Combining solar collectors with an air heat pump for domestic hot water and space heating

Installing an air-to-air heat pump in houses with direct electric heating systems is a common way to increase the efficiency and to lower the costs of the heating system. By redesigning the heat pump it is possible to make it produce domestic hot water as well and thereby create an even more efficient system. A system like this would save 75-80% of the initial energy consumption of a direct electric heated single family house and pay itself back in two to nine years.

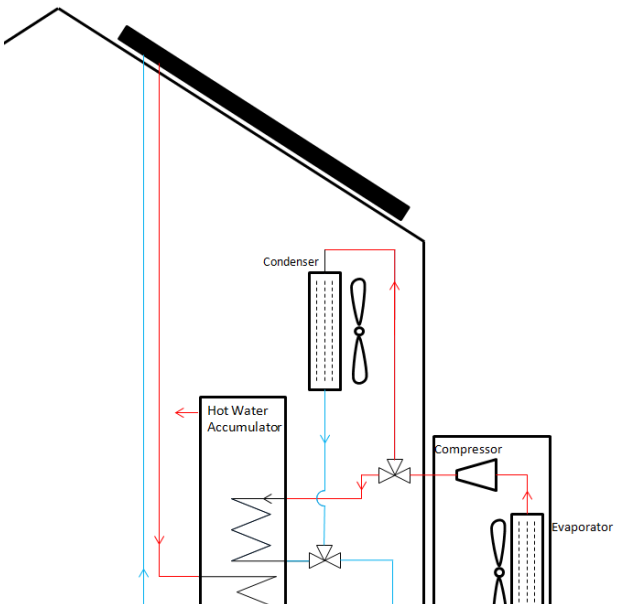
A popular science article by Erik Svantesson

During the 70s, and the decade's prequel to it, the belief was that electricity would be too cheap to meter in the future. Today we know that this prediction, as many else, did not go through. However we did build plenty of single family houses with direct electric heating systems (without a hydronic heat delivery system). These houses still stand today and are, in contrast with other heating solutions, both very inefficient and cost about 25 000 SEK/year to heat. Inefficient in the way that electricity is a high value energy source while heat, at these temperature levels, is a low value energy source.

To improve these heating systems it is common to install an air-to-air heat pump that will deliver the indoor space heating while using less electricity than a direct electric system would need. These heat pumps do not produce any energy for the domestic hot water that is left with direct electricity. Solar thermal collectors could be installed to cover the hot water load during summer, but a heating system like this would still include direct electric heating.

A master thesis study, presented in June 2015, investigated the feasibility of redesigning the heat pump in order to cover the domestic hot water demand as well.

If a diverter is added to the system the refrigerant can be sent either to warm the space air or to heat the tank. The diverter would have to be regulated together with the compressor to deliver the correct temperature to the correct place. The heat from the heat pump was only sent either to heating the indoor air or for domestic hot water. These were not performed at the same time



A suggestion of how to redesign of an air-to-air heat pump so it can deliver hot water as well. This in combination with solar panels

since the efficiency of the system would decrease substancially. One challenge with such a setting is the fact that, during certain periods, both the indoor air and the domestic hot water need heating at the same time. This investigation showed that it was possible to use the house and the water storage tank as heat batteries and keep an acceptable temperature while the other one is heated.

To research the feasibility of this system a simulation model was created in a dynamic simulation programme called TRNSYS. This software models the energy use of the house for space heating and domestic hot water for every fifteen minute during one year using weather data for Stockholm and a user schedule.

In the simulation an average Swedish single family house with four people were used as the energy need. Using a total of 17 300 kWh per year to heat the indoor space and the domestic hot water. This heating would cost about 26 000 SEK/year.

These simulations show that both the house and the tank will be able to maintain acceptable temperatures during the time heating is alternating between them. The results also show that a system like this will be able to save 75-80% of the original energy needed. This lowered energy consumption would save 19 500-20 800 SEK/year from the heating costs.

A simple pay back analysis estimates that the system would repay it selves in two to nine years. This pay back considered different electrical prices and the solar thermal collector sizes 0, 4, 6, 8 and 10 m^2. Analysis also showed that the lowest payback time would be for a system without any solar thermal collectors with a tested control function.

An interesting follow up of this research would be to investigate the possibility to use the solar panels as preheat the domestic hot water entering the heat pump. If so, the payback results with solar thermal collectors may be different.

Another question that is raised from this research is whether this heat pump could be constructed in reality. The research has only been theoretical, and a real life version of this heat pump would probably have different properties than the theoretical one. Among those are the properties of the compressor that would have to be able to deliver a broader range of pressures. When a compressor only have to deliver a small range of pressures it usually is possible to get a higher efficiency out of it. This raises the idea to use two different compressors after the diverter instead of one before the diverter.