Only solar thermal can reduce peak power demand

What saves more primary energy and costs less: solar cooling and heating with solar collectors, or conventional heating and cooling technology combined with PV modules? In a simulation of model systems for a Spanish hotel, Fraunhofer ISE puts solar thermal head-to-head with PV. A system comparison.

"A large solar heating and cooling system with an overall solar fraction of about 65 % leads to an increase of total annual cost compared to the reference system of about 4 %." That was one of the conclusions drawn by Hans-Martin Henning, Deputy Director of Freiburg's Fraunhofer ISE, in his presentation at EuroSun 2010 in Graz, Austria. And, "A large PV field with a similar area leads to higher primary energy saving at a lower increase of total annual cost."

Fraunhofer ISE gleaned the underlying data for these results from a number of simulation calculations. A hotel in Madrid served as the deployment location for the different systems. The following solutions were tested (see graphic): a reference system with a gas boiler and a compression chiller; solar thermal systems with 100, 200, and 500 m^2 of collector area for heating and hot water; solar thermal systems with the same collector area and an additional absorption or adsorption chiller (chilling capacity of 10, 20, and 40 kW); and a conventional solution with an auxiliary grid-connected PV system in three different sizes (8, 40, and 80 kW).

"First, it is important to keep in mind that our results are in relation to a particular use at a specific location," explained the project lead, Dr. Henning. "A different load structure at a different location would yield differences in the details of the results." Nevertheless, the model calculations indicate tendencies which point to the strengths and weaknesses of each of the system solutions.

Why is it, for instance, that the cost efficiencies of solar heating and cooling systems drop once a certain collector area is reached? "The biggest problem with large solar thermal systems is that there is no network into which excess energy can be diverted," Henning explains. "Excess energy cannot be exported and storage is limited. The storage tank in our model only allows storage from noon until the evening hours, which is usually the peak-load period in a hotel. Spring and autumn, in particular, are times when solar thermal systems produce high yields without a simultaneous corresponding load. The lack of feed-in and storage means that the large systems in our example do not even amortise within their 20-year service life."

Better economy at lower coverage rates

In contrast, the smaller solar thermal plants (200 m^2, for instance, without an additional chiller or with a small absorption device with a chilling capacity of 10

Scarcely distinguishable in appearance: solar collectors (above) and PV modules (below) made by Swiss manufacturer 3S. The economy of solar cooling depends on the size of the system and the technology.

Photo: 3S Swiss Solar Systems

or 20 kW), deliver significantly better performance in terms of economy. They are also the frontrunners in terms of costs and primary energy savings (see graphic). The reason is that, while smaller systems cover less of the overall energy demand, nearly all of the energy they yield can be used. “It makes no sense to try to cover as much of a building’s energy demand as possible using solar thermal,” Henning explains. “Instead, solar thermal systems should be designed to ensure that the total energy they produce can be used to the greatest extent possible.”

Sören Paulußen agrees. Paulußen is the Managing Director of InvenSor, a German manufacturer of adsorption chillers. “When a solar thermal system is designed to cover as much of the total heating and cooling energy demand as possible, it becomes uneconomical due to the lack of storage capability. It is therefore desirable for energy policies to support smaller projects which cover 20 to 50 % of the total load with renewables, rather than large-scale projects that aim for the greatest possible coverage.”

A further problem of large solar thermal systems is the high percentage of overall costs paid for the solar collectors. While an absorption or adsorption chiller can comprise 20 to 25 % of costs, the collectors can make up some 50 to 60 %. That results in a disproportionate increase in investment costs as collector area increases. Add to that, according to Henning, that, “The economy of PV systems is getting better all the time. Even thermally driven chillers – especially in the lower capacity range – are getting increasingly cheaper, in contrast to the relatively stable prices of solar thermal collectors.”

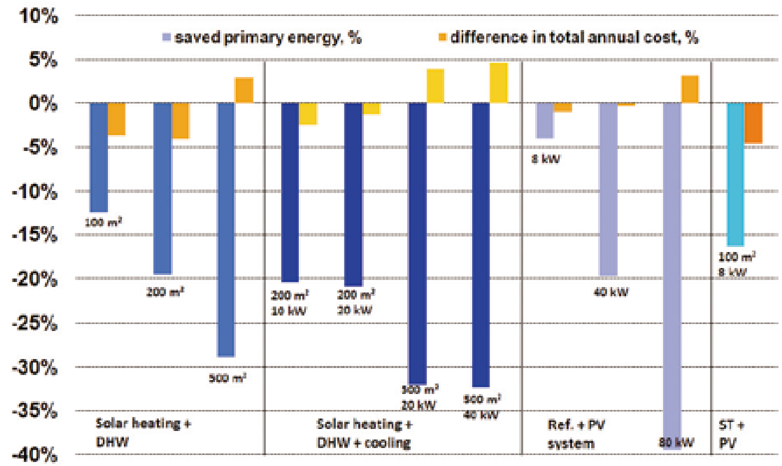
PV can export excess power

Currently, the basic advantage of PV solutions is that excess power can be exported to the grid. To make the conditions as neutral as possible, model calculations were performed without the assumption of subsidies or feed-in tariffs. However, compensation for the exported power was assumed to be 0.075 €/kWh (equal to 50 % of the assumed purchase price per kilowatt-hour).

The ability to export power resulted in a better outcome for the 80 kW PV system in Henning’s model than the solar thermal system with an equal area. The PV power produced by the system is used for both the chiller and other purposes within the hotel, and only excess power is exported to the grid. However, power availability did not coincide optimally with demand. For instance, the PV system produced excess power at mid-day which was exported to the grid, while the hotel had to draw additional power from the grid at night.

In contrast, energy from the solar thermal system can be stored in a tank for use in the evening, thus reducing peak power demand at night. This fact led Henning to a further conclusion in his presentation. “The large solar thermal heating and cooling system is the only system which leads to a reduction of peak electricity consumption of about 8 %.”

System comparison using a Spanish hotel as a model



Among the large-scale systems, the PV-supported system offers a higher percentage of primary energy savings (blue to purple bars) at a lower cost (yellow-orange bars) than a solar thermal system of comparable size. This trend is reversed in the smaller systems.

Graphic: Fraunhofer ISE

Trend toward local use of PV power

The lack of correspondence between supply and demand could even result in PV creating problems for power grids. As the number of systems increases, large volumes of power for which there is no use will be exported to the grid at mid-day. This fact has already caused a change of course for PV subsidies. In Germany, for instance, since 2010 locally consumed power is compensated at a higher rate than electricity exported to the grid.

“Today, PV profits in general from the potential to export to the grid, and to a very great extent from some feed-in rates which are very lucrative. The trend, however, is that carelessly exporting power in whatever quantity to the grid will be abandoned in favour of using the electricity locally,” Henning explains. Sören Paulußen adds, “If this trend takes hold, PV will soon have a storage problem.” And storing electricity is much more complicated than storing heat.”

Swedish absorption chiller manufacturer ClimateWell is already convinced of the superiority of solar thermal for heating and cooling applications. “According to our experience, solar thermal powered heating and cooling is vastly superior to all other green building technologies, including PV, for those customers that need both heating and cooling,” states Group CEO Per Olofsson. “Our examples include hospitals, hotels and villas. For those customers, solar thermal powered heating and cooling provides about twice as much energy as a PV-based system for heating and cooling. Our view is also that PV electricity should primarily be used for computers, lighting and white goods.” PV and solar thermal need not be mutually exclusive, however. Hans-Martin Henning believes that the future belongs to a combination of solar thermal and photovoltaics.

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