



Dynamic simulation of Ground-Coupled Heat Pumps (GCHPs): insights on the economic convenience and on the environmental benefits

Matteo Rivoire, Alessandro Casasso, Bruno Piga, and Rajandrea Sethi

Politecnico di Torino, Dipartimento di Ingegneria per l'Ambiente il Territorio e le Infrastrutture (DIATI), Torino, Italy
(alessandro.casasso@polito.it)

Ground-Coupled Heat Pumps (GCHPs) allow to achieve noticeable reduction of primary energy consumption, of CO₂ emissions, and operational costs of Heating, Ventilation and Air Cooling (HVAC) systems. The large installation expense is a strong barrier to their diffusion; however, GCHPs can be economically convenient in a number of contexts. We present a study which identifies such cases, based on integrated building-HVAC-GCHP dynamic simulations carried out with the software TRNSYS. Three building types were simulated, with very different schedules - a detached house, a hotel, and an office building - considering, for each of them, the case of a highly-insulated and a lowly-insulated envelope by adopting, respectively, the transmittance values typical of brand-new and Sixties' buildings. To take into account climate conditions, 6 locations were chosen ranging from warm Mediterranean (Seville) to cold Scandinavian climate (Stockholm).

The results of simulation allow to identify key parameters which influence the economic viability of GCHP systems, such as peak power demand and full-load equivalent operating hours. As shown in the results, geothermal heat pumps covering the whole heating demand are almost unfeasible without public subsidies, since the reduction of operational cost is not sufficient to cover the difference in the initial expense compared to a gas boiler. An exception is represented by hotels, due to their intense use of the heating system.

To reduce the initial investment, hybrid heat pump-gas boiler configurations can be adopted, where the HP is installed to cover the base demand and a backup gas boiler is used to cover peaks. In this way, a cheaper heat pump can be installed, although covering a large share of the heating demand with renewable heat from the ground.

The ratio between electricity price and fuel price is another driving parameter, since it influences the saving margin and hence the payback time of installing a heat pump. Payback times can dramatically be decreased acting on the electricity price, e.g. reducing taxes.

Finally, we analysed the effectiveness of incentives granted for different energy refurbishment interventions to avoid CO₂ emissions, finding that GCHP (and, in particular, hybrid GCHP) are much more effective than interventions on the building envelope, such as window replacement.