GHG effects of load shifting on German wastewater treatment plants

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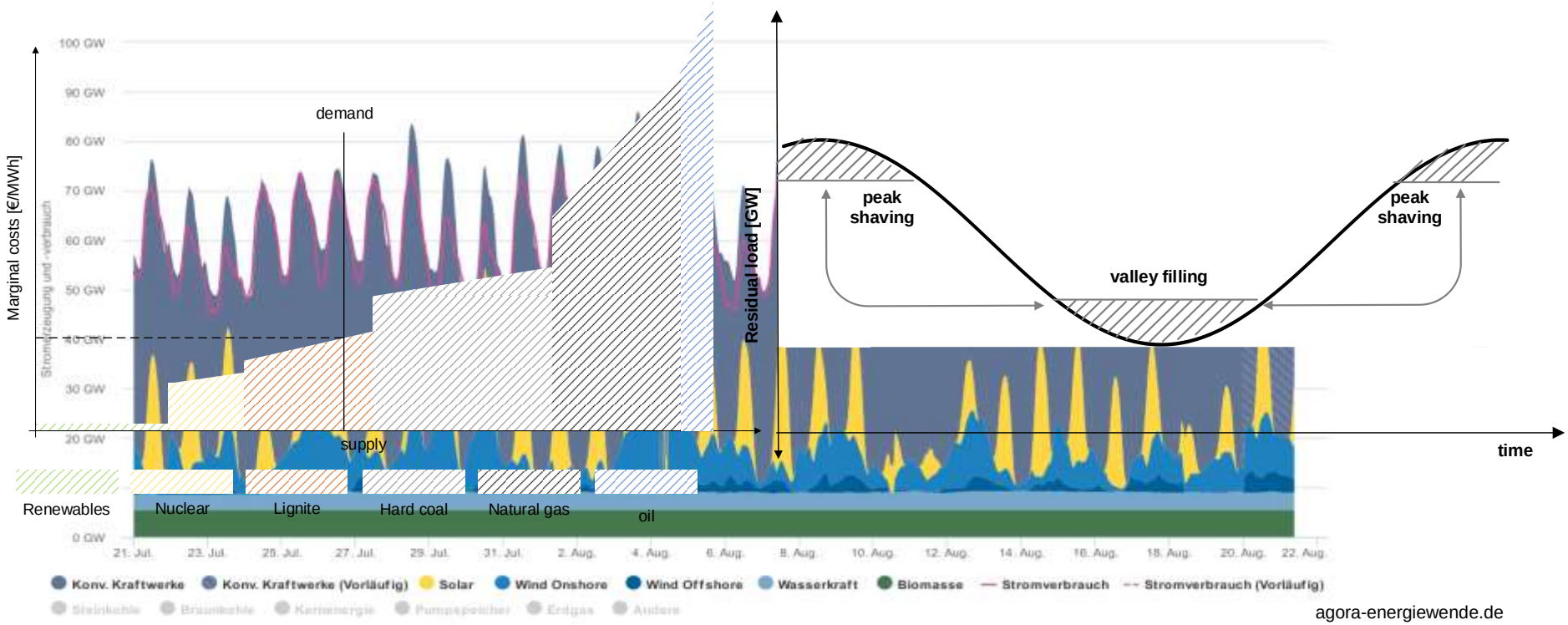
Agenda

- Introduction
- Methods
- Results
- Conclusions

Effects of integration of renewables on electricity generation



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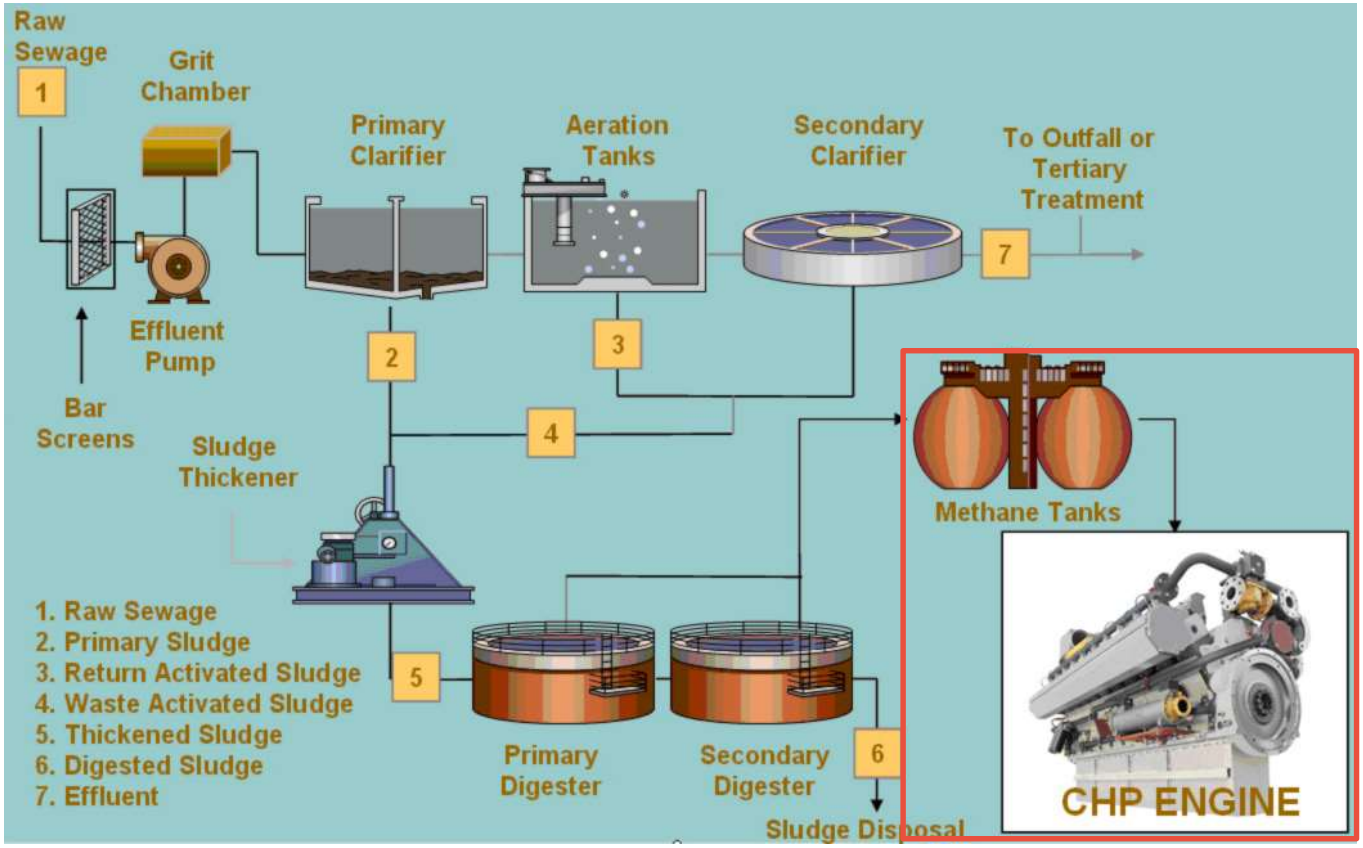
→ Expansion of renewable electricity generation needs flexibility options, i.e. load shifting

→ The use of flexibility options results in effects on costs and GHG emissions

Why wastewater treatment plants?



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Which effects does load shifting on German WWTP cause regarding costs for WWTP operators and GHG emissions in the system wide electricity generation?

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Methods

Merit Order Model (MOM) 2030

Development of a MOM for 2015 and validation

↓

Scenario transfer to 2030

Parameters
Feed-in from renewables
Costs of energy carriers
Conventional power plant fleet
Co-generation
…
..

WWTP Technical operation model

Data gathering and interpolation of model parameters

↓

Data aggregation to reference size classes

Parameters
Electricity demand
Nominal output of CHP
Electric efficiency of CHP
Volume of gas storage
…
..

Optimization of electricity supply costs and assessment of effects on costs and GHG emissions

$$Z = \sum_{t=1}^{24} (Pex_{el,t} * prex_{el,t}) \rightarrow \min.$$

Functional constraints

$$D_{el,h} = PCHP_{el,t} + Pex_{el,t}$$

$$bgstor_{el,end,t} = bgstor_{el,start,t} + bggen_{el,t} - PCHP_{el,t}$$

$$bgstor_{el,start,t} = bgstor_{el,end,t-1}$$

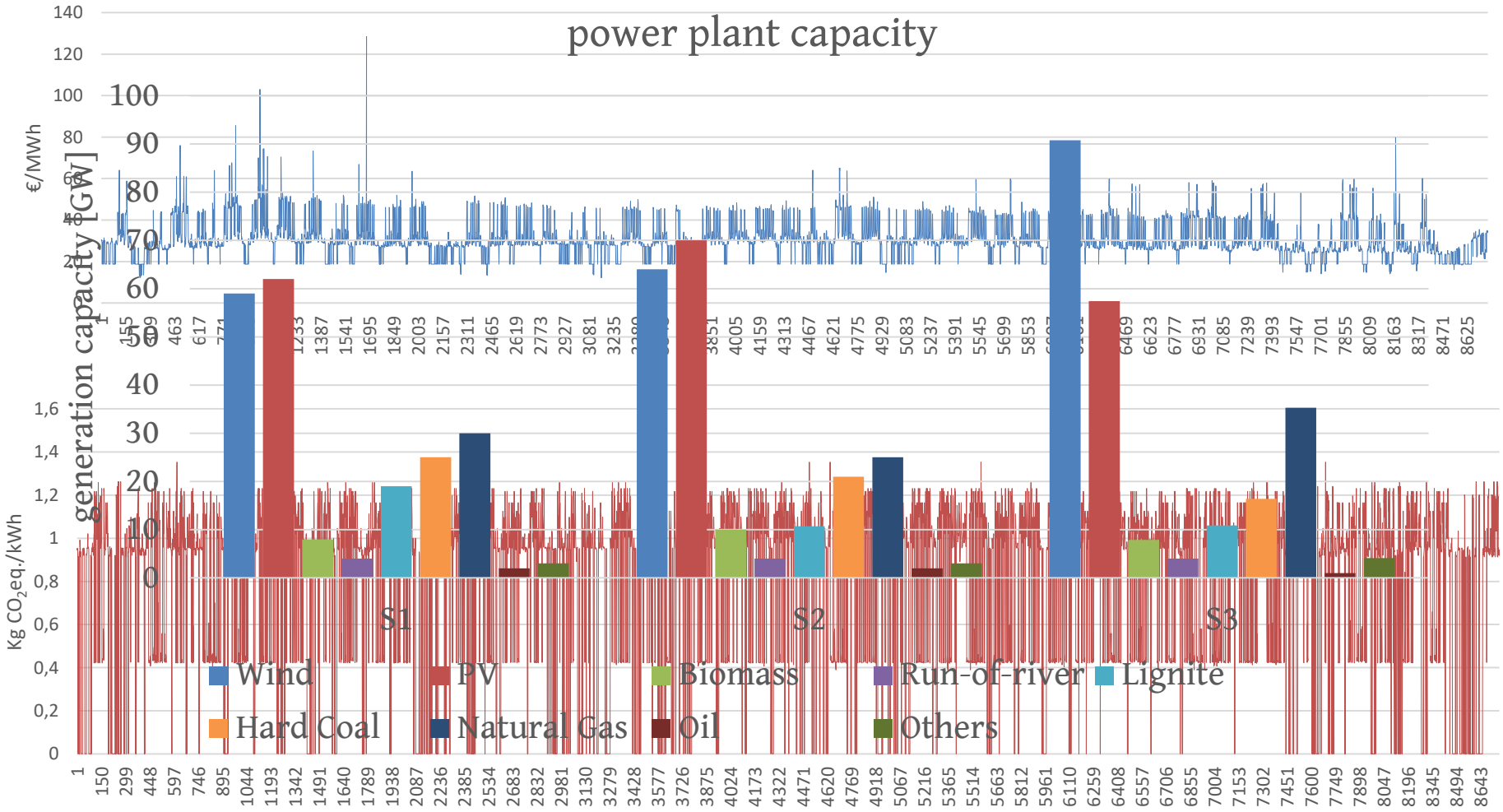
Additional constraints

$$bgstor_{el,start,t}, bgstor_{el,end,t}, PCHP_{el,t}, Pex_{el,t} \geqslant 0$$

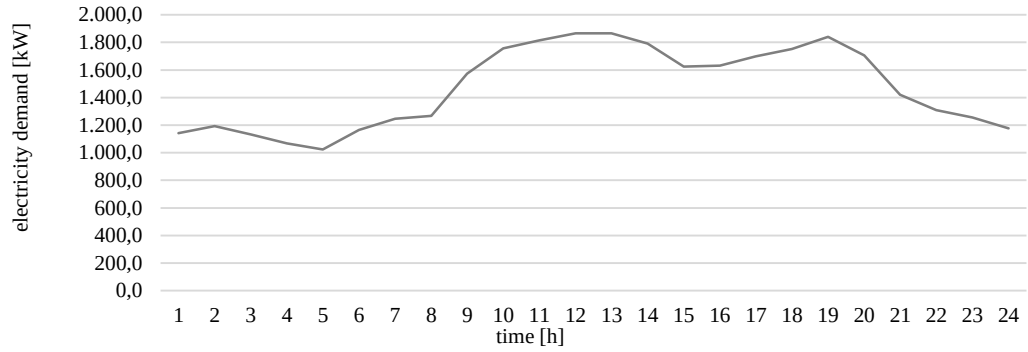
$$bgstor_{el,start,t}, bgstor_{el,end,t} \leqslant storcap_{el}$$

$$PCHP_{el,t} \leqslant CHPP_{el}$$

Methods: MOM and Scenario transfer



Methods: WWTP Technical Operation Model

Metadata			
RSC 1		>= 10,000 [PE]	<= 15,000 [PE]
number of WWTP in RSC			36
total number of inhabitants attached in RSC			367.502
Demand side			
exemplary, daily load profile			
Supply side			
electricity consumption in RSC	[kWh]		12.191.626
biogas production in RSC	[m³]		2.816.903
CHP nominal output in RSC	[kW_{el}]		1.224
biogas storage volume in RSC	[Nm³]		3.994

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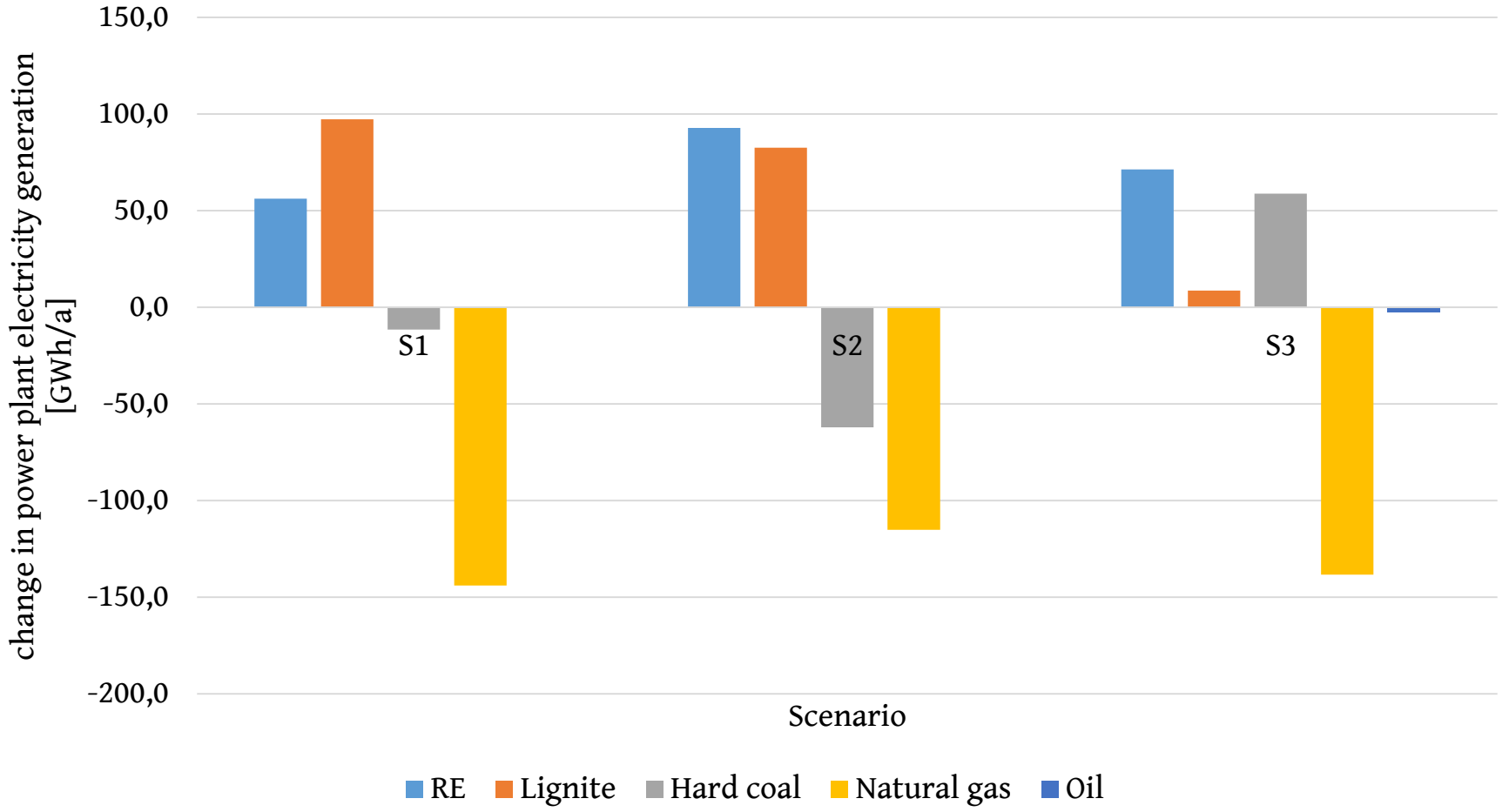
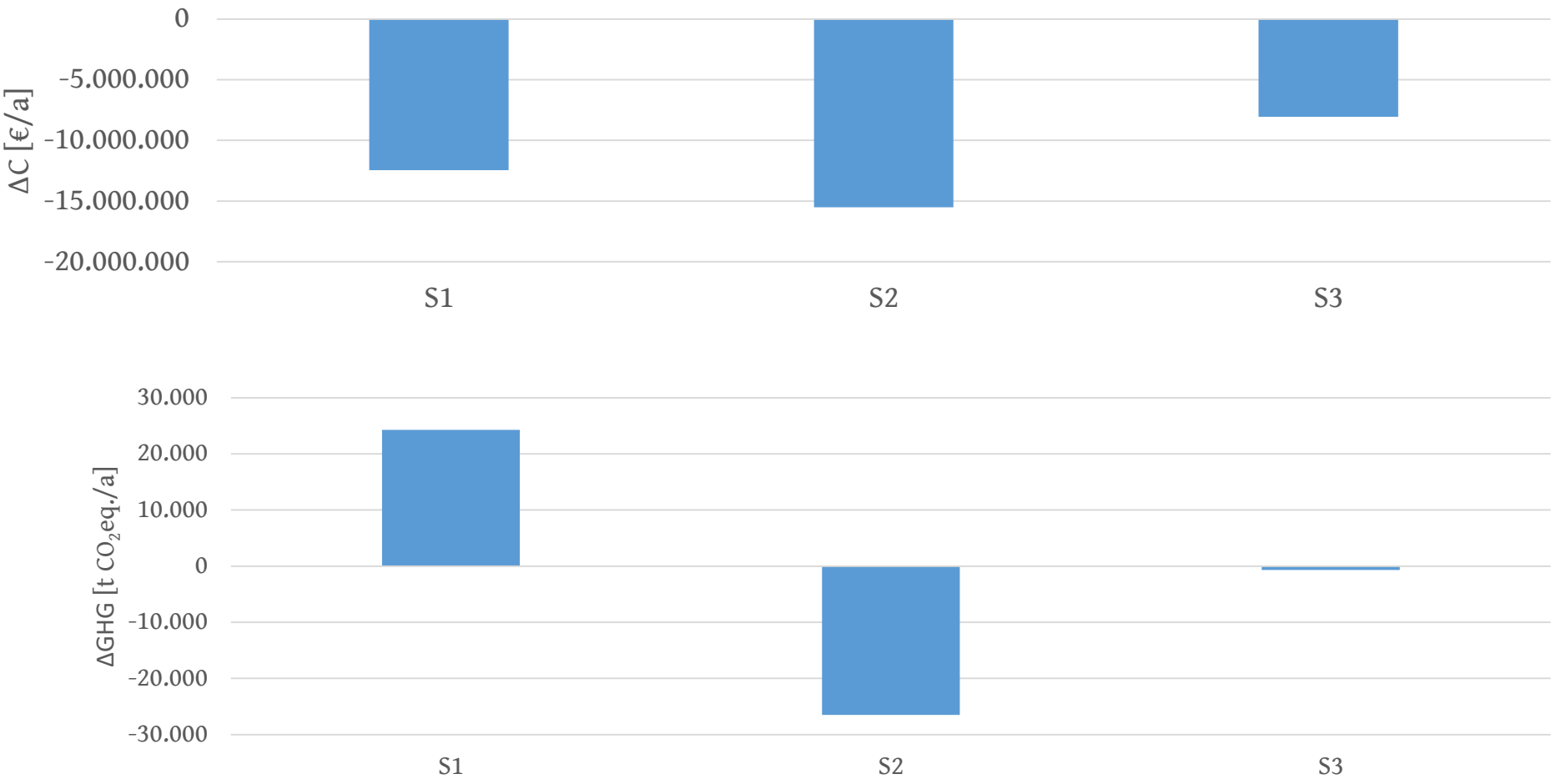
Results: Effects on electricity supply



Results: Costs and GHG effects



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Conclusions and outlook

- Load shifting is a viable option for integration of renewable energies, costs savings and GHG reductions

- WWTP:
  - WWTP do have a significant potential for integration of renewable surplus electricity
  - Is is questionable if saving potentials are an adequate motivation for WWTP operators
  - WWTP storage capacities may serves as short time storages (~9 hours)
  - WWTP storage capacities are more adequate for surplus PV integration than wind power excess generation

Acknowledgements

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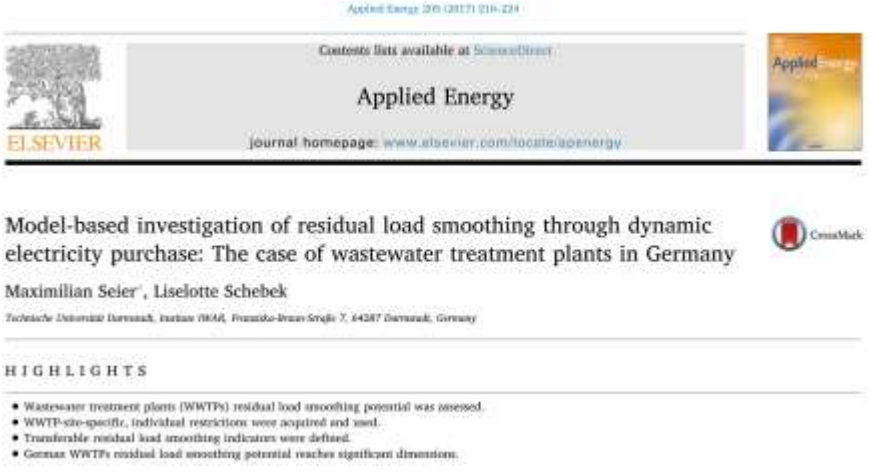
Thank you for your attention!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Model-based investigation of residual load smoothing through dynamic electricity purchase: The case of wastewater treatment plants in Germany

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HIGHLIGHTS

- Wastewater treatment plants (WWTPs) residual load smoothing potential was assessed.
- WWTP-site-specific, individual restrictions were acquired and used.
- Transferable residual load smoothing indicators were defined.
- German WWTPs residual load smoothing potential reaches significant dimensions.

if you want to read more:

http://dx.doi.org/10.1016/j.apenergy.2017.07.116