Hydrogen Electrolysis – Powered by Danfoss







EFFICIENCY

(most important parameter – apart from the electricity cost)

- DC quality (Low ripple values, important for electrolyzer)
- AC quality (Low THD, less current in transformer and cables)
- Part-load operation

GRID CONNECTION

(important for the future smart electrical grid)

- Grid code compliance (de-risk project)
- Total Harmonic Distortion (no extra filters)
- Reactive power (decreased need to install new grid, control voltage)

INSTALLATION COST & TIME

(How the converter influences cost-drivers for the site)

- Compact converter leaves small footprint (no external filters)
- Modular design (ease of quick installation)
- Liquid cooling (revenue stream for district heating)
- Back-channel cooling (low cost, no air conditioning)

UPTIME & AVAILABILITY

- Quality
- Robust
- Environment

MAINTENANCE

- Spare parts
- Excludes one unit
- Easy replacement



COS

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Cti

produc

H2



Transmission system operator is responsible for providing ancillary services:







Comparison of different PSU system architecture: **IGBT vs. SCR solution**



MV/LV Transformer

- Voltage transformation
- Galvanic isolation

Active Front End

- Convert AC to DC
- Harmonic mitigation
- Reactive power comp.
- Power factor correction

Electrolyzer



StatCOM

- Reactive power compensation
- Harmonic mitigation

MV/LV Autotransformer

- Pre-adjustment AC volt.
- Voltage transformation
- Galvanic isolation

SCR/Thyristor rectifier Convert AC to DC

Electrolyzer





THDi >35%

Functionality of the balancing services





Balancing services

Types of grid balancing services, which the TSO may acquire to secure a stable and safe operation of the grid:

Balancing services: Inst. Reserve, 1st/2nd balancing capacity

FFR = Fast Frequency Response FCR = Frequency Containment Reserve FRR = Frequency Restoration Reserve aFRR = Automatic Frequency Restoration Reserve mFRR = Manual Frequency Restoration Reserve

Max time to activate	Minimum duration	Min. aggregated bid size	Average historic prices (2019-2020)		
Ō	X	4	\$		
1 sec.	10 sec.	0.3 MW	27.000 €/MW/month (availability)		States. FFR
50% 5 sec. 100% 30 sec.	15 min.	0.3 MW	6.700-13.000 €/MW/month. (availability)		FCR-D
150 sec.	60 min.	0.3 MW	13-20.000 €/MW/month (availability)		FCR-N
5 min.	60 min.	1 MW	NA	NA	aFRR
15 min.	60 min. (15 min. ≈ 2024)	5 MW (1 MW ≈ 2024)	4000-6700 /MW/month (availability)	Up: 133 Down: 27 €/MWh (energy)	mERR





ENGINEERING TOMORROW

Functionality of the balancing services



Example (Business Case FFR)

- Only H2 production
- 5MW electric

CAPEX: no additional costs on BOP (~80k€ for frq.measurement, trading SW/spec.) OPEX: no additional costs

Estimated Revenue from FFR: pessimistic: 15k€/MW/month → 900k€/y

Time

