Understanding the similarities and differences in decarbonisation scenarios derived from different building stock models

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Overview

Modelling possible future scenarios of buildings' energy carrier mix and energy consumption levels is crucial for understanding and planning decarbonisation pathways. Comparing models' specific characteristics are important to understand different model results and reduce biases that might result from single models. However, model comparisons are often difficult to perform, if scenario specifications did not take place in a comparable manner. A scenario specification and model run task has been carried out within the scope of the ECEMF project [1]. This task covers seven scenarios representing high and low demand levels and different technology focus. The aforementioned seven scenarios ran by different building stock models, which are Invert/EELab [2], Invert/Opt [3], FORECAST [4], PRIMES-Buildings [5], and REMIND-Buildings [6].

This study analyzes the differences between seven scenarios and five building stock models. Within the scope of this study, we aim to answer the following questions. What are the possible reasons for the deviations between the different models? What are common insights and robust results across the scenarios?

Methods

As a first step, we specified the scenario narratives. Seven scenarios have been created, which represent different demand reduction levels under different supply configurations:

1. High Electrification|Efficiency Moderate
2. High Electrification|Efficiency High
3. High Electrification|Lifestyle and Behavioral Change
4. High H2/e-fuels|Efficiency Moderate
5. High H2/e-fuels|Efficiency High
6. High District Heating|Efficiency Moderate
7. High District Heating|Efficiency High

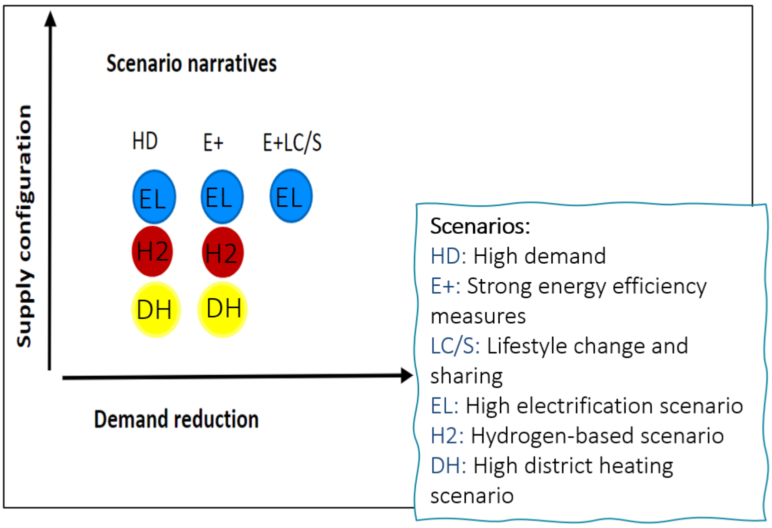

Figure 1 Scenario design

As explained above, five different building stock models are considered in this study. Invert/EELab is a techno-socio-economic bottom-up simulation model, a logit approach, with building owners represented as agents with distinct decision-making parameters. [2] Invert/Opt is an economic bottom-up optimization model (deriving an overall cost-optimum mix of renovation measures and technology choices for a specific target year). [2] FORECAST-Buildings is a bottom-up simulation model that considers the dynamics of technologies and socioeconomic drivers for the future energy demand of the buildings sector. [3] PRIMES-Buildings is a hybrid economic-engineering optimization model founded on microeconomic theory, built to represent the behaviors of consumers with embedded engineering constraints. Finally, REMIND-Buildings is an energy-economy general equilibrium model linking a macroeconomic growth model with a bottom-up engineering-based energy system model.

In the full conference contribution, detailed fundamental information, such as modeling structure, key algorithms, boundary conditions etc., will be provided for each model. Additionally, each model's general scenario specifications and internal assumptions will be reported. In order to ensure common data formats, definitions and

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structure, the results were uploaded to IIASA's Scenario Explorer tool [6]. The differences between scenarios and between models will be detected. After evaluating the results, possible reasons for the deviations will be discussed.

Results

We will deliver the results in terms of:

1. Total final energy consumption in the residential and commercial sectors,
2. Total final energy consumption by energy carriers in the residential and commercial sectors,
3. Total final energy consumption by end-use in the residential and commercial sectors,
4. Renovation rates in the residential and commercial sector,
5. Installed capacities for heat pumps in the residential and commercial sector.

Figure 2 shows the reduction in final energy consumption in the building sector for each model and each scenario in 2050. Given the absolute amount of energy demand in this sector in 2020 (15.47 EJ), the overall deviations between the models are considered as moderate. [7] Still, the differences between high and moderate scenarios are more pronounced e.g. in FORECAST-Buildings compared to PRIMES-Buildings. Reasons for these deviations include different model dynamics and also differences in the detailed scenarios specifications. In addition to the numerical comparison, we will provide further analysis of the explanation of the reasons for the deviations between models.

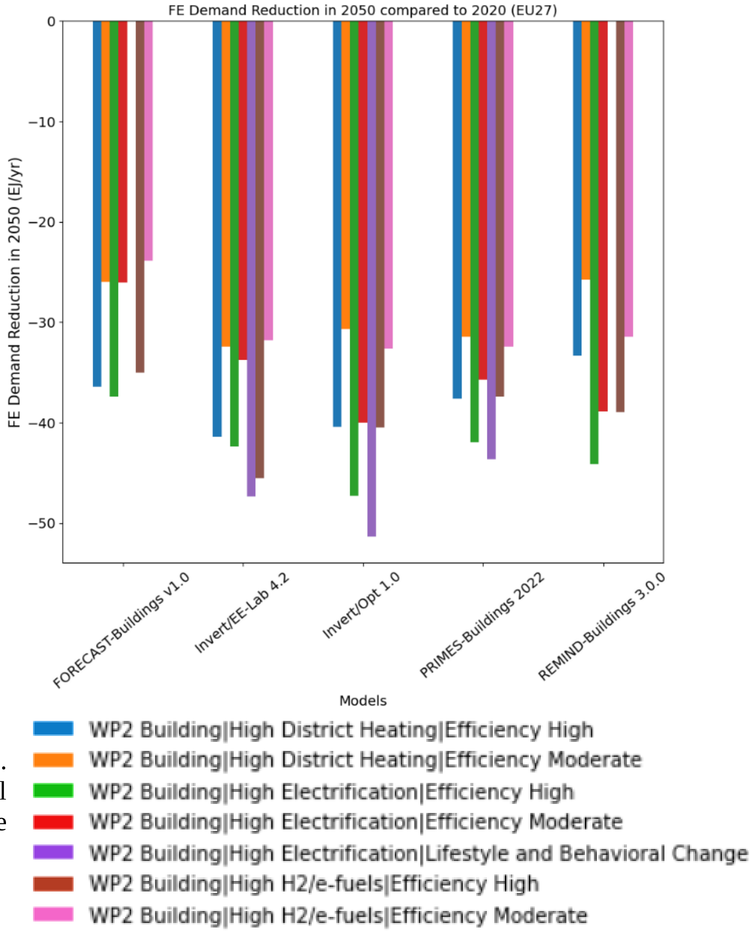

Figure 2 FE Demand Reduction in 2050 compared to 2020 by model

Conclusions

The following key learnings can be derived as common learning from all models: (1) Substantial enhancement of building renovation and related improvement of the building envelope is key for a decarbonised building stock. (2) Heat pumps play a crucial role in the supply mix of all scenarios. (3) H2 and e-fuels do not turn out to be an efficient and economically viable solution in any of the models, even not in the dedicated H2/e-fuels scenarios. (4) District heating is important for the decarbonisation process, but models lead to different intensities of district heating expansion. In the full paper, we will further expand on these insights and also discuss the reasons for deviations.

References

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