THE POTENTIAL OF THERMAL ENERGY STORAGE FOR SUSTAINABLE ENERGY SUPPLY AT CHEMICAL SITES

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Project overview: TransTES-Chem

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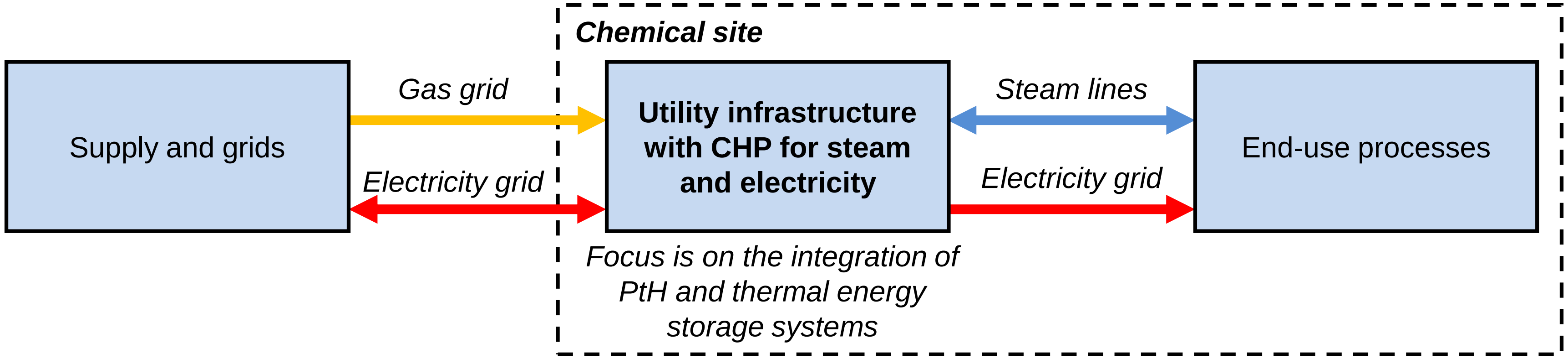
Project goals:

1. Identification of **thermal energy storage** (TES) and PtH solutions to improve the integration of PV and wind at **future chemical site utility infrastructures**
2. Development of thermal energy storage technologies
3. Strengthening the international network for thermal energy storage and Carnot batteries via IEA



Supported by:

Federal Ministry for Economic Affairs and Climate Action

on the basis of a decision by the German Bundestag

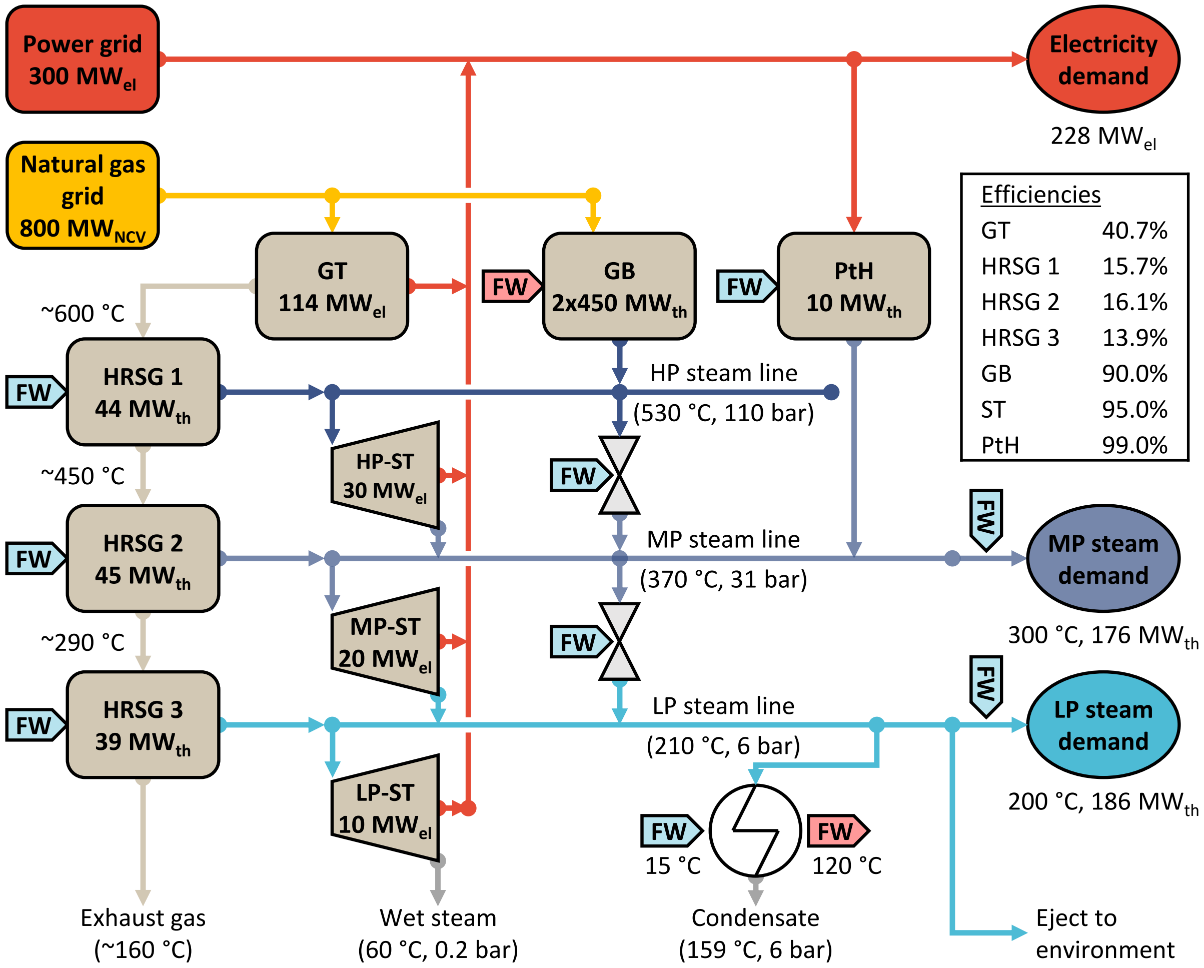
FKZ 03ET1646A-E
01.09.19 – 31.08.23

CURRENTA covestro GFal TSK FLAGSOL JPM www.jpm-gmbh.de

DLR Deutsches Zentrum für Luft- und Raumfahrt e.V. in der Helmholtz-Gemeinschaft

Method: Ideal-typical utility infrastructure (iUI)

- Foundation for general investigations
- Publicly available: https://doi.org/10.1002/cite.202100164
- Based on literature and expertise from Currenta and Covestro
- Electricity, gas and CO_2 prices depending on scenario
- Hourly resolved electricity and steam demand curves
- Implemented in Top-Energy® for operational optimization with/without flexibility measures

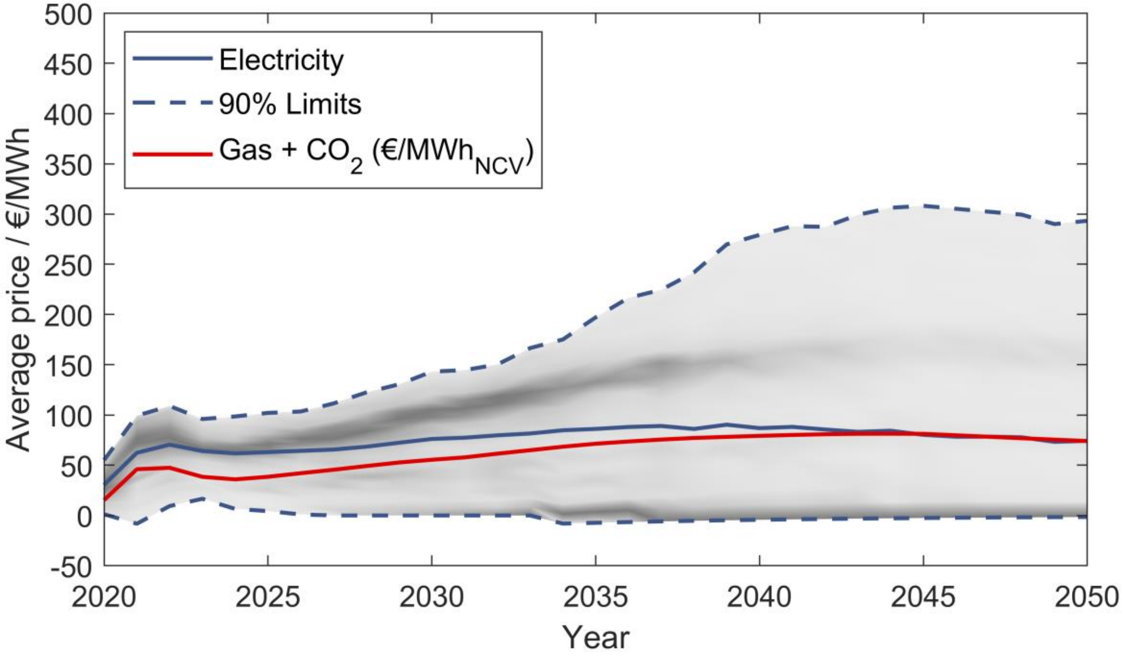


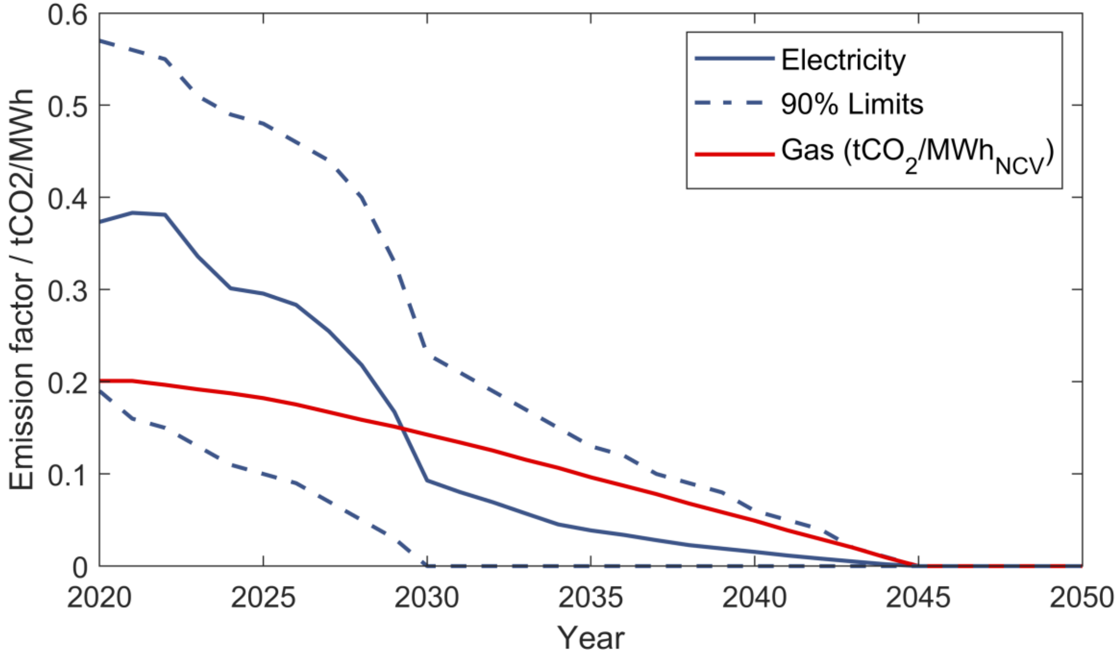
Abbreviations: FW: Feedwater, GB: Gas boiler, GT: Gas turbine, HP: High-pressure, HRSG: Heat recovery steam generator, LP: Low-pressure, MP: Medium-pressure, PtH: Power-to-heat, ST: Steam turbine

Method: Applied market scenario

Green deal scenario:

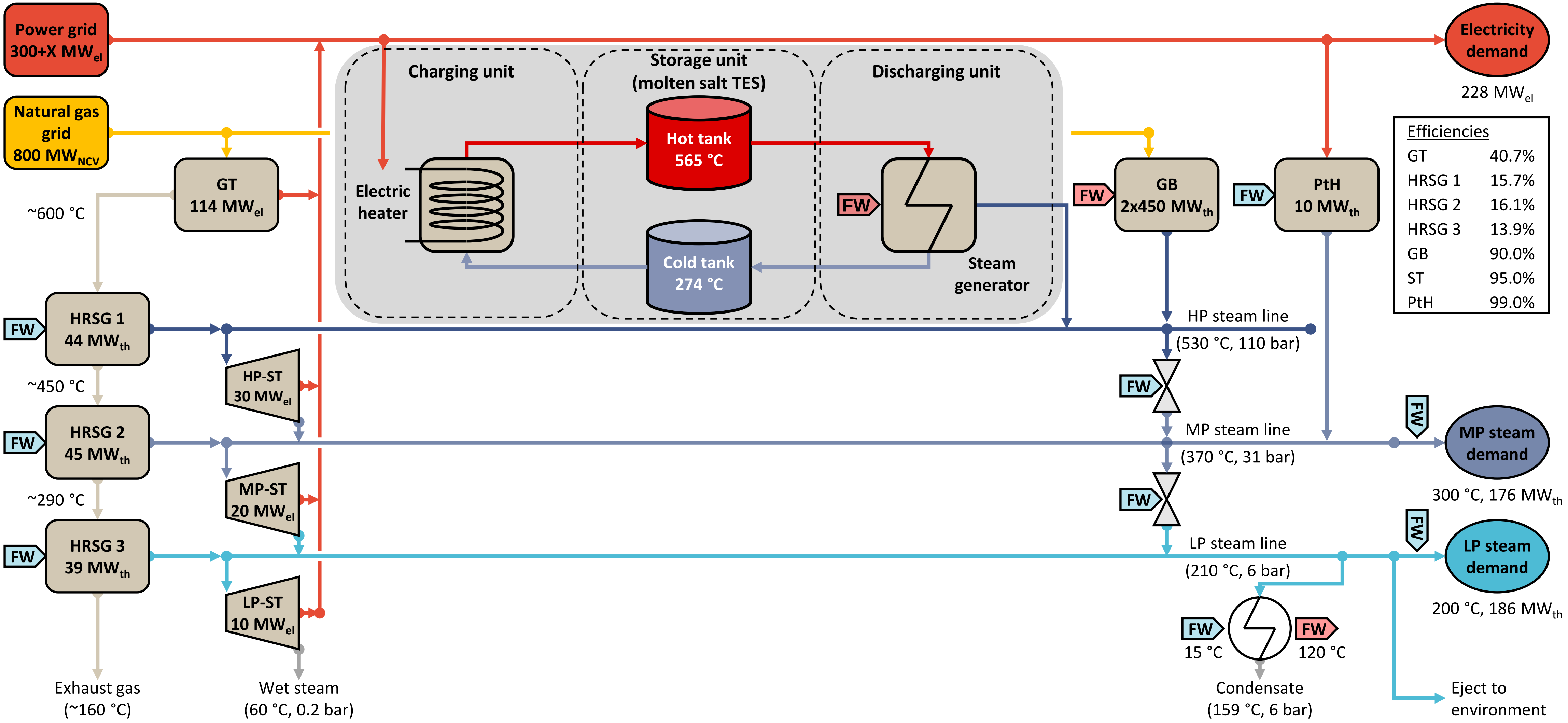
- Developed by enervis energy advisors for the German energy system
- Based on the European Green Deal
- Continuous deployment of renewables to reach net zero in 2045





*the greyscale indicates how often a certain electricity price occurs (dark = often, light = less often)

Method: Integration of 2-tank molten salt TES into the iUI



Efficiencies	
GT	40.7%
HRSG 1	15.7%
HRSG 2	16.1%
HRSG 3	13.9%
GB	90.0%
ST	95.0%
PtH	99.0%

Result: Operating strategy of a storage system in the iUI

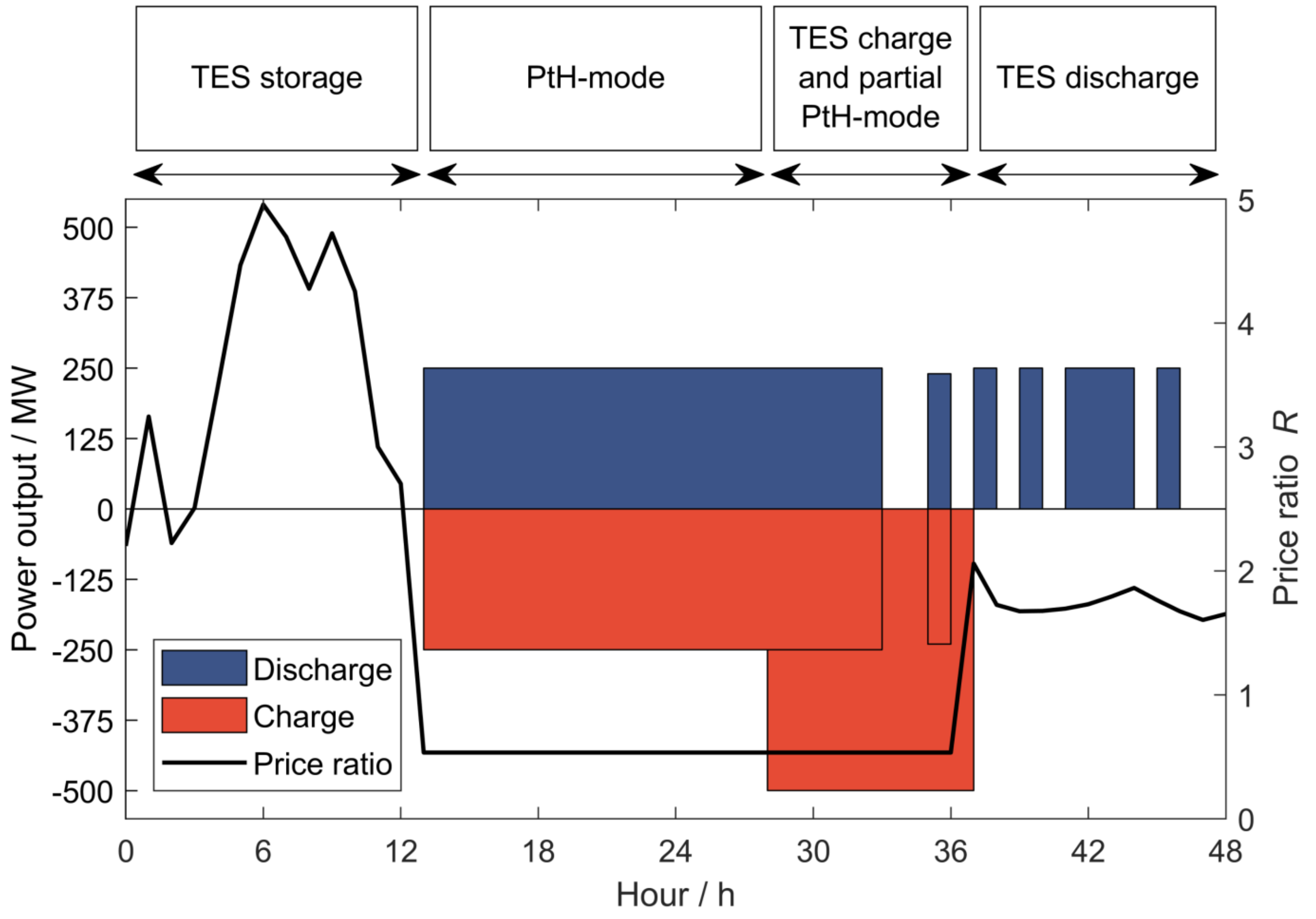
Details of the conducted simulation:

- Annual simulation for 2045
  (2 sample days selected for diagram)
- Minimize operational expenditures (OPEX)
- Storage system with:
  - 500 MW charging unit
  - 3000 MWh storage unit
  - 250 MW discharging unit

Results of the study:

- Electricity-to-clean-gas-price ratio *R* determines the TES operation strategy

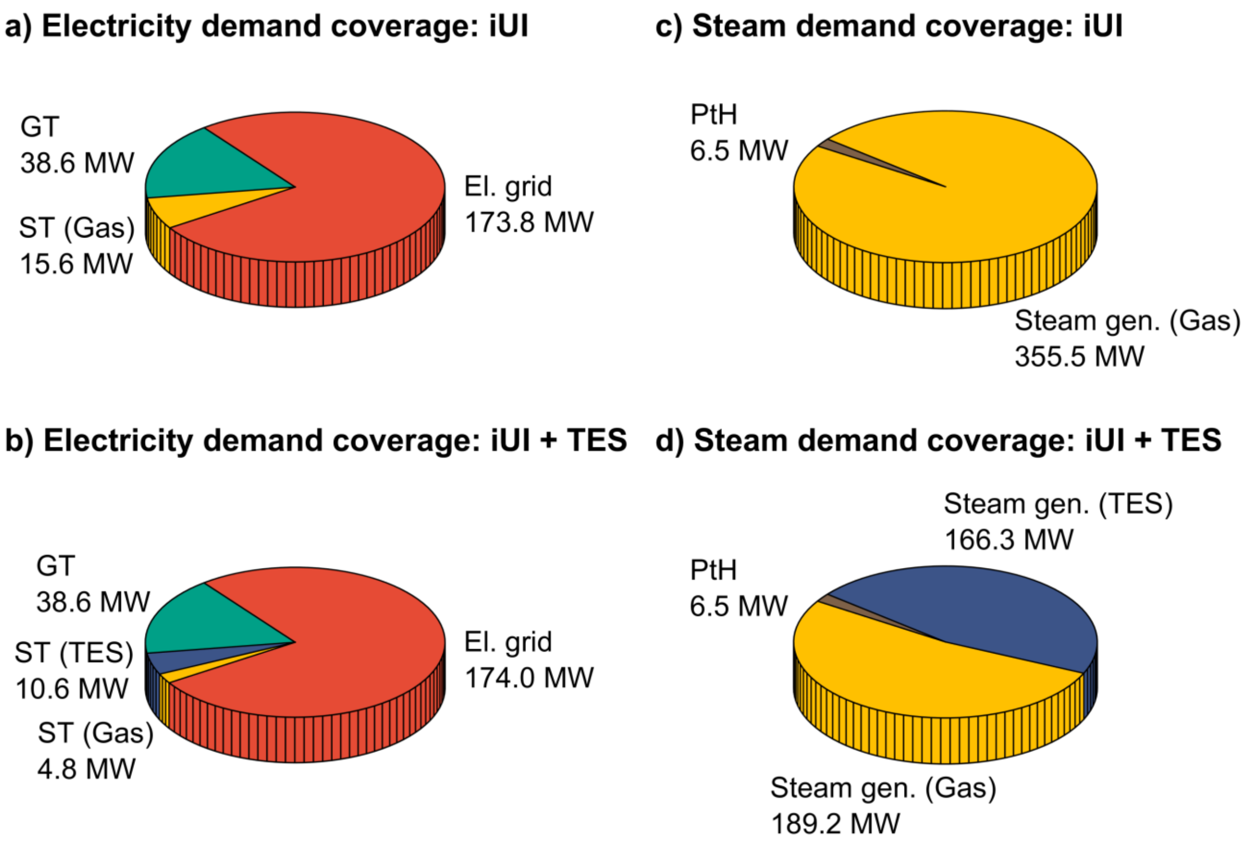
$$R = \frac{\text{Electricity price}}{\text{Gas} + \text{CO2 price}}$$



Result: Energy supply for the chemical processes with and without integrated storage system

Results of the study:

- TES provides about 2/3 of the required steam for the steam turbines
- Size of available steam turbines limits the effect of TES on the electricity side
- 50% of steam production is electrified with the PtH mode of the TES system

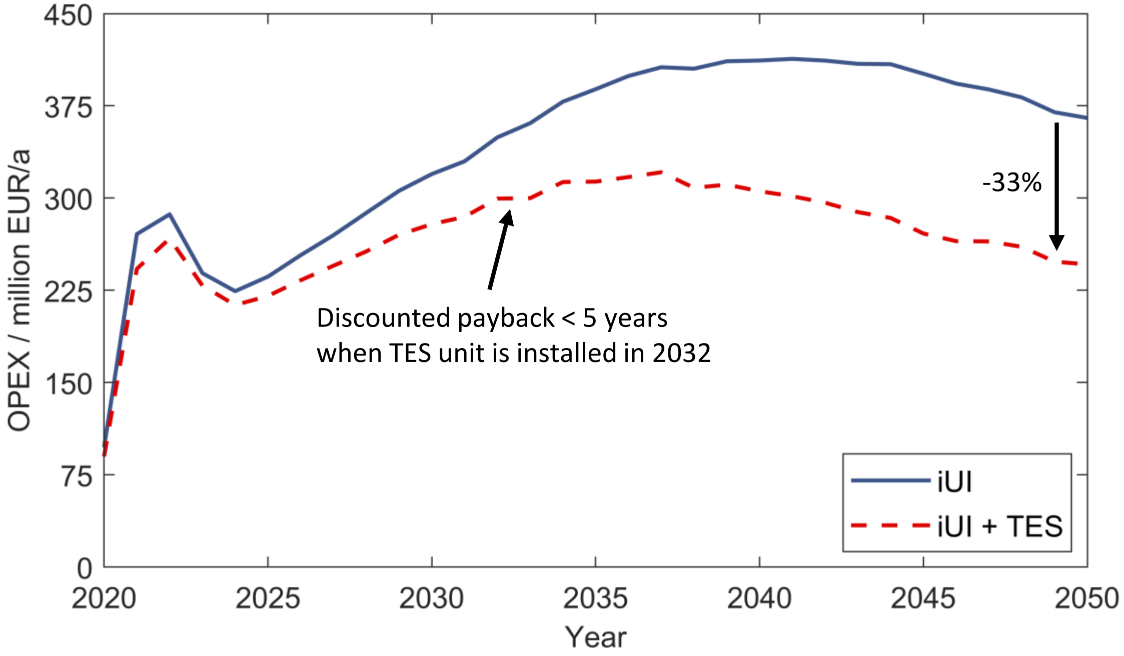


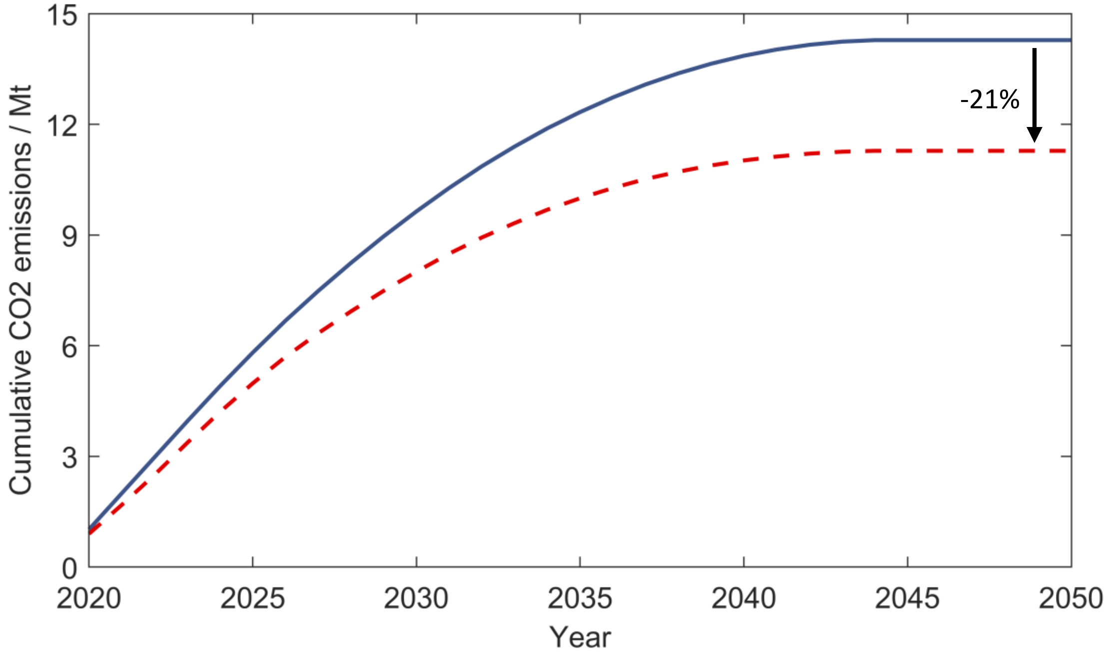
Abbreviations: ST (Gas): Steam turbine output with steam from gas-fired components, ST (TES): Steam turbine output with steam from TES, Steam gen. (Gas): Steam supplied by gas-fired components, Steam gen. (TES): Steam supplied by TES.

Result: TES impact on OPEX and CO_2 emissions

Continuous simulation from 2020-2050 (*same TES unit and minimization of OPEX*):

- With the applied market scenario, iUI operating costs nearly quadruple in 30 years
- OPEX development can be counteracted with integrated TES
- Discounted payback periods < 5 years can be reached as early as 2032
- In addition, total CO_2 emissions are reduced





Summary

- First representative ideal-typical utility infrastructure for chemical sites developed for DE (publicly available)
- OPEX of chemical site utility infrastructures increase drastically in future years
- Integrated TES system (here 2-tank molten salt) can counteract this development
  - Direct PtH mode → electrification of steam production
  - Charge and discharge mode → exploiting price fluctuations on the market
  - Payback periods < 5 years feasible
  - Total CO_2 emissions (from 2020-2050) are reduced

Thank you for your attention!

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