Felix Cebulla, 18.03.2014

energy
scenarios
school

Perspectives of electricity storages: Sensitivities of storage demand

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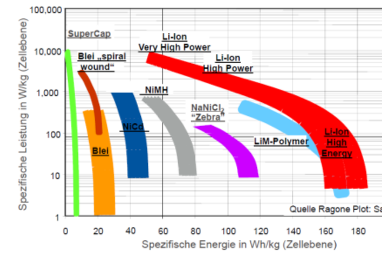
Perspectives of electricity storages

Overview PhD project, current status, research questions, proceeding

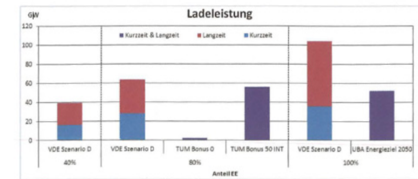
Storage technologies

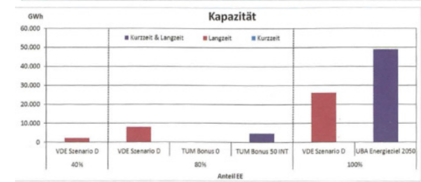
- Identification and analysis of technological and economic parameters for electricity storage technologies (literature review, expert knowledge)
- Provides a basis for the model parameterisation, hence the technological and economic input data for the model e.g. efficiencies, costs, …



Models & scenarios

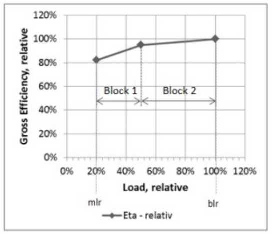
- Analysis of existing energy system models which focus on storage demand
- What amount of (dis)charge power and storage capacities do the models derive under given scenario assumptions and model constraints?
- Can one identify certain general dependencies, i.e. sensitivities of the storage demand to those scenario assumptions and the model constraints?

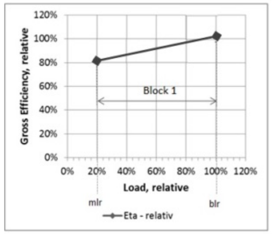




Model development

- Implementation of an advanced conventional power plant model: unit specific modelling of conventional generation considering part load behaviour/costs, ramping
- How does a more detailed model influence the storage demand?
- Advanced modelling of storage technologies, e.g. endogenous calculation of storages cycles





Sensitivities

- Model runs with main focus on the sensitivities of storage demand under different scenario assumptions, e.g. variation of generation structure or the energy demand, price paths, …
- Development of a methodology for the assessment of the main drivers on the storage demand

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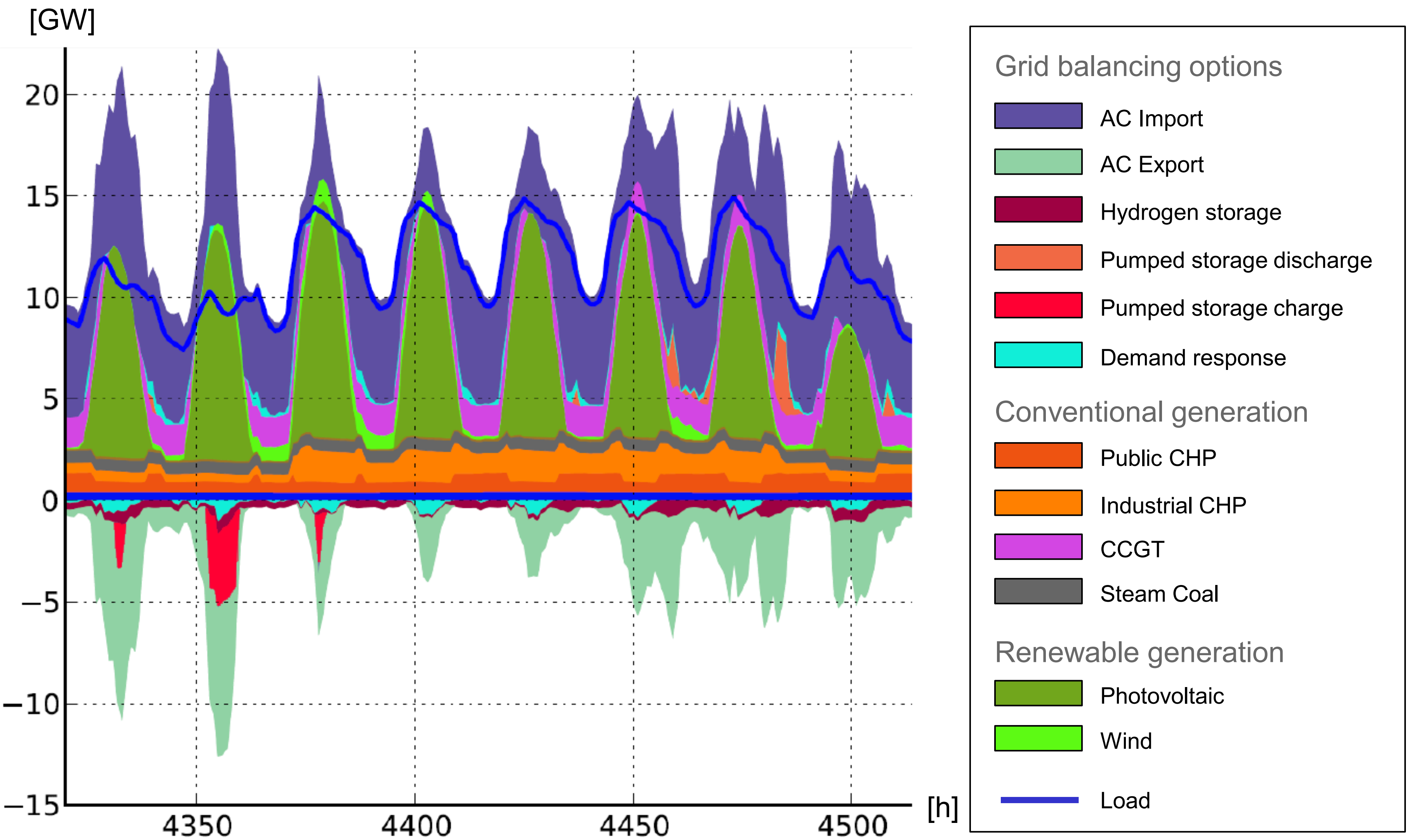
Perspectives of electricity storages

Grid balancing demand ≠ Storage demand



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Identification of influence factors on storage demand I

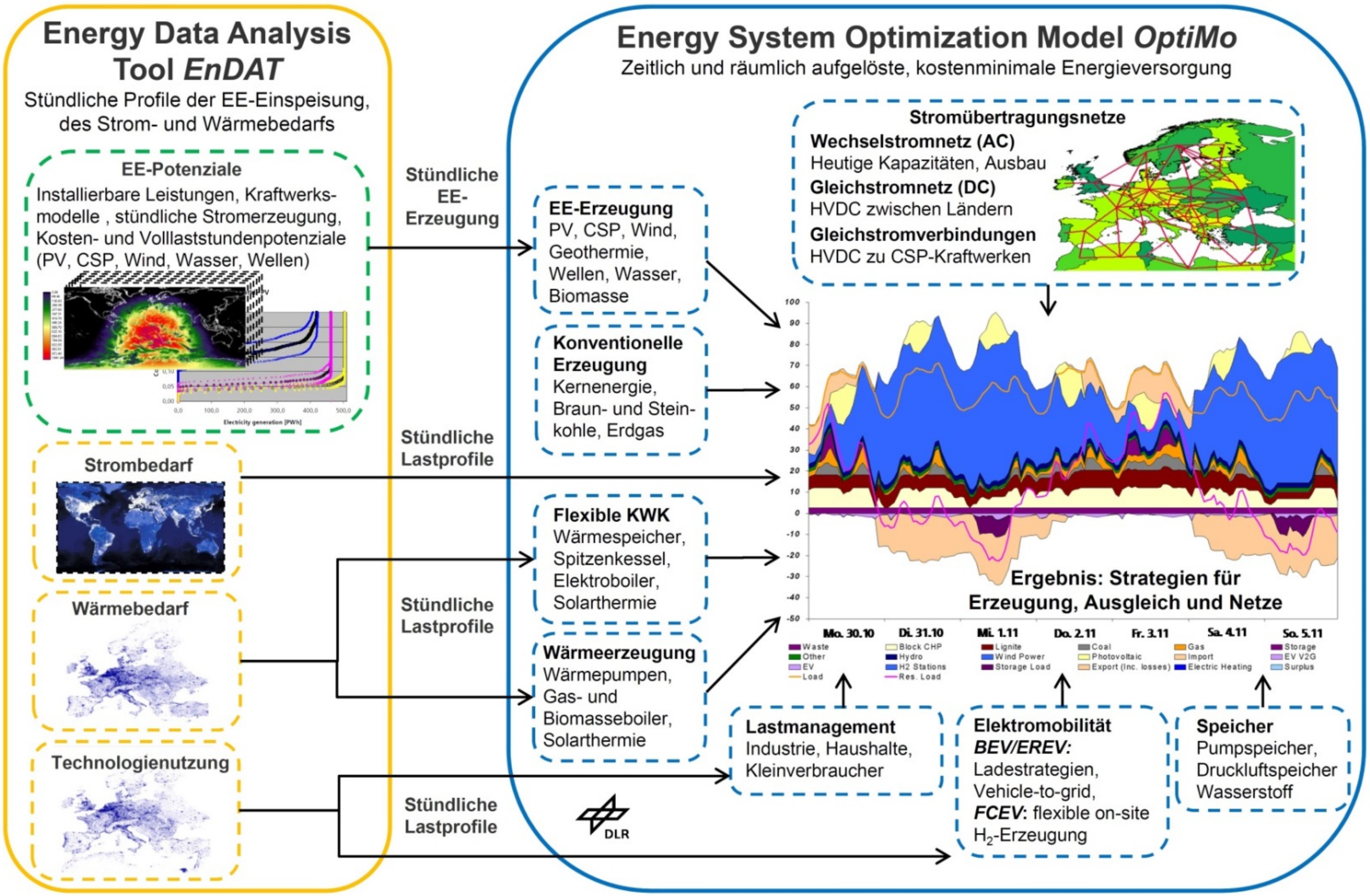
1. Different generation profiles (weather years) for the RES technologies
2. Germany: share of RES
   a) Share wind to PV
   b) High share of RES- the role of biomass
3. Variation of net electricity demand, resp. peak load, variation of load curves
4. Structure of energy supply system with regards to
   a) P2G for high temperature process heat
   b) P2G for the transport sector
   c) e-mobility (charge/discharge control)
   d) Power2heat: heat pumps, electricity heating
5. Spatial distribution of generation, storage and grid restrictions
   a) Demand response
   b) Flexible CHP
   c) Different heat demand profiles
6. Import/Export, integration into ENTSO-E
   a) No Import/Export: Germany as an island grid (merely an academic exercise)
   b) Sensitivities regarding Import/Export
      i. Installed power of grid interconnection points
      ii. Flexibility of the European power plant fleet
7. Import of dispatchable CSP electricity

Identification of influence factors on storage demand II

8. National grid expansion: identification of spatial distribution of storages
9. Dimensioning of grid interconnection points (increased installed power)
10. Spatial distribution of generation, storage and grid restrictions
11. Modelling of different RES technologies
    a) Wind energy power plants: strong and weak wind locations
    b) PV: east-west directions instead of south
12. Prognosis of uncertainty regarding
    a) RES feed in
    b) Load
13. Costs
    a) Price paths fossil, biomass, CO_2 certificates
    b) Investment costs storages, RES, conventionals, demand response, …
14. Spatial resolution of the optimisation
15. Flexibility options
    a) Flexibility of the existing conventional power plants
        i. Ramp up and ramp down, part load behaviour, minimum idle times
        ii. Demand for conventional must-run capacities (CHP, ancillary services)
    b) Demand response
    c) Flexible CHP
    d) Different heat demand profiles
16. …

Energy System Model REMix

(Renewable Energy Mix for sustainable electricity supply)



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Modelling of conventional power plants in REMix

Status and modelling approach

- Historical power plants installation based on *Platts database*
- Allows to asses how much capacity will be available considering the power plant lifetime (e.g. 30a in right-hand figure)
- Learning curves affect technical- and cost parameters of the power plant cohort

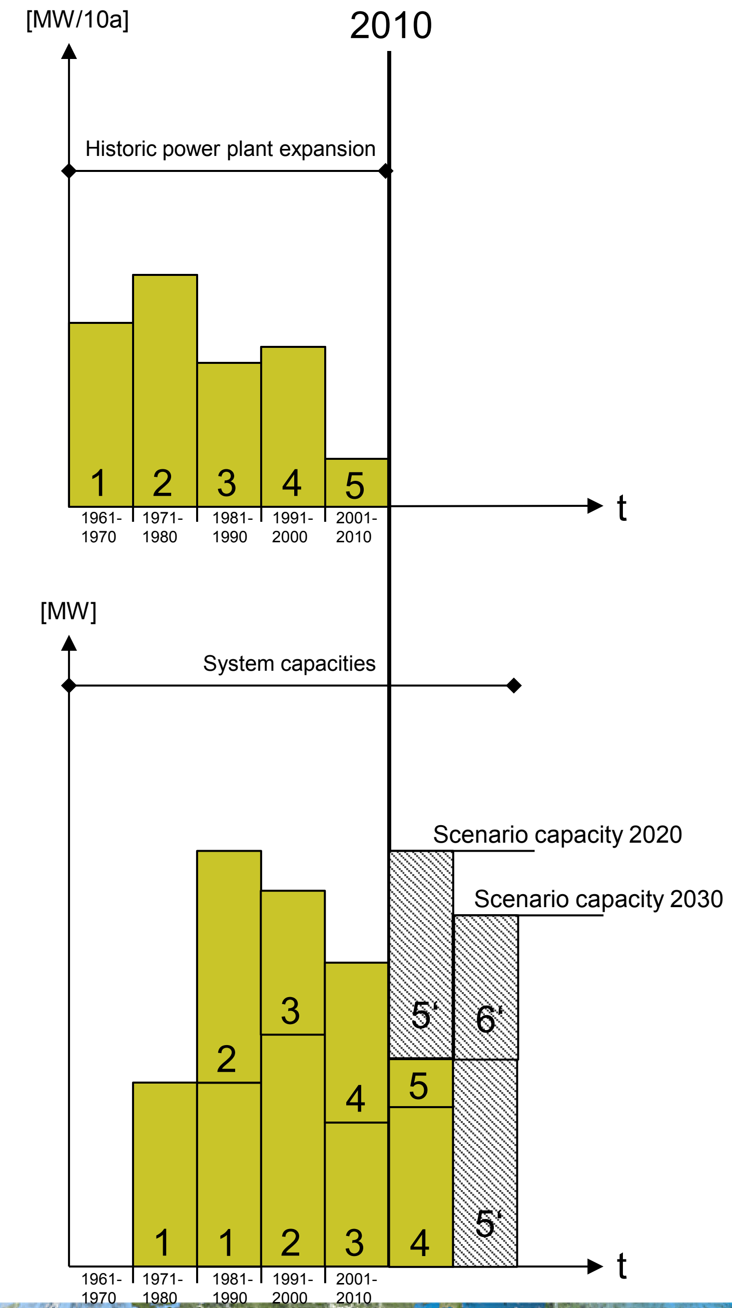
2 Conceptual approaches for future scenario capacity

a) Scenario Validation (Dispatch Optimization):

! Test the reliability of the power supply on an hourly scale and find the least cost operation strategies

b) Least cost dimensioning (Capacity Optimization):

! Dimension a least cost supply system that can reliably cover the electric load at any time



Modelling of conventional power plants in REMix

2 Conceptual approaches for future scenario capacity

a) Scenario Validation (Dispatch Optimization):

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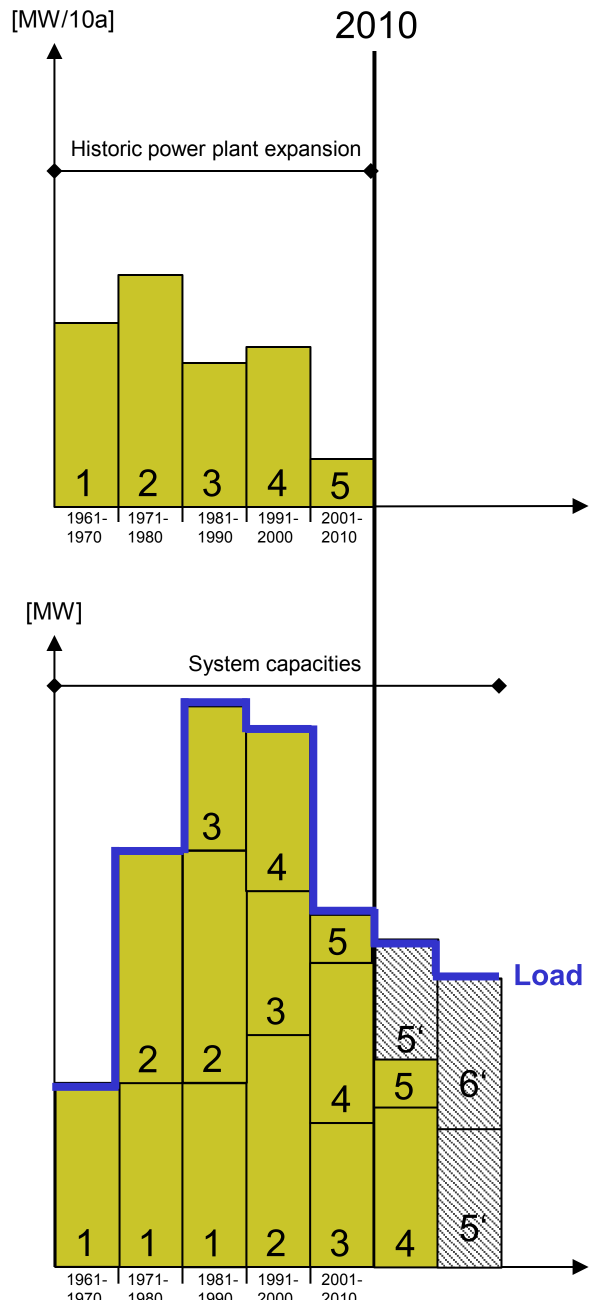
- The optimization would choose the least cost (conventional) technology which can cover the given load at any time step



Modelling of conventional power plants in REMix

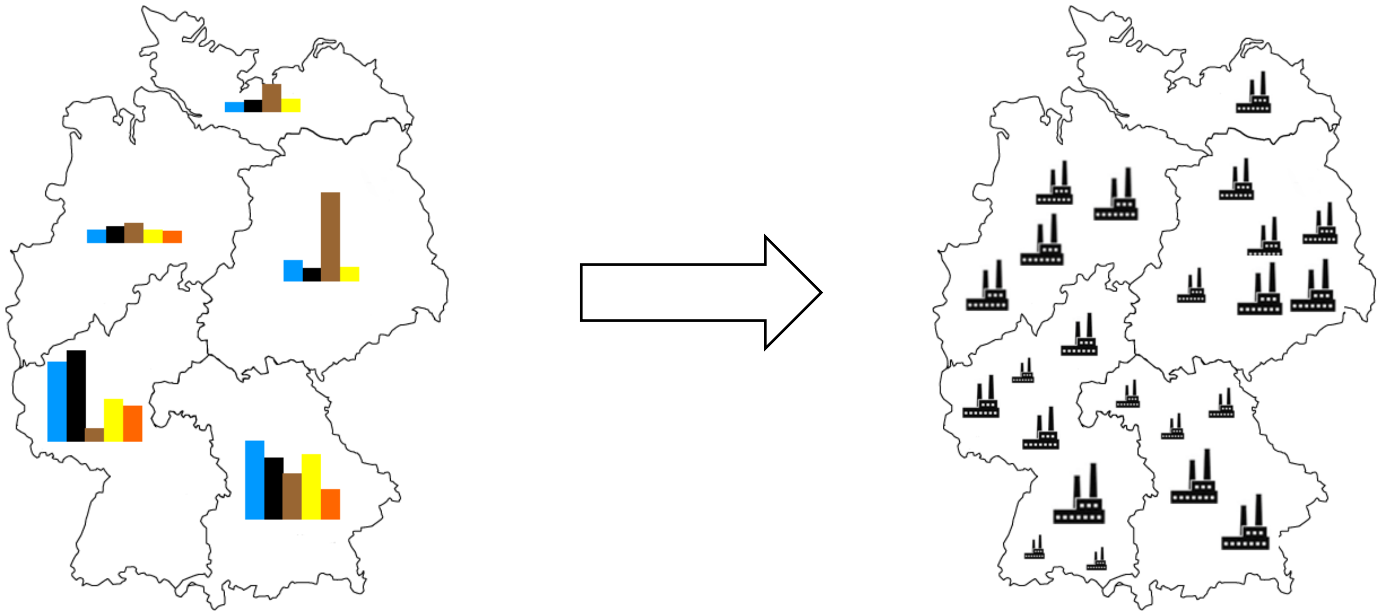
Shortcomings and room for improvements?

- Conventional capacities are modelled to optimistic at the moment- underestimation of costs and overestimation of some technology parameters, e.g. efficiencies
- Input efficiencies always at full load, no ramping and ramping costs, no consideration of hot-, warm- and cold start
- Part load efficiencies in the simplified power plant model can be included implicit via the efficiency data, i.e. assuming at lower efficiency that the efficiency at max load
- Still this will include a considerable mistake

➔ **Necessity for more detailed modelling of conventional power plants!**

Extended modelling of conventional power plants in REMix

How does the level of detail affect the grid balancing demand?



Technology specific

Aggregated and simplified modelling

- Aggregated to model nodes and technologies
- Technology and economic parameter subject to assumptions regarding price path developments, learning curves and technological progress (e.g. $€_{Inv.}$/MW ↓ & η ↑)
- Historical power plants installation based on *Platts database*
- Future additional capacity based on *scenario assumptions*
- Method: Linear Programming (LP)

Unit-/power plant specific*

Detailed technological and economic modelling

- Unit specific modelling of each individual power plant
- Efficiencies dependant on load status (part load) and ambient temperature, cooling method
- Power plant influences technical parameters (e.g. part load efficiencies, increased fuel consumption) and hence costs (increased fuel consumption, wear & tear)
- Min downtimes, differentiation of hot-, warm- and cold start
- Method: Mixed Integer Linear Programming (MILP)

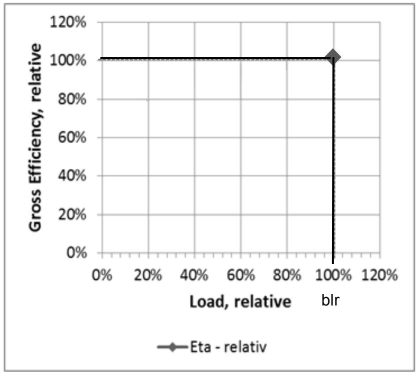
* Carróin, M., Arroyo, J.M., 2006. A computationally efficient mixed-integer linear formulation for the thermal unit commitment problem. Power Systems, IEEE Transactions on 21, 1371–1378.
Fichter, T., Trieb, F., Moser, M., 2013. Optimized Integration of Renewable Energy Technologies Into Jordan's Power Plant Portfolio. Heat Transfer Engineering 35, 281–301.

Extended modelling of conventional power plants in REMix

Modelling of tech. parameters, e.g. efficiency

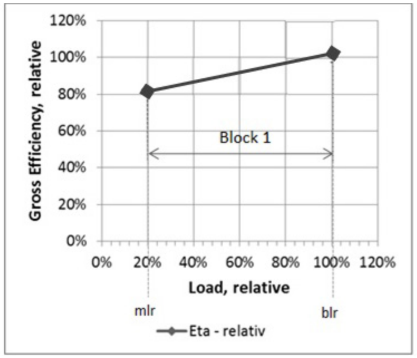
Option A. (basic)

- Static efficiency @ one point of the load: η (blr) = max. load
- This approach complies with the todays stage of development of the modelling of conventional power plants in REMix



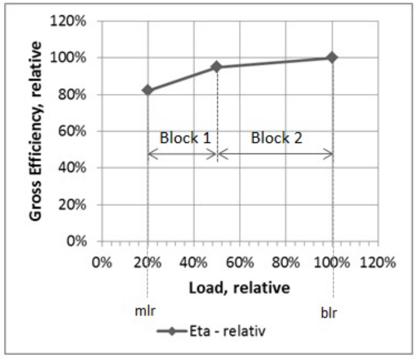
Option B. (simplified)

- simplified part load efficiency @ 2 load points: minimal load = η (mlr), maximal load = η (blr)



Option C. (detailed)

- detailed part load efficiency @ 3 load points: min load = η (mlr), part load = η (mlr), max load = η (blr)
- within the advanced conventional module, all options are modular



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Extended modelling of conventional power plants in REMix

Conclusion: research questions and expected results

1. It is expected that the detailed conventional modelling will most likely lead to an increase in grid balancing demand
2. The advanced approach will make model simplifications at other points necessary due to computational aspects
3. Question is, which level of detail has a significant influence on the modelling result, i.e. grid balancing demand?
4. Furthermore which level of detail is 'justifiable' with respect to other model simplifications which go along due to increased computing times?
5. In consequence, several model runs based on a simple energy system with different configurations of the degree of detail are required, to assess the influence on the modelling results

Thank you for your attention!

Questions?

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