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Smart Grids, District Heating and Cooling, and Heat Pumps Integrated with Thermal Energy Storage Sessions

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In the keynote presentation, Tommy Walfridson discussed the growing need to balance the electricity grid in the EU due to increased renewable energy production. He explained how individual heat pumps could help by offering balancing services. He also mentioned the potential for external control of heat pumps through API solutions. A Swedish study demonstrated that individual heat pumps can contribute to balancing services.

Another presentation focused on monitoring a groundwater heat pump in Geneva, Switzerland. This heat pump supplies heat to a low-temperature district heating grid. The measurements showed that the heat pump met 85% of the early heat demand. The seasonal performance factor (SPF) was 3.69 for heat production and 4.28 for space heating.

The use of absorption-heat exchangers as transfer substations in district heating grids was explored in a study. These heat exchangers can subcool the primary return temperature below the secondary supply temperature, increasing heat capacity within the grid and facilitating the integration of renewable energy. Experimental investigations showed that subcooling of up to 20.7 K was achievable with an absorption-heat exchanger under certain conditions and increased mass flow in the secondary grid.

Fields of application for large-scale heat pumps in Germany were presented, including district heating supply, data centers, and a research center for hydrogen technology. These projects demonstrated the potential of heat pumps to contribute significantly to renewable energy in the heat supply. They also observed significant reductions in CO_2 emissions, ranging from 50% to 90%, compared to gas boilers.

Marin Forsén at Q&A with the audience during the presentation session. (Photo: Carlos Jones, ORNL)

One of the presentations in Session 1.11 discussed the feasibility of using retrofitted air-conditioners with thermal energy storage (TES) in hot countries. A transient model was developed to analyze power savings and electrical loads for a 17.5-kW air-conditioning unit in Dubai. The results showed that using a phase change material (PCM) with a melting point of 22°C can significantly improve the air-conditioner's performance. It resulted in higher coefficients of performance (COP), reduced p ower consumption during peak hours (up to 50% reduction), and increased cooling capacities by 18%.

The carbon mitigation potential of heat pumps integrated with thermal storage for grid-interactive residential buildings was evaluated. The study used ice/water-based phase change material (PCM) with a heat pump (HP) and thermal energy storage (TES). Results from a one-week analysis during the cooling season showed a 12.68% reduction in cooling utility cost, a 10.19% reduction in total electric consumption, and 50.2% of peak electric load shifted to off-peak times. By using TES during peak times, 11.92% of grid emissions were reduced. The study concluded that while this configuration offers economic advantages, further control optimization is necessary to reduce peak energy consumption. The use of phase change material heat exchangers (PCM-HX) as part of latent heat thermal energy storage (LHTES) in heat pump applications was investigated. An aluminum serpentine heat exchanger with louvered fins was experimentally studied for its thermal performance as a PCM-HX.

Another presentation highlighted how thermal energy storage (TES) can be integrated into heat pump systems to improve efficiency and capacity. By adding a third temperature body, heat pumps can operate between any two bodies, effectively delivering heat to the application. This integration allows for a smaller heat pump size without compromising heat delivery. The methodology was demonstrated for a building cooling application, resulting in a reduction in the nominal heat pump size from 3 tons to 2.4 tons.