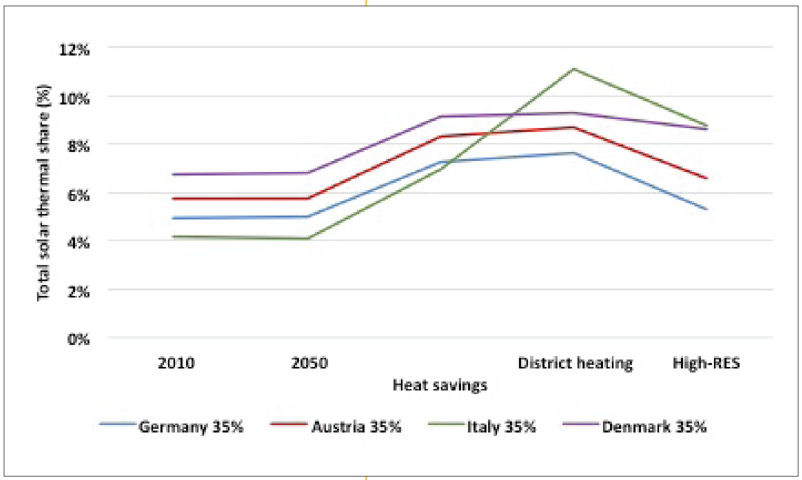
Is Solar Thermal a Viable Solution for a Future Renewable Energy System?

Solar thermal integration might in some situations be counter-beneficial for a renewable transition, especially when considering an energy system supplied by high shares of renewable energy. This is one of the conclusions from a study performed by Aalborg University as part of SHC Task 52 on Solar Heat and Energy Economics in Urban Environments. This conclusion was reached by performing a series of energy system analyses under various conditions of four national energy systems in Germany, Austria, Italy and Denmark. The solar thermal potentials were identified for each country today and in a future energy system converted to 100% renewable sources in the heating and electricity sectors. However, mixed results were found regarding the impacts on economy, environment and energy consumption when installing these solar thermal potentials.

The Aalborg University study conducted for SHC Task 52: Solar Heat and Energy Economics in Urban Environments concluded that solar thermal has a role to play in a future energy system by 1) easing the pressure on scarce resources, 2) supplying heat where no alternative heating sources are available, and 3) contributing to enhancing energy security through local energy production.

A significant benefit of installing solar thermal is the reduction in fuel consumption for fuels such as biomass, which will be in high demand in future energy systems.

These conclusions were formed based on the results of an analysis of the solar thermal potentials in each national energy system under various conditions. These systems include a current energy system (2010), a future business-as-usual energy system as projected by the European Commission (2050), a system with reduced heat demands due to building retrofits (Heat savings), and a scenario with significant expansions of the district heating systems in each country (District heating). Furthermore, a final scenario was developed supplied by 100% renewable sources in the heating and electricity sectors (High-RES). Secondly, the societal impacts of installing the solar thermal potentials were quantified for the same scenarios. Because of the societal focus no taxes, subsidies or similar incentives were included in the study and the costs included are investments, operation and maintenance, fuels, CO_2, and energy exchange while applying an interest rate of 3%. These scenarios were developed using the hour-by-hour EnergyPLAN energy system analysis tool, which has been used in more than 100 research articles. The solar thermal projects analyzed were plants for single-family houses supplying both hot water and space heating and solar thermal plants for district heating systems with short-term storages.



▲ **Figure 1. The technical solar thermal potentials for each national energy system under the assumption that 35% of all heat consumers are supplied by a solar thermal plant in the building or in a district heating network. The solar thermal share is a measure of the solar thermal supply out of the total heat supply.** (Source: Aalborg University)

The results showed that the maximum solar thermal potential in a national system is in the range of 3-12% of the total heat supply. This potential is influenced by the energy system configurations and the number of buildings connected to the solar thermal supply, either directly in the building or via a district heating network. These findings are depicted in Figure 1, which shows the variations in solar thermal potential depending on the energy system configurations. The solar thermal share increases after implementing heat savings and expansions of district heating networks, although the annual solar generation decreases due to a lower heat demand. The solar thermal potentials could increase to 6-12% when half the consumers are connected to a

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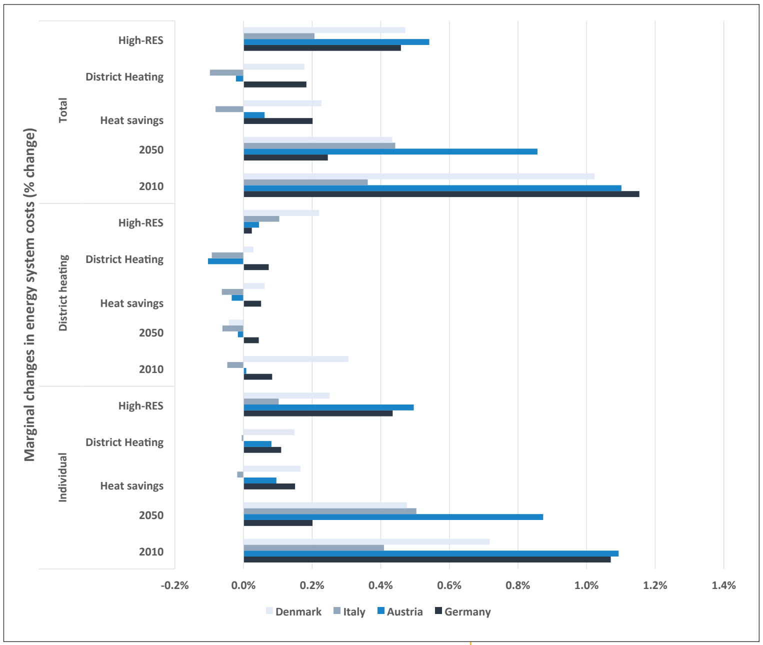
solar thermal plant while a 20% connection rate results in a solar thermal potential of 3-6%. These shares correspond to collector areas of 37-175 million m2 in Germany, 6-16 million m2 in Austria, 23-69 million m2 in Italy, and 4-14 million m2 in Denmark.



▲ **Figure 2. The change in energy system costs for each national energy system when installing the maximum solar thermal potentials. The change in energy system costs is a comparison to a system with no solar thermal plants installed.** (Source: Aalborg University)

The economic impact of installing these solar thermal potentials is illustrated in Figure 2, which shows that the costs increase when installing the solar thermal potentials directly in individual buildings whereas the costs in some cases either reduce or increase in district heating networks. When installing both of these types an overall additional cost is expected of up to 1% compared to installing no solar thermal (for Germany this equals an extra cost of almost 5 billion /year). This highlights the importance of the type of solar thermal plant and in which part of the energy system solar thermal is installed. In the high renewable scenario, the costs increase for all solar thermal types and energy systems because of the competition with other renewable sources that might provide the same heating for lower costs (e.g., geothermal, excess industrial heating, heat pumps). Installing solar thermal could therefore increase the total energy system costs, but this is highly impacted by the energy system configuration. Extreme cost reductions of up to 65% compared to current costs are necessary for solar thermal potentials in the individual buildings to become cost-neutral within the energy system.

Some of the heating sources in a future high-renewable energy system, as the one designed in the study, provide constant base-load generation thereby allowing less room for fluctuating renewables such as solar thermal. Similarly, the advantages of solar thermal reduce in terms of reductions of fossil fuels and CO2-emissions when transitioning towards a high-renewable energy system as the technologies replaced will also be renewable sources. Solar thermal might therefore end up competing with other renewable resources in the energy system.

A significant benefit of installing solar thermal is the reduction in fuel consumption for fuels such as biomass, which will be in high demand in future energy systems. The study proved that the entire energy system biomass consumption can be reduced by 0-2% when installing the solar thermal potentials, and this share increases if only the reductions within the electricity and heating sectors are considered. Solar thermal should therefore contribute to replacing combustion technologies such as biomass boilers, especially when no other renewable technologies are available.

The overall conclusions are rather similar across the various national energy systems, despite the significant differences in terms of energy system configurations, climate, and energy resources and demands. This verifies that the findings might be applied to diverse countries, and also countries not directly investigated in the study.

Factors such as lower temperatures in district heating networks, seasonal district heating storages in combination with solar thermal, solar thermal for cooling, and industrial purposes could improve the solar thermal potential and feasibility.

The implications of the study are that long-term planning is required for installing solar thermal. Solar thermal will be part of the future energy systems, but should be carefully investigated for its impact on the entire energy system and the technologies that are replaced. Solar thermal has a role to play by reducing local demands for biomass, which can instead be used in the transport or industrial sectors. The transition towards a 100% renewable energy system is challenging and a variety of energy sources are necessary, including solar thermal technologies.

This article was contributed by SHC Task 52 experts, Prof. Brian Vad Mathiesen and PhD Fellow Kenneth of Aalborg University, Denmark. Additional information can be found here on Task 52, University of Aalborg, Sustainable Energy Planning Group: or www.EnergyPLAN.eu