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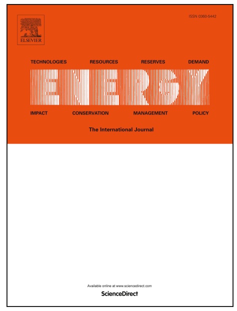

Impact of different improvement measures on the thermal performance of a solar collector field for district heating

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Impact of different improvement measures on the thermal performance of a solar collector field for district heating

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Abstract

The paper describes the impact of different measures to improve the thermal performance of a solar heating plant for district heating applications. The impact of the different measures was evaluated through a validated TRNSYS-Matlab model. The model included details such as effect of the flow regime in the absorber pipes on the collector efficiency, flow distribution in the collector field, thermal capacity of the pipes and shadows from row to row. The improvement measures included variation of the operating temperatures, accurate input to the control strategy, feedback control on the outlet temperature of the collector field, control strategy based on weather forecast and use of different heat transfer fluids. The results showed that accurate input to the control strategy improved the yearly energy output of the plant by about 3%. If accurate input is not technically or economically feasible, a feedback control on the field outlet temperature seemed to be a valid alternative. The integration of weather forecast in the control strategy did not give relevant improvements. Higher glycol concentrations in the solar collector fluid gave better results than lower concentrations, as the higher frost protection guaranteed by the former outweighed the better thermophysical properties of the latter.

Keywords: solar heating plant; solar collector field; TRNSYS; flow regime; control strategy; flow distribution.

Nomenclature

A_{field}	collector area of the collector field	[m^2]
a_1	heat loss coefficient of collector at $T_m - T_{amb} = 0$ K	[W m^{-2} K^{-1}]
a_2	temperature dependence of the heat loss coefficient of collector	[W m^{-2} K^{-2}]
c_p	specific heat	[J kg^{-1} K^{-1}]
DH	district heating	
E_{DH}	energy delivered to DH	[GWh]
$E_{DH,w}$	energy to DH, weighted on the temperature difference $\Delta T_{s\text{-}DH}$	[GWh]
$E_{DH\ 2.5}$	energy to DH at a temperature T_{toDH}, such that $\Delta T_{s\text{-}DH} < 2.5$ K	[GWh]
$E_{DH\ 5}$	energy to DH at a temperature T_{toDH}, such that 2.5 K $< \Delta T_{s\text{-}DH} <$ 5 K	[GWh]
E_{el}	electricity consumption	[MWh]
E_{frost}	energy injected into the collector field in frost protection operation	[GWh]
F_f	correction factor for heat exchanger fouling	[-]
G_{tot}	total solar irradiance on the collector plane	[W m^{-2}]
K	proportional gain constant (in PID controllers)	
$\dot{m}$	mass flow rate	[kg s^{-1}]
nom	subscript referring to nominal conditions	
Q_{sol}	theoretical power output from the collector field	[W]
P_{el}	electrical power	[W]
t	time	[s]
T_{amb}	ambient temperature	[°C]
T_d	derivative time (in PID controllers)	[s]
T_i	integral time (in PID controllers)	[s]
T_{in}	inlet temperature to the collector field	[°C]
T_m	mean fluid temperature in the collector field	[°C]
T_{out}	outlet temperature from the collector field	[°C]
$T_{setpoint}$	set point outlet temperature for the collector field	[°C]
$T_{DH,r}$	return temperature in the DH network	[°C]
$T_{DH,s}$	supply temperature in the DH network	[°C]
T_{toDH}	temperature of the fluid delivered to the DH network (after shunt)	[°C]
u	control signal from PID control	[-]