End of project popular science description

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The end of project popular science description must not exceed two pages and include the following:

Introduction

The overall aim of HeatReFlex project was to explore and demonstrate that by investigating, rethinking, and combining user/community practices, business models, device and process management, and data and computing techniques, we can enable a bottom-up energy system based on renewables, energy communities and flexibility, which can be widely adopted for heating/cooling sector.

To address the objectives of this project, the team started with a simple case study where our existing knowledge, concepts, and systems could be put together, integrated, and refined, forming a strong basis for the next cases. The cases were then progressively enlarged and developed the community, the business model (adding social aspects, self-consumption, and trading), the devices (adding different thermal energy sources, storage, conversion, and external/trading systems), and the data and computing (supporting short and long-term energy balancing and optimization). For each case, a set of criteria to assess the efficiency of the systems was defined. By shifting from end-use kWh savings to the measure of all primary energy savings, and by moving from a building-bound analysis to a broader systemic-perspective, our analysis finally offered a valuable tool for policymakers to benchmark the competing technologies on the heating and cooling market.

Moreover, the project strengthened cooperation, knowledge sharing, and research and development activities between Danish and Turkish actors in the energy sector. It created not only a strong synergy between the partner universities in terms of researchers training and support for future innovation projects and fundraising, but also associated them with other industry/government partners for value creation and higher quality assurance in skills, knowledge and entrepreneurship.

Results

HeatReFlex was successfully concluded in April 2022 as planned. During the project work, different optimal solutions for green and flexible heating/cooling in local communities, cities and beyond were identified to better integrate and utilize energy sources, thermal storage options, and energy conversion units. From a system-wide perspective, heating and cooling needs in all provinces of Turkey were determined and primary resource factors (PRFs) were calculated to understand the most appropriate plan/technology for heating/cooling purposes in different zones while estimating the contribution of each heating/cooling plan toward the policy goals. In a local perspective and for domestic applications, different integrated energy and combined cooling, heating and power generation (CCHP) solutions were proposed and analysed (according to exergy, economic and sustainability aspects) leveraging different technologies such as solar boosted biomass-driven and geothermal-driven micro-CCHP systems. As a focus area of this project, Turkey's waste-to-energy potentials were also analysed in detail. The potential of electricity generation from biogas obtained from wastewater sludge with rich organic content that emerges during the treatment of wastewater was revealed. In addition, the electricity generation and district heating potentials of the exhaust gas generated in the sludge incineration process applied for the sludge disposal process at low source temperature were evaluated. In the context of landfill gas obtained from solid waste, electricity generation and district heating potentials from the exhaust gas of the cogeneration plant integrated into this system were determined. Advanced energy, exergy, thermoeconomic, and environmental analyzes and optimizations of the scenarios developed using the real operating data of these systems were made. Also, different systems have been designed for the PV-powered heat pump district heating and cooling capacity of treated wastewater.

According to the studies carried out within the scope of the project, it was understood that the PRF values of some renewable energy sources such as sun and wind are still quite low in Turkey and they are not yet at a level to produce an alternative solution to the use of natural gas for heating/cooling, thus there is a need on development of policies and solutions necessary for a systematic roll-out of district heating and cooling in

Turkey. It was also clearly observed that Turkey's waste-to-energy potential as a foreign-dependent country in energy is remarkably high and could be effectively used to meet the residential/industrial demands. Finally, direct electrification of hearting sector (such as individual heat pumps instead of oil-fired boilers in houses and large electricity-driven heat pumps in communities) through higher deployment of renewables was found as a crucial development phase of sector coupling in Turkey.

Conclusions

Turkey is the IEA country with the greatest, projected medium to long-term increase in energy demand specially in building sector. With a growing economy, a young and increasingly urbanized population, it is a significant challenge to secure the necessary energy supply at a cost-competitive price. Renewable energy accounts for about 18% of primary energy consumption in the heating and cooling sector and the country is highly dependent on energy imports from neighboring countries.

The HeatReFlex project which was a joint Danish-Turkish cooperation, supported Turkey in developing a technical framework for optimal planning and operation of thermal energy devices and processes in small to large-scale energy communities supporting distributed heating/cooling generation, storage, conversion, and flexibility with respect to the technical constraints, regulations and policies. The project also contributed to developing energy efficient and low-carbon solutions in both supply and demand sides while strengthened research capacity in both countries. In the context of local energy networks, the project developed several operational planning models for co-generation (heat and power), energy storage and demand response actions with appropriate market/business schemes. The project also studied the potentials of biofuel-based energy production and biogas-/landfill gas-based heating and cooling solutions from industrial units such as wastewater treatment plants, municipal solid waste plants and sewage sludge incineration plants. On a broader scale, the project made a performance assessment and benchmarking of heating/cooling plans in different regions of Turkey and evaluate the contribution of such heating/cooling plans at community-level. In this regard, six different alternatives (including the Wind Energy, Bio Energy, Solar Energy, Hydro Energy, Geothermal Energy and Waste Heat) for 81 provinces in Turkey were examined according to four criteria PRF value, installation cost, operating cost and CO2 emission. Last but not least, having had networking events with companies, advisors, and knowledge institutions in the district heating sector and being a sister project to Strategic Sector Cooperation between Turkey and Denmark on “Efficient and Low Carbon Heating and Cooling”, the project team managed to establish an efficient synergy among partners and potential customers, collaborators, advisors, private/public utilities, municipalities and other stakeholders with an interest in energy.

Recommendations

The current energy policy objectives of the Turkish government place key emphasis on increasing domestic energy production including harvesting unused surplus heat and enabling a low-carbon transition of the energy sector and achieving the long-term objectives for renewable energy, energy efficiency and district energy in accordance with the Intended Nationally Determined Contributions (INDC) and the Sustainable Development Goals (SDG) 7,9 and 11. To this end, measures shall be taken to increase the use of renewable energy (such as geothermal energy) for heating and cooling purposes. Studies regarding determination, grading, protection and utilization of renewable energy source areas appropriate for co-generation of electricity and heat in different locations shall be supported. Moreover, pilot projects aiming the efficient utilization of renewable energy sources for heating/cooling purposes and those targeting hybrid systems should be further promoted. Finally, it is of great importance to prepare legislation for heat market in order to accommodate different central and district heating and cooling structures based on renewable energy sources, co-/tri-generation and micro-cogeneration systems.