Abstract 5: Synergies among the usage of HP's with solar PV systems.

From the paper "Drivers to heat pump adoption by European Households".

A heat pump increases the self-consumption % of a residential PV-installation around 10%. The increase in the self-consumption % brings financial benefits for the users is in the order of 80 – 120 €/year ~between 8% and 20%of average consumption (case study with a PV installation of 5kWp and a 250 liter tank, calculated with 0,293 euro/kWh for electricity consumption and 0,078 euro / kWh feed-in tariff).

The combination of a heat pump and solar panels (PV) is a great way to save energy. The heat pump can partially run on free electricity thanks to the PV installation. Further in this section a Daikin-internal case study will be cited to indicate how much can be saved when combining a heat pump with PV technology.

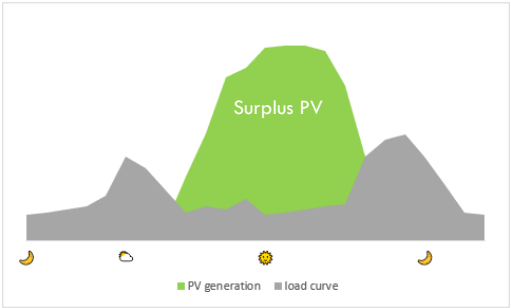
Heat pumps and PV

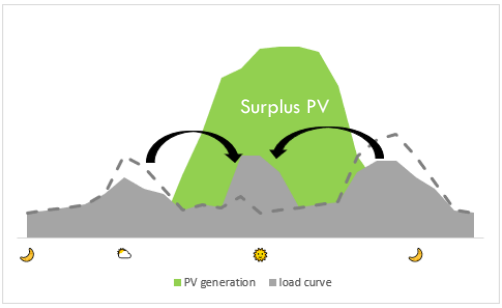
PV panels generate electricity by converting solar energy with which two things can be done:

- It can be used in the home and thus reduces the electricity bill at the end of the month (self-consumption)
- It can be transported back to the grid for which a monetary fee will be paid (feed-in tariff).

Feed-in tariffs are a policy tool to promote investment in PV panels by offering households an above-market price for what is delivered to the grid. Because the PV market is maturing, this incentive is less needed and the feed-in tariffs are reducing in many countries across Europe. This means that improved self-consumption becomes progressively more important to optimally benefit from PV installation. Heating the house and hot water with a heat pump instead of with gas is a great way to do that. It shifts consumption away from gas towards (partially free) electricity.

Typically a house is heated only during the winter and shoulder seasons while PV panels generate the most electricity during the summer. However, heat pumps are also used to heat up a domestic hot water tank for showers and baths. The demand for hot water remains stable year-round. Moreover, the time of the daily reheat of the tank can be optimized. Households with PV panels should schedule the tank heating at noon time when typically a lot of PV capacity is available and the household demand for electricity is low. In this way, the heat pump utilizes available solar energy when available. Providing free hot water is more interesting than exporting the available solar energy to the grid at unfavourable feed-in tariffs.





Secondly, the hot water tank coupled with the heat pump can act as an 'energy battery'. Excess solar energy can be used to produce additional hot water, more than what the household typically needs during the day, effectively storing energy for later use.

The Daikin heat pumps have optimized algorithms to maximise the use of excess solar energy.

Case study

A Daikin case study shows the impact of installing a heat pump with PV optimisation. This case study was done in Belgium in June 2022 and consisted of a Daikin Altherma heat pump with 250 litre tank and a PV installation of 5kWp.

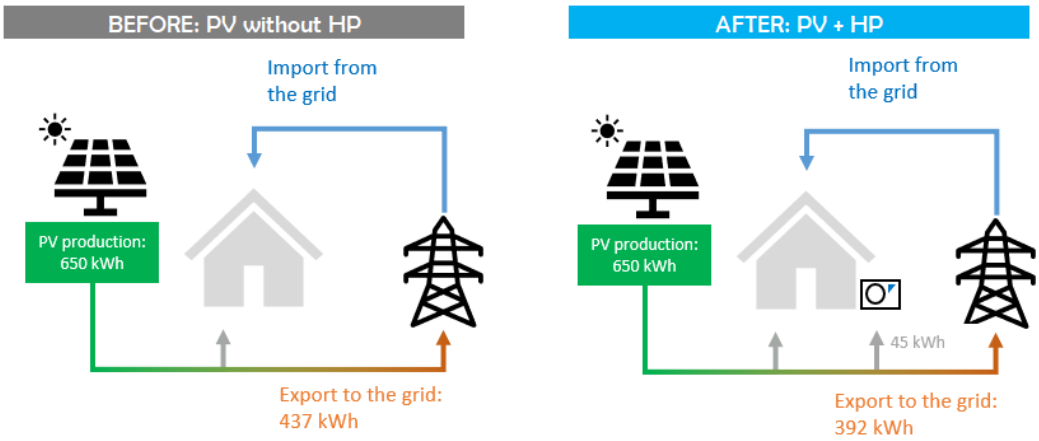
Because the feed-in tariffs are reducing, the benefits of PV can be optimized by increasing the self-consumption ratio. The self-consumption ratio is the percentage of the total PV production that is used by the household and thus not exported to the grid.

The formula for self-consumption is:

$$Self\,consumption = \frac{(Total\,production - Export)}{Total\,production}$$

In this case study the self-consumption ratio was increased in 2 ways:

1. Increasing the electricity consumption by producing hot water with a heat pump instead of the gas boiler and thus exporting less energy to the grid;
2. Store excess energy in the domestic hot water tank by increasing the temperature an additional 10°C whenever PV is available. This stores thermal energy in the tank and reduces the demand for electricity from the grid at a later time when PV energy might not be available.



$$SCR = \frac{650 - 437}{650} = 33\%$$

$$SCR = \frac{650 - 392}{650} = 40\%$$

The test site shows a very clear improvement in the self-consumption ratio: from 33% without the heat pump to 40% with the heat pump and its PV optimization algorithm during the month of June 2022. When extrapolating these results over a full year, 35% to 50% of the energy needed to produce domestic hot water can be covered by free PV energy, resulting (with the energy prices of June 2023) in energy savings of 90 to 120 euro, just for the domestic hot water production. This is more than the 23 euro that could have been gained from exporting this additional energy to the grid. When considering also space heating and/or even cooling the energy savings are higher.

Conclusion

A heat pump increases the self-consumption % of a residential PV-installation around 10%. The financial benefits for the users is in the order of 80 – 120 €/year (case study calculated with 0,293 euro / kWh for electricity consumption and 0,078 euro / kWh feed-in tariff).

For more details on the case study or a more detailed explanation of how the heat pump optimalisation works please refer to the complete paper.