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Student Thesis

Master Level Thesis

European Solar Engineering School

Evaluation of an Energy System for multi-family houses with Combination of Exhaust Air Heat Pump and PV

Case Study: Demonstration Building of The EU Energy Matching Project, Sweden-Ludvika

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Abstract:

This thesis investigated application of the heat recovery ventilation using an exhaust air heat pump and a roof top photovoltaic (PV) system for a group of three multi-family houses located in Ludvika, Sunnansjö. The buildings in the existing condition have mechanical ventilation and a centralized heating system consists of a pellet boiler as the main source and an oil boiler as back up.

Exhaust air heat pump (EAHP) has been known by the previous relevant researches as an effective solution to promote the energy efficiency in the buildings. Furthermore, reduction in PV cost has made the PV as a financially viable option to be contributed in supplying electricity demand.

In this respect, this thesis aimed to calculate the potential of energy saving in the case study using the combination of EAHP and PV. For this purpose, the buildings and the proposed energy system were simulated to enable the comparison of energy demand before and after the renovation. The simulation was gradually progressed through several phases and each stage created the prerequisites of the next.

Since the buildings were relatively similar in terms of boundary conditions, one of the buildings were initially modeled and the concluded space heating (SH) demand was extrapolated to the three buildings scope. The simulation of the building was done using 3dimensional thermal model offered by Trnsys3d. The primary results were also calibrated against the available annual fuel consumption data. In the second phase, a pre-developed TRNSYS model of the energy system was completed using the result of previous step as the total SH demand as well as the estimated domestic hot water (DHW) consumption from a stochastic model. This simulation produced the electricity demand profile of the heat pump when the heat pump provided the total heat demand. Subsequently, the electricity consumption of the flats and operational equipment were estimated using stochastic model and available monthly measurement, respectively.

Since the feasibility and optimal placement of 74 kW PV modules offered for these buildings had been already examined by the author in another study, the final simulation were performed in an hourly basis considering PV production and total electricity demand; i.e. EAHP, flats consumption and operational equipment.

The results of the simulation showed that 21 % of total electricity demand during a year could be supplied by the proposed PV system even without any electrical storage, whereas 74 % of total yearly PV production is consumed by the local loads. The results also proved that removing old inefficient oil boiler and supplementing the pellet boiler with the combination of EAHP and PV could mitigate the annual purchased energy (including electricity and pellet) by approximately 40 % compared to the current condition.

Keywords:

EnergyMathcing project, Energy system, Novel heating technologies, On-site Renewable Energy, Low temperature heating system, combined solar technologies and heat pump, photovoltaic and exhaust air heat pump, nearly zero energy buildings, simulation of building and energy system

Anything beyond this, the teacher’s directives apply.