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From Local to National: Heat Demand Projections from Municipal Heat Plans in Germany towards 2045

Tilman Hesse, Öko-Institut e.V., ISEC 2025, 16th April 2026

Co-authors: Veit Bürger, Marc Stobbe, Benjamin Köhler, Jessica Thomsen, János Bánk

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Background & Objectives

- Obligation to develop municipal heat plans following the National Heat Planning Act (Wärmeplanungsgesetz or WPG):
  - Municipalities > 100.000 inhabitants: Heat plans need to be finalised by mid-2026
  - All other municipalities: Heat plan finalised by mid-2028

- Varying stages of implementation: some municipalities have already completed their heat plans; many are currently in the development phase

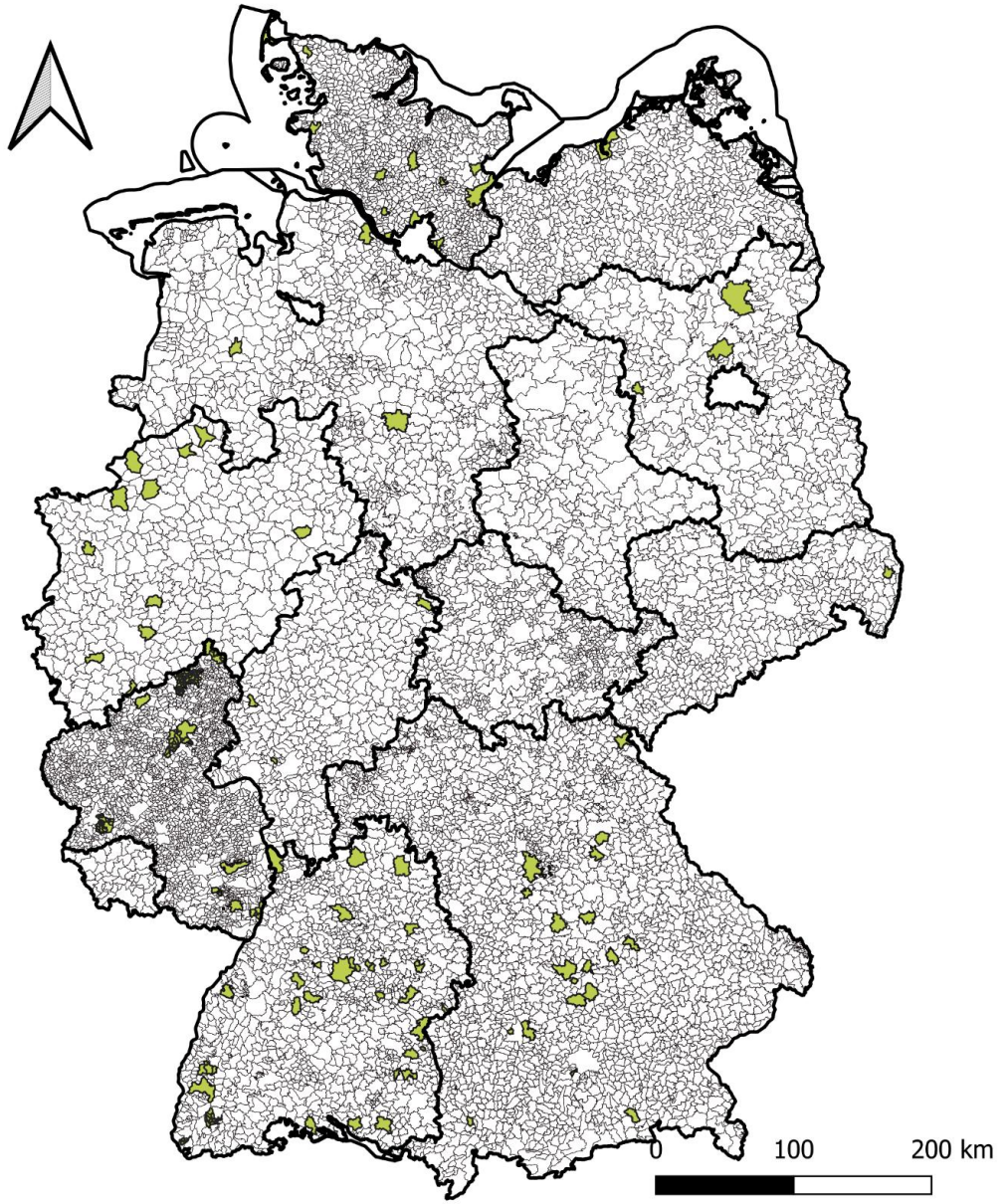
- Project KOMpare: Systematic compilation and comparison of municipal heat plans
  -> Objectives:
  - Identify overarching patterns, trends, and differences
  - Establish suitable approach to upscale existing heating plans to national scenario
  - Compare this bottom-up approach with top-down energy system scenarios

Evaluation of existing heat plans

Municipalities included in the analysis

Federal state	Total number of municipalities	Finalised heat plans*	Analysed municipalities
Baden-Württemberg	1.101	237	47
Bayern	2.056	20	20
Berlin	1	0	0
Brandenburg	413	4	3
Bremen	2	0	0
Hamburg	1	0	0
Hessen	421	5	3
Mecklenburg-Vorpommern	726	1	1
Niedersachsen	941	4	3
Nordrhein-Westfalen	396	11	11
Rheinland-Pfalz	2.301	120	120
Saarland	52	0	0
Sachsen	418	2	1
Sachsen-Anhalt	218	0	0
Schleswig-Holstein	1.104	16	14
Thüringen	624	0	0
Deutschland	**10.775**	**420**	**223**

** as of May 2025*



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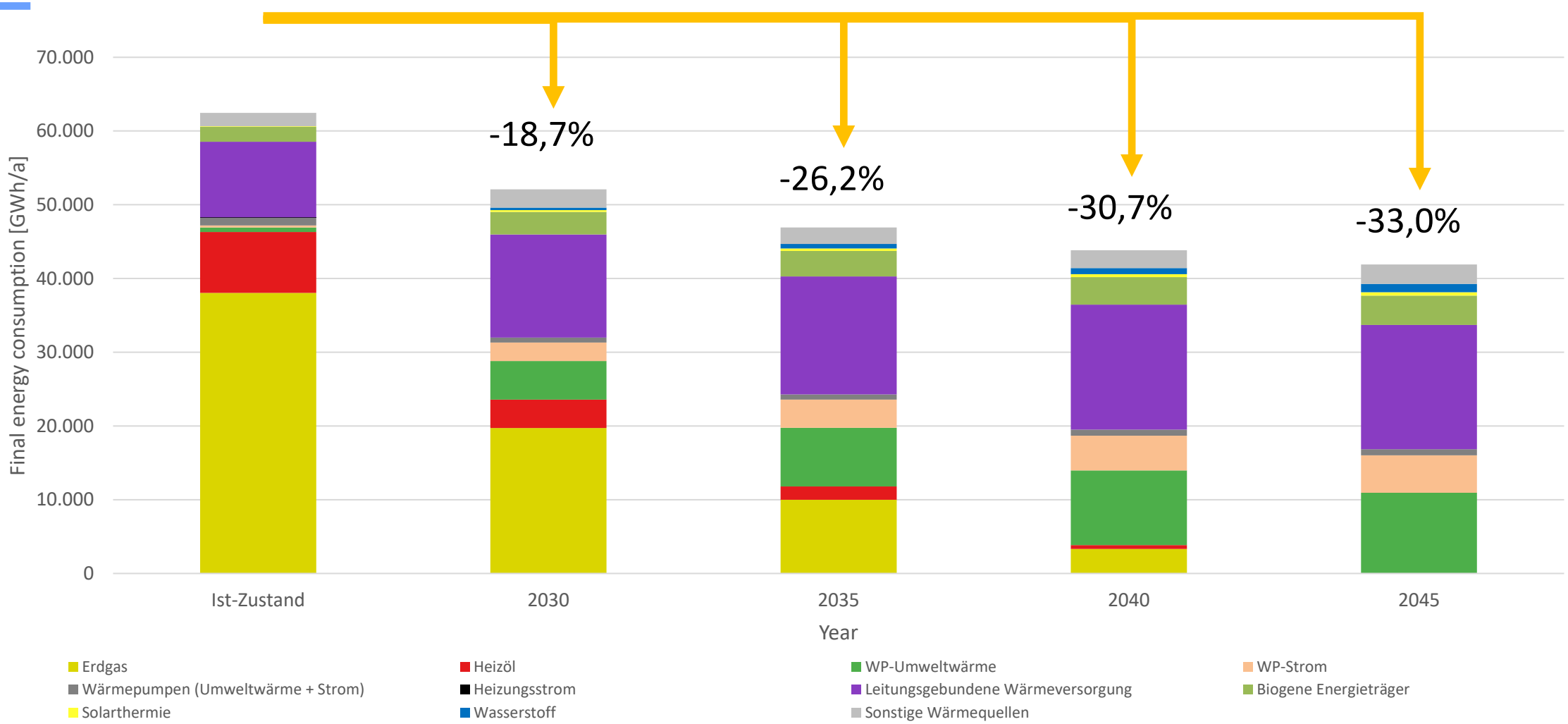
Trends in final energy consumption for evaluated heat plans



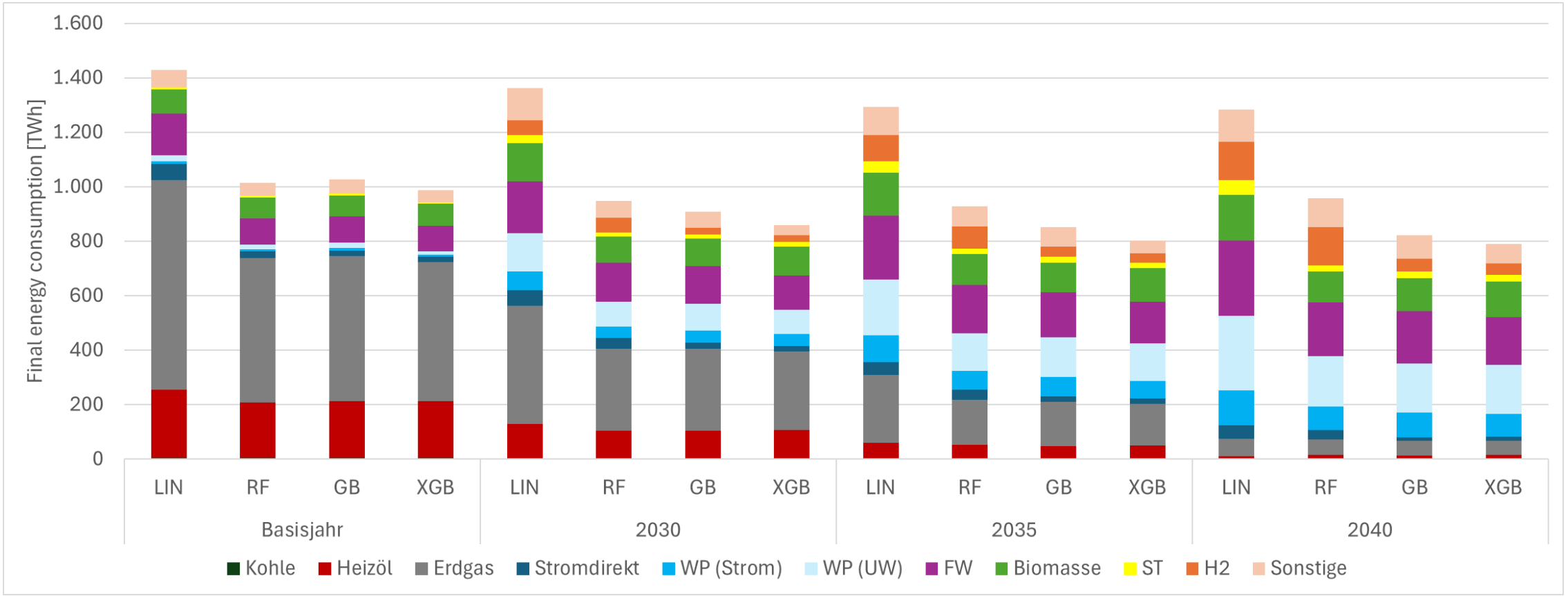
Scaling-up to a national bottom-up scenario

Machine Learning (ML) approach

- machine learning is about training a **model**
- **training data** comes from the evaluated municipal heating plans (n = 223)
- each evaluated heating plan contains data on energy consumption in the current state and for future reference years (2030, 2040 etc.)
- each municipality in Germany has specific characteristics: number of inhabitants, area, federal state affiliation, heating degree days, etc.
- for training the model different regressors can be used
- based on the training data, the model predicts which energy carrier distribution can be expected in each municipality in Germany.
- n = 223 heating plans are probably too few cases for maximising the advantages of the ML approach
- however: since more and more heating plans are being completed over time, the training data set constantly improves, which should yield more robust scaling-up results

Future energy carrier distribution

Regressors: LIN: linear; RF: random forest; GB/XGB: gradient boosting



WP: heat pumps; UW: ambient heat; ST: solarthermal

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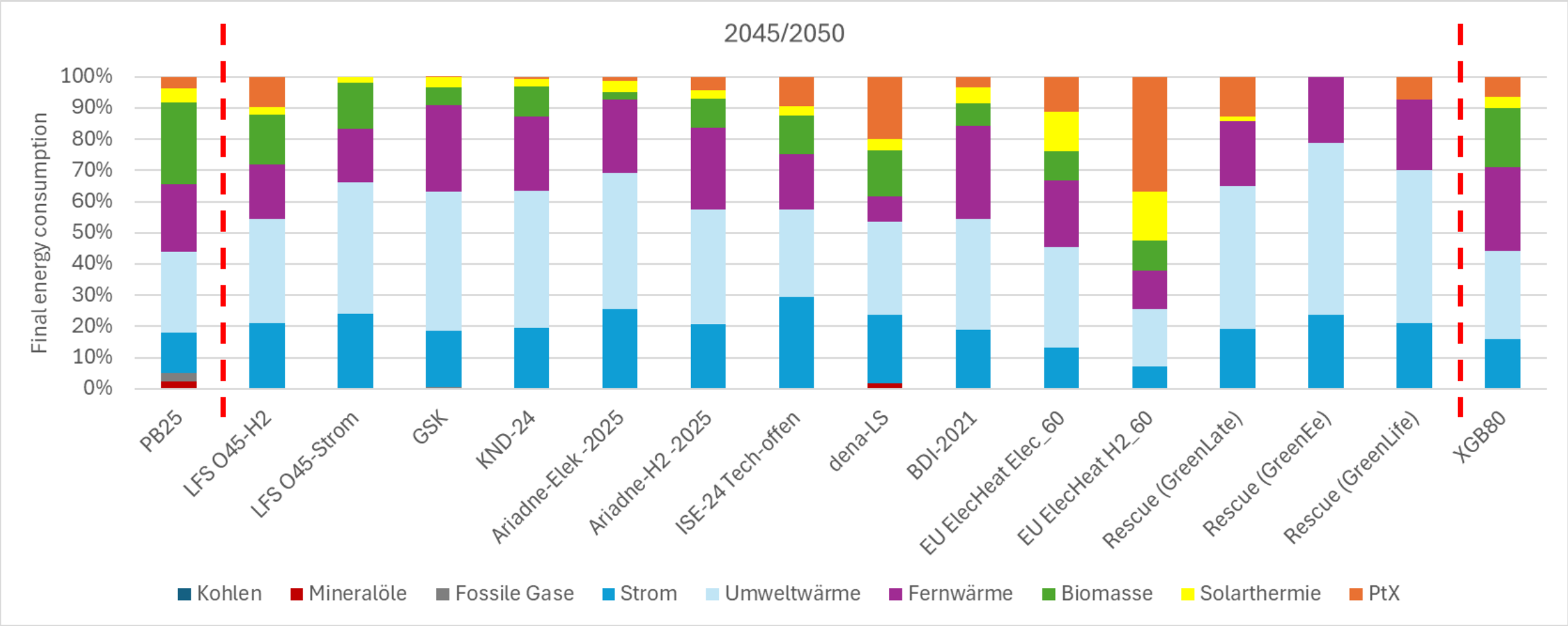
Findings

- Generally, the ML approach seems to work well
- Reduction in final energy: correct trend, but extent of reduction uncertain.
- Main energy carriers develop plausibly for each regressor: natural gas, heating oil, district heating, biomass, heat pump environmental heat, heat pump electricity.
- Deviations in base year between linear regressor and other regressors require further analysis
- Current training data volume likely too small (n = 223); Over the course of this year, more municipal heat plans will be evaluated, with a target of n = 1,000.
- Outlook: More robust projections by end of 2026; additionally, comparison with top-down scenarios: what insights can be drawn from comparing bottom-up vs. top-down?

Scenario comparison

Scenario comparison 2045/50



Findings

2045/50 – upscaled compared to top-down scenarios

- at upper end of absolute final energy consumption
- comparatively high share of biomass usage
- at upper end of DH usage
- below average for heat pump usage

Important disclaimer/reminder:

- scaling-up is based on a comparatively small sample (n = 223)
- Results more robust once the sample size increases!

-> upscaled bottom-up heat plans foresee comparatively **moderate gains in energy efficiency** with **slightly above average use of centralised DH** while decentralised heating systems show **above average use of biomass** and **below average use of heat pumps** compared to top-down scenarios

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Contact

Dr. Tilman Hesse
Öko-Institut e.V.
Tel. +49 761 29545-287
t.hesse@oeko.de

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