RUHR-UNIVERSITÄT BOCHUM

MODELLING TO GENERATE ALTERNATIVES FOR DECARBONIZING THE ENERGY SUPPLY OF A LARGE UNIVERSITY CAMPUS

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Motivation

Background

Net-zero until 2045

- **Energy transition:**
  - Decentralisation, flexibility, intermittency, etc.
  - Energy systems models: simplifications, reduction to cost-optimisation

→ **Dealing with uncertainties, especially values, preferences and norms of decision-makers**

- **Exemplary role of universities:**
  - Promote sustainability
  - Develop campus decarbonisation strategies
  - Translate strategies into practice

→ **Finding accessible, interdisciplinary approaches**

Modelling to generate alternatives:
- Find *many* near-optimal solutions instead of *one* cost-optimal

Esser et al., *Modelling to generate alternatives for decarbonising the energy supply of university campuses* (in review)

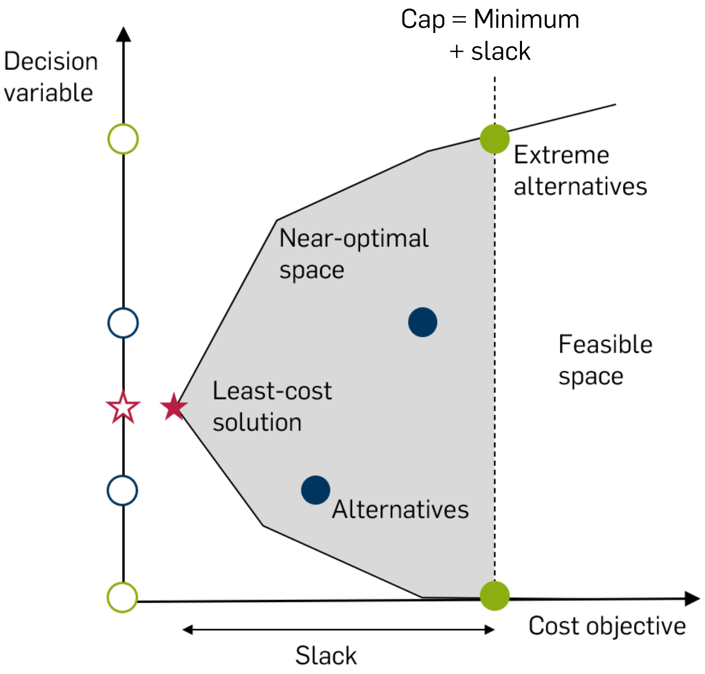
Aim

- **Combine scientific and interdisciplinary methods**
- **Develop a novel method to:**
  - Explore diverse, near-cost-optimal decarbonisation paths
  - Conduct a practical yet generalisable case study based on real data and serve as a role model for other universities
  - Support decision-making
  - Promote sustainability within higher educational institutions

Esser et al., *Modelling to generate alternatives for decarbonising the energy supply of university campuses* (in review)

Methods

Modelling to generate alternatives (MGA)



1. Obtain single-objective optimum ★
2. Determine slack
3. New problem formulation:
   - Original objective → new constraint to cap maximal cost-deviation from optimum
   - New objective → sum of weighted decision variables
4. Iterate to generate near-optimal alternatives:
   - Heuristic weights: iterative Hop-Skip-Jump to diversify quickly ●
   - Analytical weights: find extreme values for each variable ●

Esser et al., *Modelling to generate alternatives for decarbonising the energy supply of university campuses* (in review)
MGA based on DeCarolis, *Using modeling to generate alternatives (MGA) to expand our thinking on energy futures*, Energy Economics 2011. https://doi.org/10.1016/j.eneco.2010.05.002

Optimisation framework

- **Modelling framework:**
  - Backbone: Highly adaptive mixed-integer linear optimisation framework
    - Objective: Cost-minimisation
  - MGA: Implementation into Backbone
    - Extremely flexible and universally applicable

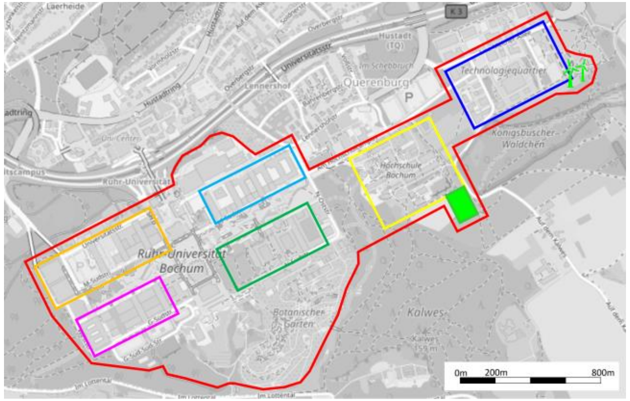
➡ Openly and freely available

Esser et al., *Modelling to generate alternatives for decarbonising the energy supply of university campuses* (in review)
Optimisation framework available at https://gitlab.vtt.fi/backbone/backbone

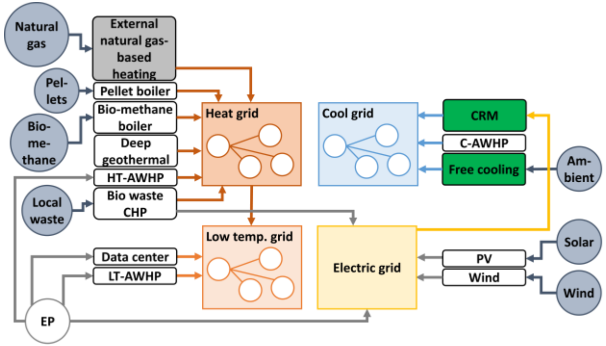
Case study: Ruhr-University Bochum (RUB)

Aim: explore possible ways to reach climate-neutrality until 2045

Campus top-down and system boundaries:



Model structure in Backbone:



Model key data:

- 8760h/a
- 75 nodes
- Power, heating and cooling
- Target year: 2045
- Zero CO2-emissions

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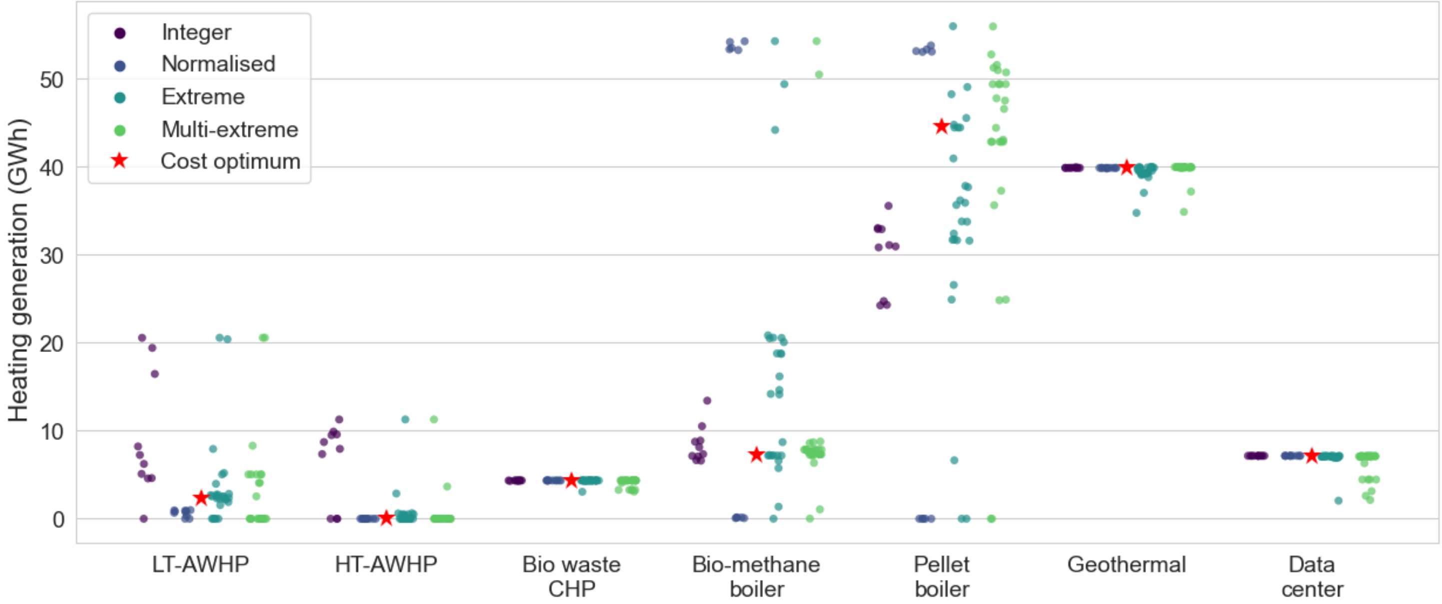
Results

Must haves and choices (1% extra cost)



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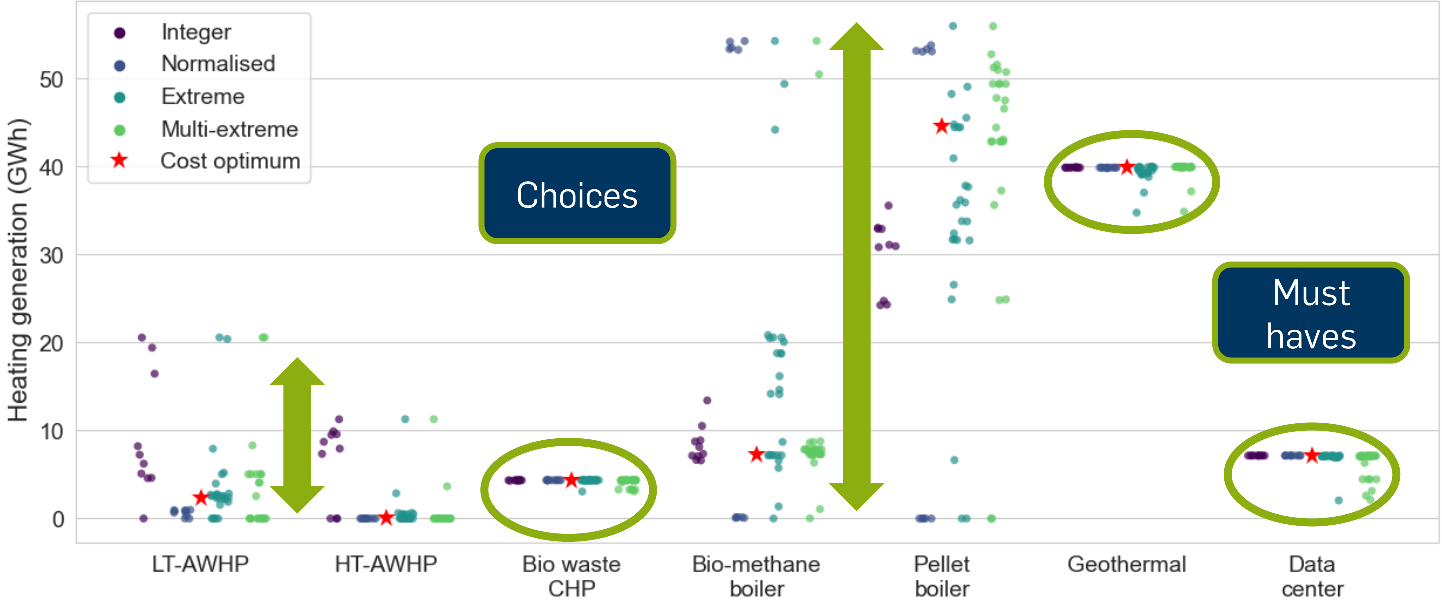

Wide scope for decision-making even for small cost deviation

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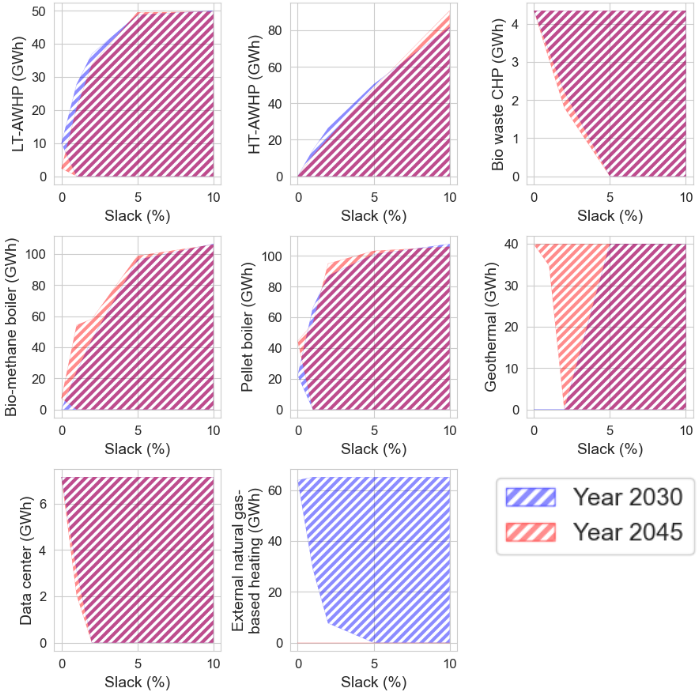
Path dependency (1-10% extra cost, 2030 + 2045)



- 2030 and 2045 areas overlap largely
- Draw attention to stranded assets or contradictory investment implications
- Show potential to reduce emissions earlier at extra costs

➡ **Extended scope and knowledge for decision-making**

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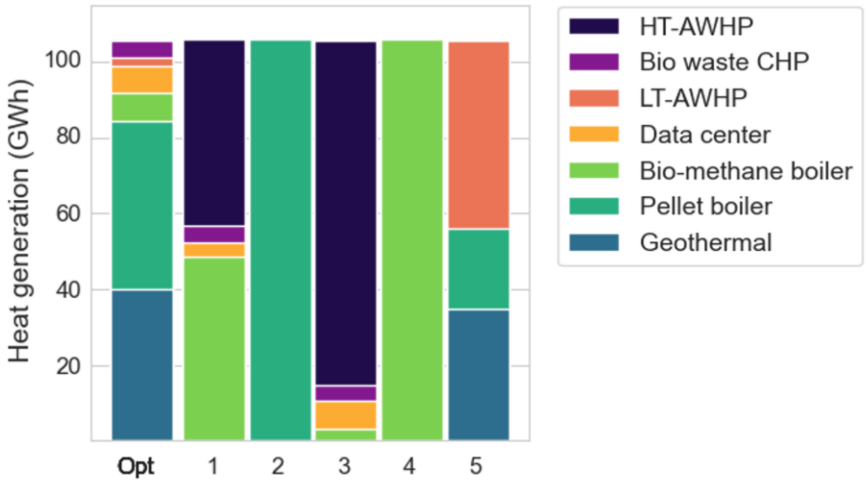
Discrete alternatives and potential interests

- Least-cost vs alternatives 2 and 4:
  - High/ low diversification vs high/ low realisation and maintanace efforts
- Alternatives 3 and 5:
  - Potential synergies with research and teaching

➔ **Reduced uncertainty if any technology not desired, infeasible or poorly parameterised**



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Conclusion and outlook

Conclusion

- **MGA:**
  - Reveals space of opportunities set by certain restrictions
  - Different MGA variants have individual strengths and weaknesses
  - Highly flexible implementation in Backbone openly and freely available

- **MGA for university campuses:**
  - Valuable insights for decarbonisation strategies
  - Reduces uncertainty, increases feasibility
  - Supports the decision-making process

Esser et al., *Modelling to generate alternatives for decarbonising the energy supply of university campuses* (in review)

Outlook

- **Ruhr-University Bochum:**
  - Findings will be used internally to support the decision-making:
    1. Guide the internal preference elicitation
    2. Commissioning of in-depth feasibility studies
    3. Set theoretical approaches into practice!!

- **Beyond Ruhr-University Bochum:**
  - Encourage to adopt the presented approach
  - Promote sustainability

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THANK YOU FOR YOUR ATTENTION

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