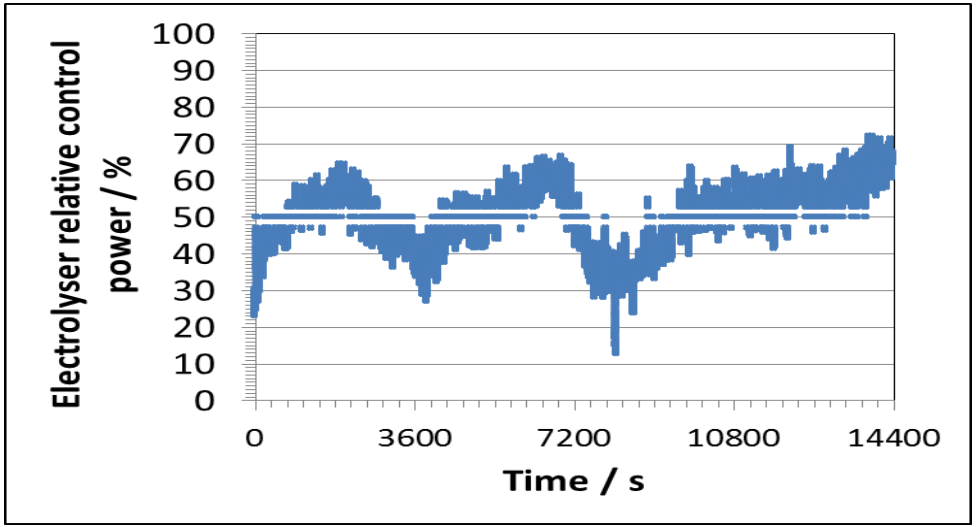
Protocols draft worked out for FCR, aFRR, mFRR, RR, both positive and negative. Being experimentally verified for AEL and PEMEL

Example: FCR testing Protocol

Protocol first test



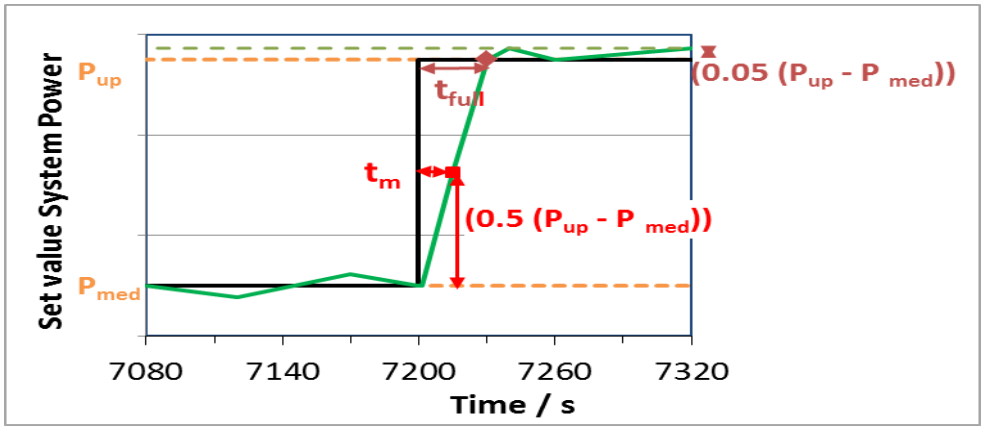
Protocol second test



Test protocols for electricity grid services

Example: FCR testing Protocol

Data evaluation



Test protocols verified and electrolyzers qualified

ITM 35 kW PEM electrolyzer operated at DTU

Hydrogenics 50 kW PEM electrolyzer operated at DLR

NEL 300 kW alkaline electrolyzer operated at NEL

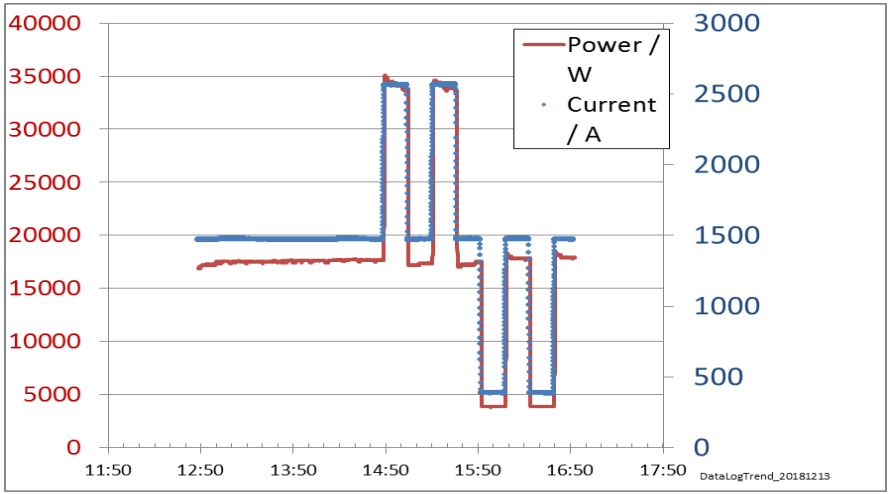
IHT 25 kW alkaline electrolyzer at FHA

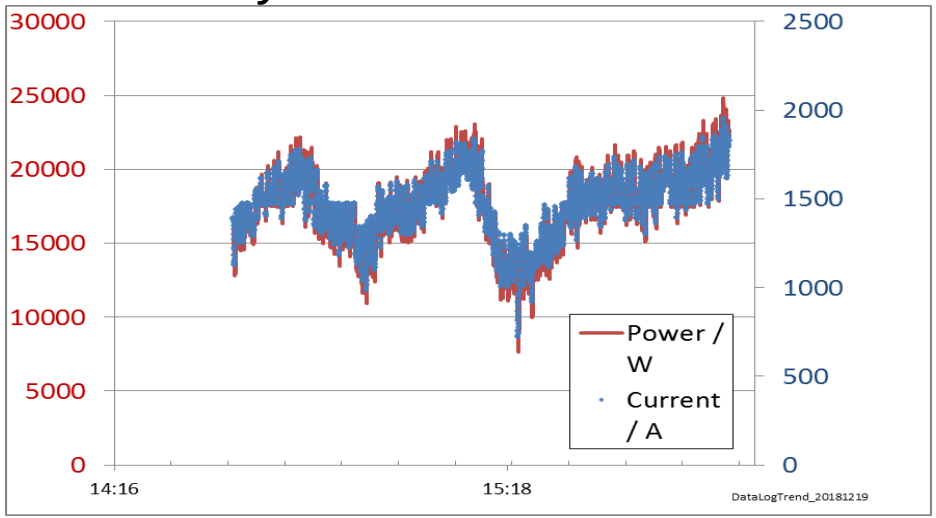
IHT 120 kW electrolyzer at IHT

Test protocols for electricity grid services

Example: FCR testing Protocol

Experimental verification 50 kW PEM electrolyser test at DLR





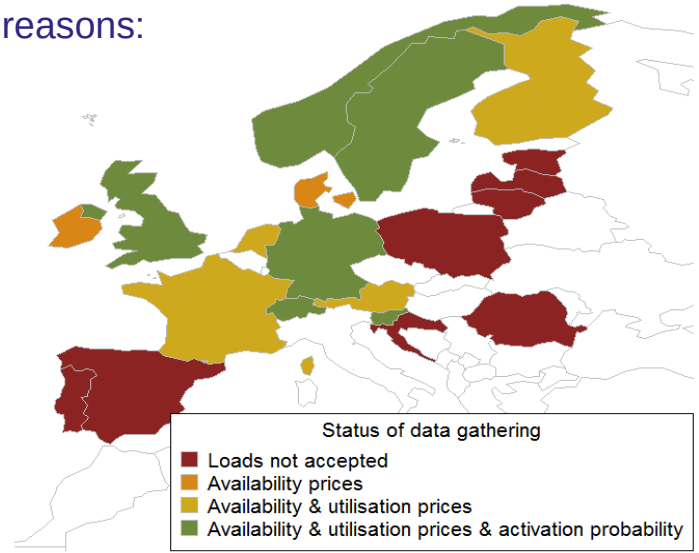
Test protocols verified and electrolyzers qualified

- Typically today electrolyzers current controlled. Grid services require power control → adaptation necessary but possible
- The stack's performances of PEMWE passed the FCR tests
- First dynamics tests of alkaline electrolyzer system performed: variations in few seconds possible
- Inclusion of total system power (including BOP) into grid service test to be discussed respectively depending on system setup and electrical connection

Economic analysis

- Grid services products in Europe more or less all fit in the same categories (FCR, FRR, RR), but their exact characteristics (including remuneration) vary from one country to another.

- A survey was sent to European TSO to get the exact picture
  - 30 countries with approx. 140 services, 58 candidates fulfilling minimum requirements
  - Exclusion of approx. 80 services for the following reasons:
    - Non-rotating mass not allowed
    - Load not allowed
    - Survey not answered (except France and UK)



Followed methodology

Analysis of grid services remuneration (2 possible components: price for availability & price for utilization) ➔ To be published soon…

Multi-criteria analysis (main criteria considered: interest of grid service, electricity prices, RES potential, H_2 market) to identify the countries which are the most likely to offer positive business case

2 promising countries with 7 grid services

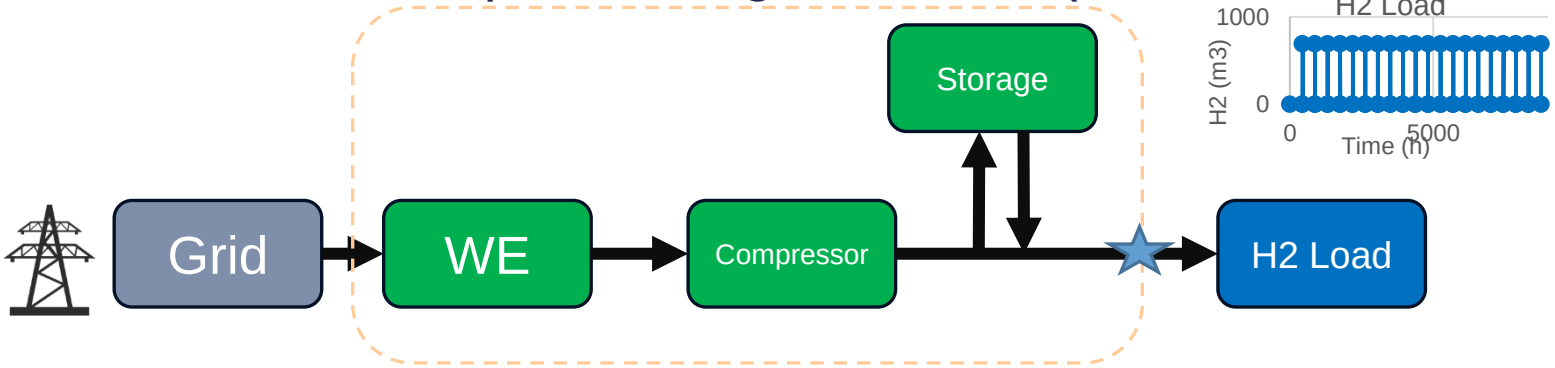
- Germany, aFRR+, aFRR-, mFRR+, mFRR- and FCR
- Norway, mFRR+ and mFRR-

2 potential profitable business cases today selected with industrial partners:

- Industry with a constrained demand of process-hydrogen (the on-site-production is economically advantageous over supply of centrally produced H_2)
- Distributed hydrogen fuelling station

Example of business case we are planning to analyze

- Germany, today, WE to meet a **variable** H_2 load for an on-site HRS+ to provide 1 grid service (FCR or aFRR)



Input assumptions
Electricity prices
Germany in 2017
+FCR/aFRR prices 2017

Tech/Eco assumptions for system components
Data of 2017 FCH-JU as basis

Key indicator considered : levelized cost of H_2 supplied (LCOH)

Summary:

- First drafts of testing protocols for water electrolyzers performing grid services are available
- Experimental verification in progress
- Second draft, experimental verification, final version for standard
- Economic analysis of selected cases

Interested in evaluating our testing protocols? Get in contact with us!

Thank you

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