

## 9th Conference on the Regulation of Infrastructures

Florence School of Regulation

# The value of avoided curtailments - Increasing welfare through the involvement of transmission system operators (TSOs) in the operation of power-to-hydrogen units

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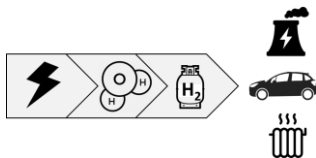
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- Increasing renewable curtailments due to grid congestions
- Reduction of curtailments offered by 'sector coupling' technologies e.g. Power-to-hydrogen (PtH<sub>2</sub>)

Power-to-hydrogen (PtH<sub>2</sub>):

- Electricity is used to produce the energy carrier hydrogen
- Pilot project stage – market-based operation is not profitable



- TSOs have full information about grid flows and balancing needs. However, vertical unbundling rules forbid them to operate both generation and conversion units.
- **Shared operation of PtH<sub>2</sub> units might offer opportunities for both market participants and TSOs**

Can the involvement of TSOs in the production of hydrogen open up business cases for PtH<sub>2</sub> units and lead to welfare gains due to avoided curtailment costs?

## Consecutive combination of two tools:

### 1. Step - Electricity market model

- Day-ahead market
- Cost-minimizing market dispatch
- High level of technical details (e.g. Storage, operational constraints, CHP & district heating)

➔ **Result: hourly dispatch and day-ahead price of uniform market zone, no grid constraints**

*Market dispatch might technically not be feasible due to technical grid constraints*

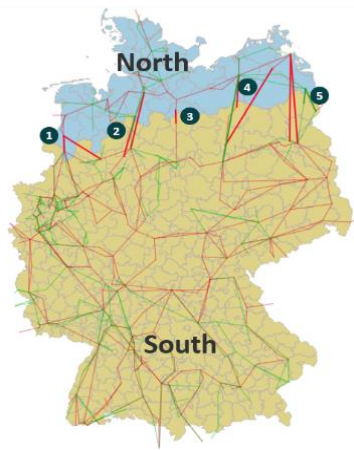
### 2. Step – Congestion management model

- DC power flow (PTDF – matrix)
- Location of the generations and the loads
- Technical constraints of transmission system
- Cost-minimizing resolving of grid congestions

➔ **Result: Redispatch & curtailment actions**

## Case: Germany in year 2022

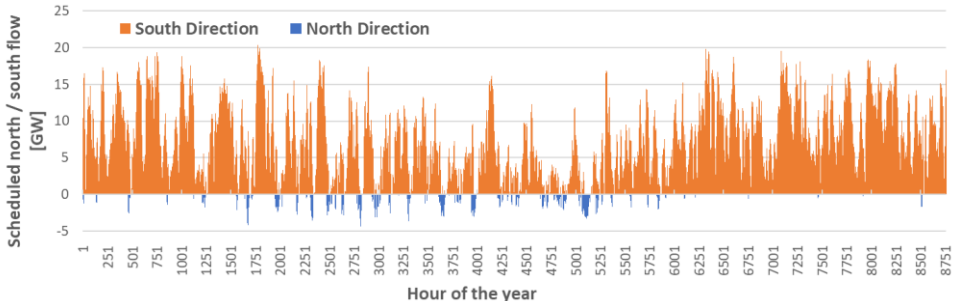
- 37% renewables in 2018
- Curtailments of 5.4 TWh in 2018 (tripled in 4 years)
- Compensation of 635 million € for unused electricity
- ~6.7 ct/kWh levy for compensation of renewables
- Grid expansion delayed: missing public acceptance and administrative burdens



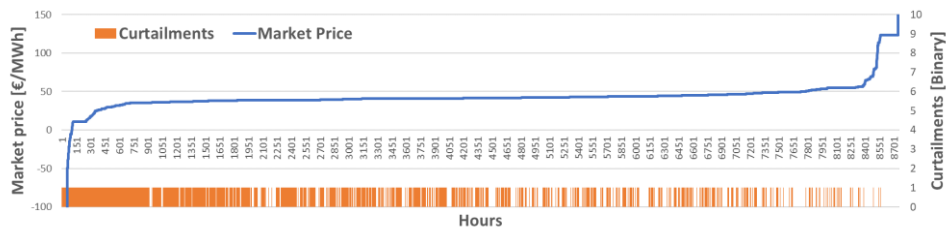
# Model results - Horizon 2022 (1/2)



## 1. Step – Day-ahead market dispatch: Significant scheduled north/south flow



## 2. Step – Curtailment actions: Positive correlation of market price and curtailments



# Model results - Horizon 2022 (2/2)

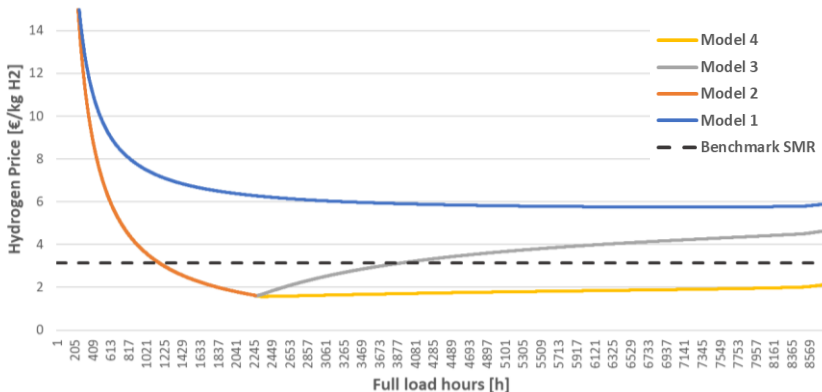
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- 1 Model - Fully market-based operation**
- Market-participant owns and operates PtH<sub>2</sub> unit
  - Private investment WACC
  - Market price + charges for levies, taxes and tariffs

- 2 Model - Fully system-based operation**
- TSO owns and operates PtH<sub>2</sub> units
  - Public investment WACC
  - Only curtailed electricity as PtH<sub>2</sub> feed at zero cost
  - No charges for levies, taxes and tariffs

- 3 Model - Combined operation / current market-conditions**
- TSO owns PtH<sub>2</sub> units → Public investment WACC
  - TSO priority operation (only curtailments + no charges)
  - Market-participant supplementary operation (electricity from market + charges for levies, taxes and tariffs)

- 4 Model - Combined operation / relaxed market-conditions**
- TSO owns PtH<sub>2</sub> units → Public investment WACC
  - TSO priority operation (only curtailments + no charges)
  - Market-participant supplementary operation (electricity from market + No charges for levies, taxes and tariffs)



## The assessment of different business model showed that ...

... a relaxation of regulations can lead to welfare gains and to a production of competitive hydrogen

... the involvement of TSOs is key to maximize the competitiveness of PtH<sub>2</sub> units that leads to welfare gains

...The use of otherwise curtailed electricity could help to foster the market introduction of PtH<sub>2</sub> and a hydrogen economy that might be required in coming years to better integrate renewables and to meet climate objectives.

## Obtained insights suggest that:

- The relaxation of vertical unbundling rules on regulatory sandboxes should be put on the agenda
- Sharing responsibilities between 'public' and private sector opens up new opportunities

## Limits and further work:

- Lack of flexibility provision in the system → integration of neighbouring countries
- PtH<sub>2</sub> is a price taker that do not have impacts on the electricity price → Endogenous operation of PtH<sub>2</sub>
- Unity capacity analysis does not provide insights on the magnitude of capacity → Endogenous PtH<sub>2</sub> sizing

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# Thank you

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