Spatial flexibility in redispatch:

Supporting low carbon energy systems with Power-to-Gas

16th and 17th Dec. 2020: 78th Semi-annual ETSAP workshop

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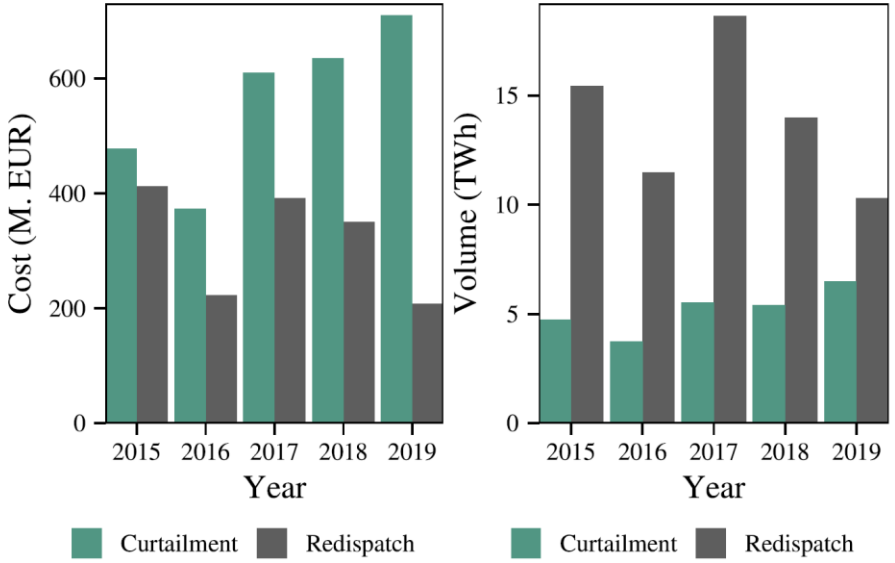
https://doi.org/10.1016/j.apenergy.2020.116201

Motivation

Rising congestion management costs due to RES integation



Motivation

From problem identification to our research contribution

Problem

- Historically centralised and fossil fuel-based power generation
- Decentralised and intermittent RE electricity generation is challenging
- System Operators need to curtail vast amount of RE electricity in order to maintain a stable grid

Idea

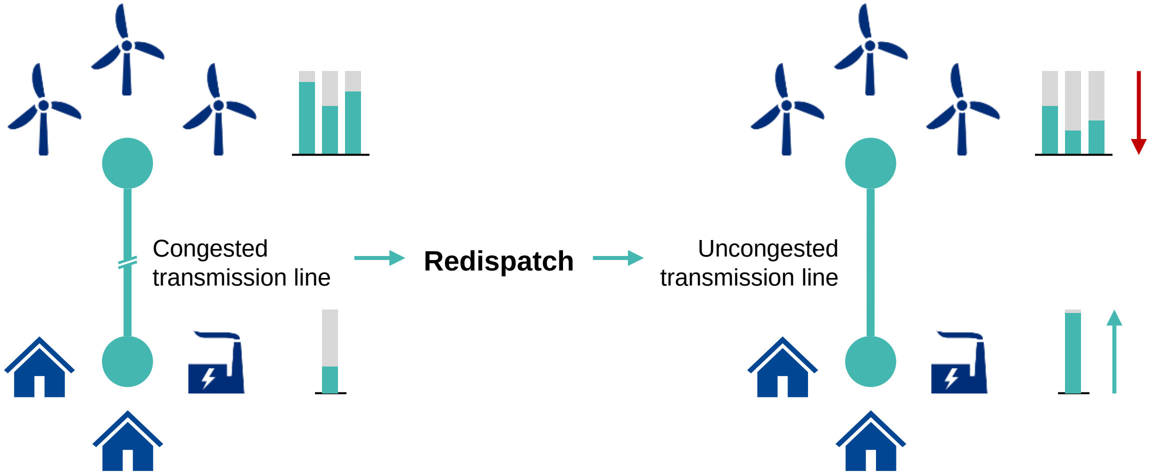
- Making use of already existing infrastructure may help to support other energy sectors
- Power-to-Gas can be used to shift energy from the electricity towards the gas sector
- System operator can use PtG in order to reduce curtailment during redispatch

Research & contribution

- **To what extent can PtG provide flexibility in redispatch?**
- **Which factors drive SNG production when PtG is used to reduce curtailment and redispatch volumes?**

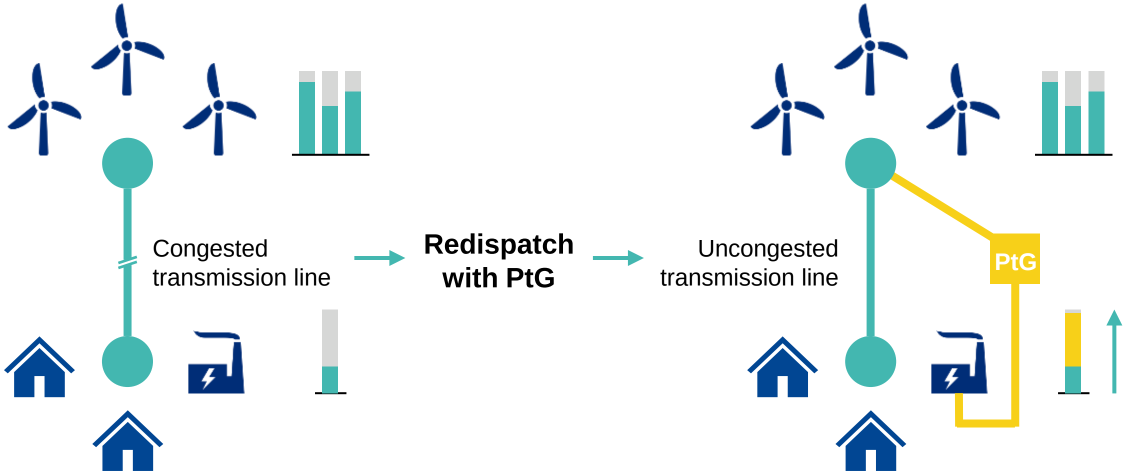
Methodology

Redispatch explained



Methodology

Redispatch enhanced by Power-to-Gas



Methodology

Two-stage model approach

Spot market

Model one: Day-ahead economic dispatch
- Copper plate
- Ramping
- Merit order

$$\min_{P^{DA}_{g,t}} \sum_t \sum_g c^{mc}_g P^{DA}_{g,t}$$

c: Cost parameters
P: Generation variables

Sets
t in T: Set of hours
g in G: Set of generation units
e in G: Subset of GfG units
r in R: Set of renewables
n in N: Set of nodes

Transmission grid + PtG

Model two: Congestion management
- Transmission constraints
- Redispatch of conventional power plants
- Curtailment of RE units

$$\min_{\Delta P^+_{g,t}, \Delta P^-_{g,t}, E_{g,t}} \sum_t \sum_n \Bigg[\sum_g \Big(c^{mc}_g \Delta P^+_{g,t} + (\overline{\Psi}_t - c^{mc}_g) \Delta P^-_{g,t} \Big) + \sum_s \frac{\overline{\Psi}_t}{\eta_s} \Delta P^+_{s,t} + c^{VOLL} P^{lost}_{n,t}$$

Low capital letters: Parameters
Large capital letters: Model variables

Methodology

Two-stage model approach

Spot market

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$$\min_{P^{DA}_{g,t}} \sum_t \sum_g \mathrm{c}^{\mathrm{mc}}_g P^{DA}_{g,t}$$

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Transmission grid + PtG

Model two: Congestion management
- Transmission constraints
- Redispatch of conventional power plants
- Curtailment of RE units

- PtG + redispatch with GfG units

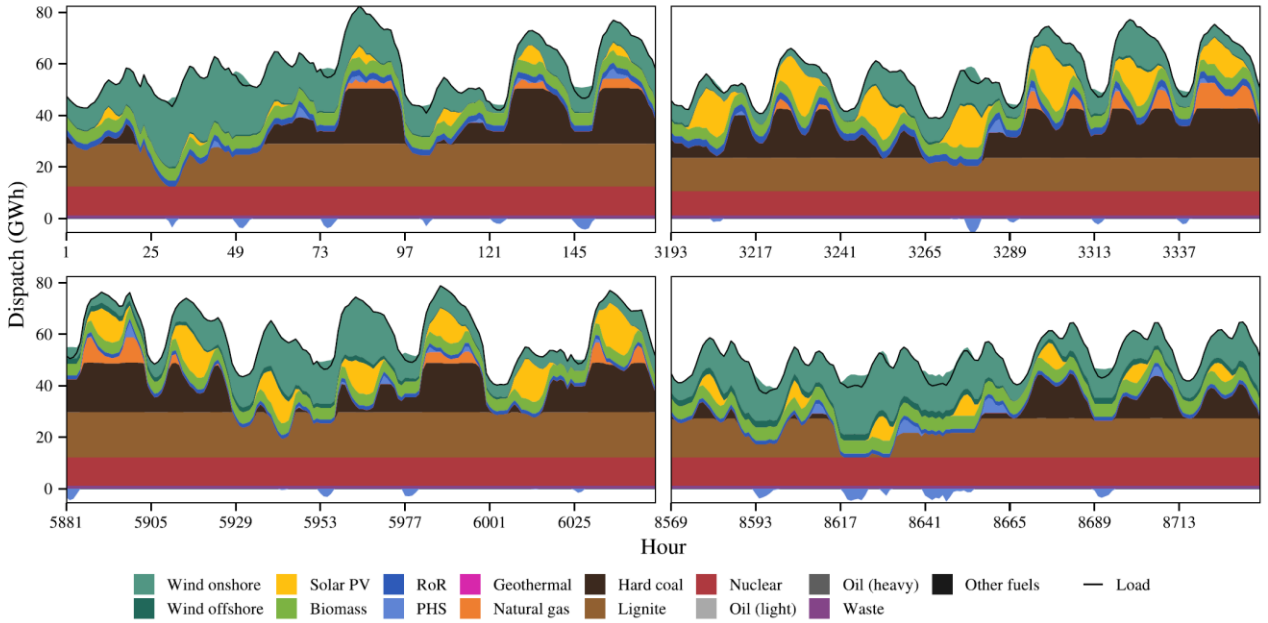
$$\min_{\Delta P^{+}_{g,t}, \Delta P^{-}_{g,t}, E_{g,t}} \sum_t \sum_n \Bigg[\sum_g \left(\mathrm{c}^{\mathrm{mc}}_g \Delta P^{+}_{g,t} + (\overline{\Psi}_t - \mathrm{c}^{\mathrm{mc}}_g) \Delta P^{-}_{g,t} \right) + \sum_s \frac{\overline{\Psi}_t}{\eta_{\mathrm{S}}} \Delta P^{+}_{s,t} + \mathrm{c}^{\mathrm{VOLL}} P^{lost}_{n,t} + \sum_r \frac{\overline{\Psi}_t}{\eta_{\mathrm{E}} \eta_{\mathrm{M}}} D^{PtG}_{r,t} + \sum_r \mathrm{c}^{\mathrm{OM}}_e P^{PtG}_{e,t} \Bigg]$$

PtG

Low capital letters: Parameters
Large capital letters: Model variables

Model results

Economic dispatch: Four exemplary weeks



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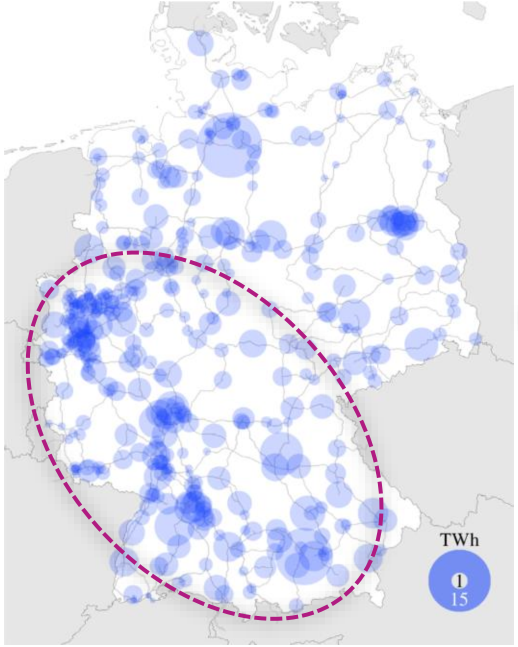
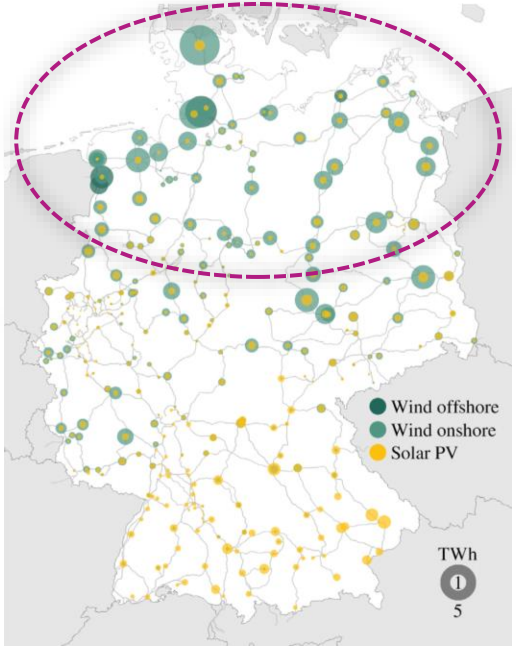
Model results

Imbalanced distribution of load and supply call for redispatch measures



Annual load

+



Annual RES generation

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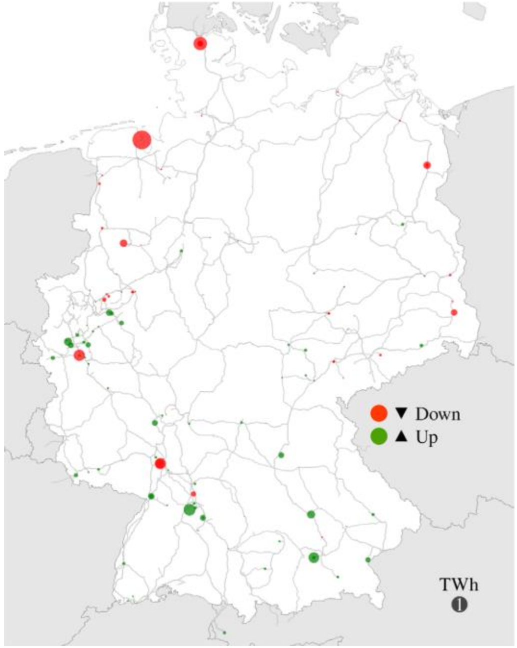
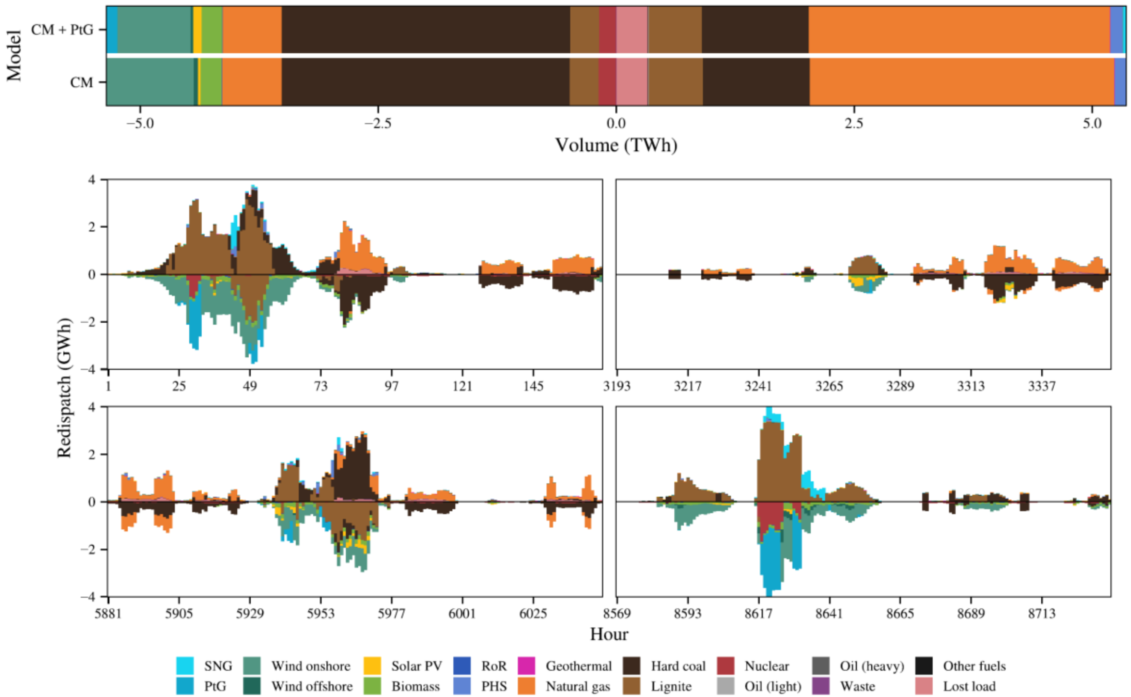


Annual redispatch

Model results

Imbalanced distribution of load and supply call for redispatch measures



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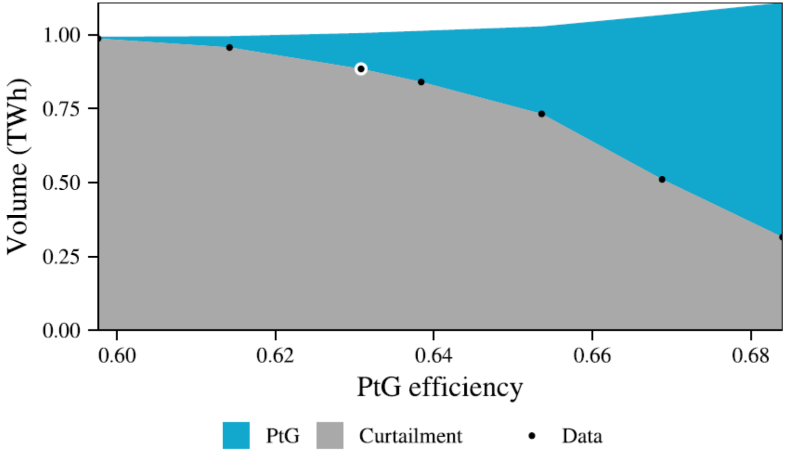
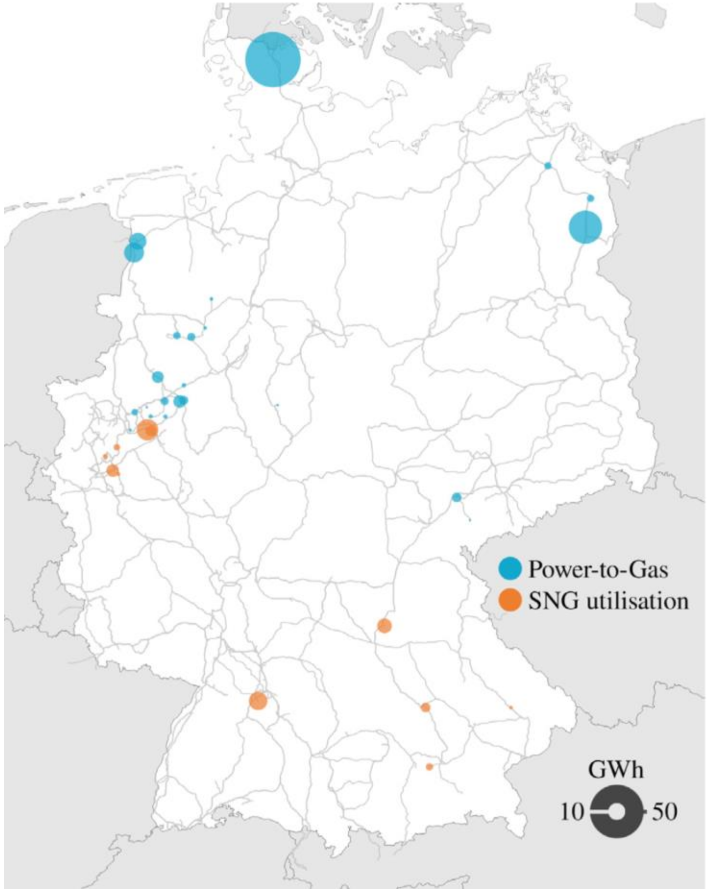
Model results

Power-to-Gas usage naturally reduces curtailment

Sensitivity analysis on varying PtG efficiency





Conclusion

PAPER HIGHLIGHTS

- Power-to-Gas can shift pressure from electricity to gas infrastructure.
- The utilisation of Power-to-Gas in redispatch reduces curtailment by 12%.
- Based on 427 analysed node, 5 nodes show a high potential for Power-to-Gas usage.
- Results are supported by ongoing projects of transmission system operators.
- The feasibility of Power-to-Gas depends on technology efficiency and the CO_2 price.

REPRODUCIBILITY

- Open access publication and open source model using Julia (JuMP) and R
- Model code under MIT licence: https://github.com/bobbyxiong/redispatch-ptg

Thanks!

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Acknowledgements

open ENTRANCE

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 835896

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