Power-to-Heat and thermal storage in heat networks

Summary

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Summary

Power-to-Heat and storage as the next step in heat transition

Energy transition is well underway with energy supply and energy use becoming more sustainable in various applications. The next step in energy transition is to make supply and demand more sustainable. There are two main ways to do this: using electricity when there is a lot of renewable generation and utilising energy storage. In the heat sector, this can be achieved by converting electricity to heat (Power-to-Heat, P2H) and storing that heat so that it can be put to good use at a later time.

In this study, we focus on the opportunities for using P2H and thermal storage to make heat networks more sustainable. For P2H we have considered two techniques: heat pumps and electric water heaters. For thermal storage, we look at tank storage (TTES), storage in an isolated hole in the ground (PTES) and high-temperature storage in an underground aquifer (HT-ATES).

The objective of the study is to connect the worlds of electricity and heat by providing insight into the potential and development of P2H and storage (P2H+S). During this study, we defined the business case and identified the technical potential of P2H+S. In addition, we mapped the impact on the electricity system by modelling electricity generation and sources in heat networks in an integrated manner. Finally, we analysed the barriers and formulated policy recommendations based on this analysis to get P2H and thermal storage up-and-running.

Policy needed for long-term storage

PTES and HT-ATES systems can store heat for periods of weeks, months or even a whole year. Although PTES in particular is already a well-developed technology abroad, both PTES and HT-ATES are currently still in the demonstration phase in the Netherlands and both have limitations regarding the locations where the systems can be built. Both techniques still have technical limitations that need to be resolved and the market for both systems is still very limited. The technology and market can be developed further by introducing a temporary investment grant for large-scale long-term thermal storage. Furthermore, we recommend developing a review framework to promote the standardisation of the process for granting permits for soil storage systems.

P2H+S has a useful systemic role, under the right conditions

P2H+S contributes to harnessing surpluses from renewable sources such as solar and wind and reducing the use of natural gas, both directly in the heat grid and indirectly in the electricity sector. Indeed, E-boilers and heat pumps with storage can use electricity when it is cheap and therefore clean, and avoid consumption at times when it is expensive and therefore polluting.

This firstly requires that the deployment can be flexible: e-boilers can always be flexibly deployed if they are an extra feature in a heat grid and are not needed for normal operations. In contrast, heat pumps are often one of the main sources of a heat network and can only be used flexibly if they have excess capacity and storage. This means that heat pumps that have a relatively large capacity in relation to the heat demand can be used flexibly. However, heat pumps wear out quickly from many starts and stops and involve high investment costs, making them expensive to deploy only part of the time.

Secondly, a positive contribution to the energy system requires P2H deployment to be based on electricity prices rather than on the heat demand. Otherwise, P2H may still be deployed at times when virtually all electricity comes from fossil-fuelled power plants, increasing CO_2 emissions and possibly requiring additional power plants to be built to meet demand. This is a limited problem for heat pumps because of their high efficiency, but the use of e-boilers at the wrong times is negative for the system as a whole. Although the price of electricity currently already provides an incentive to avoid peak times, there may be other incentives to turn on the e-boiler at unfavourable times. For example, in the Netherlands, emissions from e-boilers in a heat network are determined based on the average emission factor and not on the actual emissions at the time of deployment.

Power-to-Heat has sufficient potential to make a noticeable impact

There is technical potential in the Netherlands to deploy some 600 MW of e-boilers in heat networks by 2030. This is significant in terms of an average electricity demand of over 21 GW. The potential is expected to grow to 1.9 GW by 2050, which would allow them to make a noticeable contribution to the utilisation of surpluses. E-boilers have a high output, but are used infrequently and therefore produce little heat: about 2 PJ/y in 2030 and 9 PJ/y in 2050, both about 10% of the total projected heat supply by heat networks in the Netherlands. E-boilers currently have a business case mainly in grids with expensive sources such as natural gas due to significant grid tariffs, but that may change after 2030.

In current projections, heat pumps have the potential to provide about 4 PJ/y of heat in 2030, growing to 7 PJ/y in 2050 and accounting for about 7% of total heat from heat networks in 2050. Heat pumps have a high efficiency and often run for many hours, giving them a potential electrical capacity of only about 150 MW in 2030 and about 250 MW in 2050. Current projections for heat networks primarily use geothermal and HT/MT waste heat rather than heat pumps. As a result, the potential of heat pumps is now mainly in smaller grids, but this could grow significantly if geothermal and HT/MT residual heat do not take off and heat pumps are widely deployed in large grids.

Heat storage is a welcome addition to other forms of energy storage.
The combined potential storage capacity of all thermal storage in heat networks is 0.6 PJ in 2030 and 1.4 PJ in 2050. While this appears low relative to total heat demand, this storage is charged and discharged several times a year. Heat storage therefore makes a noticeable contribution to filling the total energy storage needs.