Techno-socio-economic energy system optimization: A pareto-based approach

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DPG spring meeting

DLR Institute of Networked Energy Systems

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Gefördert durch:
Bundesministerium für Wirtschaft und Klimaschutz
aufgrund eines Beschlusses des Deutschen Bundestages

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aufgrund eines Beschlusses des Deutschen Bundestages

grant number 03SBE111

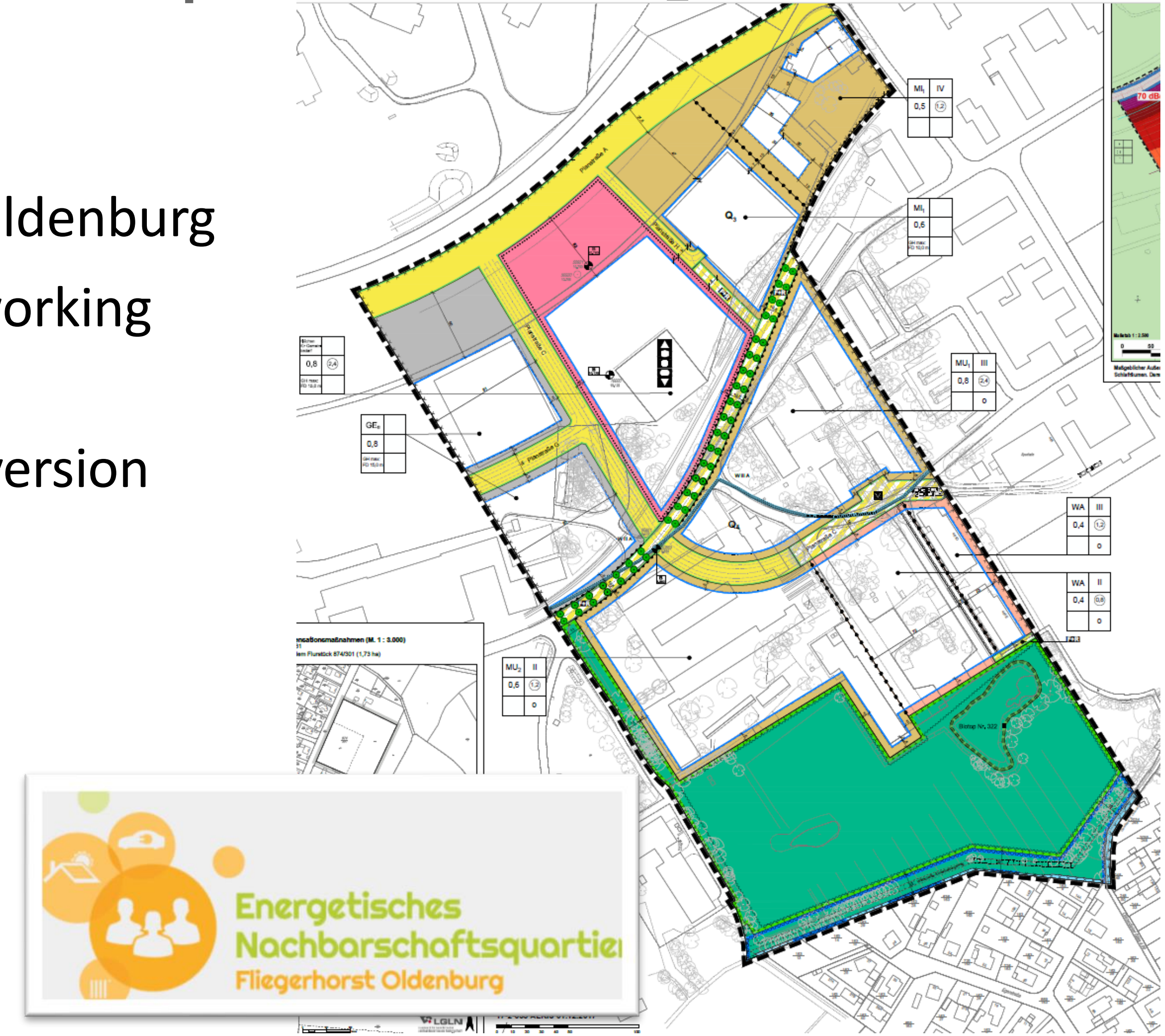
ENaQ – Energetisches Nachbarschaftsquartier Oldenburg

Development plan

- Former military airbase in Oldenburg
- Combination of living and working
- 50% of roofs for energy generation, storage, or conversion
- 50 % social housing
- District car park and reduced car traffic

Task:

- Create “ecological” district



Techno-socio-economic goals

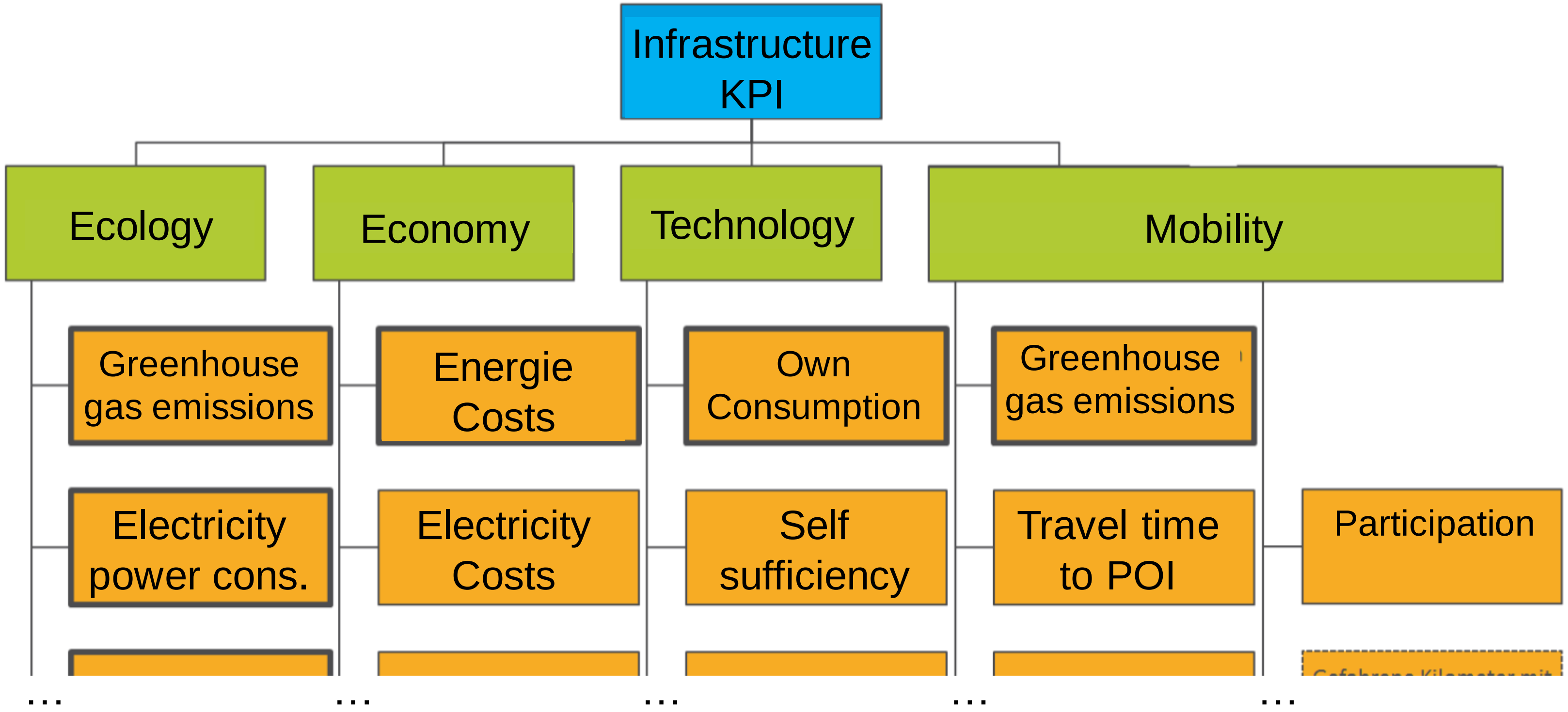
Energetisches Nachbarschaftsquartier
Fliegerhorst Oldenburg

Stakeholders

> Municipality
> Housing cooperative
> Energy supplier
> Network operator
> Researchers

Stakeholder panel

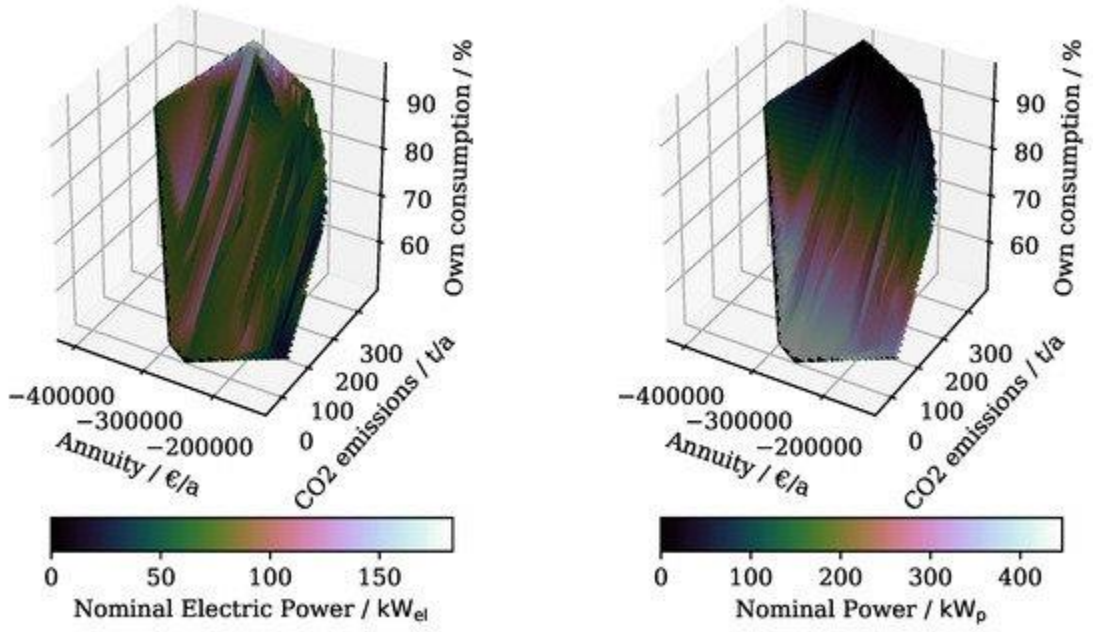
> Early in the project
> Agreement on goals
> Formulation of indicators



Pareto-based approach

What to optimise for?

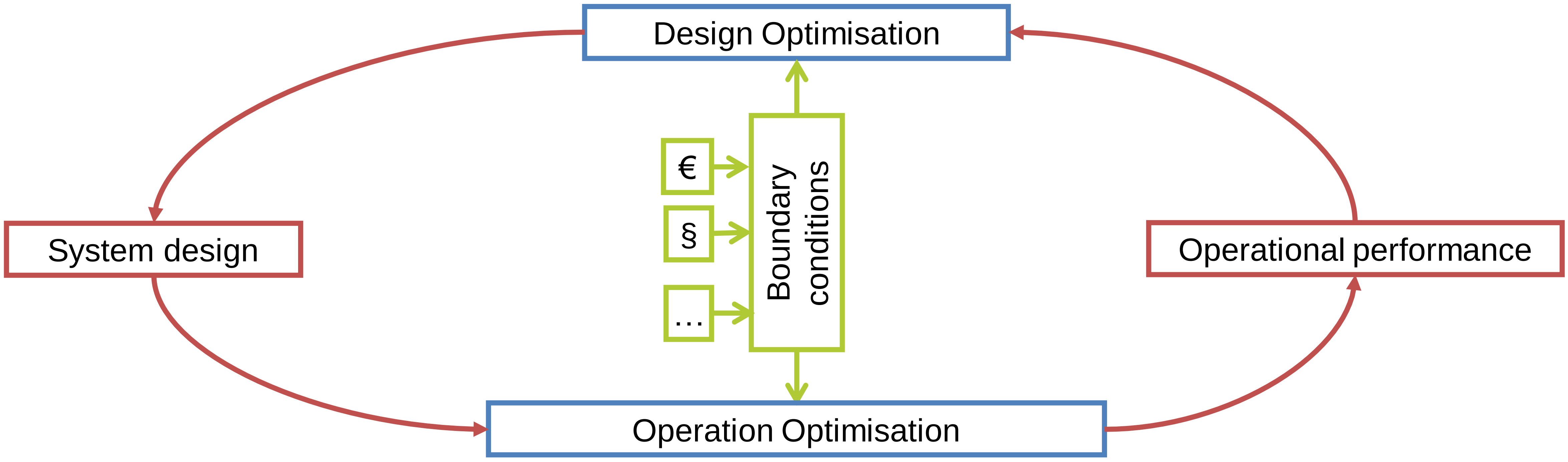
- Pick one KPI
- Create new compound KPI
  → Example: Virtual carbon price
- Multiple KPI at once
  → Allows to weight later



(a) CHP (b) PV

L. Schmeling et al. Development of a Decision-Making Framework for Distributed Energy Systems in a German District. *Energies* **2020**, *13*, 552. https://doi.org/10.3390/en13030552

Optimisation process



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Abstract Energy System Graph

Generic energy system model

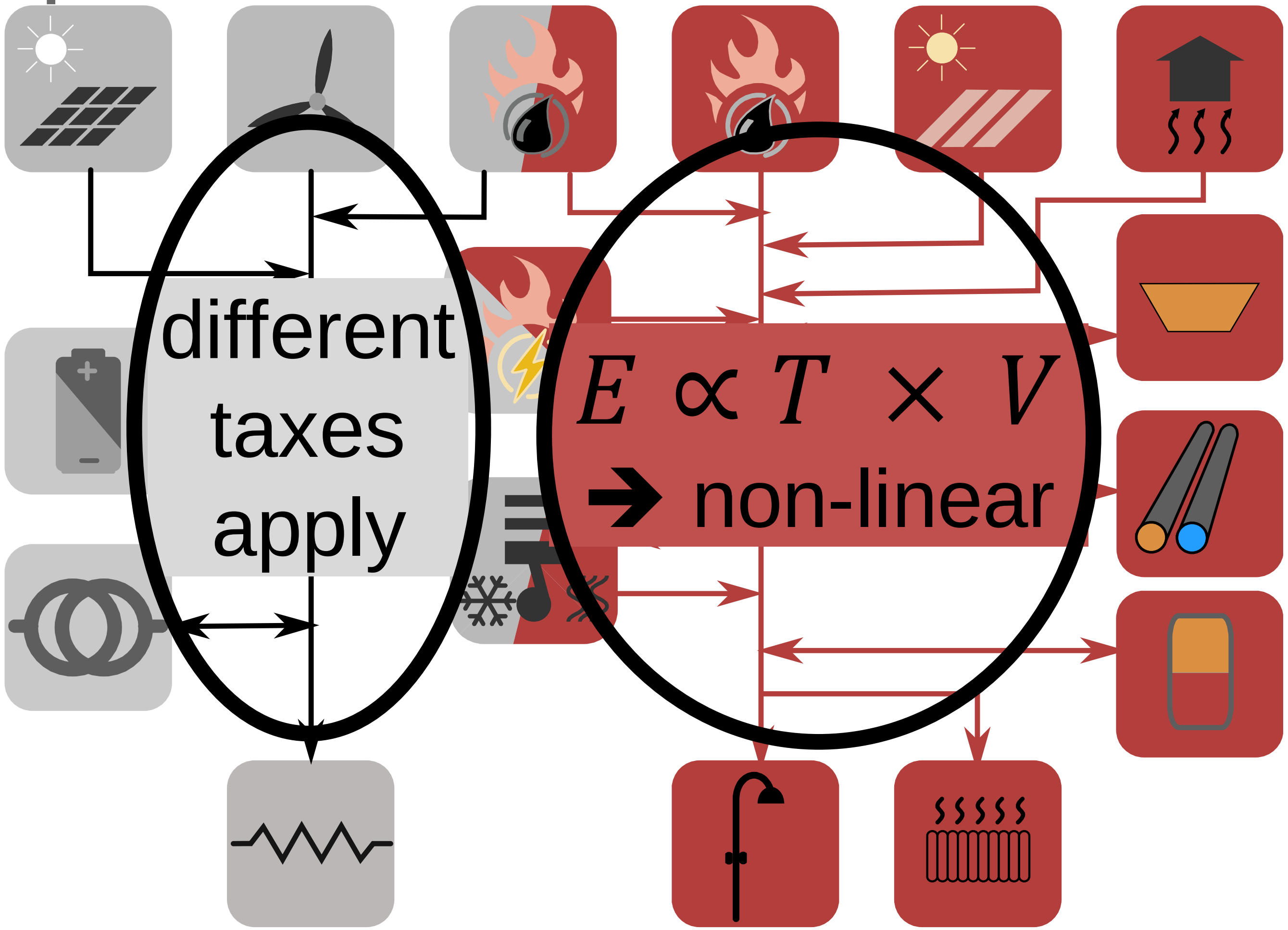
- Linear, single objective → fast
- All techs sized by parameters
- Size 0 to switch off

Supply

- Specific production time series for renewables (i.e. in W/m²)
- Grid assumed fully elastic

Demand

- Fixed time series
- Demands must be supplied



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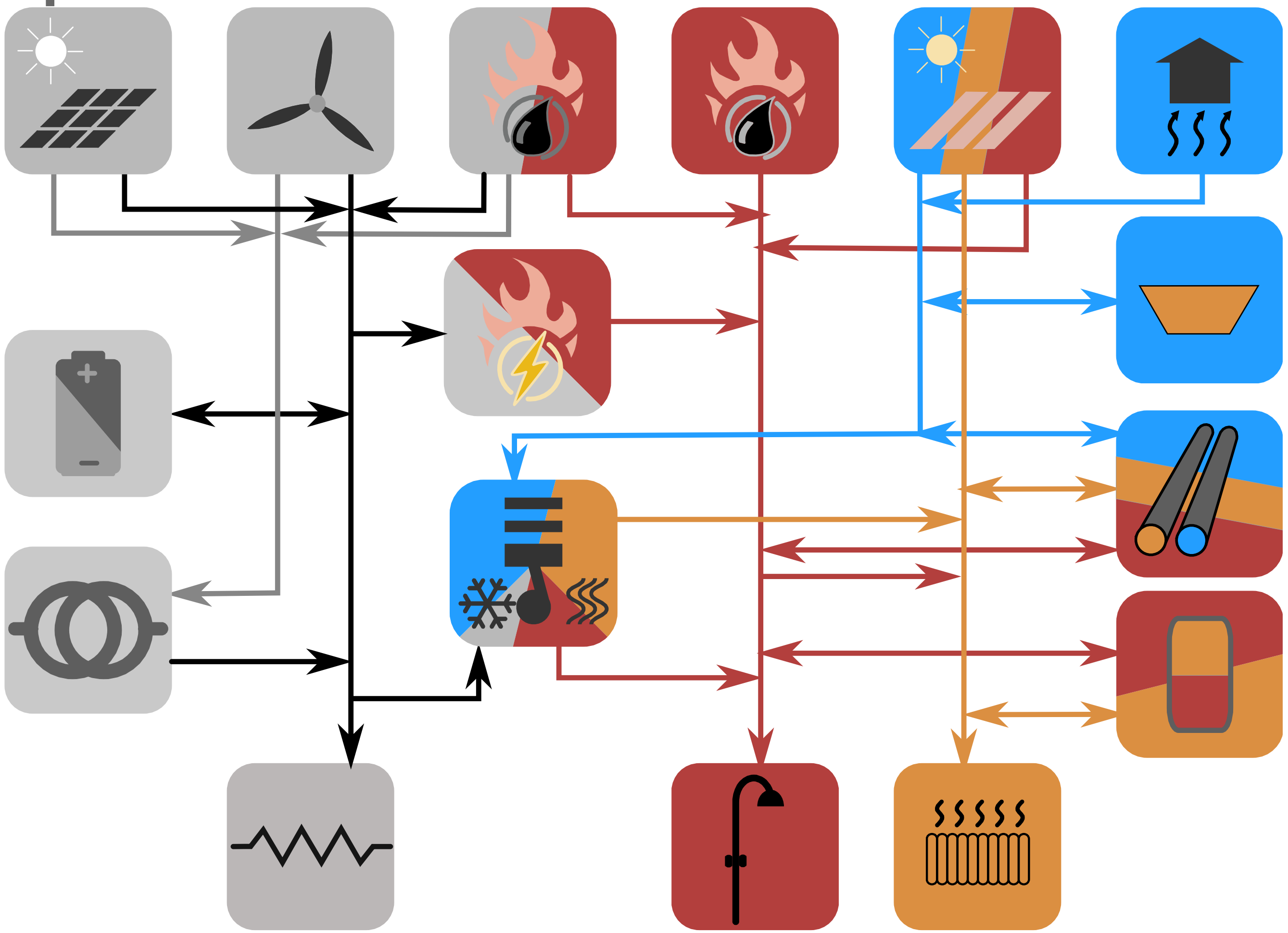

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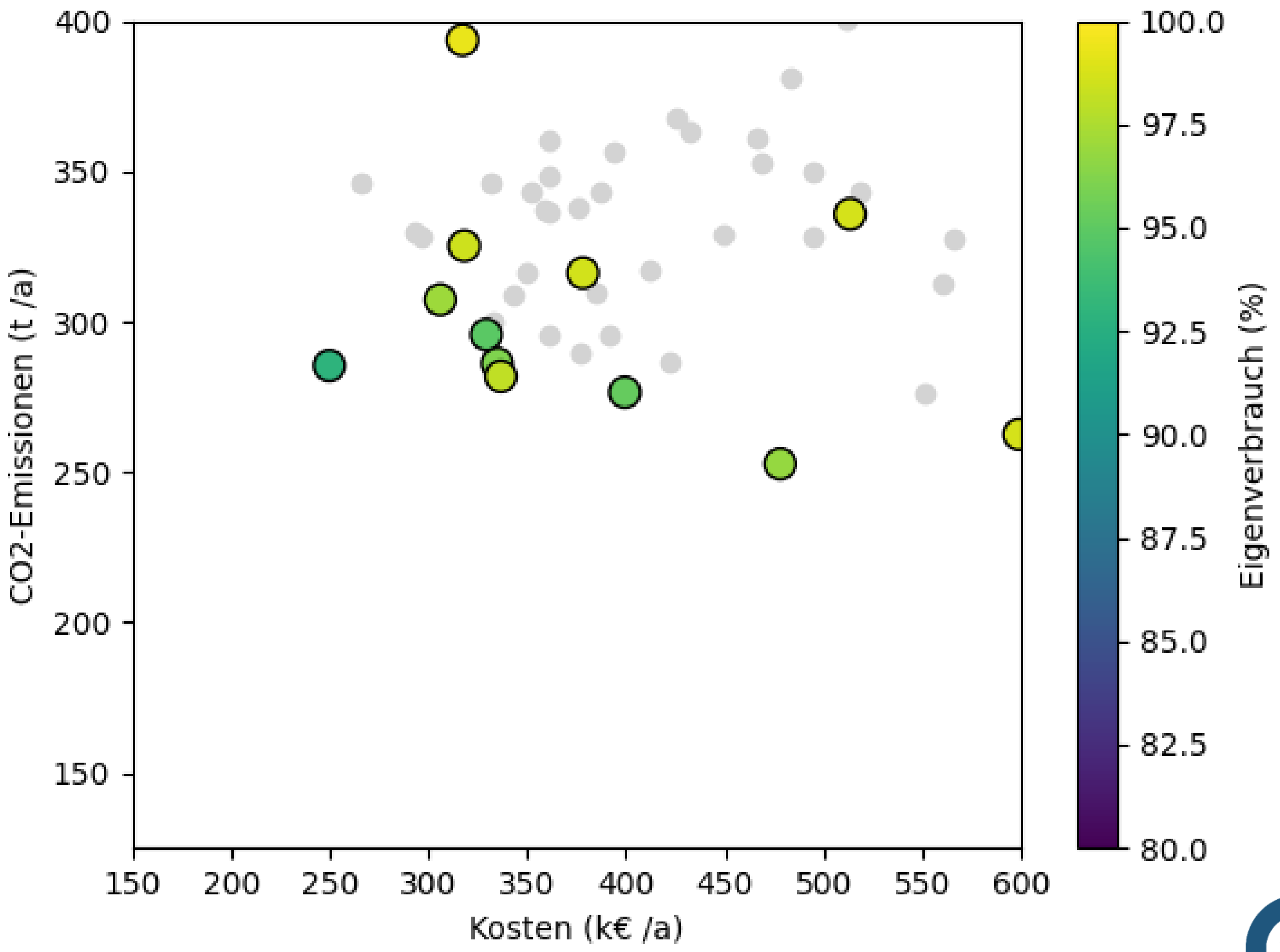
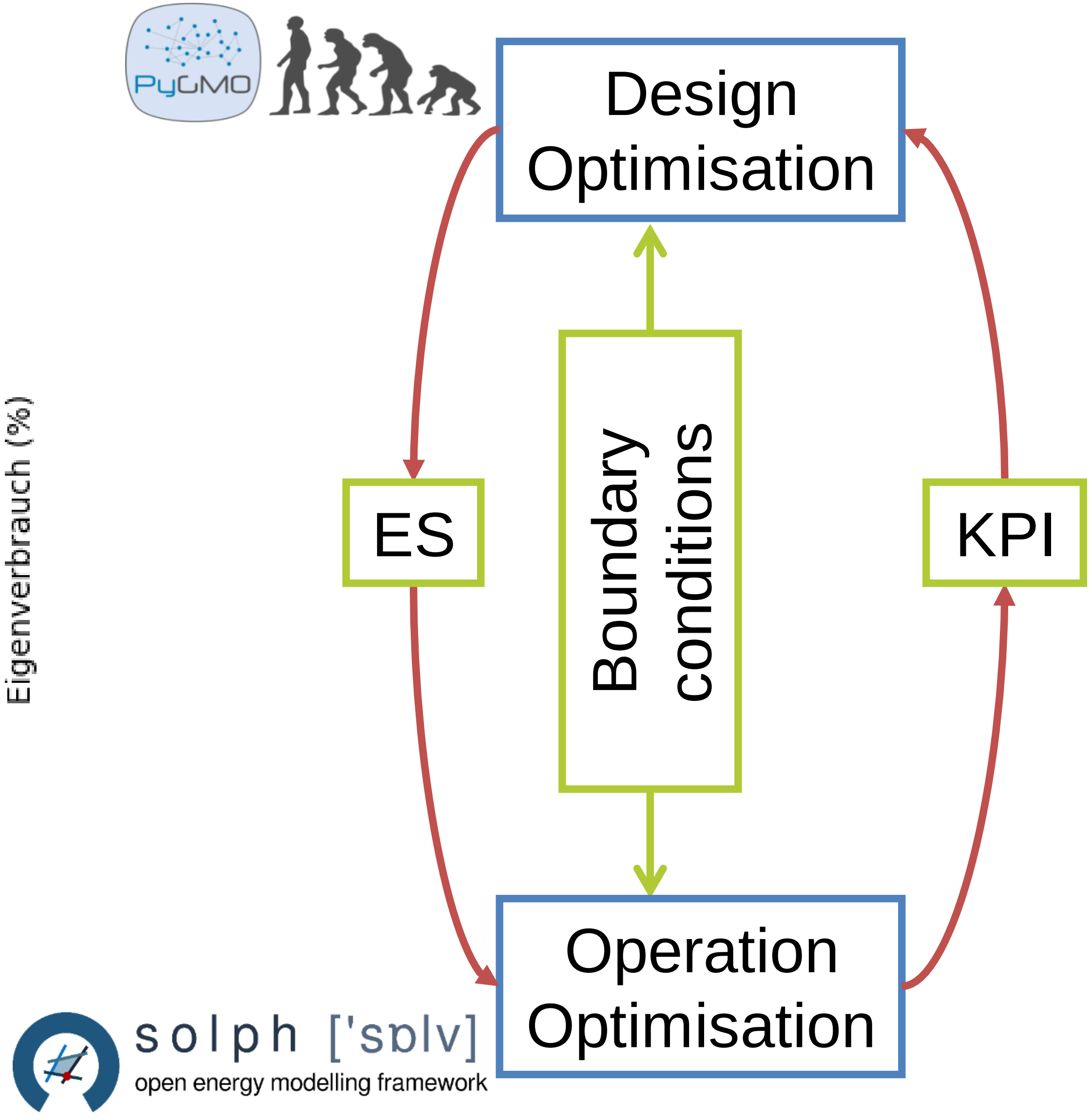
Mathematical description: arXiv:2012.12664
Python package: https://pypi.org/project/mtress/

Pareto optimisation in action





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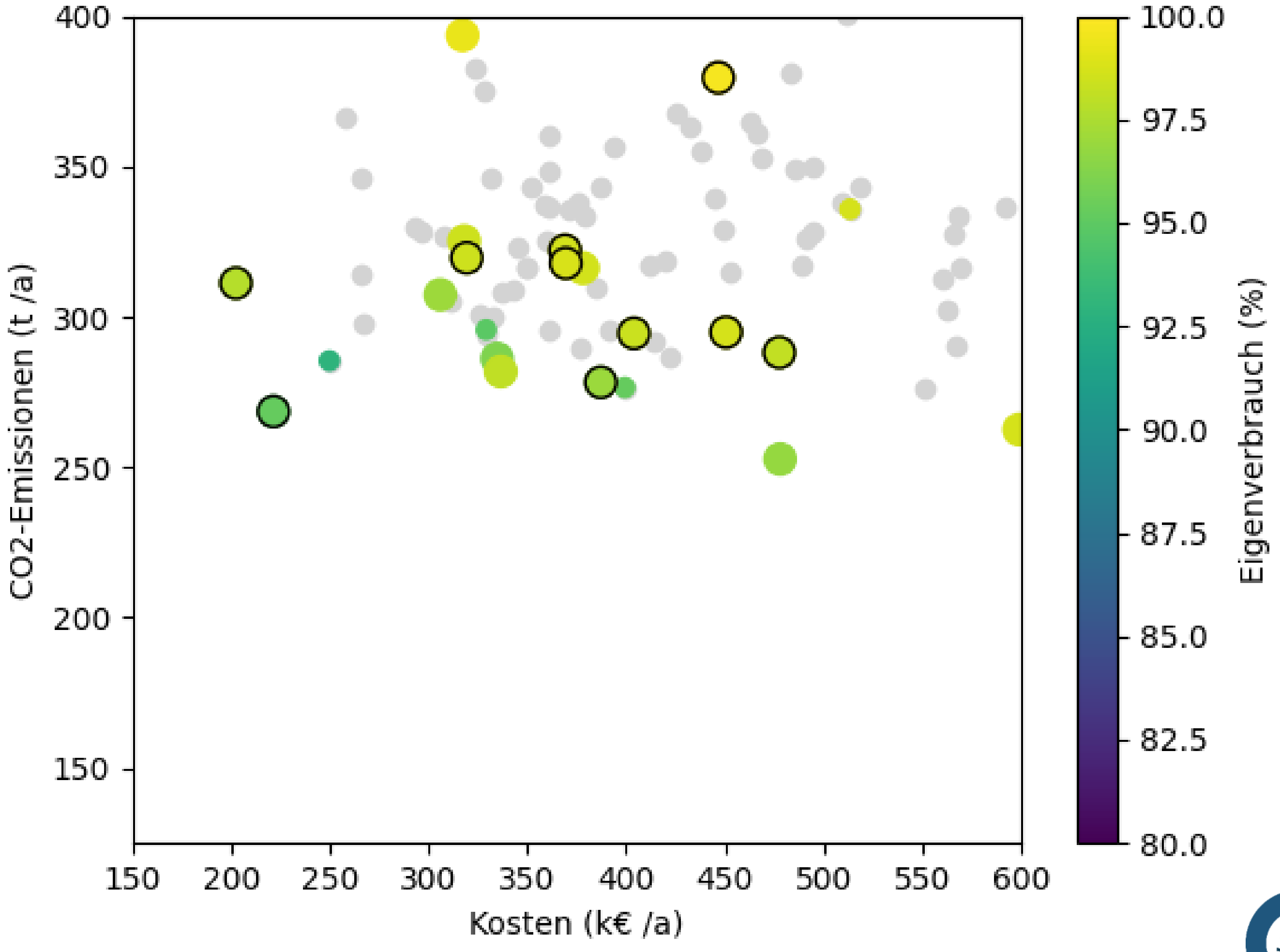

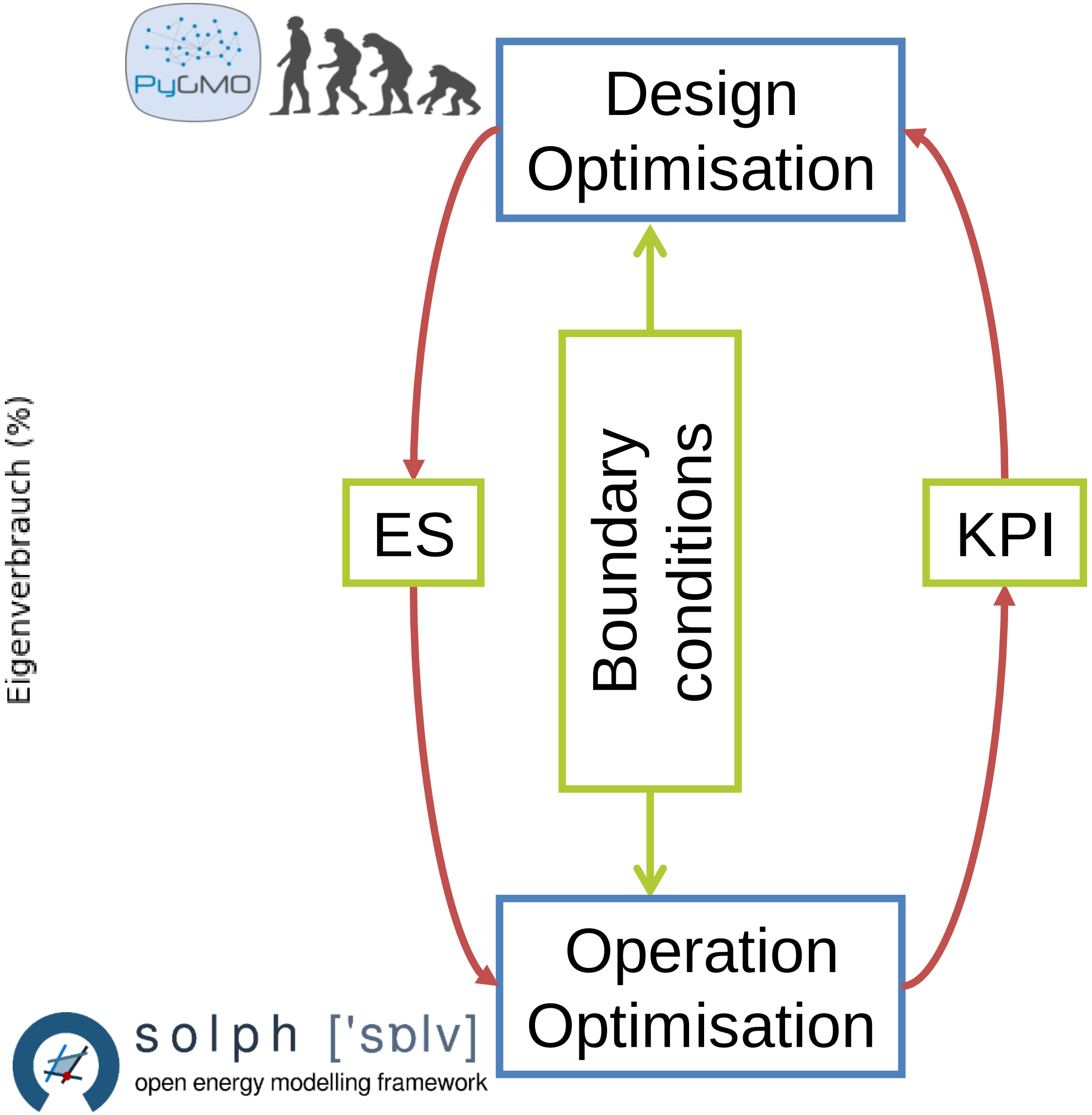

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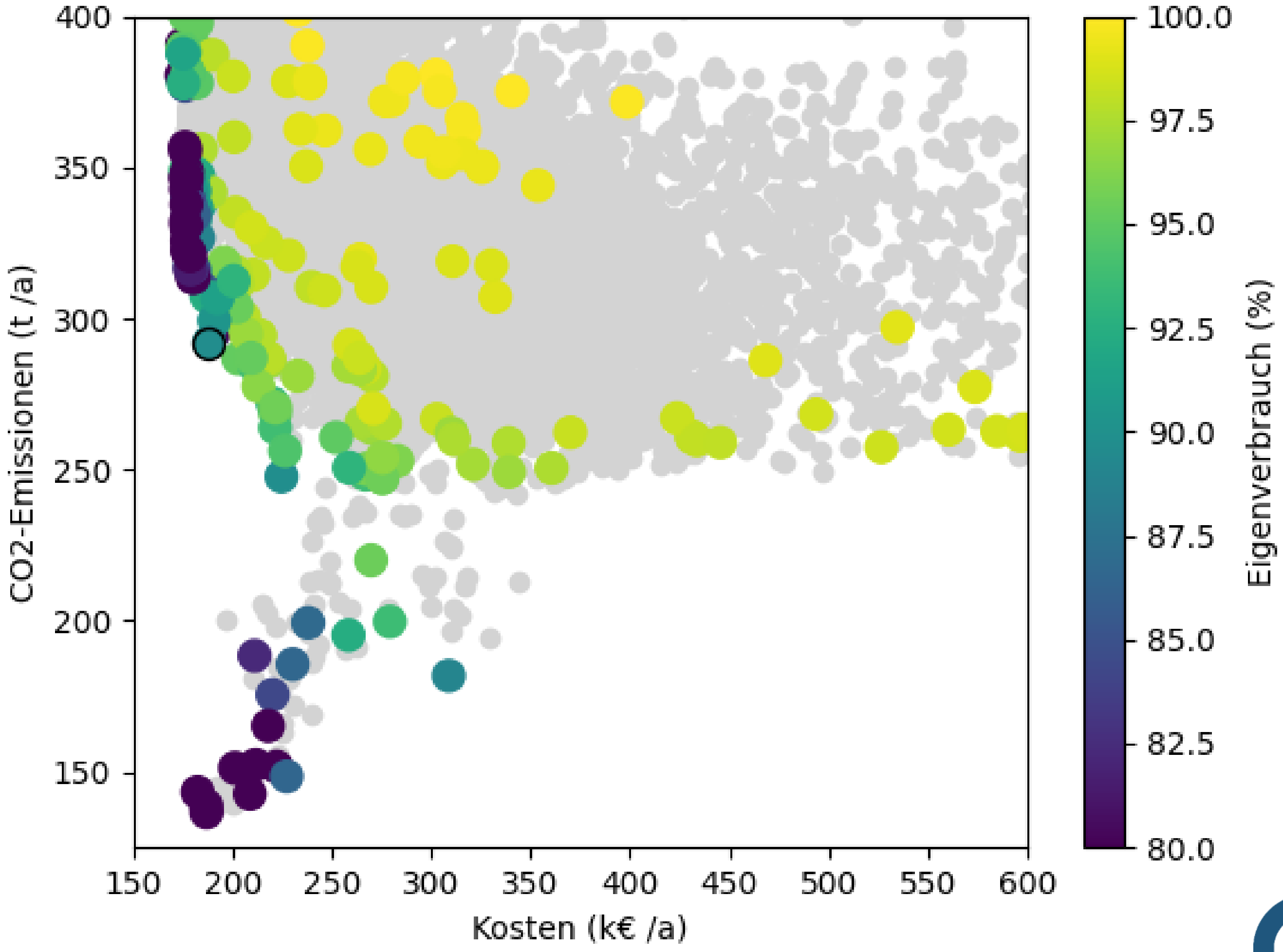

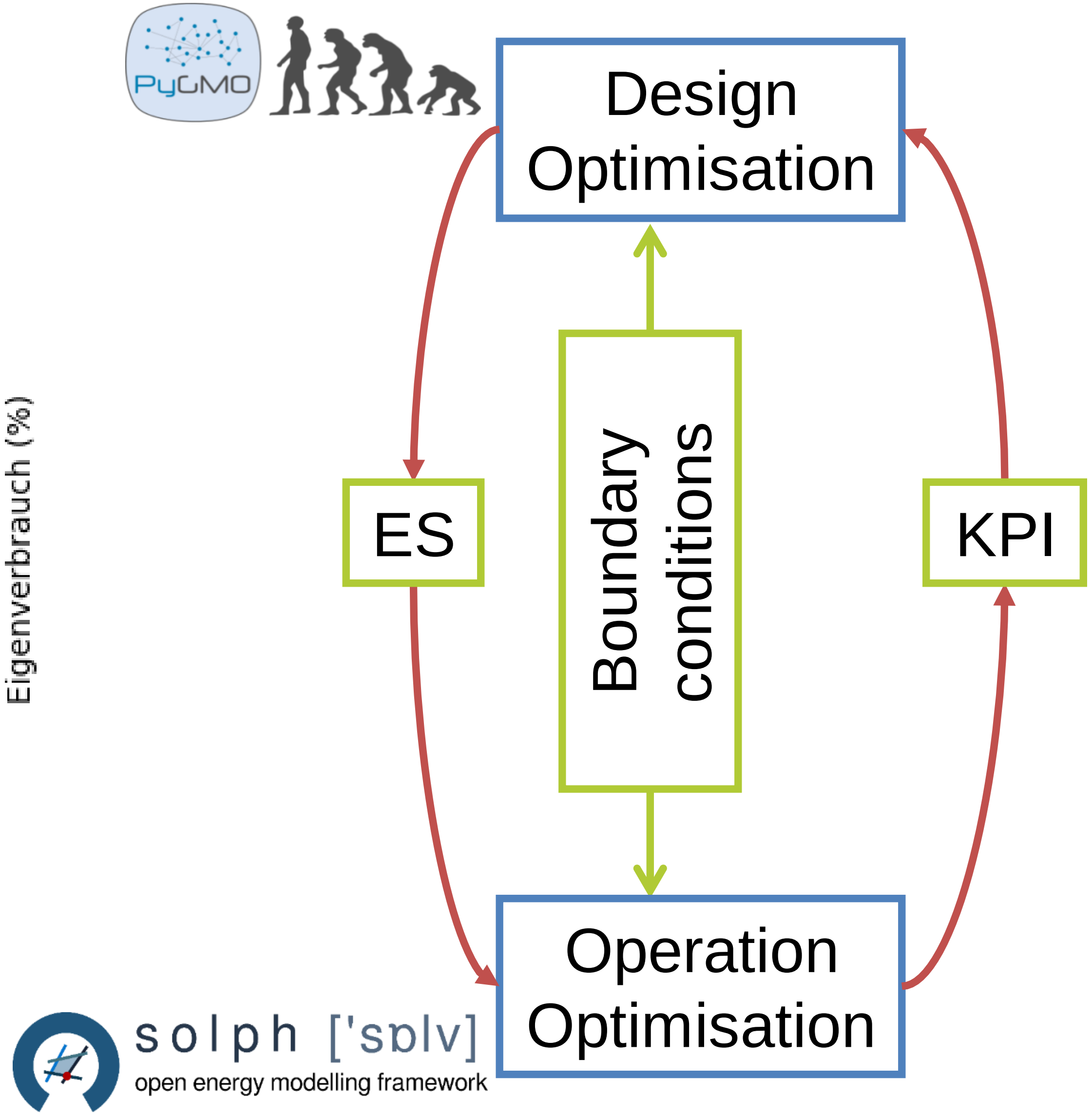

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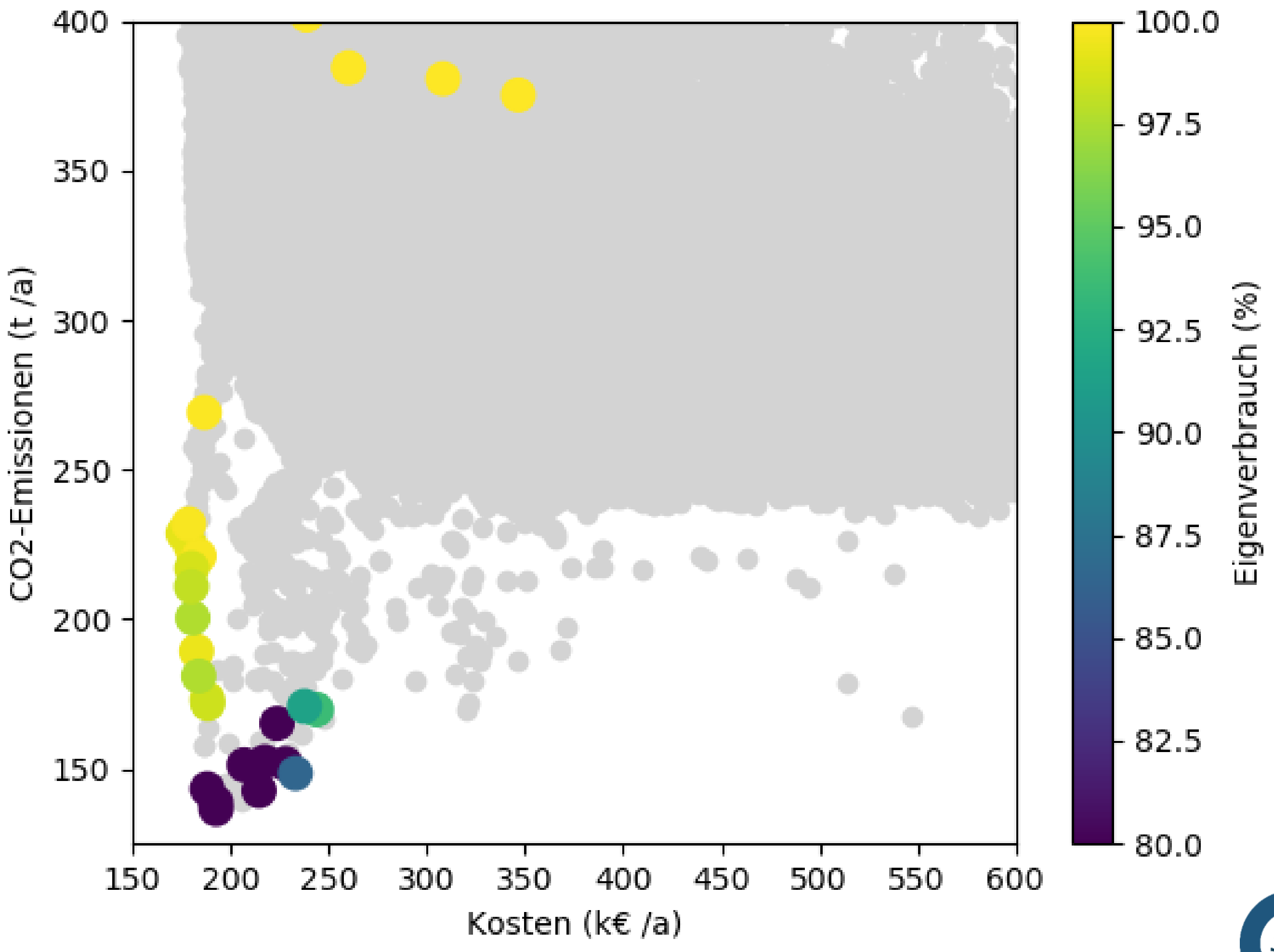
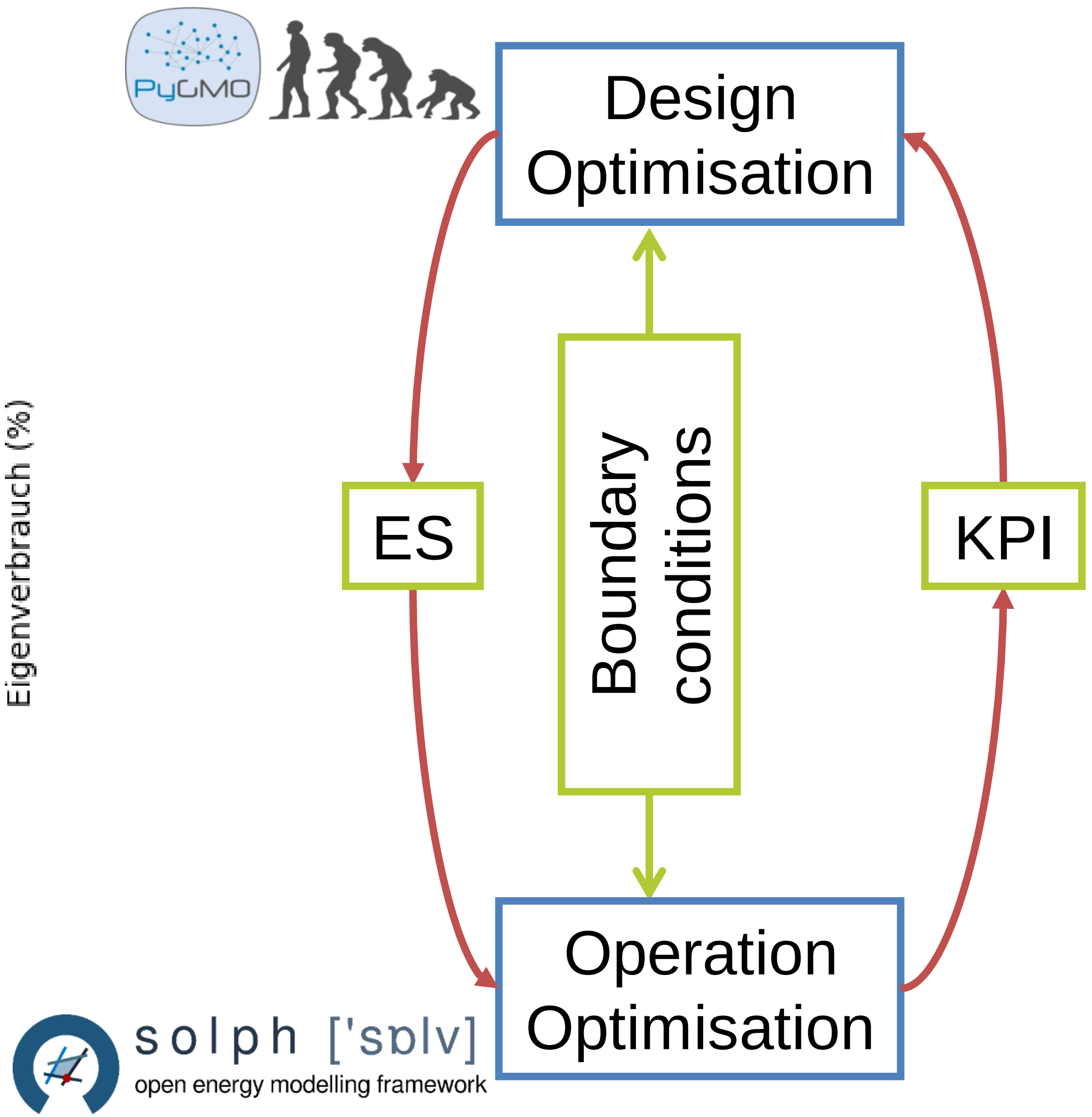
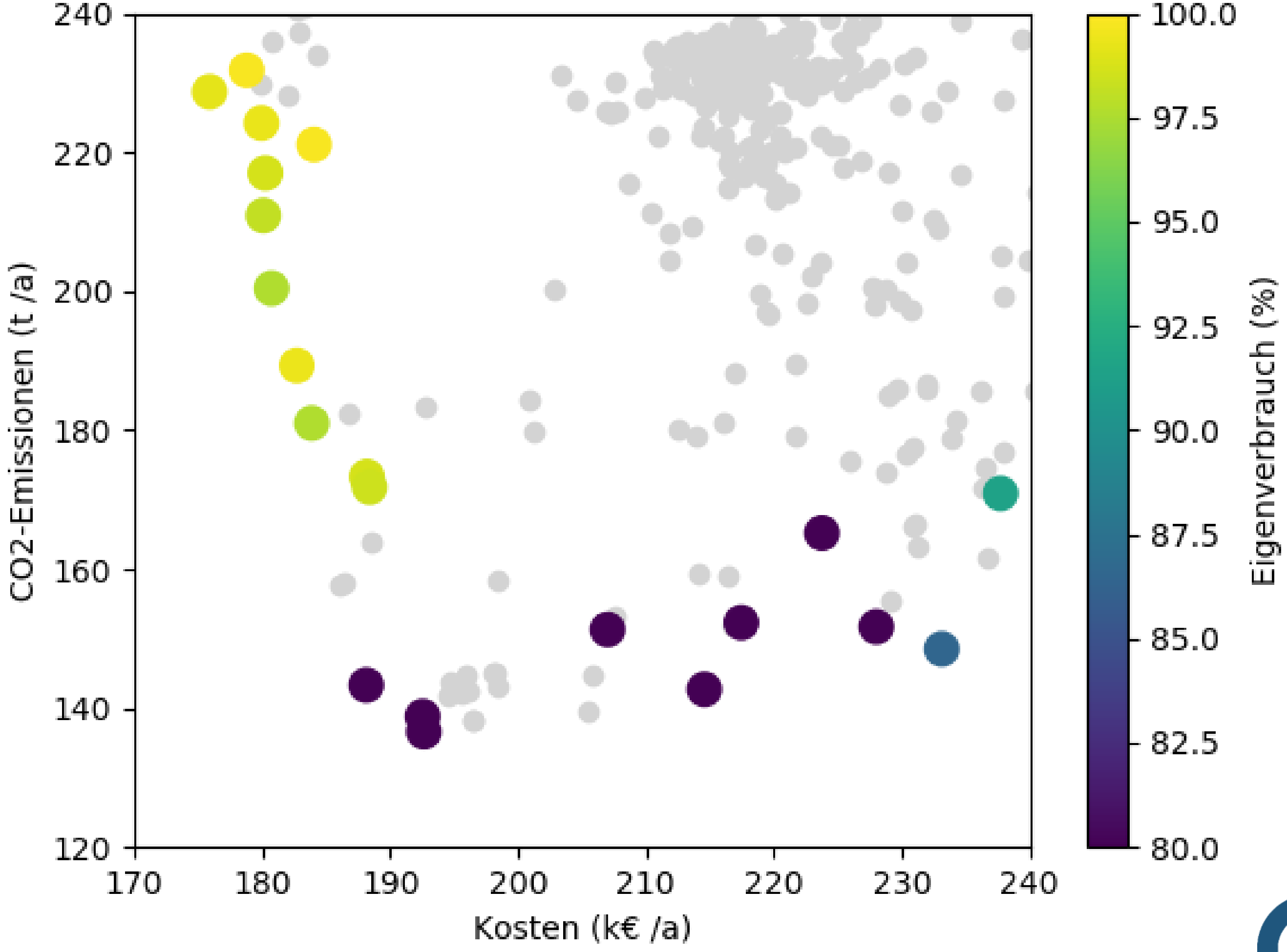
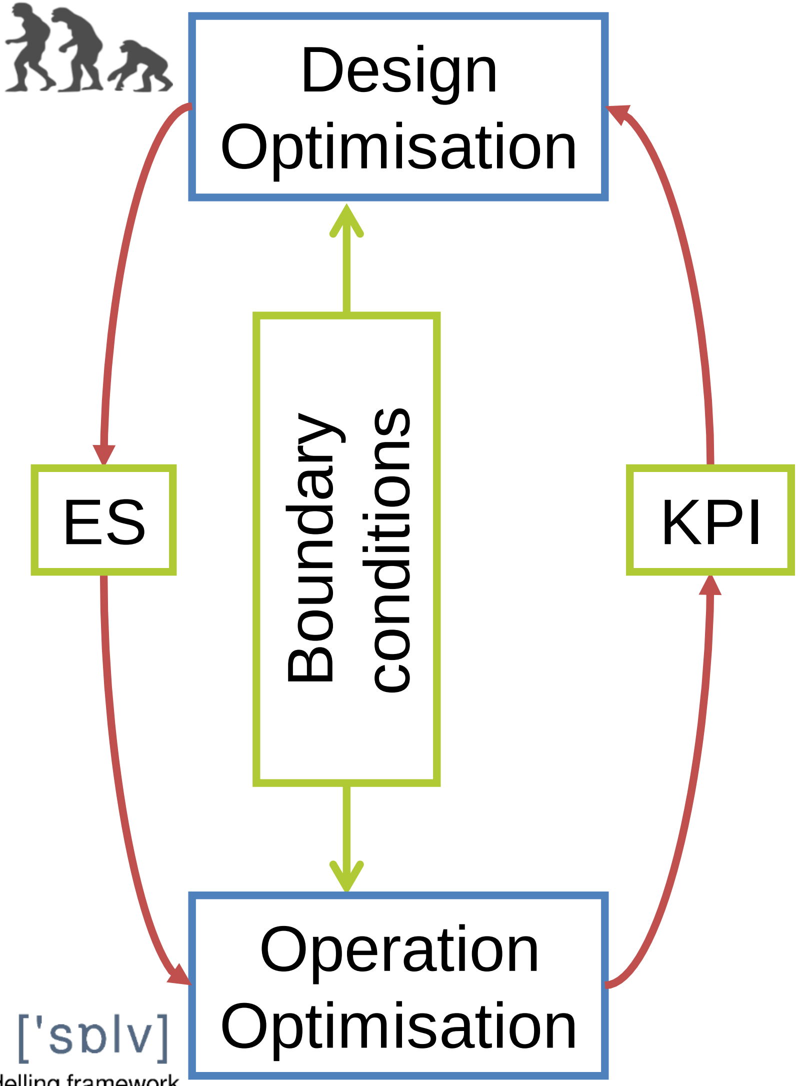




Example pareto-optimal results



PyGMO



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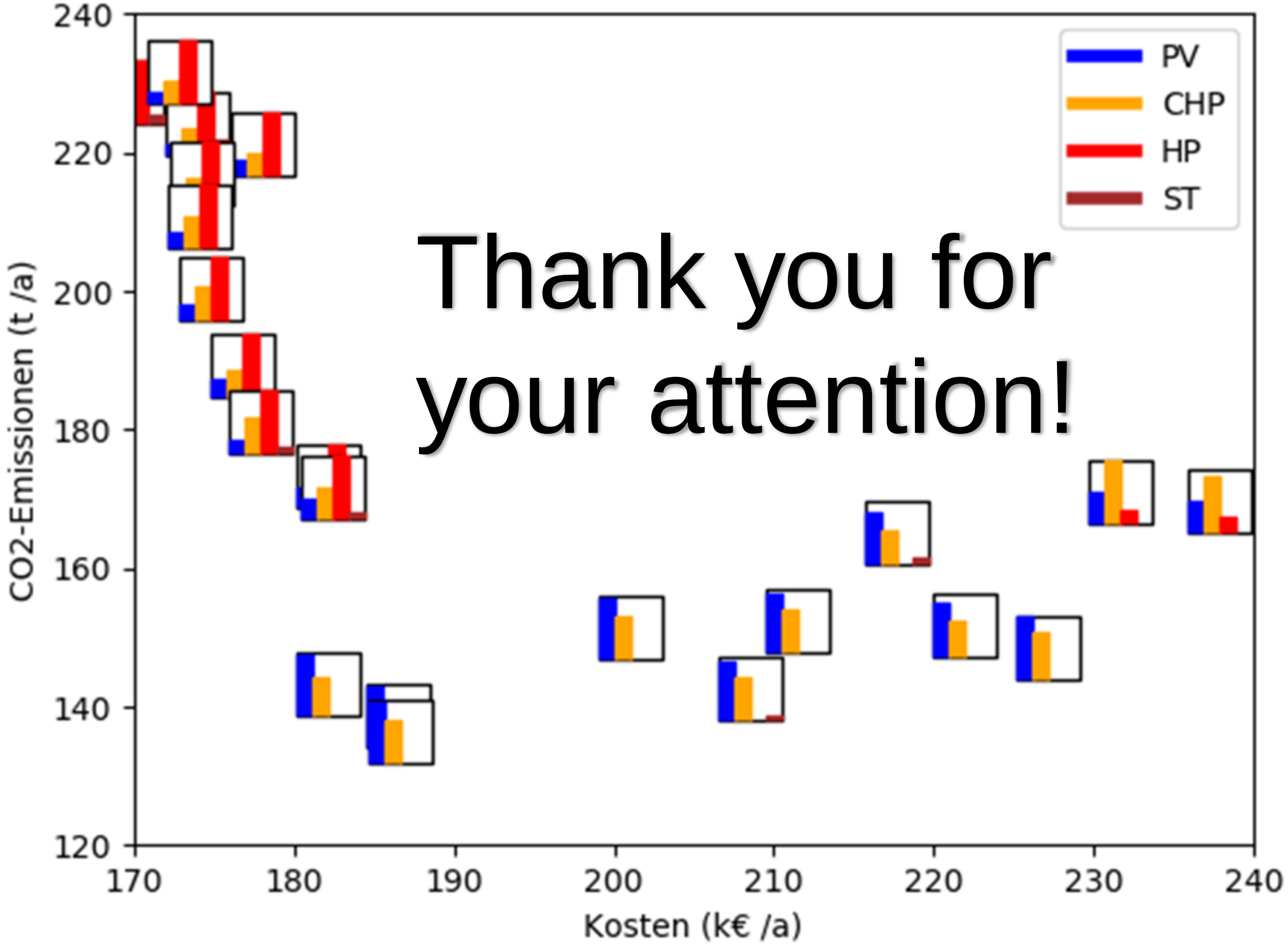
Example pareto-optimal results



Thank you for your attention!

Optimal operation

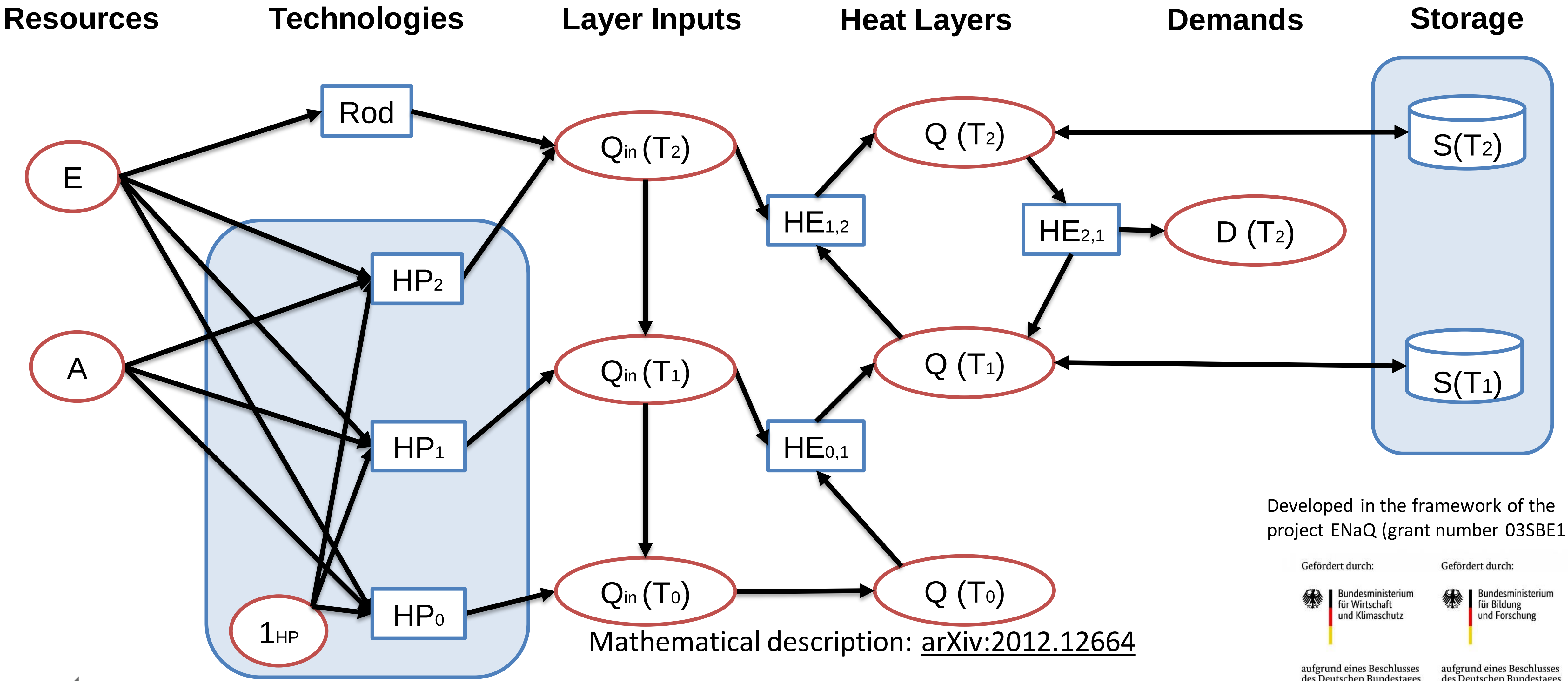
- Linear, single objective
- Costs (€/a) incl. CO2 price

Optimal design:

- Non-linear
- Multi-objective
  - Emissions (t/a)
  - Costs (€/a)
  - Own consumption (%)
- Allows for late decision

Backup

MTRESS: multi-layer heat model



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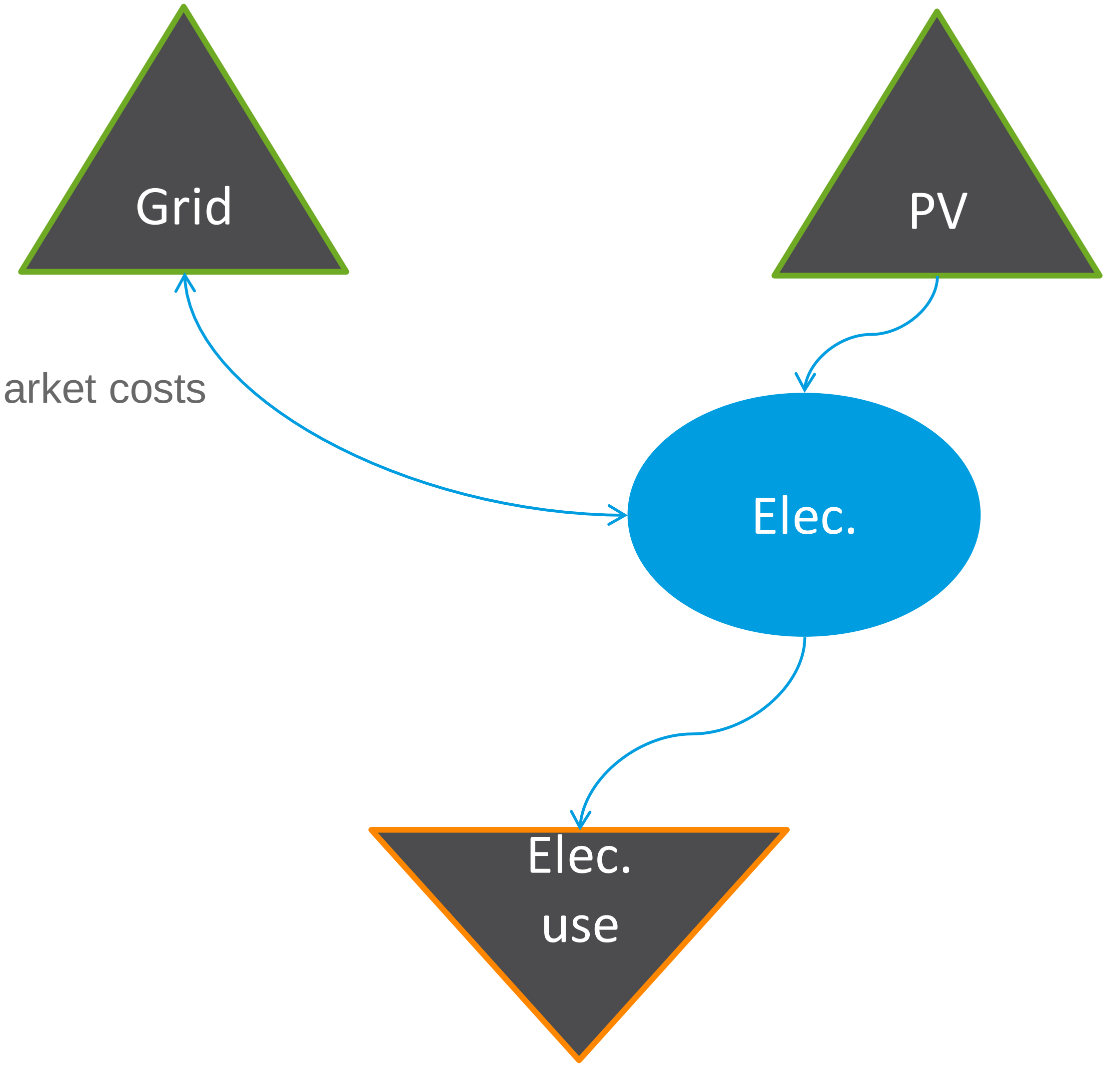
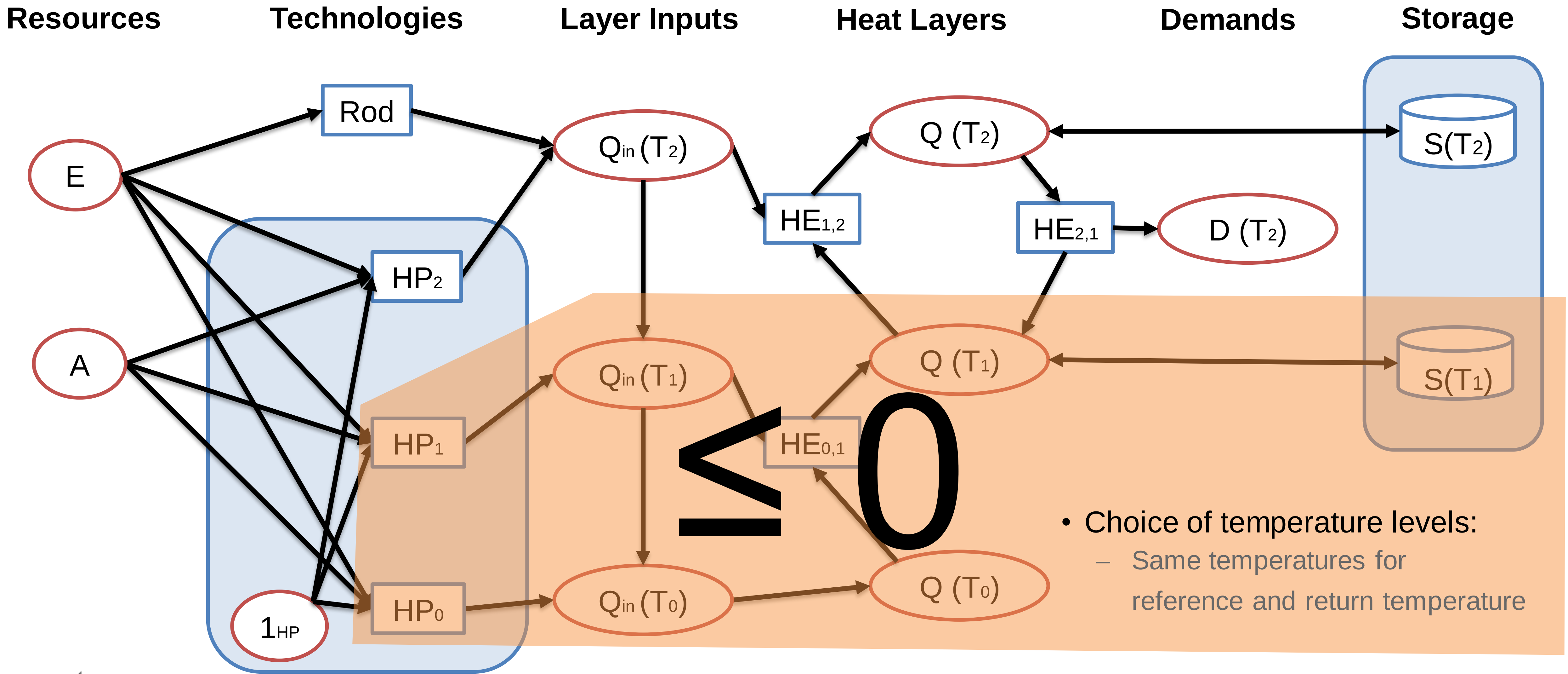
Computational Performance (1/2)

- Complex systems need more time
- How to reduce complexity?
- Try allowing non-exclusive grid connection
  - Revenue selling highly subsidised generation bigger then market costs
  - Feed-in without overproduction becomes attractive
  - Technically impossible (only one meter +/-)
  - Allow this, hope for the best
    - ➢ Save time (factor >100 possible), correct afterwards
    - ➢ Error might be small or large, depending on prices
    - ➢ Not always the best way, results possibly useless
- Time-slicing (optimise e.g. weeks)
  - No seasonal storages usable
- Choice of temperature levels
  - Same temperatures for reference and return temperature



Computational Performance (2/2)



- Choice of temperature levels:
  - Same temperatures for reference and return temperature