



Combining Solar Thermal Plants with Heat Pumps

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Agenda

- A simple calculation example of
 - A solar thermal plant ...
 - A heat pump ...
 - ... and a combination of these
- Some results
- Practical considerations
 - Dimensioning
 - Storages
 - Operating strategies
- Conclusions

A solar thermal plant ...



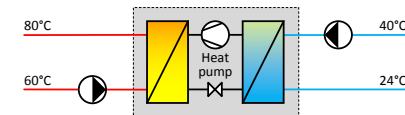
$$q_{coll} = \eta_0 \cdot G - a_1 \cdot \Delta T_{coll} - a_2 \cdot \Delta T_{coll}^2 \quad (1)$$

where $q_{coll} = \frac{Q_{coll}}{A_{coll}} \quad (2)$

$$\Delta T_{coll} = T_m - T_{amb} \quad (3)$$

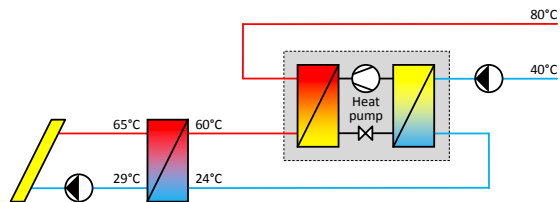
and $T_m = \frac{T_{coll,in} + T_{coll,out}}{2} \quad (4)$

A heat pump ...



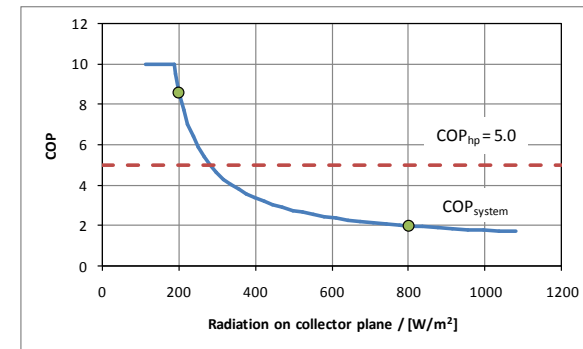
$$COP_{hp} \equiv \frac{q_c}{P_{hp}} \quad (5)$$

... and a combination

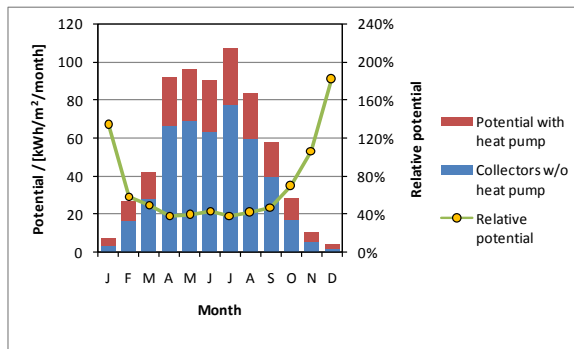


$$COP_{system} \equiv \frac{\Delta q_{system}}{P_{hp}} \quad (6)$$

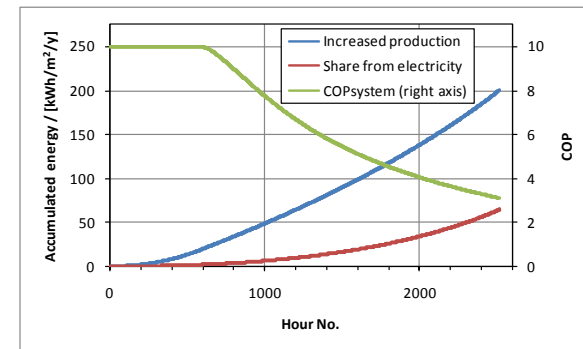
COP as function of the radiation



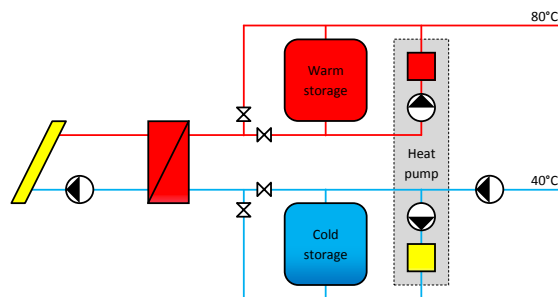
Production potential



Compromise between COP and potential



An example with storages



Conclusions

- COP_{system} is not the same as COP_{hp}
- COP_{hp} can be measured, COP_{system} cannot
- When the radiation is low
 - COP_{system} is high
 - Production potential is low
 - A compromise must be found between these
- Dimensioning is challenging
- Dynamic simulations are necessary



Thank you for your attention

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