Technology Collaboration Programme
by IEA

Heat Pumping Technologies
MAGAZINE
Heat Pumps Unleashing Flexibility and Sector Coupling
Vol.42 No.1/2024
A HEAT PUMP CENTER PRODUCT

Topical Article

Fitting Large Amounts of Heat Pumps in the Energy System

DOI: 10.23697/azm1-8429

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In the face of increasing electricity consumption and the need for a resilient energy system, integrating large amounts of heat pumps poses both challenges and opportunities. Adriaan van Eck from Flexiblepower Alliance Network (FAN) explores the concept of energy flexibility and its value in navigating the complexities of the modern energy landscape. By leveraging smart appliances like (hybrid) heat pumps and embracing open standards, such as the S2 communication standard, the potential for optimizing energy usage while minimizing comfort impacts becomes evident. This article sheds light on the importance of open standards in scaling up energy flexibility and shaping a sustainable energy future.

Introduction

In the next decade, millions of relatively heavy electric appliances are expected to be installed in and around homes and offices. This will cause electricity consumption to increase significantly, which will put pressure on the electricity system. At FAN, we believe that smart appliances like (hybrid) heat pumps can contribute to both relieving pressure on the electricity grid and reducing energy bills for the owner, provided they can be easily used for this purpose. We promote the use of open standards for this because that's the only way to make this feasible on a large scale.

What is Energy Flexibility, and how is it valuable

Energy flexibility is the ability to alter the use of energy without a significant impact on comfort. The latter part, 'without a significant impact on comfort', is often overlooked in discussions about the energy transition. At FAN, we believe that Energy Flexibility will help the energy transition, but it is important that we can apply energy flexibility without large

adaptations in our lives and work. Of course, it's even better when there is no impact at all. The anti-legionella cleaning cycle of heat pumps is a good example: this energy-intensive process offers certain degrees of freedom to shift to moments when the national or regional energy demand is less stressed without anybody losing comfort. Of course, this needs to be executed within legal and hygienic boundaries and with the technical limitations of heat pumps in mind.

The value of energy flexibility can be demonstrated by looking forward to the future. An all-electric home may have a peak electricity consumption that is 5 times higher than compared with a classic home. [1] On top of that, the energy demand for heating is centered around the winter: In a cold winter period, many homes and buildings will have a large heat demand at the same time and for a large part of the day.

In a world with many heat pumps, this may lead to an electricity demand of 10 to 20 times the demand of today. In the Netherlands, such a scenario may take place in a period of 5 – 10 years. With this in mind, it is easy to see that both energy generation and transportation and distribution of the needed energy will be a challenge and that a more evenly distributed energy demand will be very beneficial.

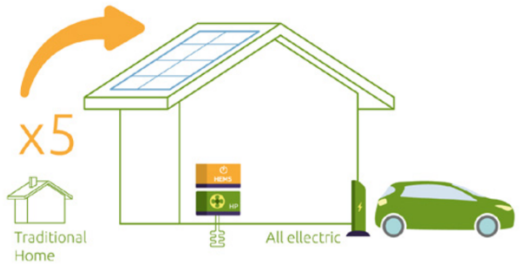

Figure 1. An all-electric home may need 5 x as much electricity as a classic home

In our 2022 study "Energy Management Opportunities for the Home", we've analyzed the value chain of energy flexibility. The most relevant benefits for the owners of heat pumps are:

1. Dynamic energy prices: use energy at cheap moments and avoid expensive moments,
2. Optimization of one's own energy generation, storage and consumption,
3. Grid connection optimization: stay within certain limits or bandwidths.

The most relevant benefits for the energy system stakeholders (grid operators, utilities, energy communities, service providers, etc) with respect to heat pumps are:

1. Portfolio optimization: Energy companies are constantly coordinating supply and demand to fulfill contractual agreements,
2. Congestion management: reduce the strain on national, regional and local grids.

Next to these, other values may come into play, for example fiscal values or sustainability values like minimizing the CO2 footprint of your energy consumption.

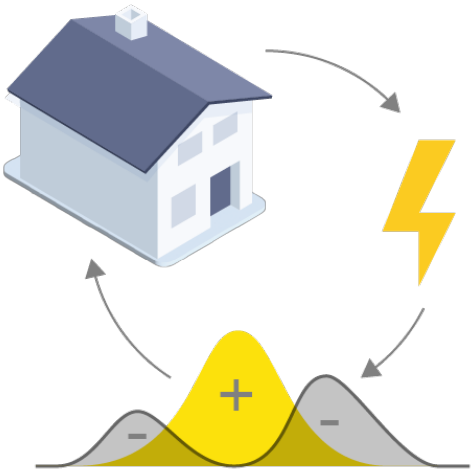

Figure 2. Reducing peaks via shifting energy demand to off-peak periods

Energy Flexibility and (hybrid) heat pumps: combining the value(s)

At FAN, we often talk about The Big 4: PV systems for solar energy, electric vehicles (EV) and their chargers, batteries, and (hybrid) heat pumps. Many companies, researchers, and service providers have developed or are developing strategies and services to optimize these devices and their use cases for congestion management, energy price optimization and other challenges.

In our vision, combining the various energy flows within the home or building is the best way to limit the impact on comfort and still get the best out of the possibilities offered by the devices. PV systems, EV chargers, batteries, and (hybrid) heat pumps are very suitable for this purpose when they are combined in a smart approach, for example, by using an Energy Management System (EMS) and the smart meter.

The rationale behind this is quite obvious: the ultimate goal of energy management is to mitigate a shortage or a surplus of energy demand; adapting the energy usage of heat pumps or EV's is only the means to it, not the goal in itself. At one moment, the heat pump offers the best opportunity to adapt to the energy demand; at another moment, an EV or a home battery may offer the best chance.

And there is another reason. In case the heat pump is optimized by an individual energy service provider and the EV by a different one, the risk occurs that the heat pump may demand more energy because the energy price is low, and at the same time, the EV is postponing it's charging due to congestion management needs. The net effect would be zero, and the energy system would be worse off.

Why do we need open standards?

Energy optimization requires a lot of information and connectivity. A wifi chip or matter implementation may make your heat pump smarter, but it's not enough. Heat pump research carried out by FAN reports that 94% of the heat pumps sold in The Netherlands in 2021 are connectable. [2]. The report also shows that a large variety of protocols and standards exist, both for control and for communications. One could think that this makes it easier to develop smart energy services since there will always be a technology that suits your needs. Yet, it is the other way around: because there are so many standards, a utility or service provider would need to implement many of them, which is very costly to develop and maintain.

Let's take a look at the functionalities someone needs to integrate if one wants to do smart things with energy usage:

- Retrieve information from the residence or building and its users. What is the current state of affairs, and what is expected during the coming period? What is the temperature in the building, will someone be at home today, and how much battery charge is needed to drive the EV tomorrow?
- Retrieve and combine information from external parties: the energy grid platforms, energy prices on markets, weather forecasts, etc.
- Retrieve information from heat pumps and other devices, for example, state of charge, the maximum power consumption and the like
- Send commands or messages to adapt the energy usage according to the optimization needs and possibilities.
- Gather and register data for settlement and billing.

Combining all these functionalities is a complex task, and it does not help if many brands and organizations have their own proprietary protocol to access them. Standards will make it easier and less expensive to use appliances for smart energy services; that's why we need them. These standards need to be open and maintained by independent bodies to prevent vendor lock-in and assure interoperability between devices and services in the energy system.

Energy flexibility and (hybrid) heat pumps: the elegant way

At FAN, one of our focus areas is energy management in homes and buildings. As already mentioned, we want to integrate the energy flows of 'the big 4', for the best result and minimal impact on comfort. From this perspective, FAN has been working with partners in the S2 consortium to promote the adoption of S2, an open communication standard for energy management.

S2 aims to simplify the combined use of energy flexibility of multiple smart devices in homes and buildings.

In S2, there are two entities that communicate with each other:

- A **Customer Energy Manager** (CEM) which orchestrates the flexibility provided by the appliances in the building.
- A **Resource Manager** communicates the energy flexibility information of an energy-smart appliance

The Customer Energy Manager and the Resource Manager communicate via the S2 standard.

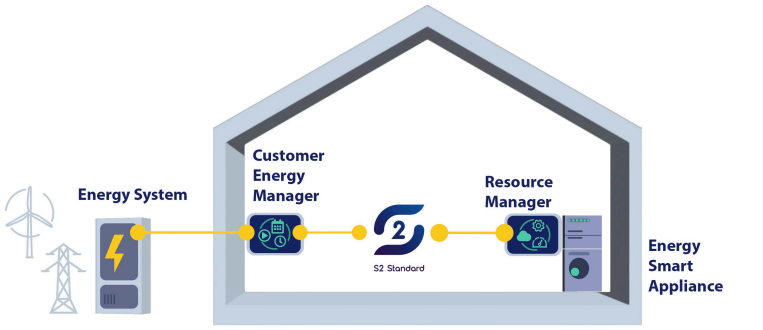

Figure 3. Concept of the S2 standard with a customer energy manager and a resource manager

Thanks to its setup, S2 does not require heavy integration with the firmware of energy smart appliances, and it respects the internal logic, safety and security limitations of devices. There is also no limitation for manufacturers: S2 can be used with cloud services and via local control.

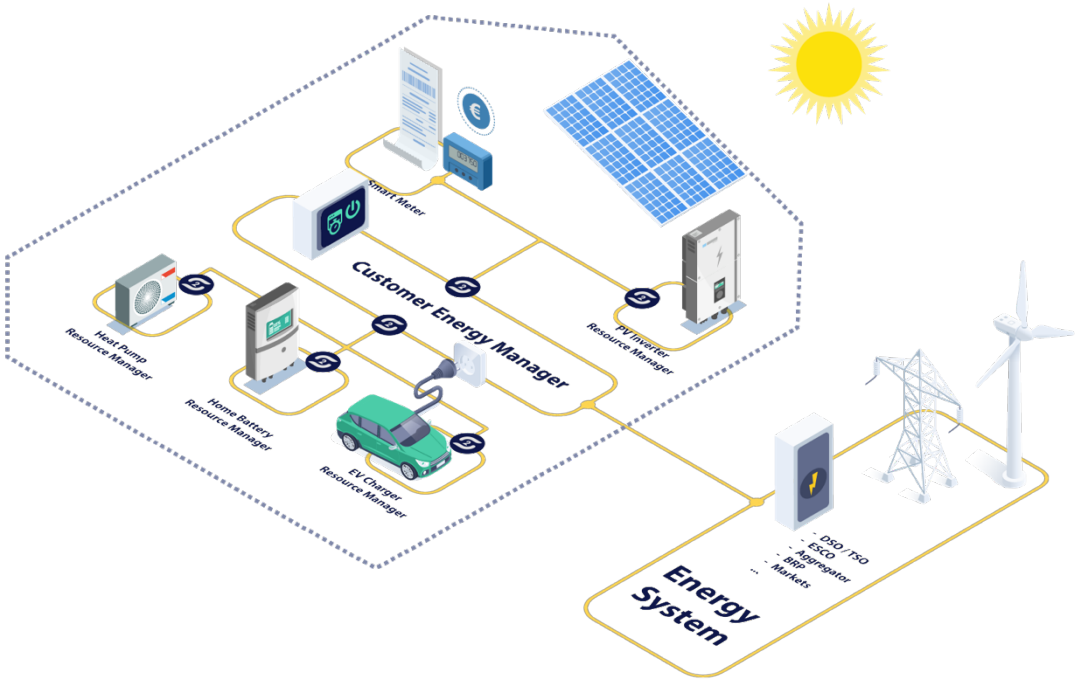

Figure 4. The S2 standard in the energy system

Final remarks

In the coming decade, we expect millions of larger appliances to be installed in the built environment. At FAN, we believe that energy flexibility will be key in assuring a resilient, sustainable energy system, and we believe that this flexibility can be used without a significant impact on comfort. Open standards will be crucial to scale up the use of energy flexibility.

Notes and references

1. Energy Management Opportunities for the Home, FAN and Elaad, Dec 2022.
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