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Grid Services as Byproducts of a Water Electrolyser

- Assessment of promising grid services considering the electrolyser size and features as well as the possible end uses of hydrogen
- The goal is to decrease the production costs of hydrogen
- TSO grid services are considered

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General Approach

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1. Select suitable grid-service (GS) products:
   - Goal: Find GS-products that are likely to reduce H_2 production costs significantly

2. Analyse today's typical WE applications:
   - Goal: derive constraints for water electrolyser operation!

3. Formulate reasonable strategies for grid services operations
   - Goal: reduce electricity costs
   - Considering 4 power reserve grid service products (1 in Norway, 3 in Germany)

4. Calculate the LCOH for all grid service products
   - Goal: Make costs comparable to identify savings as a result of each grid service offering

Select Suitable Grid-Service Products

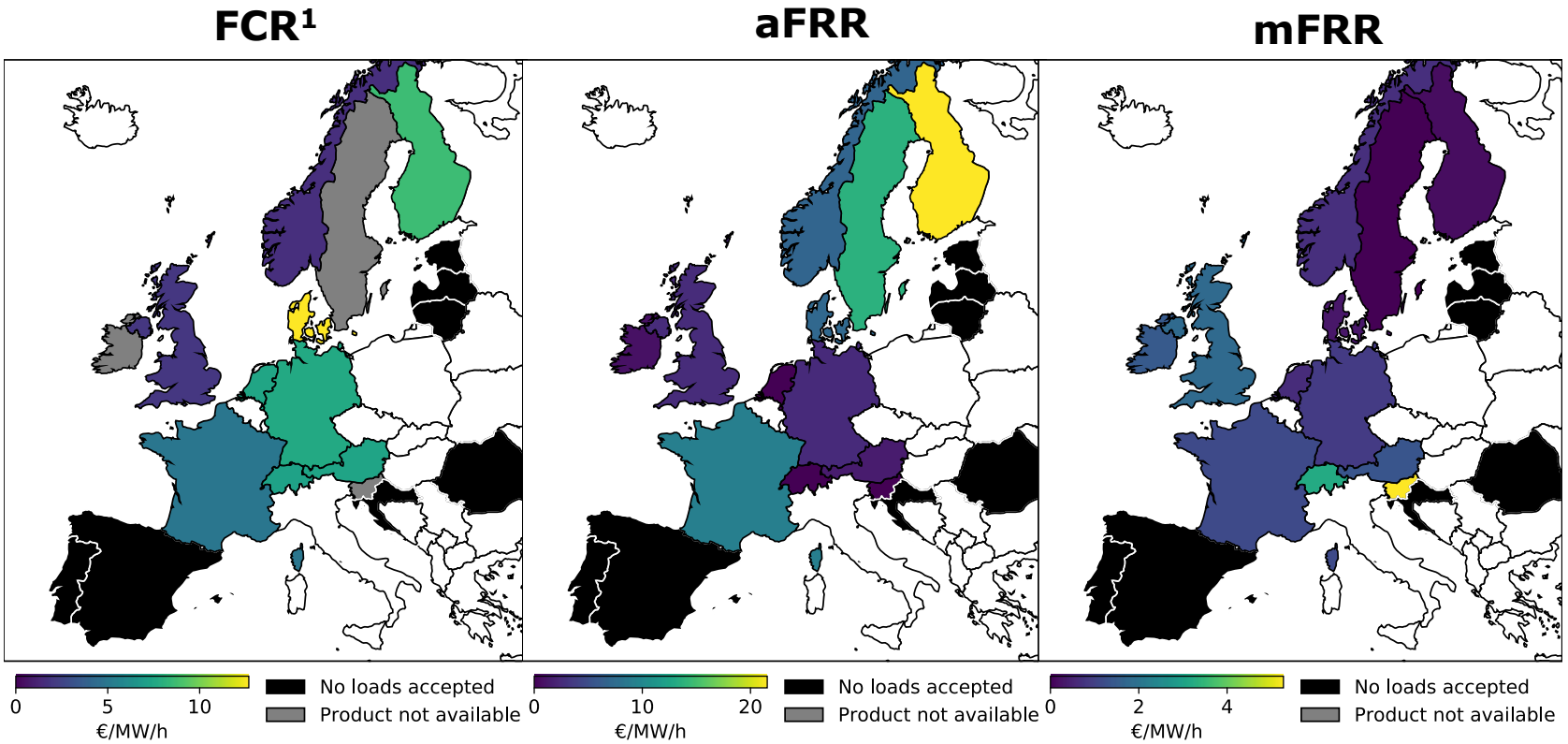

Figure: Survey results (average availability prices of 2016)

Based on GS prices, power prices and predicted H_2 demand, following GS were selected for further assessments:

- Germany: **aFRR**
- Germany: **mFRR**
- Germany: **FCR**
- Norway: **mFRR**

[1]Where FCR-N and FCR-D were available, FCR refers to FCR-N

Today's Typical WE-Applications

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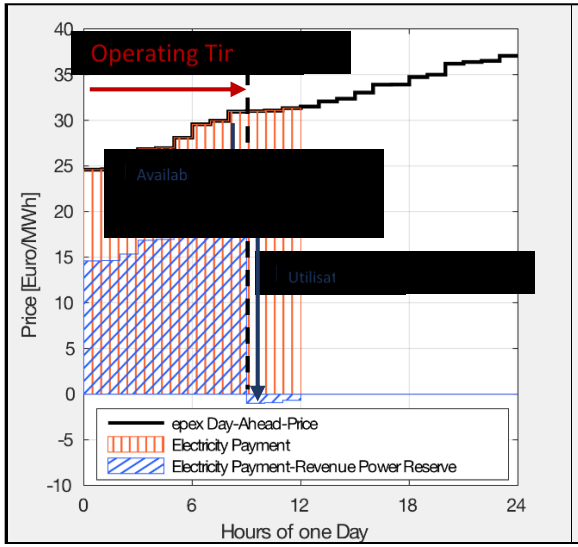
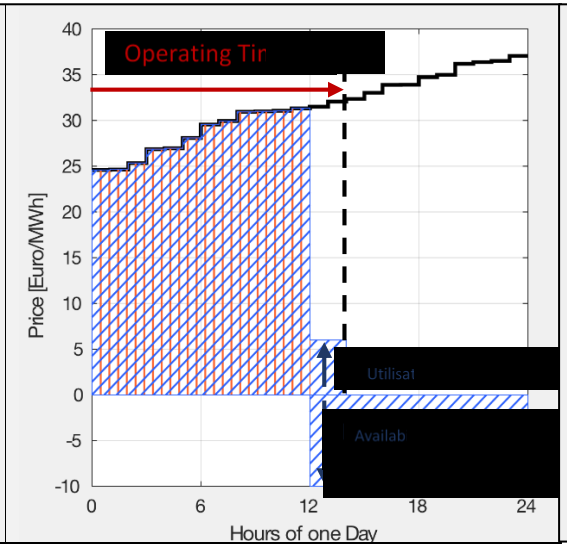
	A Industry with Constant Demand of Process-Hydrogen	B Industry with "Unconstrained" Demand of Electrolyser-H2	C Distributed Hydrogen Fuelling Station	D Power to Gas connected to the Natural Gas-Grid
Economical Reasoning	On-site production economically advantageous over the supply of centrally produced H_2	No economic justification other than PR. Unless we give PR a value.	On-site production economically advantageous over the supply of centrally produced H_2	Revenue: Gas-Price Not regarded as being profitable in the mid-term!
Full Load hours	CAPEX predominate cost factory: Dimensioning for +/- 8000 FLH		Due to the fluctuating character of H_2 demand: oversized electrolyser +/-4500 FLH	
Storage-Assumptions	H2-Storage due to fluctuations: 24h-Storage		Due to the short-term H2 demand fluctuations: 24h-Storage	

Formulate Reasonable Strategies for Grid Services Operations

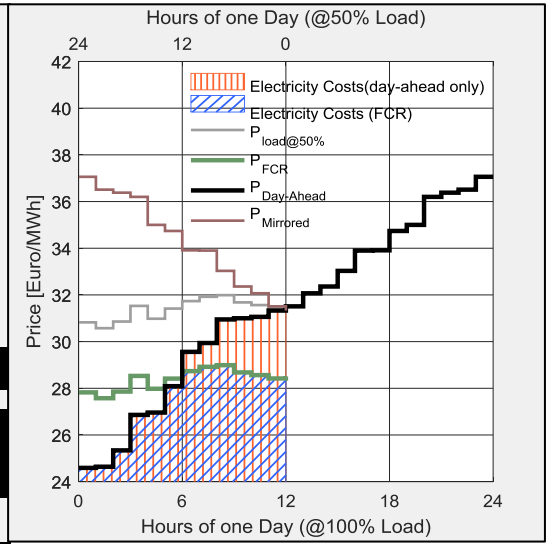
Asymmetric positive (FRR+)



Asymmetric negative (FRR-)



Symmetric (FCR)



Example of one day and an electrolyzer operating 12h/day (4380 full load hours)

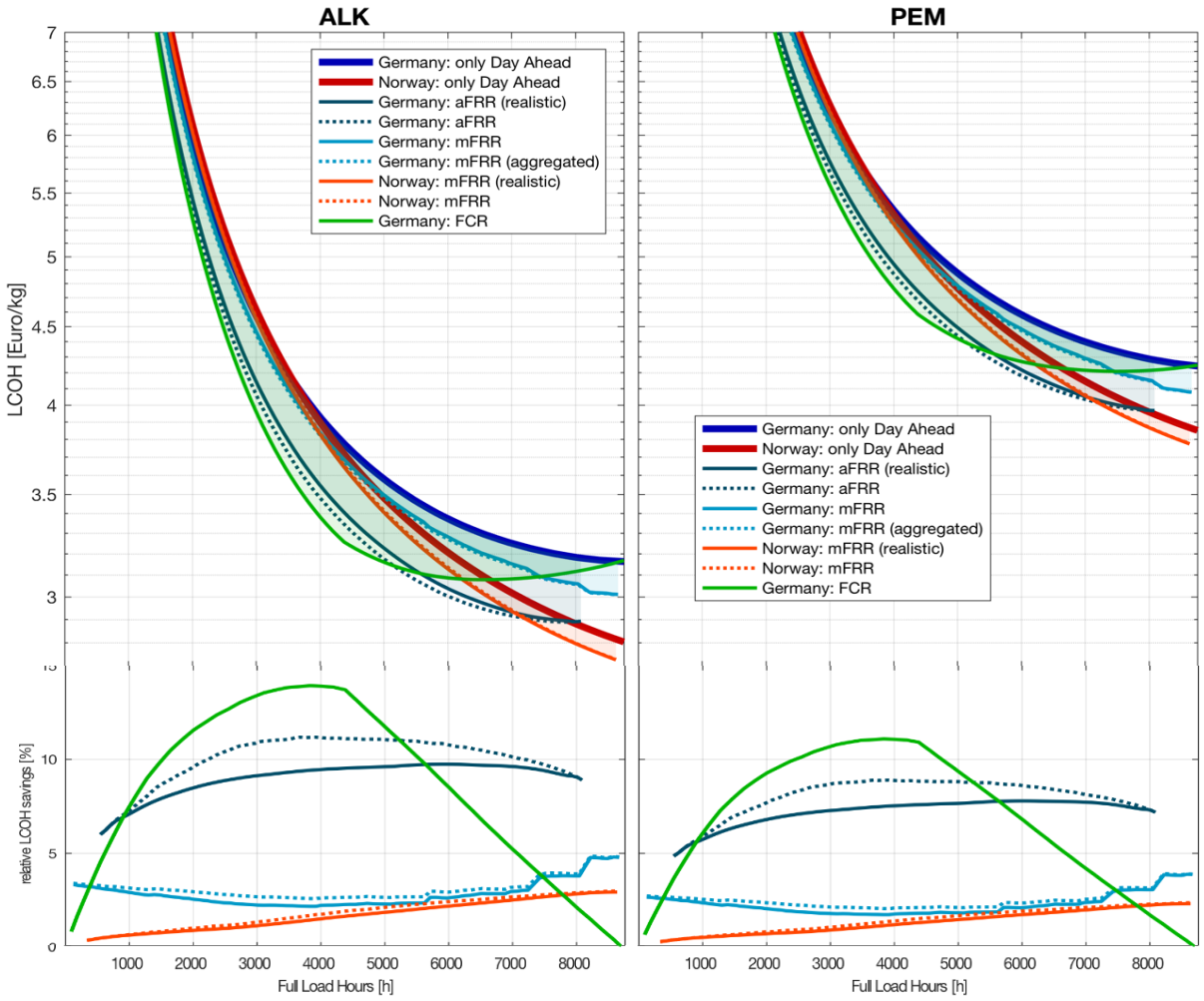
Calculate The LCOH For All Grid Service Products

	Alkaline (ALK)	PEM
Nominal Power	1 MW	
Maximal Power	1 MW	
Maximal Power (Positive Sensitivity)	1 MW	2 MW
Power Consumption	58 kWh_e/kg	63 kWh_e/kg
Lifetime - System	20 Years	
Stack - Lifetime	80'000 h	40'000 h
Degradation	not considered	
CAPEX - System	1'200 €/kW	1'500 €/kW
CAPEX - Stack replacement	420 €/kW	525 €/kW
OPEX	4 %/CAPEX	
Weighted average cost of capital (WACC)	8%	

Table 1: Assumptions [1]

- Electricity costs based on the strategies introduced prior were calculated using historical prices (2016,2017) [2],[3],[4].
- Electricity costs have been added to the assumptions in the table for both the Alkaline and PEM WE types. As a result, the levelised costs for hydrogen (LCOH) have been calculated for different full load hours scenarios.
- To calculate savings due to grid services, a base-case scenario is introduced. The underlining assumption of this scenario is, that the WE purchases the electricity at the day-ahead market during lowest price hours for each day.

Results



Conclusions

LCOH-Savings up to:

- 11-13% due to FCR (Germany)
- 7-9% due to aFRR (Germany)

Limitations

Due to following reasons, the results might show an overly optimistic picture:

- Splitting of revenues between WE and aggregator
- Temporal splitting of contracts reduce the revenues further
- Reliability of WE-load
- Stand-by power consumption
- …

Questions?

References

[1] TRACTEBLE; engie; Hinicio, "STUDY ON EARLY BUSINESS CASES FOR H2 IN ENERGY STORAGE AND MORE BROADLY POWER TO H2 APPLICATIONS," FCH, 2017.

[2] EPEXSPOTAUCTION, "MARKTDATEN, DAY-AHEAD-AUKTION,," 21 9 2018. [Online]. Available: https://www.epexspot.com/de/marktdaten/dayaheadauktion.

[3] Nordpool, "Nordpool: Historical Data," 22 1 2019. [Online]. Available: https://www.nordpoolspot.com/historical-market-data/.

[4] Bundesnetzagentur, "SMARD Strommarktdaten," 21 9 2018. [Online]. Available: https://www.smard.de.