Hamburg considers innovative heat storage scheme

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By Jeffrey Michel 8.2.2017

Institutions in Hamburg are proposing to build a large underground thermal heat storage system that could supply roughly a quarter of the city's heating needs with waste heat from industrial and power plants. If successful, it would make Vattenfall's plans to realise a CO2-neutral district heating network superfluous. It could also serve as an example for other cities.

district heating pipes in Hamburg

German climate policy tends to focus on the electricity sector, but electricity constitutes only about one-fifth of total energy services. The residential and industrial heating sectors not only demand nearly half of all energy used, but solutions for their decarbonization are harder to come by due to over 40 million households as well as commercial buildings that rely on locally available energies.

A good deal of this demand can be interlinked in cities by district heating networks, which account for around 5% of total German energy consumption. They can use waste heat from industrial processes and geothermal sources as well. The Netherlands, for example, has recently announced it wants to go down this route, gradually replacing its natural gas heating system with district heating networks supplied with waste heat.

Vattenfall's Moorburg power station in Hamburg

In Hamburg, a proposal has now been presented for a large heat storage system under the city. Heat produced in the summer from industry, waste incineration, renewable energies and seasonally heated river water could be captured for use during the winter.

Hamburg to be climate neutral in 2050

Hamburg is a city in transition. In November 2015, Vattenfall's new Moorburg coal-power station – Germany's second largest coal power plant – entered service on the southern bank of the Elbe River after many years of delays over technical and environmental conflicts. One of the problems with Moorburg, as I explained in an article for Energy Post back in 2014, is that this new plant is poorly located for delivering heat in addition to generating power. In order to serve the existing heating network, a 4.4 km pipe tunneled underneath the river would have been required.

Vattenfall, which already supplies district heat to parts of Hamburg from its 321/955 MW coal-fired CHP plant at Tiefstack and the 260/433 MW installation in Wedel west of the city, is now planning a €83.5 million refurbishment of Wedel to prolong existing heat supplies in compliance with more stringent environmental standards.

> ***With Continental Europe's oldest modern water supply system dating back to 1842, Hamburg has catalogued a quarter million drill holes***

At the same time, the city has said it wants to achieve "climate neutrality in Hamburg heat operations by 2050". In response to this, Vattenfall is considering configurations using "heat storage, power-to-heat, industrial heat, decentral solutions and possibly gas-CHP that will replace the existing plant".

However, the Hamburg Institut, a local ecological planning office, and Consulaqua, a subsidiary of the municipal waterworks Hamburg Wasser, see a more immediate path toward reducing the CO_2 footprint of district heating.

Hamburg is situated on the Elbe River above two expansive sand aquifers for fresh and salt water with an intervening, nearly impervious clay layer. Similar geological prerequisites already permit heat energy to be stored below the Bundestag parliamentary building in Berlin. In Hamburg, a far greater amount of thermal energy could be sequestered underground sufficient for supplying one-quarter million homes and an equivalent additional amount for commercial buildings. This is approximately one-fourth of all structures in Hamburg, which extends over a land area equivalent to that of New York City.

During the warm months, cold saltwater from beneath the city could be pumped to the surface and heated by factories, waste incinerators, gas plants, and surplus renewable energy. It would subsequently be injected at a different location below the clay strata for heat storage. As the winter approached, pumping the heated saltwater up from storage to the surface would enable the thermal energy to be withdrawn for heating distribution. The cooled saline solution could then be pumped back into the aquifer from which it had been originally taken.

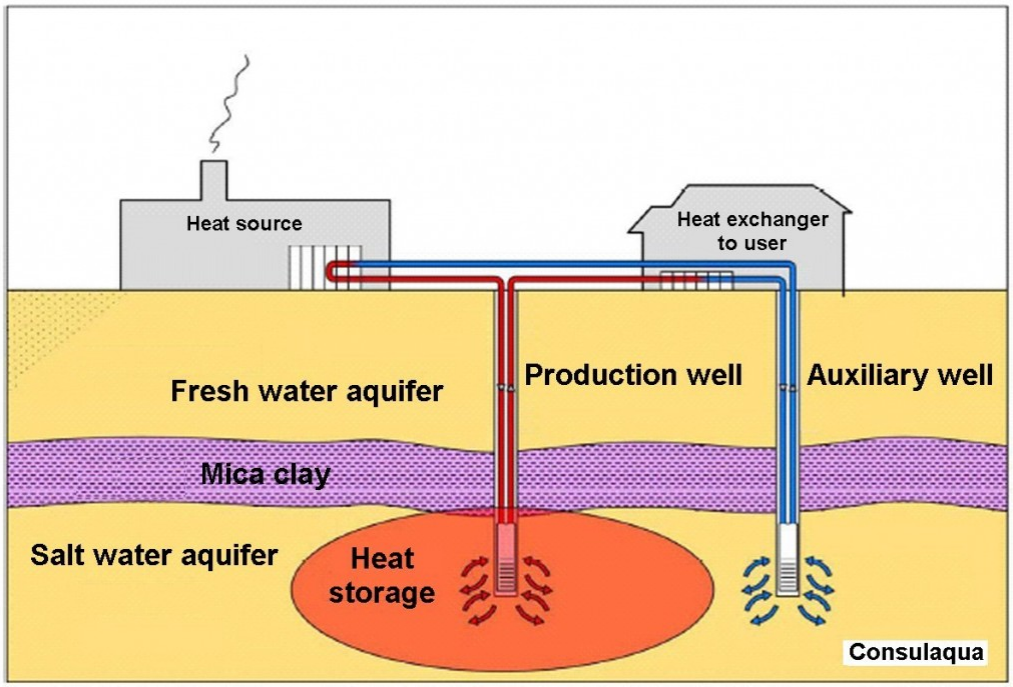
> ***Favourable geological conditions exist throughout the Germanic Basin between South England and the eastern border of Poland***

The achievable heat storage capacity is practically infinite, since layers of sand awash in saltwater lie below the entire city. Due to incident solar energy along its course, the Elbe River is warmed excessively during the summer months. Bathing is therefore prohibited to preclude communicable diseases, but the river becomes a ready source of thermal energy for storage.

The waste heat that Hamburg produces in its industrial facilities – notably the Aurubis copper smelter and ArcelorMittal steelworks – as well as in electronic data centers and refrigerated warehouses could be added as needed.

Local warming as response to global warming

The heat storage concept is exemplary for Germany's innovative energy transition. The dissipated heat of gas-fired combined heat and power is produced in alternation with renewable energies. That is, whenever solar or wind power is insufficient, more gas can be burned. The excess renewable grid power available at other times, however, may be efficiently converted by heat pumps into warm water and stored for the winter.

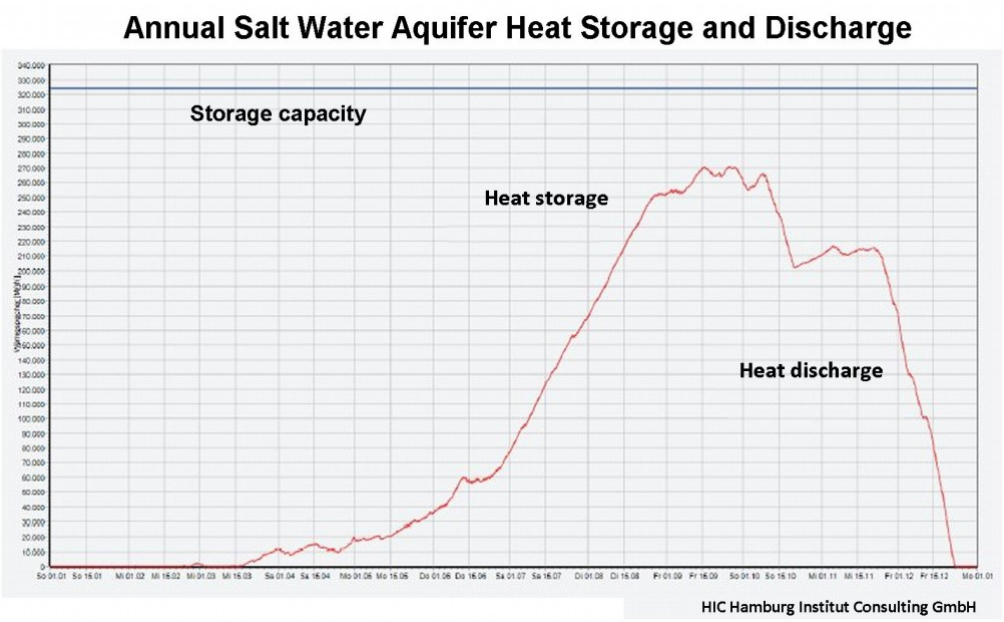


Underground storage realized for this purpose becomes more economical in relation to size. The volume of a large reservoir increases by the cube of the radius while radiated heat is lost only over the squared outer surface area. About a third of the stored energy is ultimately dissipated underground, a tolerable margin according to Consulaqua.

Standard drilling equipment is used to tap into aquifer reservoirs. Hamburg already has hundreds of drinking water wells. With Continental Europe's oldest modern water supply system dating back to 1842, Hamburg has catalogued a quarter million drill holes. Heated salt water can be pumped into the ground at many places as is done for drying large building sites.

> ***With 1,800 km of heating pipes already installed beneath the city, heat could be readily transported from producers to central storage***

Parts of the district heating network are maintained at over one hundred degrees, while temperatures in aquifer storage would lie between 70 and 80°C. The water in the transport pipes would therefore require additional heat, which is why experts from the Hamburg Institut prefer a storage site under a planned trash and biomass incineration plant in Stellingen that could provide auxiliary heating.



Consulaqua estimates that aquifer storage functionality could be achieved for only about €1 million, compared with Vattenfall's long-range project costs approaching half a billion euros for the CO_2-neutral replacement of the Wedel power plant.

Hamburg Institut has calculated storage expenses of one cent per thermal kWh including storage losses, with another cent covering unaccountable inaccuracies. Industrial waste heat is available for 1–2 c/kWh, resulting in maximally four cents altogether. District heating customers are currently paying double that price in Hamburg.

Additional heat exchanger costs are said to be marginal. With 1,800 km of heating pipes already installed beneath the city, heat could be readily transported from producers to central storage.

While no timetable has been set, early implementation in Hamburg could subsequently be emulated by other cities. Favourable geological conditions exist throughout the Germanic Basin between South England and the eastern border of Poland. Time will tell how successful this concept could become.

Editor's Note

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