Role of cogeneration and heating networks in renewable energy systems

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Overview

Since the production of energy accounts for three-quarters of global emissions, mitigating climate change requires the decarbonization of the energy system. Cutting emissions implies to shift supply of primary energy to renewable electricity. The design of future energy systems based on renewable energy is subject to many open and widely discussed questions; in particular: What place will synthetic fuels like hydrogen have in such a system, how can heat supply be decarbonized and what kind of thermal backup capacities do high shares of solar and wind require?
The future role of cogeneration and heating networks intersects all these questions. Apart from electricity, hydrogen is the only energy carrier available to provide renewable heat. At the same time, hydrogen power plants are one of the few options to backup intermittent generation from renewables. However, high costs suggest restricting the use of hydrogen to highly efficient plants and to times when all other options are exhausted. Cogeneration combined with other technologies in local heating or district heating networks matches both these requirements.

Methods

The question is analyzed based on a detailed capacity expansion model that covers the transformation of the European energy system in the next 30 years and is based on the open modelling framework AnyMOD. To achieve an accurate representation of the heating sector and the rest of the energy system, the model introduces several methodological advancements:
First, the level of temporal detail is varied by energy carrier. For example, residential heat is balanced at a four resolution to account for the thermal inertia of buildings, but electricity is modelled hourly to accurately reflect the variation of renewables. Decreasing the temporal resolution for certain carriers also facilitates solving the model.
Second, the model considers how operation of systems in the heating sector is much more restricted than in the power sector. In the power sector, operation of each plant is flexible as long as total demand is met, but operation of residential heating systems is inflexible and proportional to total demand. Options for a more flexible supply of heat in the model include residential heat storage as well as local and districtict heating systems.

Preeliminary Results

Preeliminary results suggest that due to its high costs, hydrogen is not an economical option for inflexible residential heating systems, even with combined generation. However, in district heating systems cogeneration with hydrogen serves as a peak-load technology.

Conclusions

The results demonstrate the impact of sector integration on both the electricity and the heating sector, and how cross-sectoral analysis of these impacts can identify synergies when decarbonizing the energy system.

References

Bloess, A., Schill, W.-P. and Zerrahn, A. (2018). "Power-to-heat for renewable energy integration: A review of technologies, modeling approaches, and flexibility potentials"; *Applied Energy*, 202, 1611-1626.

Brown, T., Schlachtberger, D., Kies, A., Schramm, S. and Greiner, M. (2018). „Synergies of sector coupling and transmission reinforcement in a cost-optimised, highly renewable European energy system."; *Energy*, 160, 720-739.

Bloess, A. (2019). "Impacts of heat sector transformation on Germany's power system through increased use of power-to-heat." ; *Applied Energy*, 239, 560-580.

Göke, L. (2020). "AnyMOD - A graph-based framework for energy system modeling."; *Working Paper*.

Göke, L. (2020). "AnyMOD.jl - A Julia package for creating energy system models."; *Working Paper*.