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# Classification, potential role, and modeling of power-to-heat and thermal energy storage in energy systems: A review

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## Summary

Most of the power-to-heat and thermal energy storage technologies are mature and impact the European energy transition. However, detailed models of these technologies are usually very complex, making it challenging to implement them in large-scale energy models, where simplicity, e.g., linearity and appropriate accuracy, are desirable due to computational limitations. In the literature, the main power-to-heat and thermal energy storage technologies across all sectors have not been clearly identified and characterized. Their potential roles have not been fully discussed from the European perspective, and their mathematical modeling equations have not been presented in a compiled form. This paper contributes to the research gap in three main parts. First, it identifies and classifies the major power-to-heat and thermal energy storage technologies that are climate-neutral, efficient, and technologically matured to supplement or substitute the current fossil fuel-based heating. The second part presents the technology readiness levels of the identified technologies and discusses their potential role in a sustainable European energy system. The third part presents the mathematical modeling equations for the technologies in large-scale optimization energy models.

## Highlights

- Classification, potential, and models of P2H and TES technologies are presented.
- Heat pumps, boilers, resistance heaters, and hybrid systems are the most promising P2H.
- Sensible and latent heat storages are the most prominent TES.
- CHP will play an essential role in coupling power and heat sectors.
- Mathematical models of P2H and TES for large-scale energy models are presented.