Dynamic exergoeconomic analysis of a heat pump system used for ancillary services in an integrated energy system

The integration of different energy sectors, such as the electricity and heating sector, is an effective way to integrate large shares of renewable energy into the energy system. Heat pumps allow efficient heat production based on electricity. As such, they may be used to provide two different services - the generation of heat and the provision of demand flexibility as ancillary services for the power system. The paper presents a method to assess the impact of providing demand flexibility on the performance of the conversion system based on a dynamic exergoeconomic analysis. A way to allocate the cost of heat and flexibility products based on the difference in exergy destruction was proposed. The method was applied to a case of a groundwater-source heat pump system supplying a district heating island system. It was found that providing demand flexibility causes higher exergy destruction, mainly due to heat losses during storage and the need to reheat the fluid using an electric heater. The major part of the additional exergy destruction was not related to heat pump regulation. When providing flexibility the overall cost of the system increased and according to the proposed allocation, demand flexibility accounted for 12% of the overall cost.