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Geothermal heat pump combined with a hybrid solar energy system

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This project focuses on optimization of the thermal part of a geothermal heat pump which is supplemented by a solar energy system that produces both electricity and heat.

The geothermal or ground source heat pump consists (GSHP) of a water/water heat pump connected to a ground loop. Even a very energy efficient GSHP is still an expensive heating system because of the high energy taxes. Therefore this project focuses on optimizing the thermal performance of the GSHP for a minimal electrical consumption and additionally has the possibility of covering the rest of a households electrical consumption by means of solar cells. This project is based upon simulation and numerical analysis in Engineering Equation Solver (EES).

The solar energy system consists of PVT-panels (Photo Voltaic Thermal) which is hybrid panels with solar cells that is cooled by a liquid. By cooling the solar cells, the electric efficiency will increase because of the solar cells negative temperature dependent characteristic of 0,4 – 0,5 %/°C. Without any cooling the solar cells easily reaches temperatures as high as 70 °C which limits the efficiency to around 15 %. With ground cooling the temperatures can be held at 40 °C or lower, and results in an electrical efficiency up to about 20 %. On an annual basis the electrical output will be increased with 15 – 20 %.

The heat that is removed from the solar cells can be utilized, even though the temperature level is much lower than what is used in the household, eg. hot water supply. This is done by accumulating the heat in the ground as a result of circulation of the fluid from the ground loop (up) through the solar panels. Depending on the soil conditions it is possible to store the solar heat at least 1 – 3 months. The stored heat can contribute positively to the efficiency of the heat pump which directly results in a decreased need of external supply of electricity and hot water for either heating or domestic hot water usage.

By dimensioning the energy system correctly it is possible for a household to be self-sufficient with both heat and electricity. The normal water supply is still needed, just as it will be necessary to be on the grid to store the produced electricity for later use.

Facts:

- Geothermal heat pumps are one the most energy efficient heating sources on the market, but due to high taxes on electricity it is not a cheap system in use.
- Due to restrictions in the maximum size in the electrical output of a solar energy system it is interesting to optimize on the annual production of the system to cover as much of the households electrical consumption as possible.
- Relatively small difference in the construction cost with and without cooling of the solar cells.
- Geothermal heat pump combined with a hybrid solar energy system secure independency of energy prices for at least 25 years.
- Increased electrical efficiency minimizes the need of roof space for the solar panels.

References:

Truelsen, F. S. & Nygaard L. (2011) *Integrated design and planning of BIPV/T for Solar Decathlon 2012.* Technical report, DTU