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 integration
**Motivation**

From problem identification to our research contribution

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**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

Redispatch
Methodology
Redispatch enhanced by Power-to-Gas
Methodology
Two-stage model approach

Minimize \( \sum_{t} \sum_{g} c^{mc}_{g} P^{DA}_{g,t} \)

\( c \): Cost parameters
\( P \): Generation variables

Sets
- \( t \) in \( T \): Set of hours
- \( g \) in \( G \): Set of generation units
- \( e \) in \( G_{fG} \): Subset of GfG units
- \( r \) in \( R \): Set of renewables
- \( n \) in \( N \): Set of nodes

Transmission grid + PtG

\( \min \sum_{t} \sum_{g} \Delta P^{+}_{g,t} \)

\( \sum_{t} \Delta P^{-}_{g,t}, E_{g,t} \sum_{t} \sum_{n} \left( c^{mc}_{g} \Delta P^{+}_{g,t} + (\bar{\Psi}_{t} - c^{mc}_{g}) \Delta P^{-}_{g,t} \right) \)

\( + \sum_{s} \frac{\bar{\Psi}_{t}}{\eta_{s}} \Delta P^{+}_{s,t} + c^{VOLL} P^{lost}_{n,t} \)

Low capital letters: Parameters
Large capital letters: Model variables
Methodology
Two-stage model approach

\[
\min_{P_{g,t}^{DA}} \sum_t \sum_g c_g^{mc} P_{g,t}^{DA}
\]

c: Cost parameters
P: Generation variables

Sets
\( t \in T \): Set of hours
\( g \in G \): Set of generation units
\( e \in G_\text{fG} \): Subset of GfG units
\( r \in R \): Set of renewables
\( n \in N \): Set of nodes

\[
\begin{align*}
\min_{\Delta P_{g,t}^+, \Delta P_{g,t}^-} & \sum_t \sum_n \left( c_g^{mc} \Delta P_{g,t}^+ + (\bar{\Psi}_t - c_g^{mc}) \Delta P_{g,t}^- \right) \\
& + \sum_s \frac{\bar{\Psi}_s}{\eta_s} \Delta P_{s,t}^+ + c^{\text{VOLL}} P_{n,t}^{\text{lost}} \\
& + \sum_r \frac{\bar{\Psi}_r}{\eta_E \eta_M} D_{r,t}^{\text{PtG}} + \sum_r c_e^{\text{OM}} P_{e,t}^{\text{PtG}} 
\end{align*}
\]

Low capital letters: Parameters
Large capital letters: Model variables

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Model results
Economic dispatch: Four exemplary weeks
Model results
Imbalanced distribution of load and supply call for redispatch measures
Model results

Imbalanced distribution of load and supply call for redispatch measures
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 CO2 price.

REPRODUCABILITY
• 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

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