

Life-Cycle Cost and Life-Cycle Assessment of Photovoltaic/Thermal Systems (PV/T) in Swedish Single-Family Houses

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Abstract : The application of photovoltaic-thermal hybrids (PVT), which delivers both electricity and heat simultaneously from the same system, has become more popular during the past few years. This study addresses techno-economic and environmental impacts assessment of photovoltaic/thermal systems combined with a ground-source heat pump (GSHP) for three single-family houses located in Stockholm, Sweden. Three case studies were: (1) A renovated building built in 1936, (2) A renovated building built in 1973, and (3) A new building built-in 2013. Two simulation programs of SimaPro 9.1 and IDA Indoor Climate and Energy 4.8 (IDA ICE) were applied to analyze environmental impacts and energy usage, respectively. The cost-effectiveness of the system was evaluated using net present value (NPV), internal rate of return (IRR), and discounted payback time (DPBT) methods. In addition to cost payback time, the studied PVT system was evaluated using the energy payback time (EPBT) method. EPBT presents the time that is needed for the installed system to generate the same amount of energy which was utilized during the whole lifecycle (fabrication, installation, transportation, and end-of-life) of the system itself. Energy calculation by IDA ICE showed that a 5 m² PVT was sufficient to create a balance between the maximum heat production and the domestic hot water consumption during the summer months for all three case studies. The techno-economic analysis revealed that combining a 5 m² PVT with GSHP in the second case study possess the smallest DPBT and the highest NPV and IRR among the three case studies. It means that DPBTs (IRR) were 10.8 years (6%), 12.6 years (4%), and 13.8 years (3%) for the second, first, and the third case study, respectively. Moreover, environmental assessment of embodied energy during cradle- to- grave life cycle of the studied PVT, including fabrication, delivery of energy and raw materials, manufacture process, installation, transportation, operation phase, and end of life, revealed approximately two years of EPBT in all cases.

Keywords : life-cycle cost, life-cycle assessment, photovoltaic/thermal, IDA ICE, net present value

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