BUILDING-STOCK MODEL BASED SCENARIOS UNDER DIFFERENT PRICE SIGNALS

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Overview

Energy models have been used as a base for mapping energy flows or analyzing energy systems, and are typically used for policy-making, investment planning, legislation, and regulation. Energy scenarios are used to assess the impacts of different developments under specific assumptions. Scenarios can be used to aid in mapping different energy or price futures. Therefore, this work aims to observe how scenarios in different types of building stock models respond to different price signals under different decarbonization targets. Various price scenarios created within the scope of the European Climate and Energy Modeling Forum[1] (ECEMF) project were used. ECEMF is a Horizon 2020 project which aims to establish a European forum to bring together energy and climate researchers and policymakers and deal with how to achieve climate neutrality. [1]

Methods

Two building-stock models are used in this work, one is Invert/EE-Lab[2], and the other is Invert/Opt[3]. Invert/EE-Lab is a techno-socio-economic bottom-up building stock model involved in more than 40 projects in EU-27+ countries. [2,3] It is a myopic simulation tool that considers the effects of different policy decisions such as economic incentives, research, and technology development on the total energy demand, energy carrier mix, CO_2 reductions, and also costs for space heating, cooling, and hot water preparation in buildings. [4] Invert/Opt is an optimization model derived from the aforementioned model. It determines the combined optimization of the building shell and heating system to reach the least cost building stock status in a certain target year.

Both models are used to derive scenarios with different levels of decarbonization efforts under various price signals.

A set of price sensitivity scenarios is prepared to assess the responsiveness of building-stock models to prices of input energy commodities and CO_2. The procedure for deriving these price sensitivity scenarios is based on a set of scenarios reaching net-zero CO_2 emissions in Europe established from the open ENGAGE[4] database, containing 26 scenarios from five different Integrated Assessment Models. [5] The initial set of carbon and energy prices are calculated by taking the median of prices of all scenarios of each model, and then the median of those model-based prices. Then, four different price scenarios are developed to test various responses based on different prices levels. These scenarios were named *High Price*, *Low Price*, *High Gas and Liquids Price*, and *High Electricity Price*, respectively. Likewise, to extend the scope of the ECEMF project, two additional scenarios, named Reference Scenario and Decarbonization Scenario, will be developed to see the future in the case of business as usual and to apply complex measures for the carbon mitigation goal, respectively. In these scenarios, the base year is 2019 and the simulations are done annually until 2050. Energy prices for scenarios are calculated as follows:

- *High Price*: The average energy prices of scenarios are calculated from each model, then the maximum price is chosen.
- *Low Price*: The average energy prices of scenarios are calculated from each model, then the minimum price is chosen.

[1] ECEMF: https://www.ecemf.eu/
[2] https://invert.at/
[3] https://eeg.tuwien.ac.at/gitlab/mostafa/invert_opt
[4] https://data.ece.iiasa.ac.at/engage

- *High Gas and Liquids Price*: Price of natural gas, oil, and biomass liquids gathered from *High Price* scenario, the rest of the energy carriers gathered from Initial Price set.

- *High Electricity Price*: Price of electricity gathered from *High Price*, the rest of the energy carriers gathered from Initial Price set.

Results

For each scenario, we will derive the scenario results for each member state as useful final primary energy demand, costs, energy carrier mix, and technology choices of heating systems on the national level. Further, we will point out the additional costs of decarbonizing the system under the different price scenarios.

In particular, we will show how the price sensitivity for both involved models will differ under various decarbonization targets. For this purpose, we will assess under various decarbonization targets (1) the range of resulting energy demand levels, (2) the range of the resulting technology and energy carrier mix, and (3) the range of total costs, each resulting from the different price scenarios in each of the two models.

Conclusions

With this study, we are aiming to help to understand how energy price signals affect sectoral demand reduction potentials, sectoral bottlenecks, and challenges, and the pace at which decarbonization may occur in the building-stock sector until 2050. The conclusions will cover (1) recommendations for modelling of energy price-related uncertainties in techno-economic stock models like building stock models and (2) the relevance of these energy price-related uncertainties for policymaking in the building sector.

References

[1] https://www.ecemf.eu/about/

[2] Müller, A., 2015. Energy Demand Assessment for Space Conditioning and Domestic Hot Water: A Case Study for the Austrian Building Stock (PhD-Thesis). Technische Universität Wien, Wien.

[3] Forthuber, S., Müller, A. and Kranzl, L., 2021. Global sensitivity analysis of a techno-socio-economic building stock energy model. [online] Publik.tuwien.ac.at. Available at: <https://publik.tuwien.ac.at/files/publik_300364.pdf> [Accessed 13 April 2022].

[4] Kranzl, L., Aichinger, E., Büchele, R., Forthuber, S., Hartner, M., Müller, A., Toleikyte, A., 2018. Are scenarios of energy demand in the building stock in line with Paris targets? Energy Effic. https://doi.org/10.1007/s12053-018-9701-1

[5] Riahi, Keywan, Betram, Christoph, Drouet, Laurent, Hasegawa, Tomoko, Dalla Longa, Francesco, Desprès, Jacques, Fosse, Florian, Fragkiadakis, Kostas, Fricko, Oliver, Gusti, Mykola, Humpenöder, Florian, Keramidas, Kimon, Kishimoto, Paul, Kriegler, Elmar, Nogueira, Larissa P., Oshiro, Ken, Popp, Alexander, Rochedo, Pedro R.R., Takakura, Junya, … Weitzel, Matthias., 2021. ENGAGE Global Scenarios (2.0) [Data set]. Zenodo. https://doi.org/10.5281/zenodo.5553976