ENERGY MANAGEMENT OPPORTUNITIES FOR THE HOME

FLEXIBLEPOWER ALLIANCE NETWORK

Elaadnl

TKI URBAN ENERGY
Topsector Energie

The increase of heat pumps, EV charging stations and solar panels is having a large impact on the energy system

Flexible control of these devices within homes will make it possible to change, shift or distribute electrical supply and demand in time. This helps coordinate the generation and usage of sustainable energy and reduce peak loads.

Colophon

AUTHORS

Arjan Wargers
ElaadNL

Adriaan van Eck
FAN

PUBLICATION

Title	Energy Management Opportunities For The Home
Version	1.2
Date	December 2022

ILLUSTRATION & DESIGN

Marcel Nahapiet • nahapiet.com

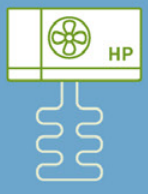


TABLE OF CONTENTS

Preface 7

Management Summary 13

Introduction to the Role of Home Energy Management Systems 17

Problem and objective 25

Approach to the research 37

Value chain of residential energy flexibility 43

Value chain 1Energy consumers 44

Value chain 2Energy system 46

Value chain 3Social values 48

HEMS and use the cases for energy management 51

Smart charging of electric cars 52

V2G: The electric car as a battery on wheels 56

The home battery 58

The (hybrid) heat pump 60

Energy management for the home 67

Appearances HEMS 74

The Road to Interoperability 77

Security, privacy and consumer trust 80

Findings 83

Priority is changing: energy management in homes is needed and is becoming more urgent 84

The market must take the lead in the HEMS roll-out 84

There is a need for direction, clarity and a regulatory framework 86

Consumer awareness of the necessity and possibilities of energy management is low 87

Manufacturers are now all focusing on energy management 87
Combining devices is preferred.....88
Good interoperability is a prerequisite.....88
A hybrid image qua appearance 89
Privacy and security 89
Energy poverty.....90
The opportunities for collectives and collaborations 91

Recommendations 93
Preconditions for residential energy management 94
Consumer Roadmap.....96
Energy systemstakeholder roadmap.....98
Roadmap for manufacturing stakeholders 106

Acknowledgments & epilogue.....112

Appendix.....115

Appendix 1: People involved 116

Annex 2: Challenges to the electricity grid 120
Bandwidth model + ... 121

Appendix 3: Some smart home protocols 122
EFI / S2 122
ModBus.....124
EEbus.....124

Definitions and Abbreviations 126

About FAN

Founded in 2013, the Flexiblepower Alliance Network (FAN) sees energy flexibility as a vital step in the energy transition. FAN contributes to an open, fair and sustainable energy system, whereby the surplus of supply and demand of sustainable energy can be managed by energy flexibility. Using open standards, FAN strives for maximum application and access to flexibility in the energy system. This way sustainable energy supplies can remain reliable, affordable and accessible in the future. While the freedom of choice remains central for end users.

About ElaadNL

ElaadNL tests and researches smart and sustainable charging of electric vehicles. In its Arnhem Lab, ElaadNL conducts all kinds of charging tests on electric vehicles ranging from passenger cars to electric buses to trucks, and the associated electrical infrastructure. This open Test Lab is a meeting place for new models and innovation in the field of (smart) charging of electric vehicles and related research into the interaction of underlying power grid. In addition, ElaadNL is investigating the integration of smart charging with the use of other ‘energy-intensive’ devices via Home Energy Management Systems. As a Test Lab, a HEMS demonstration environment has been set up where ElaadNL demonstrates how different electrical devices can interact with each other. ElaadNL is eager to share its knowledge with other parties to ensure a rapid transition toward clean mobility.

Preface

TKI Urban Energy

The importance of smart energy management in homes

The Role of Home Energy Management Systems in Managing Energy Supply and Demand

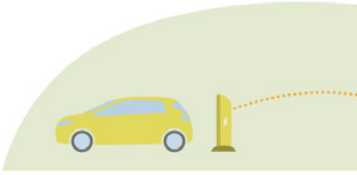
The rise of all-electric homes and electric vehicles (EVs) is leading to a sharp increase in electricity demand in residential areas. With this energy transition, the electricity system is slowly but surely coming under pressure. Electrification of the heating demand and mobility leads to an increasing electricity consumption.

Moreover, this demand for electricity is not spread over the day, but large peaks arise at specific moments; for example, after work, when everyone plugs in the electric car around dinner time. Also, the demand for electricity often does not overlap with the time solar and wind energy is generated.

Home Energy Management will play a role to balance the supply and demand of electricity, to prevent overloading of the electricity grid and to better coordinate the generation and use of sustainable energy. Flexible control of appliances for residential consumers makes it easier to change, off set or spread out part of the supply and demand for electricity over time.

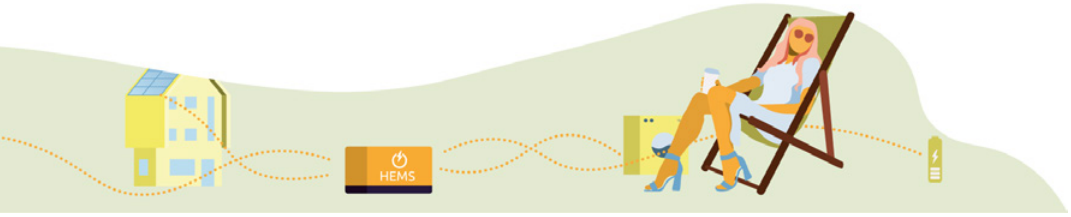
It is not likely that the consumer will charge the car faster or slower by hand. Likewise, the average consumer will not take the time to reduce energy bills by "manually" optimizing their energy consumption. Digital solutions and new smart energy services are needed to automate this process through the use of a Home Energy Management System (HEMS). Home appliances on a HEMS system can be flexible and tailored to either self-generated energy or affordable energy prices.

> *This can be done by using a Home Energy Management System (HEMS) that can adjust all flexible devices to the availability of self-generated energy or energy prices.*



Many pilots already show that it's possible to technically control devices in a smart way via a HEMS. The challenge is how to enable companies to develop more services that are commercially attractive. Control of flexible devices requires close cooperation between the energy sector, installation companies, energy cooperatives, building systems suppliers, and the owners / occupants of buildings. This report provides insight into what is needed to further scale up HEMSs and how this can be achieved.

RVO and TKI have commissioned the Flexiblepower Alliance Network and ElaadNL to provide an overview of the state of affairs around HEMS. These organizations work together on the next steps in the form of a roadmap, which is outlined in this report.



ABOUT TKI URBAN ENERGY AND THE NETHERLANDS ENTERPRISE AGENCY

Maarten de Vries & Jasmijn Kleij work for TKI Urban Energy, part of Top Sector Energy. The organization encourages companies, knowledge institutions, social organizations and governments to work together on energy innovations. The Netherlands Enterprise Agency (RVO) is a government authority focused on the Dutch business climate. Dutch entrepreneurs can turn to them with questions on sustainability, agriculture, innovation and international entrepreneurship.

Together, TKI Urban Energy and RVO promote research into energy innovation to accelerate the sustainable, a reliable and affordable energy system in the built environment and infrastructure. They do so by financially supporting initiatives, bringing stakeholders together and sharing. This way, they strengthen the economic competitiveness of involved Dutch businesses and knowledge institutions. Are you aspiring to innovate in the field of flexibility? TKI Urban Energy or RVO may be able to support you with your ambitions.

The employees of TKI Urban Energy are available to validate your ideas and help you find partners for consortiums or other co-operations. You can contact RVO to inquire if your idea is eligible for subsidy (co-financing) from the Top Sector Energy.

If you would like to get in touch with RVO or TKI Urban Energy regarding this report, please contact:

Maarten de Vries

Program Manager Smart Energy

Tel: 06-1683 6490

maarten@tki-urbanenergy.nl

www.tki-urbanenergy.nl

Jasmijn Kleij

Innovation Analyst Smart Energy Systems

Tel: 06-8370 5403

jasmijn@tki-urbanenergy.nl

www.tki-urbanenergy.nl

Nicole Kerkhof

Senior Advisor Energie Innovation - smart energy systems (SES)

Tel: 06-2723 9645

nicole.kerkhof@rvo.nl

https://www.rvo.nl/klimaat-energie

The market must be in the lead at the roll-out of products and services.

This is a classic chicken-and-egg problem: consumers don't demand energy management for their homes, hence businesses won't develop services to manage energy for the homes.

Therefore it's important to have sufficient incentives for energy management.

Management Summary

Home energy management is receiving more attention due to increased electrification, especially through electric cars, (hybrid) heat pumps, solar energy and likely energy storage in the future.

This study researched the role of Home Energy Management Systems (HEMS) in homes and within the energy system. Currently there isn't any major movement towards energy management in homes. Therefore, about twenty experts were asked about the opportunities and obstacles facing HEMS. This resulted in a roadmap providing concrete recommendations to implement HEMS in the Netherlands on large scale.

Importance of energy management

The first outcome of our research describes a shared vision: Residential energy management is becoming more important, even though development is still very limited. A positive development is that manufacturers are paying more attention to energy management in relation to their products, and that parties that deal with end-consumers are looking at it seriously. Those involved agree that the integration of smart devices and energy systems need to improve, so smart energy use becomes easier and cheaper.

Market in the lead

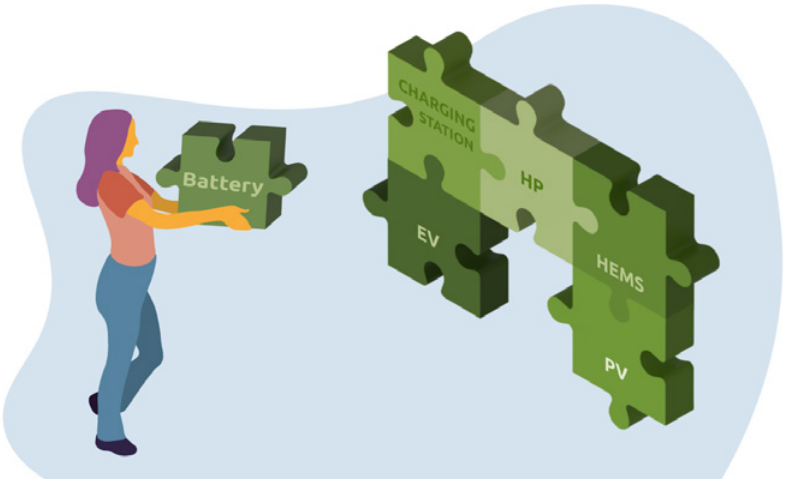
Another outcome is that ‘the market’ must take the lead in rolling out products and services. Here is chicken-and-egg problem: consumers are not yet interested in smart energy for homes, therefore energy providers and service providers aren’t creating services to help their customers.

It is important that customers have the right amount of incentives to become more interested in a smarter use of their energy flows. Since there is little awareness of the challenges and opportunities facing increased electrification, it is recommended to start as soon as possible - and not wait too long for perfect integrated solutions. This way, society can get familiar with smart energy services and grow with changing circumstances.

> *We recommend to start as soon as possible with energy management, so that society can get familiar with smart energy services.*

Unburden consumers

Energy management in homes can make a positive contribution by making the energy supply more sustainable. While there are some consumers who are leading the way with smart charging and smart heat pumps, we shouldn't forget that advanced solutions are too complex for many - in a market where energy is already very complicated. In order to get everyone involved, our advice is to **give market parties the space they need to remove the barriers for consumers.**



There needs to be a good regulatory framework and coordination between the various parties in the energy world to give more clarity in the regulations, rates, subsidies and other measures that stimulate sustainability. Chapters Findings and Recommendations discuss these points in more detail.

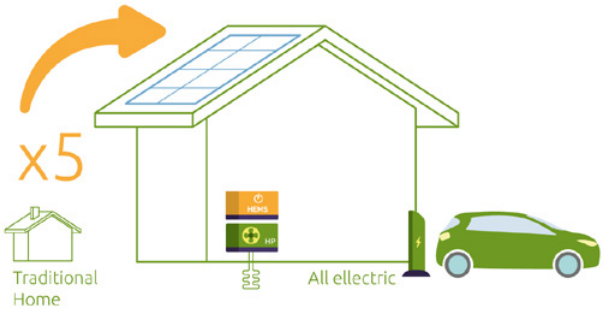
1

Introduction to the Role of Home Energy Management Systems

The energy transition in the built environment

The Netherlands is becoming more electric. If the Netherlands wants to reach its goals to achieve zero emission and independence from natural gas, the electrification of the built environment is a key step. To ensure that electrification runs smoothly, the energy system must become smarter.

One example: The peak consumption of the average ‘traditional’ household reaches is around 3.15 kW. Given that peaks do not occur all at the same time in a neighborhood, the average peak demand of that neighborhood is around 1 – 1.5 kW per home. This system is changing radically due to the increase in heat pumps, electric cars and solar energy.

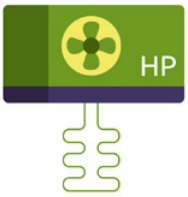


peak consumption

Traditional home: peak consumption is around 3,15 kW

All-electric home: peak consumption up to x5 times higher

Heat Pumps

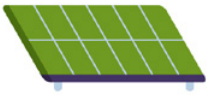


Heat pumps require a more power, from 2 kW (hybrid) to 6 kW (all-electric) per home.In the case of persistent cold, heat pumps will often all run at the same time. According to Tennet, research shows that by 2030, heat pumps could lead up to 5 GW of new electricity demand nationwide. Without flexibility, this may require an extra 3 to 4 large gas-fired power stations to meet the power demand on days without sun and wind. By smart-controlling many hybrid and all-electric heat pumps, the inflexible electricity demand can be limited to 1 GW.◆

◆ *Source: TenneT E-Top 22 januari 2021*

Systems that facilitate energy management in homes are called Home Energy Management Systems (HEMS).

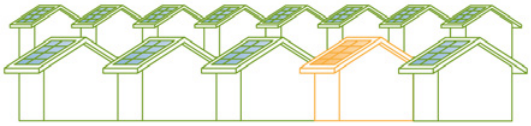
PV system



Standard solar panels have a capacity of 250 to 350 Wp and each panel can generate approximately 212 to 315 kWh per year in the Netherlands. The output however, is still developing. About 15 solar panels are needed to make an average household energy-neutral all year round. In extreme cases, this can result in a peak of 4 kW per household. In the Netherlands, around 0.7 GW of capacity has been installed for the residential sector alone. A significant peak can result if solar panels all start feeding in at the same time, especially when combining peaks from large scale solar parks and wind farms.

EV Charging station & EV

A standard charging station for EV's charges at 11 kW. There are also EVs that charge via one phase and therefore require 3.7 kW. Chargers of 22 kW also exist, as is the standard in Germany for example.



Houses

The above presents **challenges for homes**. These peaks do not occur at the same time, and when we take solar panels into consideration, we talk about feed-in and not consumption. However, each of these devices as a category already contribute to a household's peak load. Given that a household has a maximum power supply between 8 and 17 kW, there is a chance that the peak power of a household with a heat pump, charging station and solar panels exceeds the grid connection - especially if individual device peaks happen simultaneously.

Electricity Grid

The energy transition also creates **challenges to the power grid.** Grid operators rolled out the electrical grid based on the average peak capacity of the households. The developments outlined above will require more grid reinforcement because energy amenities in neighborhoods are not designed for this ever-increasing demand for electricity, which is occurring more and more simultaneously.

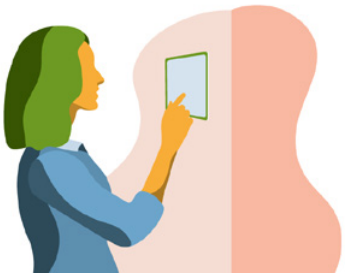
Balancing of supply & demand

Finally, this poses **balancing challenges between energy generation and consumption.** Much of sustainable energy is generated at a time when there is not much demand - likewise, there is a lot of demand often when there is no sustainable energy generation.

These peaks, their non-synchronicity and the associated grid-reinforcements pose a challenge. Fortunately, there are solutions: The usage of these devices the devices mentioned above have a great deal of built-in flexibility. By better matching supply and demand, we can use this flexibility to make sure that not all the electrical generation needs to be fed in. Likewise, we can assure that not all electrical demand happens at the same time. This is what we call energy management. The systems that facilitate energy management in homes are called Home Energy Management Systems (HEMS). For example, the use of energy management makes it possible to heat the heat pump earlier if electricity is available. Similarly, it's not necessary to charge the electric car at the maximum rate at moment you get home - it can be charged at night when there is sufficient grid capacity for the required electricity.

Energy management offers opportunities to consumers, energy suppliers and regional grid operators. It also offers opportunities for balancing the national grid. Tennet, the national high-voltage grid operator, is responsible for creating this balance, indicating that flexibility from the built environment is crucial to achieve this balance.

Currently, energy management is mainly used by companies. Within households, HEM is primarily used to make sure that the energy does not exceed the contracted grid connection, this happens on a relatively small scale. At the moment, there are virtually no incentives for consumers to use energy in a smarter way, but that is expected to change - by way of dynamic energy prices, the discontinuing of the netting plan and new grid tariffs (the so-called 'bandwidth model').[θ]



We want The Netherlands to start acting now, in order to enable large scale smart energy management towards 2030. This calls for good

θ *Appendix 2 - on the challenges of the grid – deals with ideas about the bandwidth model*

energy management systems for the home. And it requires a good market design with the right incentives and means so innovative companies can provide consumers with interesting solutions. In this report we explain what's needed to scale up energy management for homes in the future.

The systems that facilitate energy management in homes are called Home Energy Management Systems (HEMS).

2

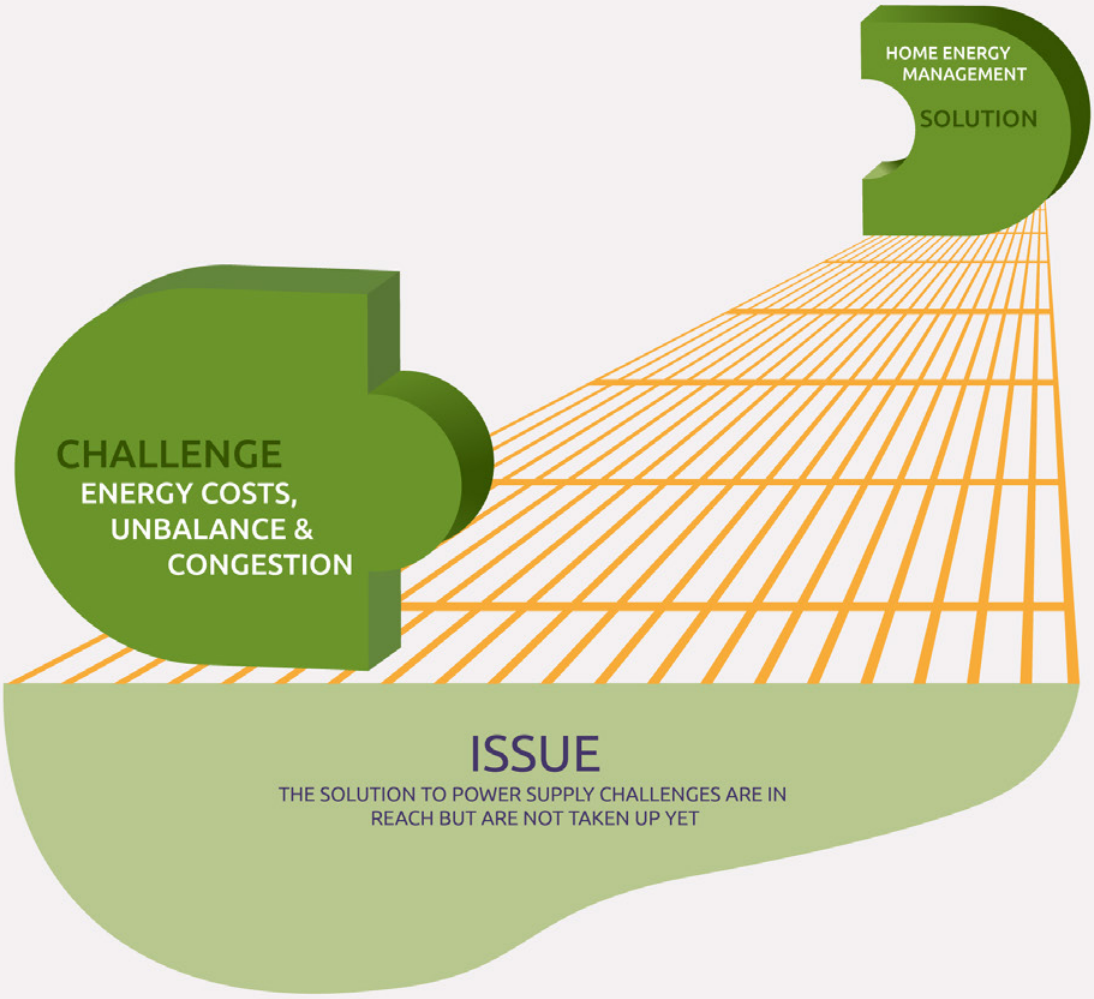
Problem and objective

The Netherlands can benefit from energy management in homes. This applies to consumers as well as to energy suppliers, network operators and other service providers in the energy system. Energy Management requires home energy management systems. These are systems that control the various devices in the home in such a way that it does its job (heating the house, charging the car) while integrating devices with each other and with the local energy system optimally.

Currently, there is no movement towards large-scale application of energy management in homes.

THERE IS NO TREND

TOWARDS HOME ENERGY MANAGEMENT SYSTEMS



What is optimal for an owner can differ per situation. For example using your own generated solar power as much as possible, fitting within the contracted grid connection capacity, using electricity at cheaper times of day, or living as sustainably as possible. Usually it's the combination of goals and preconditions that determines which management is optimal.

> *At the moment, the consumer does not benefit from energy management nor is aware of the advantages and possibilities.*

Currently, there is no trend towards a large-scale application of energy management in homes. This research aims to underline the importance of Home Energy Management Systems.

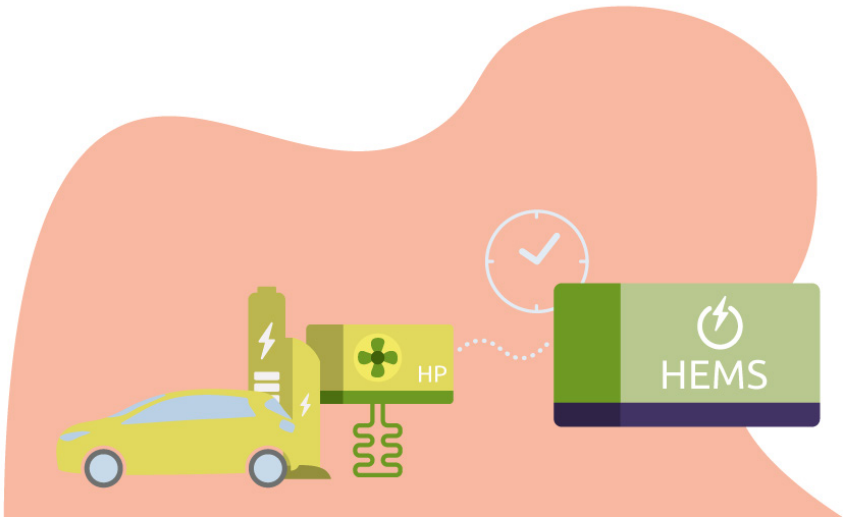
CAUSES PREVENTING THE HEMS ROLL-OUT

Broadly speaking, the causes that prevent the large-scale rollout of HEMS are the following:

Consumers do not benefit from energy management. The feed-in-tariff / net metering plan still exists; the grid tariffs do not contain any incentives to use the grid more proportionally and dynamic energy price propositions are not contracted at large scale. Potential benefits are still limited. As a result, there is no demand for associated products and services, which means these will not be developped. Energy is still a low-interest product, and energy management is a complex subject, both for consumers as well as stakeholders in the energy system.

The current costs associated with HEMS installation and management are (still) large in relation to the potential revenues. We see developments coming that will increase the benefits of flexible energy consumption. By using HEMS, these benefits can actually be achieved without compromising comfort. However, due to the lack of interoperability between devices, the costs are still too high. We do not fully know what developments in new grid fees, changes to the netting plan and dynamic electricity tariffs will mean for consumers.

The aim of this research is to identify bottlenecks and opportunities, so that a roadmap can be drawn up to make energy management more attractive. In addition, this research provides guidelines for the development of services related to energy management and HEMS and for reducing the costs of HEMS itself.



Obstacles facing a large-scale HEMS rollout

Consumers

At the moment there is no incentive for the vast majority of consumers to implement energy management; the most common reason for installing a HEMS is to prevent overloading of the grid connection and, by extension, to prevent an increase of the contracted grid connection. Consumers rarely ask for smart energy solutions for their home. The attention to energy and energy management has been increasing recently, but has not yet led to a large HEMS demand.

About twenty experts were interviewed for this research ▼. The group at large indicated that consumers want reduction to costs or at least minimize rising costs as much as possible while maintaining comfort. Beyond that, there is a small, but growing group of consumers who would also like to use energy management from a sustainability perspective. At the same time, consumers do not know much about energy management or home systems that take care of energy for them. Energy remains a 'low-interest' product for most consumers.

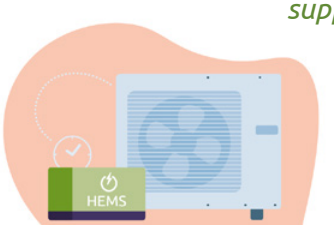
Energy companies

On the other hand, most energy companies don't yet know how to use home energy management. Energy companies understand the challenges of future energy supply, they see the upcoming opportunities and want to work on them in general. How to take advantage of the opportunities on the consumer market on large scale remains complex and too elusive for energy companies on several levels. Current pricing and regulations do not yet directly ensure the large-scale provision of energy management services. There is a lot of uncertainty about future developments in this area. Energy management is technically complex due to the absence of clear standards and best practices. This makes the development of large-scale cost-effective propositions to end consumers virtually impossible at the moment.

▼ *Chapter 3 details the approach of this study, whereby appendix 1 lists the parties involved in this study.*

Those interviewed indicate that market players will soon increase demand for energy management applications. More specifically, it is expected that net metering will be phased out, new grid fees are enacted and more suppliers will offer dynamic electricity pricing. The need for energy management will increase, partly due to these developments and the consumers desire to keep costs under control while maintaining comfort. Take the developments in Flanders for example, where energy management attracted a lot more interest and new demand has increased sharply due to changes in net metering and grid fees.

> *It is expected that the net metering plan will be phased out, new grid fees and more suppliers with dynamic electricity prices.*



Finally, based on the interviews, we see interoperability, integrating charging stations, solar panels and heat pumps to make them work together with HEMS (a precondition for energy management to function properly) has not yet been achieved.

The Importance of Deploying Large-Scale Home Energy Management Systems Today

In addition to optimizing energy use in homes, energy management can contribute to the stability of the energy system, and hence to enlarge the share of renewable energy in the mix. Various devices [■], such as electric cars, solar panels, heat pumps, home batteries and possibly air conditioner units each have the potential to provide flexibility. Recent developments such as fluctuating energy prices, congestion management, solar generation optimization, balancing the grid, smart charging of electric cars and heat pumps are quickly increasing the value of energy management. This demonstrates the need for HEM and HEMS.

> *The energy transition requires flexibility among consumers, the so-called 'residential flexibility'.*

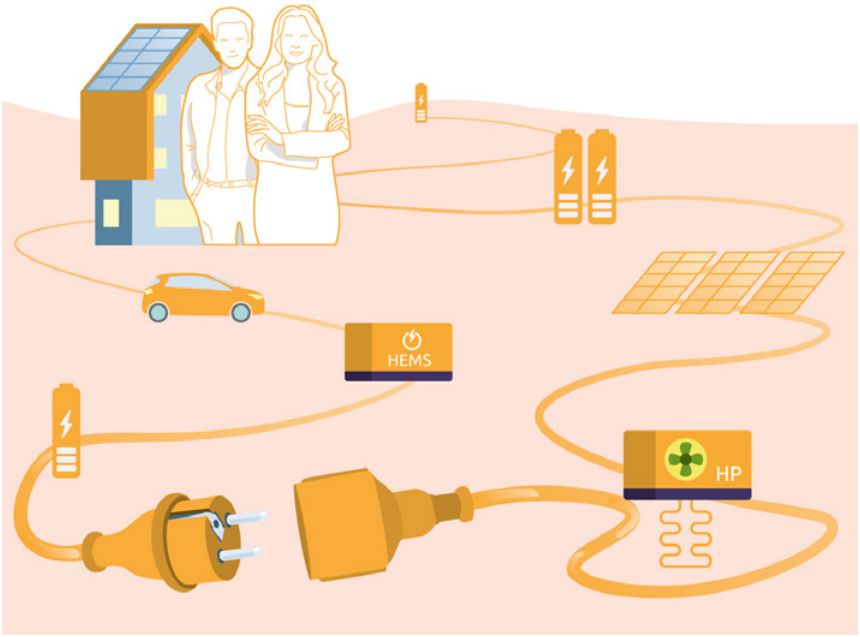
All these developments require the use of flexibility from the various devices and systems to help regulate usage for the consumer. Interoperability between devices, for example, is an aspect that can already be addressed. Today, governments and grid managers can still adjust and / or determine what the connectivity (protocols) between the HEMS and the grid managers system should look like.

It will take some time before large scale future energy management can be utilized. Manufacturers, consumers and energy suppliers alike need more experience integrating devices. Energy markets must be linked to residential flexibility. Interests

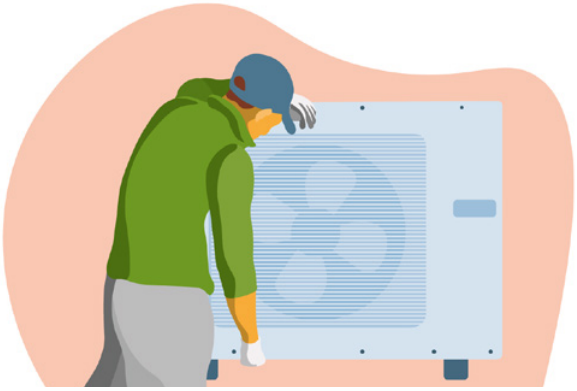
■ *The main focus is now EV, WP, PV and the home battery. Home Appliances are not considered a priority: : Flexibiliteit in de gebouwde omgeving wegwijzer voor ondernemers. (in Dutch).*

from grid operators must lead into consumer incentives. Social interests must be considered and embedded into regulations. There needs to be an increased awareness of the opportunities offered by energy management. To provide good models and best practices for home energy management in a few years, it is essential to create the right conditions now.

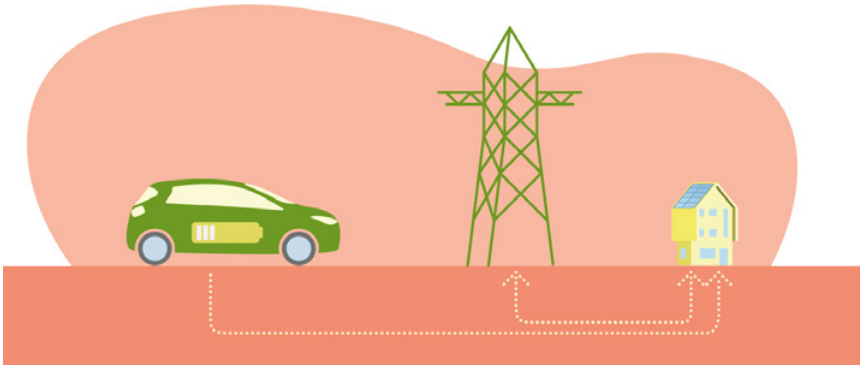
Finally, there is still a risk that a silo effect is created, in which the flexibility is only unlocked from a single device, without a HEMS. In such a case, a considerable amount of potential flexibility is missed out on, which can be at the expense of consumer comfort. Integrated energy flexibility and deployment via HEMS is necessary to optimize energy consumption for the various energy parties in the energy system that need it.

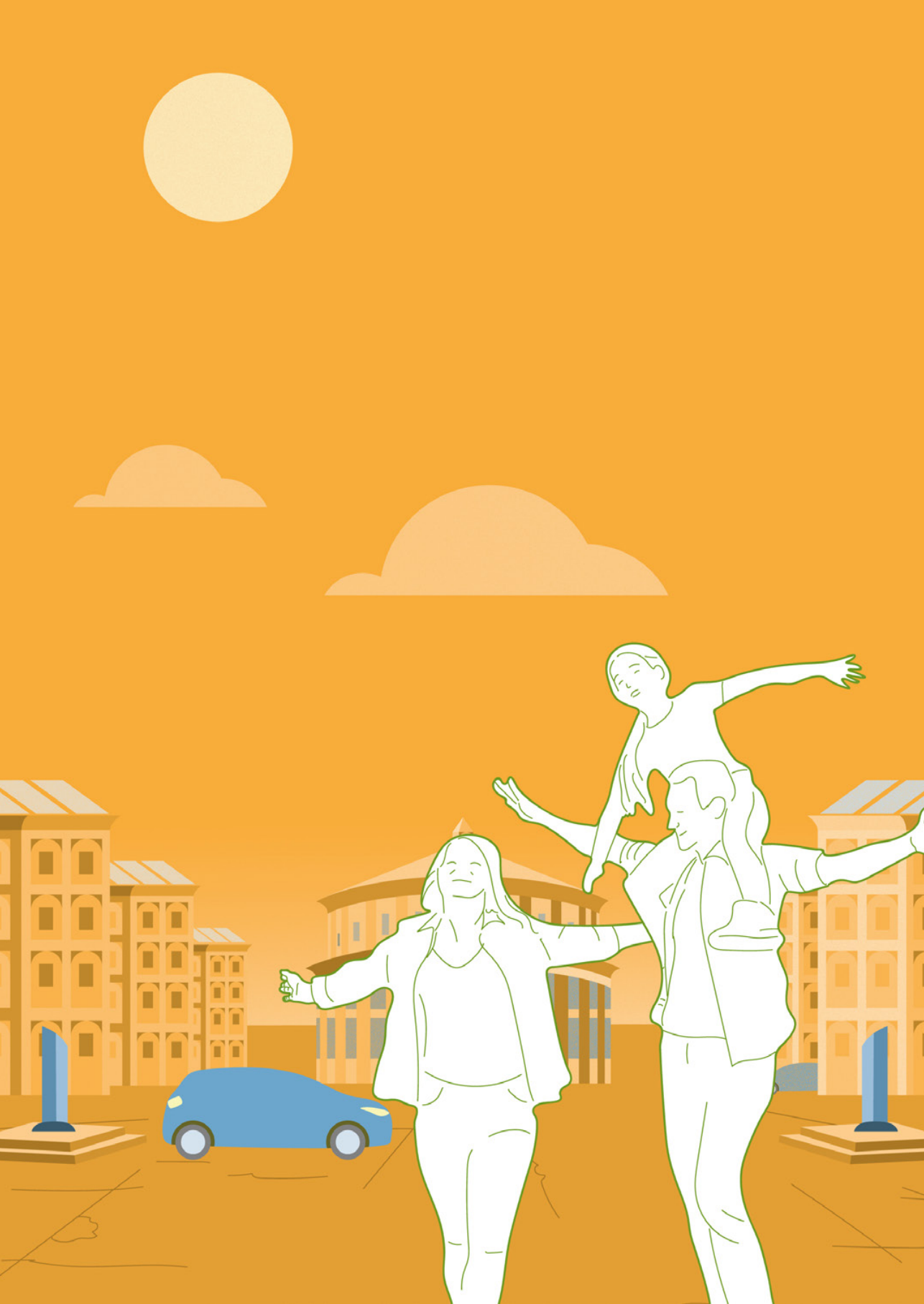


It is important to set up energy management in a cost-effective and therefore standardized way. This means that the HEMS must clearly communicate with various devices through standardized interfaces. It is now time to shape this standard together in order to organize energy management in a cost-efficient way for the consumer (and all other stakeholders).



There is a risk that a silo approach will arise, in which the flexibility is only unlocked from a single device.





3

Approach to the research

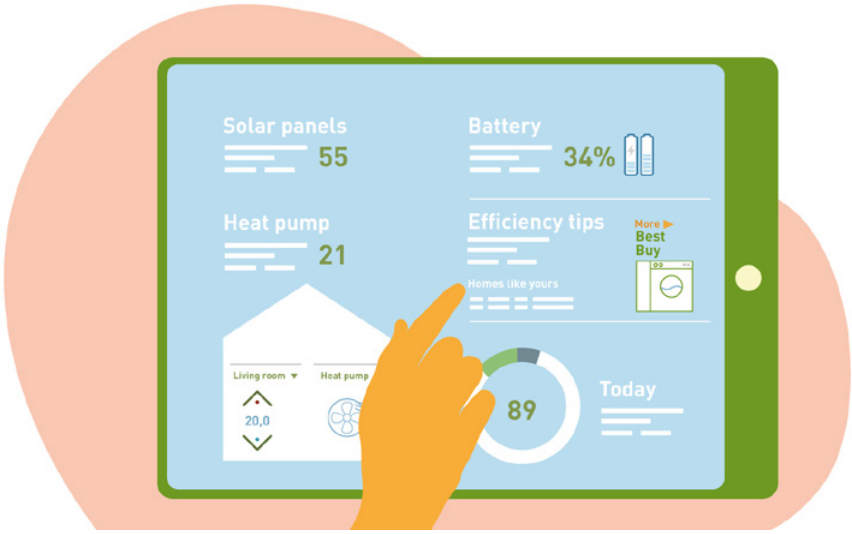
Set-up, organizations and steering committee

FAN, ElaadNL and TKI Urban Energy strive to promote the use of Home Energy Management Systems to deal with surpluses and shortages of electricity as well as possible. This is why these parties have taken the initiative to this research. ElaadNL and FAN were asked to draw up a proposal and a research plan. Next, a steering committee was established by the directors of the FAN association, RVO and TKI Urban Energy as members.

After an inventory of relevant topics, the scope of the research was determined. To safeguard the content, an expert group has been established by stakeholders who represent all parts of the energy sector, who represent all views and interests from the energy sector, as well as, the technical sector and general social interests. The experts were interviewed individually. Their input was processed and addressed during an expert session to address contrasting views or principles.

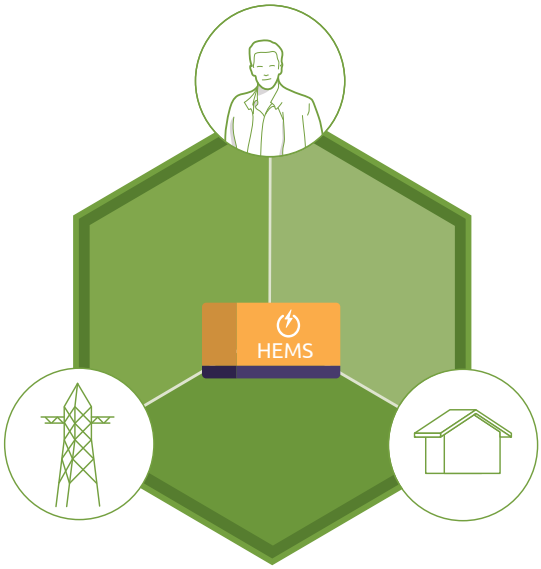
An assessment committee was established to validate the various visions and interests. This consisted of experts who represented the interests of various technical and energy sectors, and societal interests such as privacy, ethics and sustainability.

The experts and evaluators were asked to provide insights into the design of this study and draft report. See Appendix 1 for the experts and assessors consulted.



Three angles

The research was conducted from three angles: the energy consumer, the home and the energy system. The various experts were asked about energy management and HEMS from these perspectives.



The energy consumer

The first actor is the **energy consumer.** Without the cooperation of energy consumers, home energy management will not be able to contribute to the energy transition. In addition to financial aspects, this angle looks at both psychology and behavioral science, but also includes issues such as manageability, ownership, affordability and fairness of the energy system.

The energy consumer can return energy back to the grid if he has solar panels and / or battery storage. In that case, the term “prosumer’’ is often used.

Energy system

From the perspective of the **energy system**, we examined the technical challenges to the grid, such as balancing and congestion, safety and robustness of the energy system. Besides that, we examined the interdependencies between parties such as commercial energy companies, network operators, energy collectives, governments and how regulators can hinder the roll-out of HEMS - and how this can change the trend.

Home

The point of view of the **home** relates to the efficient and effective management of the energy supply and demand (and feed-in) of electricity. This applies to controlling devices ‘behind the meter’; controlling heat pumps, electric cars and other appliances that require a lot of electricity. It also implies the interaction ‘before the meter’; for example; how does a desired situation where the system uses less energy between 5 pm and 8 pm, lead to a decrease of energy consumption by EV chargers?

The research was conducted from three angles: the energy consumer, the home and the energy system. Without the cooperation of energy consumers, home energy management can't contribute to the energy transition.

4

Value chain of residential energy flexibility

We examined what possible incentives best promote the use of energy flexibility. From the interviews, various energy system motivations emerged and grouped into three value chains:

- Value for energy consumers
- Value for the energy system
- Social value

Value chain 1
Energy consumers

Flexible and efficient consumption and feed-in: dynamic energy prices

The increasing dynamics of supply and demand for electricity have resulted in more fluctuations in electricity prices in recent years. In the commercial energy market, there are types of contracts enabling companies to benefit from these dynamic energy prices. In the Netherlands, it is not very common on the consumer market, but it is expected to increase. These contracts make it more attractive for consumers to charge their home battery and electric car when the energy price is low.

Optimization of own energy generation and consumption: Net Metering Plan

We expect the net metering plan will be phased out. This is the regulation that determines how annual generated energy (feed-in) and annual consumed energy are offset. If a consumer generates more than he consumes on a yearly base, the access generation will yield a fixed fee per kWh. It does not matter what time of the day of the year the energy is generated or how much electricity is available at that time. Phasing out this regulation will mean that it becomes more favorable to use the generated electricity from the household, to charge the EV for example.

Grid connection optimization: new grid fees

Another development to consider is the introduction of new network tariffs. Consumers now pay a fixed amount for their technical grid capacity. In rare cases, the current grid fees are already providing incentives to integrate energy management to avoid overloading the connection and prevent having to contract a larger connection. But this incentive is limited to few houses.

Grid operators are currently working on a new grid fee model that they want to introduce in a few years. This new model will provide a stronger incentive to distribute energy consumption result in lower peak loads. Then you no longer have to pay for the size of the connection, but how heavily you actually load the grid. This is somewhat similar to subscriptions made with your internet provider - not in Mbits, but in kW. This so-called bandwidth model stimulates the efficient use of grid capacity. Energy management helps consumers avoid power spikes and may help to contract lower bandwith. Both measures help to save costs.

Tax options

Taxation was also mentioned as a financial motivation. In the future, the government may use tax rules to motivate consumers to adapt their energy consumption to the challenges facing the transition.

Non-financial motives

For the average consumer, when applying energy management, maintaining comfort while saving costs is paramount. However, the respondents also see that consumers are motivated by other things. ‘Sustainability’ is one of them. This is somewhat smaller of a motivation than the desire to save costs and maintain comfort, but it is growing. In addition, we see that the innovative character of energy management is also appealing. We see this especially with the consumers who already have for example, an electric car and solar panels.

Value chain 2
Energy system

Portfolio optimization

Supply and demand must always be in balance in the energy grid. Due to the many peaks and dives in energy generation from wind and sun is more unpredictable than traditional power stations. Energy companies are constantly coordinating supply and demand to fulfill contractual agreements. To keep the balance, energy companies used to look at the production-side of the energy system, since that is easy to control. Because sustainable production is more difficult to manage, people are now also looking toward the demand side. Supply and demand are changing more and more, just as energy prices continue to fluctuate. Residential flexibility therefore is becoming more valuable as energy dynamics change and demand for electricity increases. Therefore fluctuations in market electricity prices are expected to affect consumers.

Balancing / frequency control

Secondly, it is possible to contribute to the grid balance. On the European electricity grid, the frequency must be kept at 50 Hz. This is getting more challenging in the energy transition. Currently there are several markets specializing in this balancing issue, where we are gradually seeing more demand side parties acting to provide more flexibility (instead of just production side parties). The flexible home appliances can help by allowing energy companies to pass on the associated revenues on to consumers.

Congestion prevention and management: national, regional and local

Thirdly, slowly but surely getting rewarded for more efficient use of the electrical network, (to prevent network overloads) is becoming possible. It is expected that congestion will also create challenges on low voltage parts of the grid. Congestion management can be divided into two categories: implicit and explicit possibilities.

- First there are implicit possibilities for preventing congestion. For example, by adjusting energy consumption, costs can be saved with respect to grid fees: people are encouraged to keep power demand within bandwith contract, for example avoid charging the car at full power while the heat pump is working simultaneously.

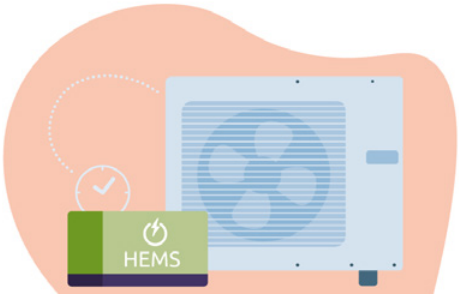
- The expectation is that explicit possibilities will come into play where potential flexibility of devices will be used upon the request of grid operators to lower the power demand. Once such example could be a grid signal instructing a battery to store a surplus of electricity. Both technically and in terms of regulations, explicit solutions in the area of flexibility still require some development, but it's is expected that these options/solutions will be needed at low voltage

For more insight into this, see the TKI Urban Energy report "Flexibiliteit in de gebouwde omgeving" (Flexibility in the built environment) from February 2021.▼

▼ *Publication: Flexibiliteit in de gebouwde omgeving*

Value chain 3
Social values

With regard to energy flexibility it works multiple ways - it helps keep costs down and contributes to the affordability and robustness of the energy system (for example, by using as much self generated energy as possible). It also helps to increase the value of sustainable energy generation, offers opportunities to integrate more sustainable energy generation and it increases the value of devices that use sustainable energy. However, not everyone has the opportunity to invest in applications that are suitable for energy management.



The respondents were asked whether or not it was fair that households with flexible devices can benefit more from energy management, where households without these devices can not. Some respondents pointed out that to a certain extent, the current grid tariff regulation promotes unfairness because the tariff is based on technical capacity of the grid. Households that use electric vehicles, solar panels and/or a heat pump use the technical capacity more and load the grid more intensively than households without these devices. The network operators recognize the fact and therefore are investigating new grid tariffs that result in a fairer distribution of costs.

The general view is that deploying energy management among consumers to keep the energy system stable and affordable can also lead to (indirect) cost savings for consumers who do not own these expensive appliances. Energy management leads to less need for grid investments and other facilities to keep the energy system robust.

The fact that consumers without (potentially) controllable appliances have fewer opportunities to participate in energy management does not necessarily lead to problems for the energy system: the lack of energy-intensive appliances in home implies that these homes will not inflict peak loads that can lead to additional costs.

Likewise, if the peaks in other households are kept low through energy management, this also has a positive effect on the all owners, because the cost of maintaining the energy system will be lower at large.


62,5%
62,5%

5

HEMS and use cases for energy management

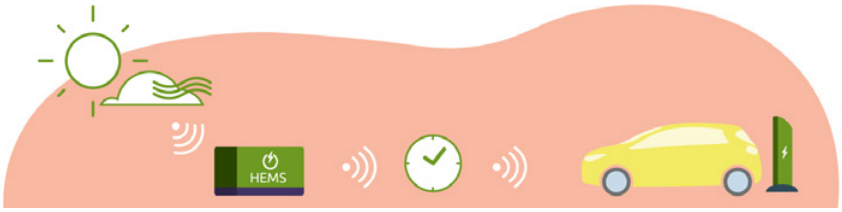
We've seen what opportunities energy management can offer the energy system which is valuable for both energy consumers and society. In this chapter, we will elaborate on specific examples of energy management that Home Energy Management Systems contribute to.

The research shows that the focus must rely on the smart use of energy-intensive applications: a large power demand, relatively large volume usage and the possibility of flexibility. Therefore these include residential solar energy generation, smart charging of electric vehicles, the flexible use of (hybrid) heat pumps and the storage, use and feed-in of energy via home batteries. Smart control of air conditioning / cooling can also be included. There is little to be gained in flexible control of home appliances like dishwashers and dryers: at the moment, the integration of these types of appliances is very complex and the energy consumption is relatively low.

Smart charging of electric cars

An electric car requires 11 kW of power on average. An electric car consumes about 10 kWh per 50 kilometers. An average 3 person household needs between 1 and 1.5 kW of power, consuming about 10 kWh per day. While these are rough sketches, they give a good indication of the impact of having an electric car or not.

Smart charging offers many opportunities. On average, a car only drives about 35 kilometers per day; there are very few cars that exceed 100 kilometers. The portion of electric cars traveling less than 15 kilometers is much larger. Both traditional and electric cars are stationary for a large part of the time. On top of that, the average EV is only charging about 30% to 40% of the total time it's connected to a charging station. Both in time and power, there is a lot of room for charge variations before the EV will be used again.



The user isn't required to adjust much for Smart charging. When you get home, you just plug in your car – but that does not mean it will immediately start charging. Combining smart technologies with an energy supplier (or other service providers) can ensure that the car is charged at the optimum time and speed in such a way that the car is charged enough. This optimization can be aimed at various aspects; for example, on the availability of sustainable electricity generated from sun and wind (charging when the sun is shining or the wind is blowing), avoiding congestion, and/or price (charging when the electricity prices are lowest).

> *Smart charging does not require many adjustments from the user. You just plug in your car when you get home, but it won't necessarily start charging right away.*

Of all the driving forces in energy management, EV's score well. From the consumer's point of view, EV's offer many opportunities to buy electricity at the most favorable rate. EV's also offer the option of making optimum use of its own generation. If future grid fees are actually set up on a capacity basis, the EV offers opportunities to stay within a contracted bandwidth.

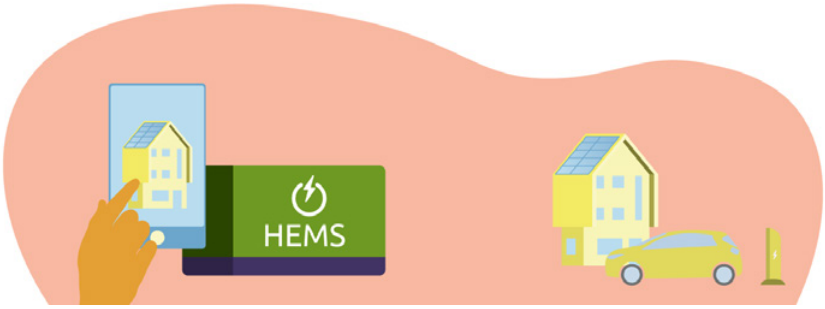
The flexibility of EV also scores well for the energy system. Energy companies and collectives can use large fleets of EVs to absorb surpluses in electricity production. Both the implicit and explicit flexibility of EVs also perform well in preventing and solving congestion problems. The national grid operator can use EVs to maintain the frequency of the grid. However, it should be noted that EV's are not always available absorb surpluses for balancing, because they are on the road or at the office. Next to that, an energy service provider can only play a role in maintaining grid-balance when a large number of EV's is available.

At the moment, smart charging is usually done by parties that optimize an electric car one-on-one for energy management. Through direct control and a local connection the total demand is managed within the capacity of the connection. But smart charging can also be controlled via a Home Energy Management System (HEMS). There are several ways to do this (which we won't go into detail) but a couple of obvious ways to mention are:

- The need for flexibility, regardless of the party, is passed on to a HEMS. The HEMS combines the need for flexibility with customer preferences. It also combines current electricity consumption and generation to the available energy management options while determining whether and how the EV charging will be adjusted. (it can be a lower or no power for example, but also full power if there is a lot of generation).

- The HEMS passes on the availability of flexibility, customer preferences, etc. to an energy service provider. The service provider's algorithms determine the best way to charge the car and send signals to the car or the charging station.

With the help of a HEMS, charging an EV can be better integrated with self-generation of the solar panels, with heat pumps, batteries, and with the general home use of electricity. This form of control maximizes the flexibility potential of the home



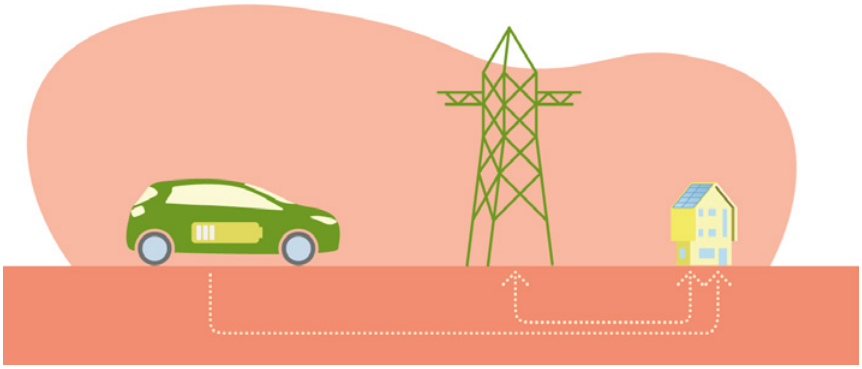
while preserving customer comfort. This is not possible however, if the devices are controlled separately.

 Value **Smart charging** for consumers	Use	Potential in 2030	Complexity
Dynamic energy price utilization	● ● ●	● ● ●	**Low**
Production and consumption optimization	● ● ●	● ● ●	**Low**
Grid connection optimization	● ● ●	● ● ●	**Low**

 Value **Smart charging** for energy system	Use	Potential in 2030	Complexity
Portfolio optimization	● ● ●	● ● ●	**Low**
Balancing / frequency	●	● ●	**Medium**
Congestion management	● ●	● ● ●	**Medium**

V2G: The electric car as a battery on wheels

The global energy sector has been talking about Vehicle to Grid (V2G) for some time now. In this context, the battery of the electric car is not only used for transport, but the car itself can be seen as a battery you can use for smart energy applications. If you only need to drive a few kilometers the next day, you can charge the car during the day from energy produced from your own solar panels and use the same car in the evening to power the house. We do not see this taking place on a large scale in the residential sphere for the time being because there are still barriers and uncertainties, both financially and technically. For example, it is still uncertain whether energy feed from the car will be alternating current (AC) or direct current (DC). The latter then requires special bi-directional charging stations that can convert DC from the car into AC. The charging stations that use an inverter for the AC/DC are a lot more expensive than conventional charging stations. In addition, there are fiscal barriers to be resolved with regard to energy tax and the power supply (and voltage) which must comply with national regulations (technical codes).



If V2G can be applied on a large scale, the application will have many similarities with that of the home battery, with the distinction that a car is mobile. Compared to a home battery, V2G is less suitable for certain services where predictability and certainty are desired, such as services for frequency control. On the other hand, V2G offers new opportunities: an EV on a charger at work offers the option to cheaply store surplus solar generation in office districts who can then later use the same energy for their homes in the evening. An EV also offers the option of storing excess generation from wind at night and returning it during the day at a more favorable rate. This benefits both energy consumers and the energy system.

With HEMSs, the value of V2G can be used optimally. Considering the other devices and preferences, charging and discharging occurs when the conditions are favorable. Here too, the optimization can either be determined by the HEMS, or it can be mainly determined by the algorithms of the energy supplier where the HEMS carries out the instructions.

Value **V2G** for consumers	Use	Potential in 2030	Complexity
Dynamic energy price utilization	●●●	●●	**High**
Production and consumption optimization	●●●	●●	**High**
Grid connection optimization	●●	●●	**High**

Value **V2G** for energy system	Use	Potential in 2030	Complexity
Portfolio optimalisatie	●●●	●●	**High**
Balancing / frequency	●●	●●	**High**
Congestiemanagement	●●	●●	**High**

The home battery

Developments around home batteries have taken off in recent years, both in number and in technology. Solar inverters are more and more ready to support battery storage. A battery can store excess power that can be used several hours later. For example, there is a premium in Flanders for those who buy or lease a home battery. In combination with new grid tariffs and the phasing out of feed-in tariffs, about 15,000 home batteries have already been installed in 2021, thirty times more than the year before.

Like the EV, the home battery also scores well in all possible ways for energy management. From the consumer's point of view, the home battery offers good opportunities to buy electricity at the most favorable rate, in order to use electricity at different moments (when it's more expensive).

The home battery also offers the opportunity of making optimum use of your own energy generation, which can yield financial benefits if net-metering becomes less attractive. If the grid tariffs are actually set up on a capacity basis, the home battery will offer the opportunity to stay within a lower contracted bandwidth, or even to allow lower bandwidth contracts, because the battery can step in when a lot of power is needed. And finally, certain consumer groups find it interesting to optimize the use of their own generation other than just financially, but reasons like an interest in technology or self-sufficiency.

The flexibility of home batteries also scores very well for the energy system. Energy companies and collectives can use home batteries to absorb surpluses and shortages in electricity production. Both the implicit and explicit flexibility of home batteries also lend themselves well to solutions related to congestion problems. Grid operators can use the home battery to maintain the frequency of the grid, because in principle they are always available. Batteries have an additional advantage for the energy system because they offer flexibility in both taking from the grid (storage), and feed in to the grid.

A HEMS is important for the home battery, because it provides insight into customer preferences, current electricity consumption and generation, and the available options for storing, using or supplying energy. Here too, the optimization can be determined by the HEMS, or can be mainly determined by the algorithms of the energy service provider where the HEMS carries out the instructions.

Value **Battery** for consumer	Use	Potential in 2030	Complexity
Dynamic energy price utilization	●●●	●●●	**Low**
Production and consumption optimization	●●●	●●●	**Low**
Grid connection optimization	●●●	●●●	**Low**

Value **Battery** for energy system	Use	Potential in 2030	Complexity
Portfolio optimization	●●●	●●	**Low**
Balancing / frequency	●●●	●●	**Medium**
Congestion management	●●	●●	**Medium**

The (hybrid) heat pump

Heat pumps require a large capacity, from 2 kW (hybrid) to 6 kW (all-electric) per household. With persistent cold, many heat pumps will run simultaneously. This could lead to a demand of 2.5 to 3.5 GW from the heat pumps in 2030 and thus create a new peak in electricity demand.

A **hybrid heat pump** is a heating system with 2 heating elements: a conventional gas boiler that works together with an electric heat pump. The advantage of such a system is that homes that are not yet well insulated enough can still largely be heated by a heat pump, whereby the gas boiler is only used on very cold days. Recent research of approximately 450 installations (70% of which is hybrid) shows that the hybrid heat pump can meet about 60% of the heat demand year-round and that each cubic meter of natural gas saved implies an additional 2.3 kWh of electricity consumption. Although these results cannot be extrapolated to the whole of the Netherlands 1 to 1, the results still provide a good impression of the impact and possibilities of hybrid heat pumps.[ϕ]

In 2021, Accenture was commissioned by the FAN association and TKI Urban Energy to conduct research into the flexibility of heat pumps[ö]. This research was based on hybrid heat pumps in existing buildings and all-electric heat pumps in well-insulated homes. The report identifies three factors that have an impact on the energy consumption of heat pumps:

- Heat requirement in the house;
- Hot water requirement for washing dishes and showering etc;
- Weekly bacterial disinfection for legionella.

ϕ *Publication: Eindrapportage Installatiemonitor*

ö *Publication: Flexibele inzet warmtepompen voor een duurzaam energiesysteem*

Some estimates of the impact on homes:

Home and type of Heat Pump	Electrical Usage kWh / year	Peak reduction (hybrid)Peak Shift. (all-e) kWh / year	Shift up kWh / year	Shift down kWh / year
Terraced House, all elec	1300 - 1940	220 - 320	100-150	170-250
Terraced Houses hybrid	900 - 1080	360 - 430	55-65	55-65
Detached house Standing all elec	2930 - 4280	480 - 680	250-360	420-600
Detached house hybrid	1940 - 2330	770 - 930	120-140	120-140

All-electric heat pump

The flexibility of the all-electric water pump is particularly interesting for consumers for optimizing the grid connection. A heat pump is well suited for temporarily shutting down. They also offer some room to buy electricity at favorable rates. But not much room; in colder weather they require a constant flow of energy. Without a home battery, heat pumps do not offer many opportunities for optimal use of its own production. Solar energy generation is mainly realized in the spring and summer, while the heat demand is mostly manifested in the autumn and winter.

For the energy system, the flexibility of the all-electric heat pumps scores in particular on its implicit and explicit flexibility: it is a good solution to avoid congestion. Grid operators can use heat pumps in the future to maintain the frequency of the grid, but this requires a lot of technical coordination still. Energy companies and collectives can use heat pumps to some extent to absorb surpluses and shortages in electricity production.

Hybrid heat pump

For hybrid heat pumps, the opportunities aren't so much in peak shifting, as they are switching to natural gas. This is called peak reduction. It offers additional options for the energy management of the consumer. The hybrid heat pump can be used to optimize the grid connection. Exceeding the bandwidth can be prevented by switching off the heat pump as well as by switching from electricity to gas. Switching between gas and electricity can be beneficial if the prices of these energy sources change. Finally, without a home battery, (hybrid) heat pumps offer only limited value in optimizing its own production.

For the energy system, the flexibility of the hybrid heat pump scores very well. The implicit and explicit flexibility of hybrid heat pumps has even more value than with all-electric heat pumps, because the possible comfort loss is easier to mitigate. For example, the hybrid water pumps help to solve congestion problems. Grid operators can also use hybrid heat pumps in the future to maintain the frequency of the grid, but this also requires a lot of technical coordination. Finally, hybrid heat pumps lend themselves better than their all-electric counterparts in their ability to absorb surpluses and shortages in electricity production.

Also for heat pumps, a local connection with a HEMS makes it possible to allow the heat pump play a role in optimizing energy management. Heat pumps may be able to be directly controlled, but without a HEMS, but it cannot be used for local optimization for example by turning it off for an hour when the induction cooker is switched on.

ALL ELECTRIC HEAT PUMP

Value **All Electric HP** for consumer	Use	Potential in 2030	Complexity
Dynamic energy price utilization	●	● ●	**High**
Production and consumption optimization	●	● ●	**Medium**
Grid connection optimization	● ●	● ●	**Medium**

Value **All Electric HP** for energy system	Use	Potential in 2030	Complexity
Portfolio optimization	●	●	**Medium**
Balancing / frequency	●	●	**High**
Congestion management	● ●	● ●	**Medium**

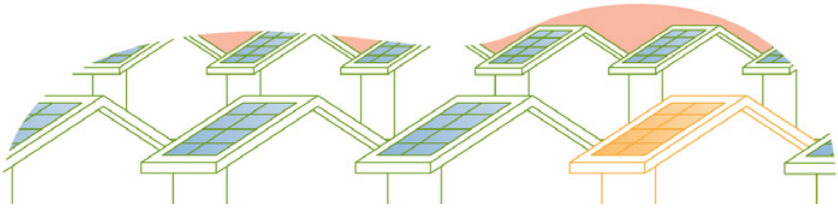
HYBRID HEAT PUMP

Value **HHP** for consumer	Use	Potential in 2030	Complexity
Dynamic energy price utilization	● ● ●	●	**Medium**
Production and consumption optimization	●	●	**Medium**
Grid connection optimization	● ● ●	●	**Medium**

Value **HHP** for energy system	Use	Potential in 2030	Complexity
Portfolio optimization	● ● ●	●	**Medium**
Balancing / frequency	●	●	**Medium**
Congestion management	● ● ●	●	**Medium**

PV / solar panels

Energy management delivers value with solar panels, because it gives more options to use your own production when it is unfavorable to deliver back to grid. If the net metering plan becomes less attractive, it will become more attractive to use your own generation. In addition, energy management for PV is particularly effective if an EV or home battery is available.



Solar energy installations are not controllable sources in and of themselves, but are sources to which the flexible consumption of other devices can be adapted. The HEMS takes care of this adjustment (within the customer's preferences).

One aspect of solar panels is that they switch off as soon as the voltage gets too high. This is a technical setting which is based on existing regulations. This shutdown is a waste and can partly be prevented through energy management by allowing the other flexible devices to consume more electricity, for example by preheating the heat pump or by storing the generated power in a home battery. A HEMS can arrange this local coordination. In this way, solar panels can make a good contribution to energy management. Not so much by adapting the production itself, but by adapting the consumption of the other devices to the solar production.

	Value **PV** for consumer [ʎ]	Use	Potential in 2030	Complexity
	Dynamic energy price utilization	● ●	● ● ●	**Low**
	Production and consumption optimization	● ● ●	● ● ●	**Low**
	Grid connection optimization	● ●	● ●	**Low**

	Value **PV** for energy system	Use	Potential in 2030	Complexity
	Portfolio optimization	● / ○	● / ○	**Low**
	Balancing / frequency	●	● ●	**Low**
	Congestion management	●	● ●	**Low**

ʎ *In order to optimally utilize the value of solar energy in relation to energy management, there must be other devices with which to coordinate energy flows. If there are none, energy management from solar energy will have a limited effect*


HEMS

6

Energy management for the home

Responding to dynamic energy prices is already a daily practice for the industry and among commercial large-scale users - For example for owners of CHPs in greenhouse horticulture. Many companies are familiar with smart energy services and energy management. Although it often involves customization, it is usually profitable because it typically involves large volumes. Increasing congestion challenges will accelerate this process.

On the other hand, the application of smart energy services within homes is still a difficult market segment. The market is interesting because of the large numbers

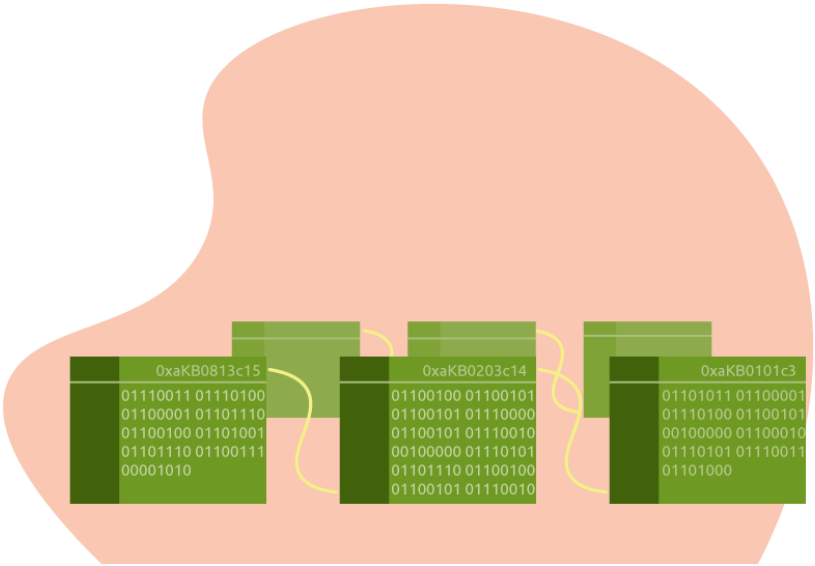
of installations and the flexibility it offers. But due to the relatively low energy demand per household, customization is not profitable here. Simple and scalable solutions to integrate devices and energy management systems are needed, that is the major challenge. This requires cooperation between many different parties, such as energy suppliers, installers and suppliers of building systems and equipment, and of course the residents.

The residents perspective sometimes gets lost in technical and social discussions. However, these points of views are essential for the acceptance of energy management. The resident must provide preferences like their desired temperature in the home, the expected use of the electric car and details such as holidays. But most importantly, the resident wants usability and comfort. Furthering digitization and combining consumer behavior knowledge enables companies to develop innovative services.

Most respondents agree that both the energy system and the consumer will gain maximum benefit from energy management when it leverages the flexibility of multiple devices. It would be a missed opportunity if the focus remains on optimizing only one use case, like just smart charging of the electric car. The risk that a 'pillarized' approach could nevertheless take place is certainly recognized. First, it is easier and secondly, suppliers of appliances do not like to step outside their own industry: smart heating is different from smart charging.

> *Far-reaching digitization in combination with knowledge of consumer behavior can enable companies to develop innovative services in this area.*

To conclude, a number of preconditions necessary to further implementation of the HEMS have been fulfilled in a positive manner. Many homes already have a smart meter. In addition, the Netherlands has a good digital infrastructure and, by extension, there is a high degree of acceptance of IoT and modern consumer services based on digital services.

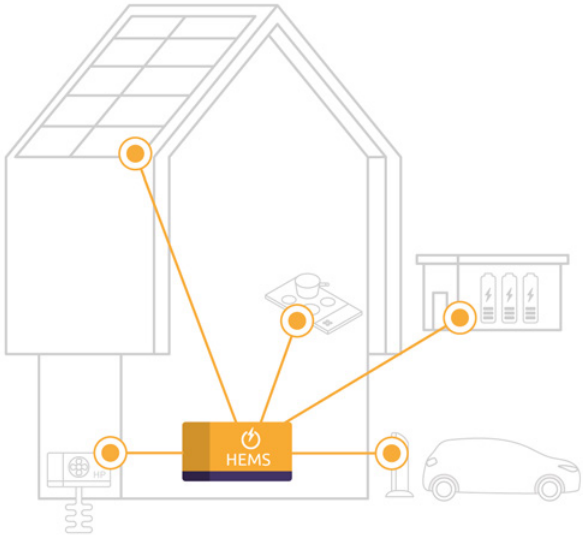


HEMS business models for suppliers

Based on the interviews, we can distinguish two different focus areas in the business models between suppliers of HEM systems and HEM services. On the one hand, we see companies focusing on integrating HEMS with the different devices. ▼

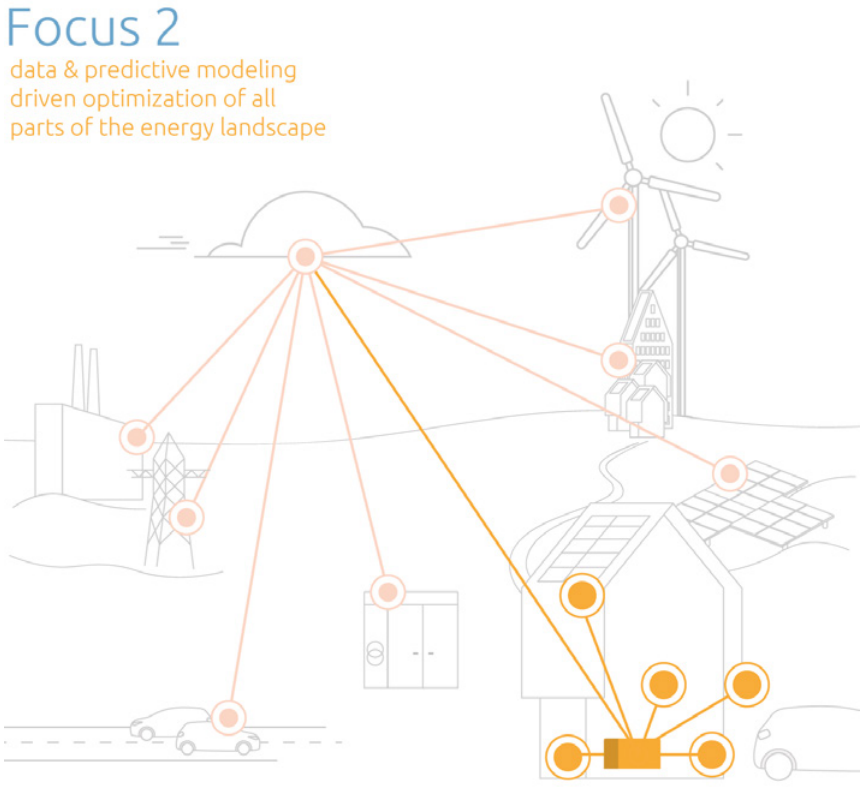
Focus 1

technical integration of various devices with a HEMS



▼ *See: Apparaten slim samenwerken (elaad.nl)*

On the other hand we see companies that focus on the development of energy management functions and algorithms to optimize energy consumption.



Focus on HEMS integration with the different devices

Those who would like to create overview of what it takes to combine all types and models of charging stations, heat pumps, inverters and batteries, will come across an incredibly large list of APIs (Application Programming Interface ⌘), programs, platforms, standards and protocols Δ. Some companies integrate a subset of those device protocols, brands, and models into their solution. These products often have a local 'box' HEMS solution, or for example, a module in their fusebox often combined with cloud services. An energy service provider does not have to develop and maintain these integrations itself, but only uses the HEMS solution to control the customer's devices.

Focus on optimal energy use

In addition to the focus on HEMS integration, we observe an approach to develop functionalities in order to deal with energy flows as optimally as possible. Within this, there are two aspects that are further developed, analogous to the value chains for consumers and that of the energy system from chapter 3:

a LOCAL OPTIMIZATION / CONSUMER VALUE CHAIN:

There is a focus to align the optimization of flexible home appliances in order to achieve cost savings without loss of comfort, or to use sustainable production as much as possible. This involves local optimization within certain parameters, such as the capacity of the grid connection, grid fees, energy production and fluctuating electricity prices on the energy market. We see that certain parties focus entirely on this local optimization.

⌘ *See: Application Programming Interface - Wikipedia*

Δ *See: 2020-06-30_In-Home Energy Flexibility Protocols.pdf (topsectorenergie.nl)*

b INTERFACES WITH THE ENERGY SYSTEM

These functions focus explicitly on flexibility needs of stakeholders within the energy system. Tennet in the case of frequency balancing for example, energy suppliers in case of prevent surpluses and shortages and regional grid operators in the case of preventing or resolving grid congestion. Flexibility from home appliances can contribute to all these needs. This need is communicated through automated interfaces, whether or not mediated through a platform. We see that certain parties focus explicitly on the interaction between the energy system and energy suppliers (like aggregators and consumers).

Companies can focus on several aspects of course. This is also still in development. Solution and service providers are likely to develop several solutions that contain certain combinations. The general consensus is that there is no 'one size fits all' solution, because the market will continue to change rapidly in the coming years.

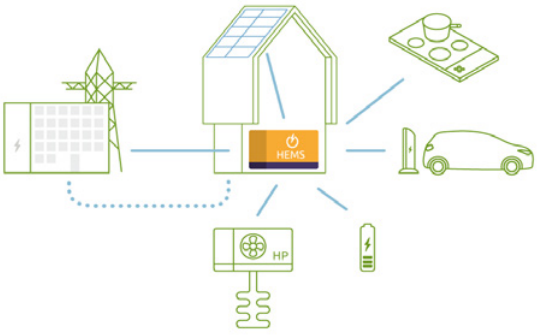
In addition to points above, we see another possible development resulting from the new generation of smart meters. The regional grid operators are studying the role that new smart meters can play in homes where a HEMS is present.

Growth from appliance optimization to energy management for the entire home

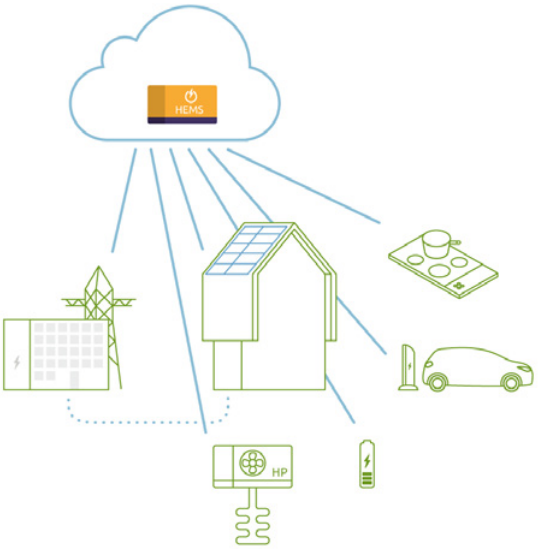
Most smart devices already have a link to a certain cloud service via the internet and are therefore, in theory, can function as a suitable ‘router’ for energy management. It is technically possible that charging stations or heat pumps could develop into a system that optimizes the entire energy management for the consumer. There are some manufacturers who have these ambitions, but most do not (yet). The main reason is that most parties have their hands full with their own product installation and further development thereof.

Appearances HEMS

HEMS may appear in various forms. On one hand, there are parties that focus on a **‘box’ or module that function as an energy manager via local integrations**, from the fuse box for example. These solutions can then communicate to for example charging stations and heat pumps wired or wirelessly. These solutions often interact with cloud services as well. On the other hand, there are parties who focus on **control through cloud services** via the internet, without the intervention of a box in the house. But these parties are still in development.



Parties that have implemented energy management primarily cloud-based are starting to realize that local integrations are also necessary to make the system more complete and are able to be integrated with other devices.



Each approach has its advantages and disadvantages. Wired solutions are considered safe and pose few problems once installed.

However, they are often too expensive to construct and are more complex to install in existing environments.

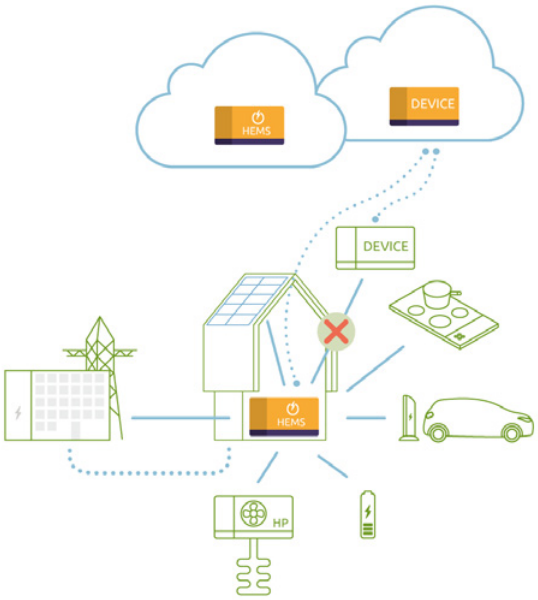
Wireless solutions are cheaper because they don't require physical cable installations, but have other challenges: thick walls; distances and neighboring signals can interfere with the signal; passwords and security protocols can change.

Local and cloud solutions also have their advantages and disadvantages. Cloud connections fail when the internet connection is lost, and all data leaves the house. Yet, cloud services are very scalable and pose few problems. In general, local solutions offer more options for privacy, but installation and long-term maintenance are usually expensive.

The study respondents were almost unanimous that there is no preference for ‘cloud – local’ or ‘wired - wireless’. Service and product developers must bet on what works best and the market will do the rest.

Hybride system

For energy management, its important to have a connection between the HEMS and devices. Whether that connection is based on predictive modeling or based on real-time signals about the flexibility status. Whether or not the connection is controlled from a cloud. In a hybrid system, all variations of those connections are possible.



The Road to Interoperability

Good interoperability agreements can keep the costs low for flexibility. It was clearly indicated that interoperability is a basic (technical) condition for optimal energy management. This will certainly need to be worked on in the near future. Manufacturers of flexible devices and (potential) HEMS builders want a standard that is impactful and widely accepted.

One way to approach this is to test products and services through pilots and upscaling programs so that resulting knowledge can be applied towards the goal of large-scale use of energy management in homes. Involve the pioneers; the consumers who already own multiple flexible devices. Energy management is possible in this group and provides a good start for the development of best practices and scalable solutions.

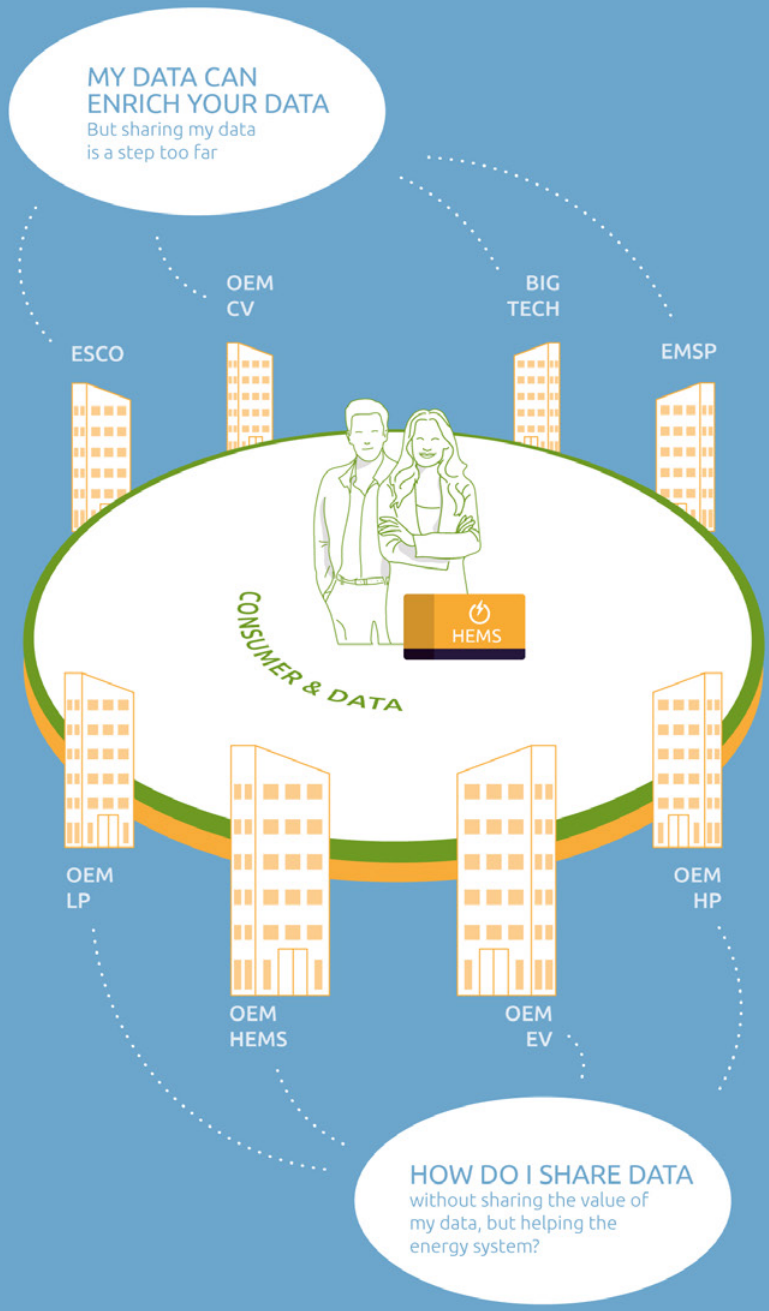
> *Manufacturers of flexible devices and (potential) HEMS builders want a standard that is impactful and widely accepted.*

All respondents clearly indicate that good interoperability standards are a must for various devices and the home to work together. Steps must be taken in the Netherlands to achieve this, but developments abroad must also be followed. This report does not aim to be exhaustive in the technical capabilities of devices and HEMS. We do explain however three striking techniques in appendix C that are mentioned by a number of respondents for integral energy management roles in the home: ModBus [ϕ], S2 [π] and EEbus [Ω].

ϕ *See: Modbus - Wikipedia*

π *See: Apparaten slim samenwerken - Elaad NL*

Ω *See: EEbus | Make the world speak energy - EEBus Initiative e.V.*


MY DATA CAN
ENRICH YOUR DATA
But sharing my data
is a step too far
OEM
CV
BIG
TECH
ESCO
EMSP
HEMS
CONSUMER & DATA
OEM
LP
OEM
HP
OEM
HEMS
OEM
EV
HOW DO I SHARE DATA
without sharing the value of
my data, but helping the
energy system?

With regard to standards, it was indicated that **manufacturers are happy to integrate other devices into their services, but are not always open to the disclose data and third-party control of their own devices.** Companies do not like to see access to business information, such as information for monitoring, maintenance and use cycles.

Respondents are positive about the idea of combining the mandatory use of (open) standards to (existing) subsidies for certain devices. Those interviewed also think that this could help in the roll out of energy management because it creates clarity and removes uncertainty for both consumers and energy suppliers and other service providers. The respondents indicate that it is not easy to set up properly or with broad support. Finally, the respondents pointed to the risk that standards sometimes contain 'dialects', with the result of devices that should formally integrate normally do not work well together.

In 2020, ElaadNL conducted research into Smart Energy protocols for the home ▲. The main conclusion from that research is that there is already a wide range of in-home protocols that are suitable for controlling energy flexibility, but all too often focus on one specific type of device. The protocols are not designed to work with other equipment. As a result, it is difficult to include different brands and types of equipment in one control system. We now need to have the 'partial solutions' and the different protocols work together. The solution would be to add an extra layer into the software architecture. This approach is the basis for a formal European standard in this area, the NEN-EN 50491, but it still needs to be tested more extensively in practice.

▲ *Publication: Apparaten slim samenwerken - Elaad NL*

Security, privacy and consumer trust

We discussed the risks related to cybersecurity and privacy with the respondents. Good (cyber) security is essential for a reliable and functioning system, both in the home and for the energy system.

Attacks on large groups of HEMS or charging stations for example can jeopardize the supply and demand of enormous power in neighborhoods and regions, which will have a huge impact on the energy grid ⌘. It is therefore important that a HEMS is protected against malicious parties, but safety also means that the HEMS is protected against unintended or improper use. Safety is the responsibility of the manufacturers and providers and should be part of the HEMS design and all its integrations.

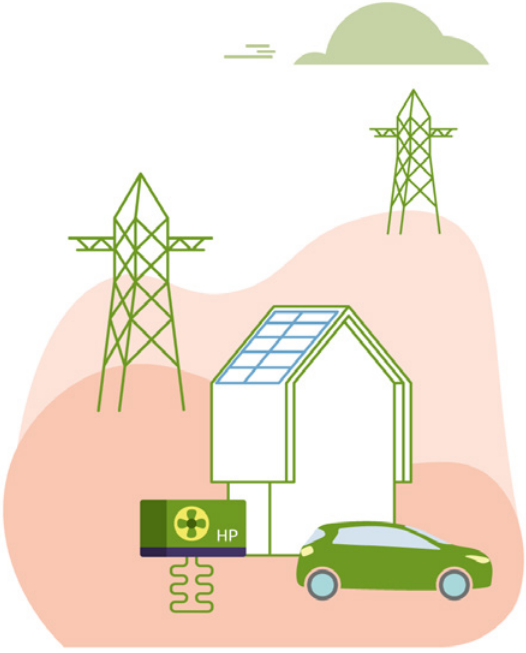
Cyber security and system security is a profession within itself. Without getting into detail, one can consider the communication encryption between the energy supplier and HEMS and between the HEMS and the energy-intensive appliances. Furthermore, the system must only be accessible to the party(ies) that provides services and that can serve the customer in a safe, reliable and verifiable manner.

Manufacturers and providers are responsible for rolling out updates as vulnerabilities are found and fixed from time to time. And the system must have reliable logging and monitoring, both for the analysis of operation and comfort, and to detect and report anomalies in behavior.

⌘ *See: Cybersecurity voor Smart Energy | Topsector Energie & Impact van Cybersecurity*

In terms of privacy, there was consensus that energy management is impossible without information about consumers and their behavior. This certainly applies to consumers who want to be relieved of the burden. When energy suppliers (and/or other service providers) offer smart services, they must explain how they handle data. They must also not share or sell data with third parties without the consent or knowledge of the customer and must report security vulnerabilities properly.

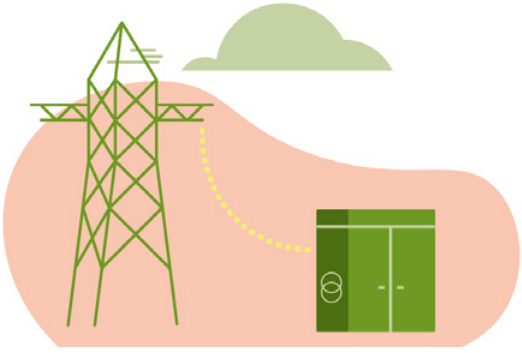
The respondents were asked whether they think that small players and newcomers could pose a greater risk to security and privacy, for example because of inexperience or because of an ambition to enter the market too quickly. The interviewees indicated that this risk exists, but that this can only be overcome through (European) laws, industry standards and regulations and monitoring compliance with them, just like in any other industry.



7

Findings

The research process resulted in a number of findings.



Priority is changing: energy management in homes is needed and is becoming more urgent

On one hand, we see a clear increase in electrical transport and electrical heating in particular. On the other hand, we are seeing higher and fluctuating energy prices, as well as increasing opportunities on the balancing markets, changes to net metering and new network tariffs - so using the flexibility of home energy can yield significant benefits. There is also a growing realization that we can take more advantage these opportunities – only if we start now by filling in the conditions to make energy management possible.

The market must take the lead in the HEMS roll-out

Most respondents refer to energy suppliers as the most ‘logical’ party in the system to offer energy management to its customers. Traditional energy suppliers have little to show in product development, because there isn’t a demand for it yet. However, energy suppliers are actively monitoring start-ups that develop HEMSs and HEM services.

Most of those interviewed, did not rule out the possibility that certain consumers (especially pioneers) will enter into agreements with independent parties that offer energy management services, independent from their energy supplier. There are already companies that offer energy management services completely independently to a limited group of consumers. Nevertheless, most of those interviewed think that energy management services for the bulk of consumers are expected to come from energy suppliers. It is expected that energy suppliers will cooperate with one or more third parties, for example to make the HEMSs technically possible, or to install, monitor and deploy energy management systems. However, the main provider remains the energy supplier and the contract is between the energy supplier and the consumer.

The driving role of energy cooperatives is also mentioned in this context. They can draw attention to the use of (collective) energy management and stimulate its application.

There is a need for direction, clarity and a regulatory framework

We now see that many parties are looking at each other. Both with regard to the technical conditions and interoperability, as well as with the development of a business case and the roll-out. Governments and grid operators view the energy management roll-out mainly as a responsibility for market parties, while market parties and consumer organizations also expect the government to play a lead role in this. Governments and grid operators are not aware of this.

Those interviewed generally agree on which party(ies) should take the lead in the roll-out of HEMS. However, there is an interesting 'stalemate' to be discovered. Commercial parties and consumer organizations see a role for the government and regulated parties (grid operators) in providing more clarity about the revenue models and flexible energy preconditions (such as adjusting the net metering, the introduction and form of new network tariffs, opportunities to contribute to balancing services). On the other hand, governments and network operators generally regard the further development and roll-out of HEMSs as a development on the free market that does not require further stimulation. They consider these legal preconditions have already been met and is now up to the market to come up with business models.

According to those interviewed, however, there is a need to provide more clarity about the preconditions to unlock flexibility.

Consumer awareness of the necessity and possibilities of energy management is low

The respondents indicate that not only is there little knowledge or understanding of home energy management and HEMS; the whole concept of ‘energy flexibility’ needs more explanation. In adition, the vast majority of consumers are unaware of current grid tariffs and net metering developments, and how this can affect their energy bill. ‘The consumer’ is not aware of the opportunities and challenges that these developments entail.

Manufacturers are now all focusing on energy management

All parties indicate that the energy management system (and the interfaces required for it) is an important attention point. They are now eorking on this in various ways.

Combining devices is preferred

Those interviewed agree that the potential of flexibility can be maximized if the flexibility of multiple devices can be combined. We see that EV, PV and in the future the home battery are often referred to as devices to be connected.

With respect to EV's, charging points are seen as the device from which flexibility can best (first) be accessed because of the amount of potential flexibility and the relative ease of accessing it. The heat pump also offers flexibility, but some specific aspects to take into account are its controllability, in particular in the field of interconnectivity (interoperability) and the impact on comfort. The advantage of the heat pump compared to EV is that it is always available, while an EV can also be on the move.

Good interoperability is a prerequisite

All respondents clearly indicated that good interoperability standards are a precondition for the various energy-intensive devices to work together. Steps must be taken in the Netherlands to achieve this, but developments abroad must also be followed. European standards such as S2 help with this.

Grid operators also have a role in this standardization by working on a standard protocol that can be used to communicate with a HEMS.

A hybrid image qua appearance

With regard to the appearances of the HEMS, we see a hybrid picture emerging: on the one hand, we see parties that focus on a 'box' that functions as an energy manager via local connections in the fuse box for example. This can be wired or wireless. On the other hand, we see more parties focusing on control through cloud services via the internet, without the intervention of a box in the house. But we see that these parties continue to develop, parties that entered the market primarily cloud-based energy management are gradually realizing that local integrations are also needed to make the system more complete.

Privacy and security

Concerning both the home and the energy system, respondents say good (cyber)security is essential for a reliable and functioning system. Combined, HEMSs can represent an enormous amount of power in neighborhoods and regions, having a big impact on the energy network. It is therefore important that the HEMS is protected against improper unintentional use and against access by malicious parties. Companies must handle consumer data properly and be clear about how it's handled, so that consumers maintain their confidence and continue to participate.

Energy poverty

Electric cars and heat pumps put a greater burden on the grid, but with today's grid rates this does not lead to higher costs for the user. Grid reinforcement required by this extra grid load will be distributed through society. Ultimately, all consumers will be contributing

With regard to energy poverty, those interviewed indicated that in general energy management does not necessarily lead to higher costs for consumers who do not have flexible appliances.

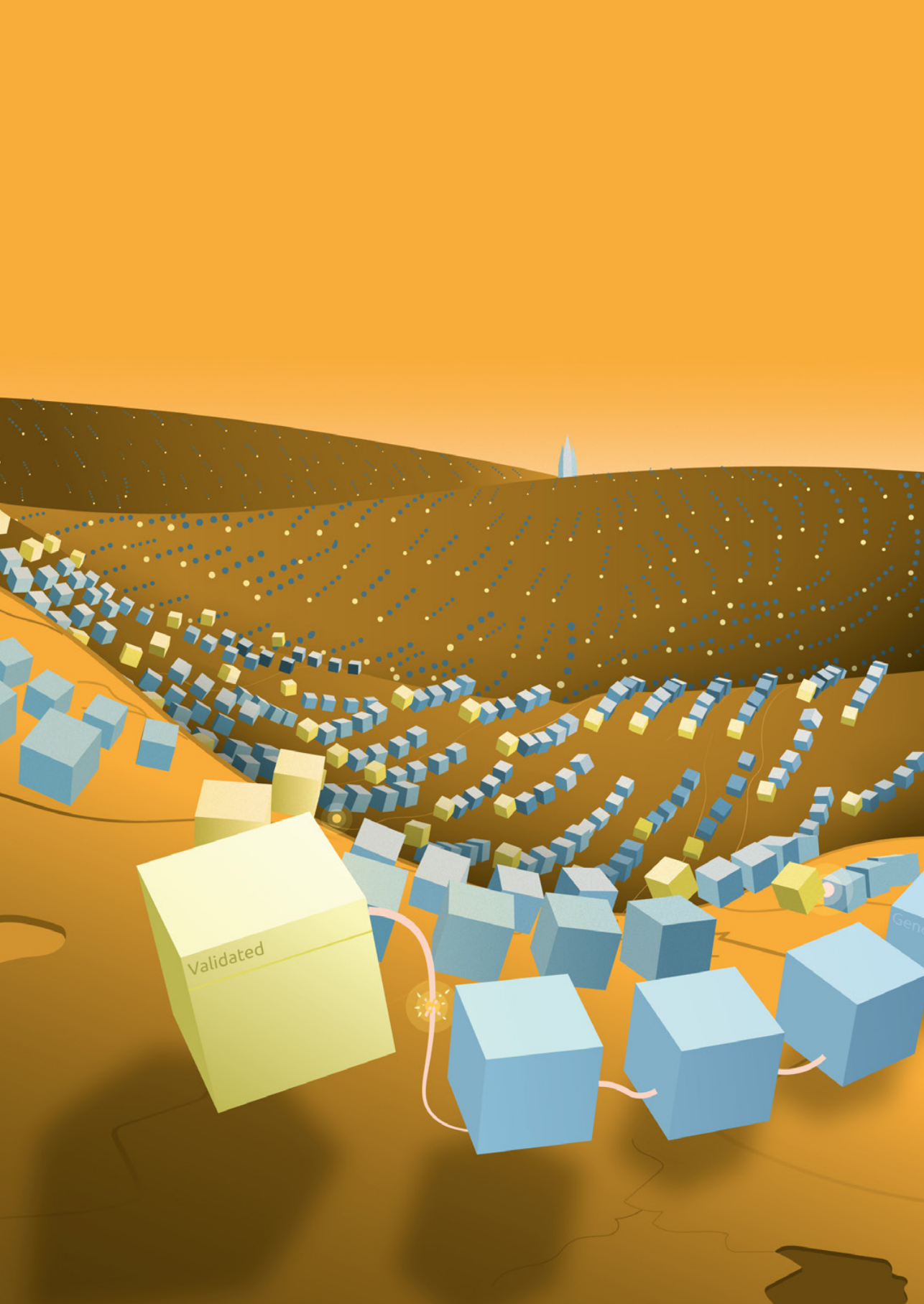
The lack of heavy appliances in certain households also means that there aren't any peaks that could lead to extra costs, for example. If the peaks in other households can be kept low through energy management, this will also positively affect the households without flexible appliances. It is expected that the new grid tariffs will also ensure a fairer distribution of costs. Energy management can lead to lower system costs, which also has a positive effect on households with a smaller purse.

Generally speaking, the impact of the energy transition on energy poverty deserves more research, according to a number of those interviewed.

The opportunities for collectives and collaborations◉

In certain cases, investments in sustainability become more profitable if they can be used collectively. In other cases, collectively is a precondition for making those investments possible at all, like in apartment complexes for example. Legislation and regulations sometimes make it complicated to collectively reap the benefits of energy management, because members cannot share energy among themselves without becoming each other's 'supplier', or because the law simply does not allow it. If such collectives are given more opportunities to be self-sufficient in (part of) the energy supply, they will benefit greatly from HEM and HEMS, both for optimizing energy flows and for the costs of energy consumption.

◉ *See: Whitepaper Collectieve Zelfconsumptie.pdf (topsectorenergie.nl)*


Validated

8

Recommendations

The research team derived a number of recommendations and preconditions from the study. The recommendations are presented per stakeholder group.

Preconditions for residential energy management

The energy system needs to provide the right incentives for energy management

One of the preconditions for the successful implementation of residential energy management is that the energy system and the 'corresponding regulatory frameworks' must provide sufficient incentives for energy management and the use of energy management systems. Steps must be taken to further develop incentives for consumers and providers of energy management services.

Costs of energy management systems must be kept to a minimum

Another precondition is that the costs of an energy management system must be limited and must be able to outweigh the benefits of its use. Interoperability is an important condition in this regard.

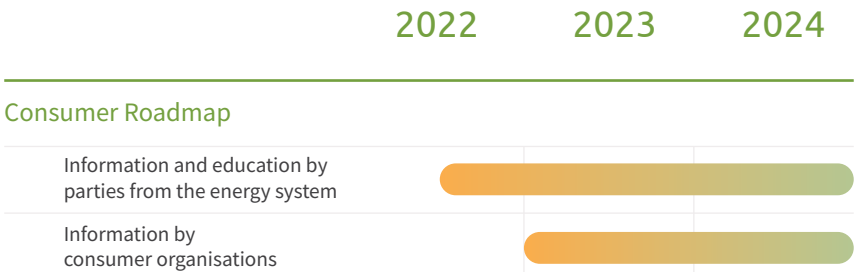
Awareness and acceptance of energy management

Another important aspect is that consumer awareness of energy management is currently very low. The awareness and acceptance of energy management (systems) must be greatly increased by making the need and use of it clear.

The preconditions for residential energy management are listed below for each stakeholder group (consumers, stakeholders in the energy system, manufacturers). Because certain preconditions have to be fulfilled by several groups, they can appear again in several groups.


Solar panels
55
Battery
34%
Heat pump
21
Efficiency tips
More
Best
Buy
Homes like yours
Living room
Heat pump
20,0
89
Today

Consumer Roadmap



Information and education from parties in the energy system

Energy management is now mainly used to save costs while maintaining comfort. Various parties in the energy system must provide consumers with more information about how the energy system is going to change. Consumers must be provided with more information about upcoming energy-related developments, such as the adjustment of net metering, new grid tariffs and energy prices, which are likely to continue to fluctuate more than before, even if the geopolitical situation becomes somewhat more stable. Consumers must also be informed about the opportunities of energy management, for example that they can use their own generation more effectively, that they can use EVs optimally, or that they can respond to the growing need for flexibility from network operators and suppliers.

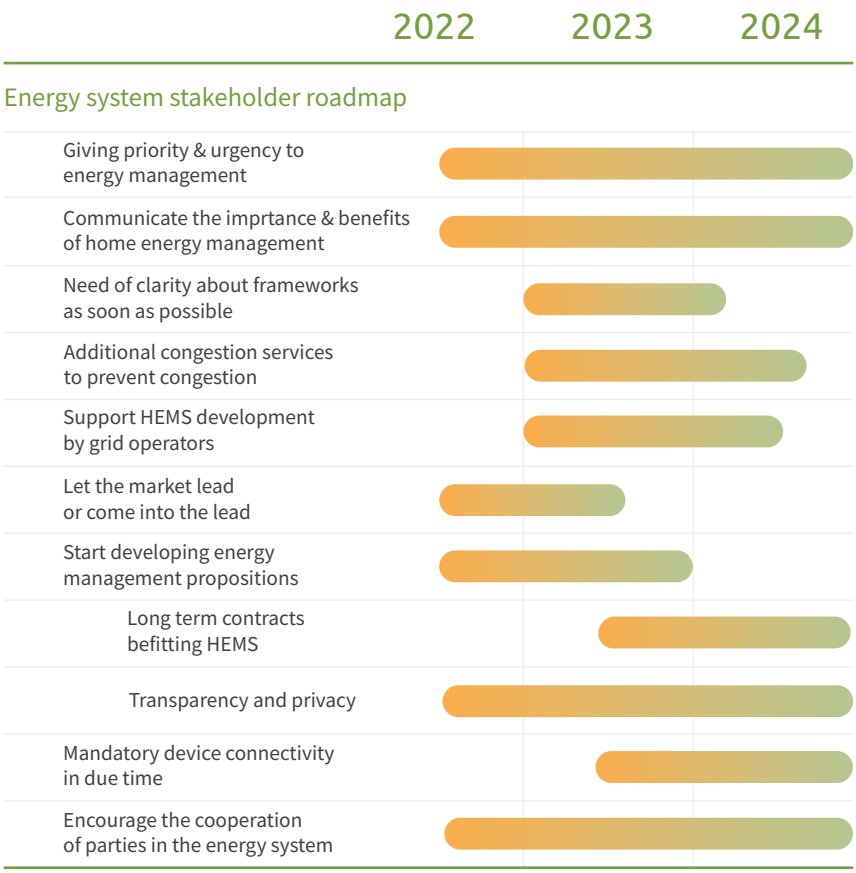
It is up to energy suppliers, grid operators and the government to communicate about this. Collaborating organizations such as ElaadNL, FAN, NVDE and sector organizations such as Netbeheer Nederland and Energie Nederland can play a role to collectively step up to this educational challenge

Information provided by consumer organizations

Given the need for information, it is up to both suppliers and consumer organizations to (regularly) communicate and explain the importance of energy management. They can outline future developments and indicate how energy management can benefit consumers. Energy cooperatives can also play an important role in this provision of information.

It is important to remember that using energy management systems makes it possible to use energy more effectively and save costs without sacrificing comfort. Consumers need to feel that they are ‘king of their own castles’, and not the grid operator or the energy supplier.

Energy system stakeholder roadmap



Now is the time to give priority and urgency to energy management

Energy management for the home can support in the challenges of our energy system quite well, but the foundation must be prepared now. In general, all stakeholders in the energy system must pay more attention to residential energy management at the moment. It is really important to start now in order to shape this properly, to prevent urgent measures to be taken in a few years' time.

Communicate about the importance and benefits of home energy management

Each stakeholder must also develop clear customer communication about energy management. That is, unambiguously explaining the need for energy management solutions. The emphasis here is on information about the cost-savings potential and sustainability. The expected changes in the net metering and the arrival of new grid tariffs must also be mentioned.

An example of an opportunity for cost-saving is the Equigy platform set up by Tennet. The Equigy ▲ platform is specifically set up to engage and aggregate residential appliances to support grid balancing. Consumers do not need to be aware of the details of this platform, but it does have added value for consumers to also know this 'source' of energy flexibility.

Grid operators, governments, consumer organizations and energy suppliers must all communicate this, preferably collectively. The importance for both the individual consumer and the society at large must be made clear.

▲ *See: Home - Equigy*

Clarity about regulatory frameworks needed as soon as possible

INTRODUCTION DYNAMIC ENERGY PRICES

The new energy law, which is still being developed, stipulates that suppliers with more than 200,000 customers are obliged to offer dynamic energy prices. This obligation enables consumers to save on electricity costs with the help of energy management. As soon as there is clarity about the new energy law, it is recommended to set up a good information campaign about it.

CHANGE IN NET METERING REGULATION AND INTRODUCTION OF NEW GRID FEES

There must be clarity as soon as possible about the change in the net metering plan and the introduction of new grid fees. Both changes are concrete and provide clear incentives for energy management. The government and the grid operators must therefore be given clarity as soon as possible about the timelines of the change in the net metering, the introduction of new grid tariffs, and the types of changes must be clarified as soon as possible.

Additional services and regulations to avoid congestion

For the purpose of congestion management, the rules regarding transport scarcity and congestion management have been laid down in the 'Congestion Management Code Decree', published by the Netherlands Authority for Consumers and Markets (ACM) in May 2022. These rules describe how congestion management, in addition to its application to the high-voltage grids, also applies to the distribution networks of the regional network operator. This mainly focuses on the higher grid levels of the regional grid operator, but the rules also apply to low voltage.

In addition to the above, the grid operators must, as soon as possible, provide clarity about additional services and regulations to prevent congestion that can be provided from the residential level. Energy suppliers and aggregators expect demand for these services to arise. Grid operators primarily see GOPACS◆ as the platform that brings grid operators and flexibility providers together. This platform is primarily designed for flexibility into big grid bottlenecks in higher voltage nets, but in principle this platform is also open for flexibility at a residential level. In addition, bilateral agreements are also being made to involve flexibility (also now at higher grid levels). There are also other opportunities to engage residential energy flexibility. These services can become additional incentives on top of the new grid tariffs. However, no clear direction has yet been determined and no communication has yet been made about this.

Further cooperation between grid operators and market parties to come up with a model in which energy management services for congestion management can be developed is highly recommended.

Here again, the expected timeline is important on the one hand and how the services of content and form relate on the other. The latter also includes the interface and technical interaction between the various parties.

◆ *See: Home - GOPACS*

Support HEMS development by grid operators

The regional grid operators have an interest in being involved in residential energy management, both for their own role in the energy system of the future and for facilitating the energy transition. They should support the development and standardization of the interfaces for energy management services and energy management systems.

Let the market lead

The government must communicate to market parties that ‘the market’ is in the lead to offer energy management services and supporting technology, and make clear what the existing regulations are already makes possible. ‘The market’ can mean ‘the energy suppliers’, but third parties can also provide the service that offer energy management services independently of the energy supplier.

Start developing energy management propositions

It is recommended that energy suppliers and other energy service providers start preparing propositions for energy management now (if they haven't already done so). A strategy that comes to mind is the collaboration with one or more technology providers.

Despite the fact that a number of respondents indicated that 'third parties' can also provide energy management services, a large proportion expect that most of the Dutch prefer services from the 'traditional' energy supplier. This could be organized in a way that a third party carries out the actual energy management for the energy supplier.

LONG-TERM AGREEMENTS SUITABLE FOR HEMS

The initial investment in HEMS can add up considerably, energy suppliers can pre-finance it and unburden consumers. From that perspective, it makes sense to contract long-term agreements with consumers. Considering the investment, it makes sense to bind customers into a longer period of, for example, five years, through lease or hire-purchase construction.

Energy suppliers must make it clear and explain that this type of construction is appropriate for long-term contracts. Therefore it helps if other parties such as consumer organizations and ACM share their support for this, because it helps to increase social acceptance.

TRANSPARENCY AND PRIVACY

Energy suppliers must be transparent about how energy management is applied. It should be shown how the energy consumption has been adjusted and how the customer has benefited from it. Also, It must be clearly explained how energy suppliers deal with consumer data.

This kind of transparency is the basis of the confidence that consumers need to have when applying energy management.

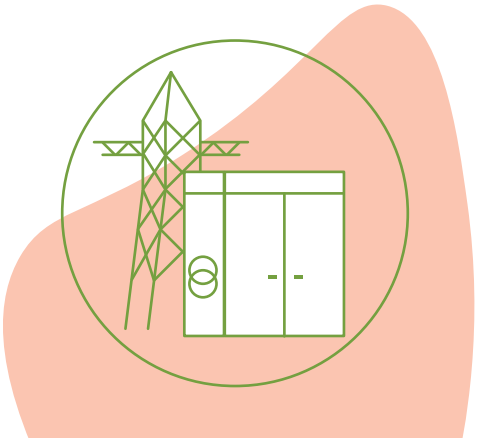
It helps if the energy sector cooperates with organizations that represent consumer interests to draw up good guidelines.

Compulsory connectivity of devices in the foreseeable future

The government must consider whether certain devices must have the option to be controlled remotely, which can be preconditions for certain subsidies. In the past, grid operators have suggested that remote control of large devices should be a requirement for certain grid connections. In that context, it has also been suggested that a home battery is incumbent to a certain amount of solar panels. Grid operators aren't against such obligations, but they must come from the government.

Such obligations that larger devices must have external control options (charging point, solar panel, heat pump and home battery) is a realistic requirement that also occurs in other countries.

Despite the fact that clear protocols cannot be prescribed at the moment, this obligation is an important incentive to increase energy management. In this context, it is important to take essential steps to get stakeholders involved today: 1) working on drawing up criteria for controllability and 2) harmonizing communication protocols for in-home energy management.



Stimulate the integration of parties in the energy system

Significant steps have already been taken into account of interoperability. It is very important that energy suppliers, network operators and other stakeholders in the energy system work together with the manufacturers of flexible appliances and HEMSs, only then can the opportunities of energy management for homes be utilized. Within the scope of this study, there are three levels:

1 All devices of the same device type (all charging stations),

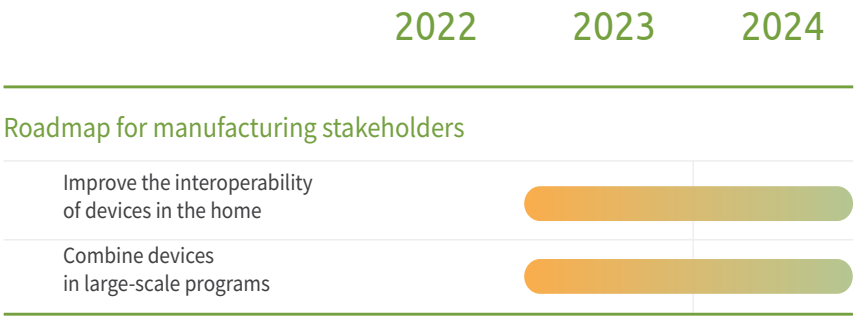
2 Between the devices in the home and the HEMS,

3 Between the energy provider and the client.

Various energy system stakeholders and device manufacturers are collaborating in various pilots to improve interoperability. This pilots can become blueprints for the future. Let these pilots and partnerships lead the right direction for further development of connectivity within the various sectors.

These kinds of collaborations should be sought after and encouraged more. One example is the Open Flex Alliance, an initiative of the FAN associaton and TKI Urban Energy. The aim of this alliance is to work with the industry to arrive at a single standard for the flexible control of multiple models and brands of heat pumps. The Open Flex Alliance takes into account the desire for manufacturers to continue to develop their own services and add added value.

Roadmap for manufacturing stakeholders



Enhance interoperability of devices in the home

Interoperability is a widely acknowledged precondition for an optimally functioning HEMS. This precondition has not yet been fulfilled properly. There is, however, great willingness to work on this together.

There is now a formal European ‘in-home energy management standard’ from the energy system: S2. Quite a step. These days, the manufacturers of charging points, heat pumps and home batteries are almost all working on connectivity . That’s also a big step, but these parties’ development is not necessarily based on S2. Nor do energy management system developers do not automatically take S2 as a starting point.

We’re calling on manufacturers to work together to develop a standard interface for each type of device in a specific sector, like charging infrastructure, heat pumps etc.. Or at least limit the number of solutions. FAN can help keep connections with manufacturers of energy management systems, and other sectors.

Also work together with stakeholders from the energy system. Ensure a good combination / translation of the internal logic of devices with the formal S2 standard.

AVOIDING TECHNICAL LOCK-IN

Good interoperability also reduces the risk of technical lock-in. It ensures that devices and services are easier to replace with devices from other brands and services from other suppliers.

Combine devices into large-scale programs

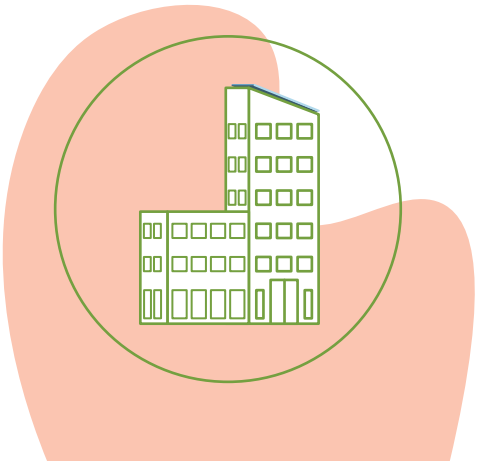
Research needs to be done regarding interoperability solutions through large-scale pilot programs. Manufacturers of HEMSs in particular have expressed the need for this while other parties endorsed this. The preference is subsidized programs in which the parties with the greatest challenges are the pioneers (grid operators, governments and energy suppliers/aggregators) that collaborate with device manufacturers and are supported by advisory organizations. Hereby, the first to test the interoperability solutions by device type.

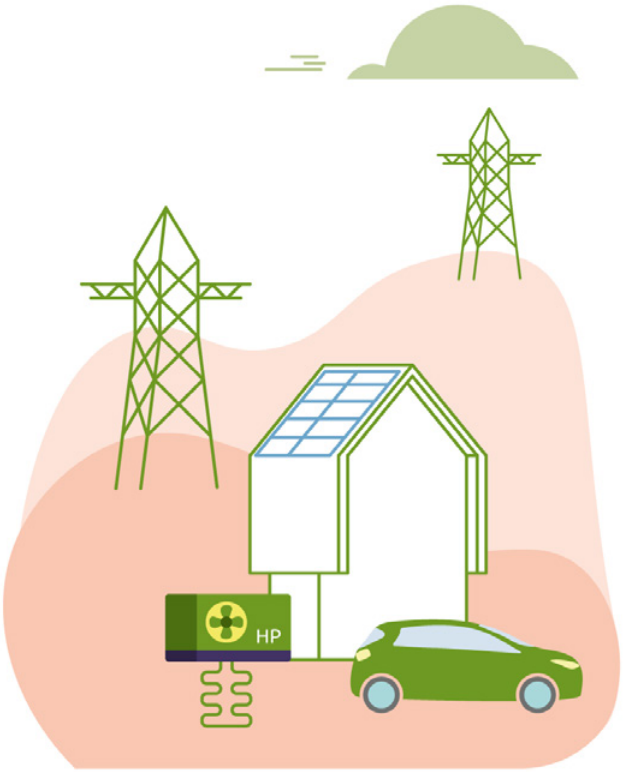
Each party recognizes that the potential of flexibility can be maximized if the flexibility of several devices can be combined. This combination can be developed in a next phase.

The final goal is that any flexible power device can be integrated. Therefore, it's recommended to begin developing various pilots with a primary focus on particular devices, after which a connection can then be made between these pilots. To obtain this, manufacturers of flexible devices and HEMSs and stakeholders from the energy system must work together.

No recommendation on appearance

This report intentionally does not make any recommendations about the HEM appearance, between local integrations and intelligence versus cloud-based solutions. Both solutions are possible, they can also be used side by side. The latter is becoming more and more visible. Each device or HEMS manufacturer has its own strategy to work with local integrations or cloud-based interfaces. We don't have a preference to any of the above strategies, the future will provide best practices one way or another.




HP

We, the authors of this report, believe that home energy management can help solve the challenges we face and stand 100% behind the findings of this report. This report is just a starting point for us: we will continue to work with our own findings, and are happy to talk to anyone who wants to work with us to reach the full potential of energy management.

Acknowledgments & epilogue

This report has been produced through many interviews and consultations with experts and steering committee members. We would like to thank everyone involved for the very good discussions, insights and valuable contributions.

SPECIAL THANKS

Special thanks to the Flexiblepower Alliance Network association, ElaadNL, TKI Urban Energy and RVO for making this research possible.

THIS IS JUST THE START

The authors of this report work within the energy transition and are fully aware of the challenges ahead. We believe that home energy management can solve important challenges and fully support the findings of this report. **For us, this report is just the starting point:** we are putting our findings to work and are happy to talk to anyone who wants to work with us to realize the potential of home energy management.

Adriaan van Eck &
Arjan Wargers

In the coming years, more and more energy will be generated sustainably. At the same time, more electric cars and electrical appliances are becoming a part of the modern household. This will greatly increase the grid usage.

Consumers are not yet motivated to consciously deal with the grid usage as it stands today. Added all together, consumers can have a big and positive impact on the grid load by using energy in a smarter way.

Appendix

Appendix 1: People involved

RESEARCH TEAM

Adriaan van Eck
Chairman and Researcher Smart Energy Technology, Flexiblepower Alliance Network (FAN)

Arjan Wargers
Research and Innovation Manager, ElaadNL

Harm van den Brink
Expert Smart grids & Electric vehicles, Cybersecurity, innovation, ElaadNL

EXPERT GROUP

Frank Geerts
Director Smart Charging, ElaadNL and chairman National Program Charging infrastructure

Winifred Roggekamp
Senior consultant and architect, Technolution

Luke Otto
Former head of heat pump development, Techneco / Remeha

Marten van der Laan
Professor of System Integration in the Energy Transition, Hanzehogeschool Groningen

Ruth Mourik
Researcher social aspects energy transition, Duneworks

Joke Kort
Senior scientist, TNO Energy Transition

Geert Verbong
Emeritus professor of System Innovation and Sustainability Transition, TU Eindhoven

Minke Goes
Manager New Business - Energy Infrastructure Solutions, Essent

Ermin Kloppenborg
Senior policy advisor, Ministry of Economic Affairs and Climate Policy

Jan Pellis
Strategy, Innovation, Business and Market Development in energy transition, aug.e, former strategist Stedin grid operator

REVIEW BOARD

Arjen Noorbergen
Founder Olisto, ex CTO Toon Smart Thermostat

Edwin Edelenbos
Manager Strategy, United DSO's of The Netherlands

Annelies Huygen
Prof. Energy Market Regulation Utrecht University & TNO.

Benjamin Grunfeld
Managing consultant Energy sector Europe and Middle East, Guidehouse.

Bob Ran
Program Manager Regional Energy Transition, TNO

Pauline Westendorp
Co-founder 02025 (sustainable local energy), Trouw sustainability 100 committee

Peter van der Wilt
Project leader energy & sustainability, Dutch Consumer Association

Pieter van Alphen
Founder Techneco Energiesystems BV (now Remeha), and figurehead Open Flex Alliance

STEERING COMITTE

Jasmijn Kleij
Innovation analyst Smart Energy Systems, TKI Urban Energy

Nicole Kerkhof
Senior Advisor Energy Innovation - smart energy systems (SES), RVO

Jaap Brouwers
Innovation consultant Alliander and board member Flexiblepower Alliance Network (FAN)

Maarten de Vries
Program manager Smart Energy Systems at TKI Urban Energy

OTHERS CONSULTED

Remco Fens
Product Manager charging equipment, Alfen

Michel Bayings
Chair eViolin, association of European charging station operators and emobility service providers

Peter Boon
CEO maxem, Manufacturer of Energy Management Systems

Xander Smit
Secretary, Club van Wageningen

Annex 2: Challenges to the electricity grid

In the coming years, more and more energy will be generated sustainably - think of private solar panels, solar parks or wind energy. Simultaneously, more electric cars and electrical appliances are entering households. This will lead to increased use of the electricity grid, which will lead to a sharp increase in the load on this network.

However, consumers have little incentive to use the grid efficiently. Due to the increase of electric cars, heat pumps, induction cooking, self-generation and feed-in of sustainable electricity, we see a greater demand for power and diversity in load patterns as well as peak moments. In the past small users could always be regarded as a homogeneous group but greater load pattern diversity leads to major differences between heavy users and light users.

With the current network tariffs, extra grid costs occur as a result of the developments above being distributed to society and therefore also passed on to those who are not responsible for the extra load.

That is neither fair nor efficient. The current tariff system today is in conflict with the cost-causation principle that the grid tariffs must comply with. Smart regulations of grid fees can encourage the customer to use flexibility. For small consumption for example, we think of slowly charging the car, or postponing the car charge if the heat pump, induction plate or dryer is used.

If preventing excessive peak loads on our grid is the goal: smart tariffs will have to provide the financial incentives for the customer to achieve it. Consequently, market parties would then offer more appliances and services that help customers to deal with the energy in a smart and flexible way.

The Dutch grid operators believe that such a price incentive can also contribute to a more proportionate and fair distribution of cost. In such a tariff structure, the user who causes greater peaks will pay more compared to those who do not burden the grid. That is a healthy and reasonable economic principle.

Bandwidth model +

Grid operators have developed a tariff model that is being worked out with all other stakeholders in the energy system. This is the Bandwidth Model+ (BBM+). The BBM+ provides an incentive for efficient use. This can be done by making a bandwith with an upper limit kW available to the customer for a fixed amount per month. At the moment, 4 bands (5 kW, 9 kW, 12 kW and 15 kW) are being considered. The higher the band, the higher the grid tariff. It is possible to purchase power outside the contracted band, but then the customer pays extra, depending on the requested extra power (kW) and the duration (h).

The effect of the BBM+ on grid operators is that costs are distributed more fairly, the network is used more efficiently while unnecessarily high peaks and congestion are prevented because customers are encouraged to stay within a (lowest possible) band.

Grid reinforcements will also be required with this tariff, but certain investments can be prevented or postponed because the customer is encouraged to reduce peak demand and distribute demand more over time.

Customers with electric cars will be encouraged to adjust their charging speed to their charging needs, instead of charging at the maximum possible power by default. It can also give impetus for more energy storage behind the meter. Finally, energy companies will be encouraged to offer innovative propositions to serve and unburden their customers.

Grid operators are aiming to introduce the Bandwidth model + as of 1 January 2025.

Appendix 3: Some smart home protocols

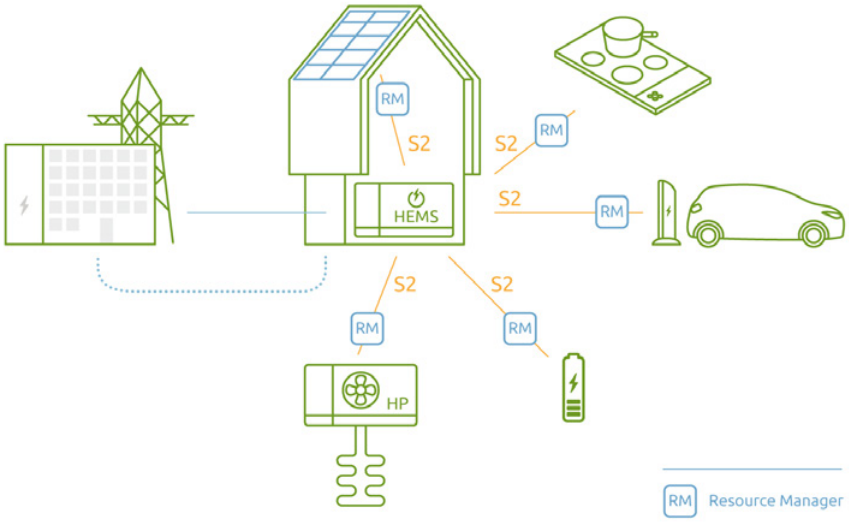
EFI / S2

In a European context, a major step has been taken to standardize a language for energy management. This language is called S2 and is a protocol that can pass on consumption schedules to the different devices in a uniform way. This is a good first step, but this solution still needs to prove itself in practice, see the next section.

Since 2012, TNO, with the help of the FAN foundation, has been working on EFI, a standard that aims to describe a common interface between energy-intensive devices and the energy system. From 2018, TNO is part of a European standardization working group, in which EFI has been developed further into S2. European countries have voted to make S2 an official European standard

The principle of S2 is based on sharing information and instructions for energy management of energy-intensive devices. The energy management system communicates via S2, in which the devices are instructed to use less energy, more energy, or to feed in.

We see that there isn't much awareness of S2 among device manufacturers yet, so that's the next challenge. S2 can be used in both wired and wireless applications.



ModBus

Many devices offer local connectivity. The most commonly used interface between devices and HEMS is Modbus. Modbus comes in three variants: Modbus RTU, Modbus ASCII and Modbus TCP. Modbus RTU and Modbus ASCII require their own two-wire wire while Modbus TCP can use any available home network via Ethernet.

An advantage of wired solutions is that there is no hassle with WIFI passwords or poor wireless connection due to thick walls or long distances. The disadvantage to Modbus is that it has a great deal of freedom, which makes cooperation between devices more difficult.

EEbus

We also hear from a number of parties, especially those with German business units, that work is being done on EEbus implementations. EEbus is a set of protocols aimed at standardizing interfaces between electrical appliances, generation and storage. EEBus is not only aimed on energy management. EEBus also works both wired and wireless. EEBus is already getting some traction, further investigations are required to look at the state of EEbus implementations.

Definitions and Abbreviations

HEM

Home Energy Management: intelligent energy management within the home to use energy more sustainably, more affordably and without loss of comfort.

HEMS

Home Energy Management System: the system that regulates the energy management of households.

Energy consumer

Consumer, can have solar panels (prosumer), end customer.

Energy supplier

Supplier of gas and electricity, usually the traditional main supplier with whom the consumer has his main energy contract.

Dynamic energy rates

Energy tariffs that can vary from day to day, or even on the same day. Currently, most consumers still have fixed energy rates, which are fixed contracts of one year or longer. More consumers are expected to enter into contracts with dynamic energy tariffs in the future.

Lock in

Being tied to a specific supplier or a manufacturer. This is possible in two ways:

Technical lock in

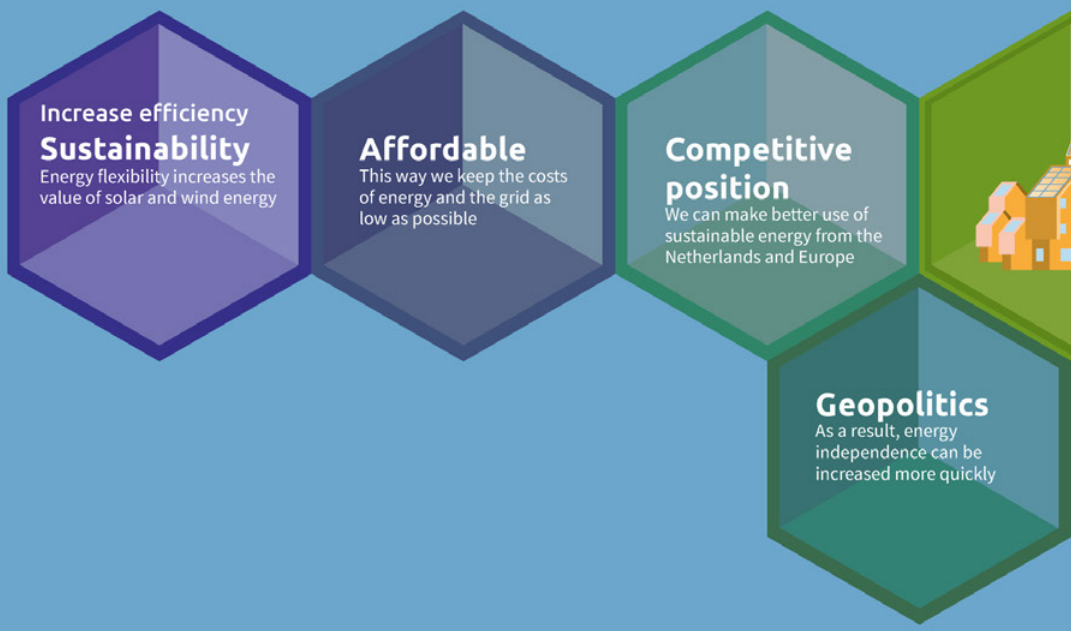
Inability to switch 'old for new' devices to work properly with the HEMS, or restrictions that make it difficult / impossible to change HEMS properly whilst keeping the integrations with existing devices. This also includes situations in which appliances do not work or work less well after termination of the agreement with an energy supplier, or when switching suppliers is problematic. These situations are comparable to a SIM lock on smartphones or changing internet providers.

Contractual lock in

An energy supplier or service provider who enters into a long-term agreement to earn back investments or pre-finance benefits to the consumer.

The energy market is deadlocked around HEMS

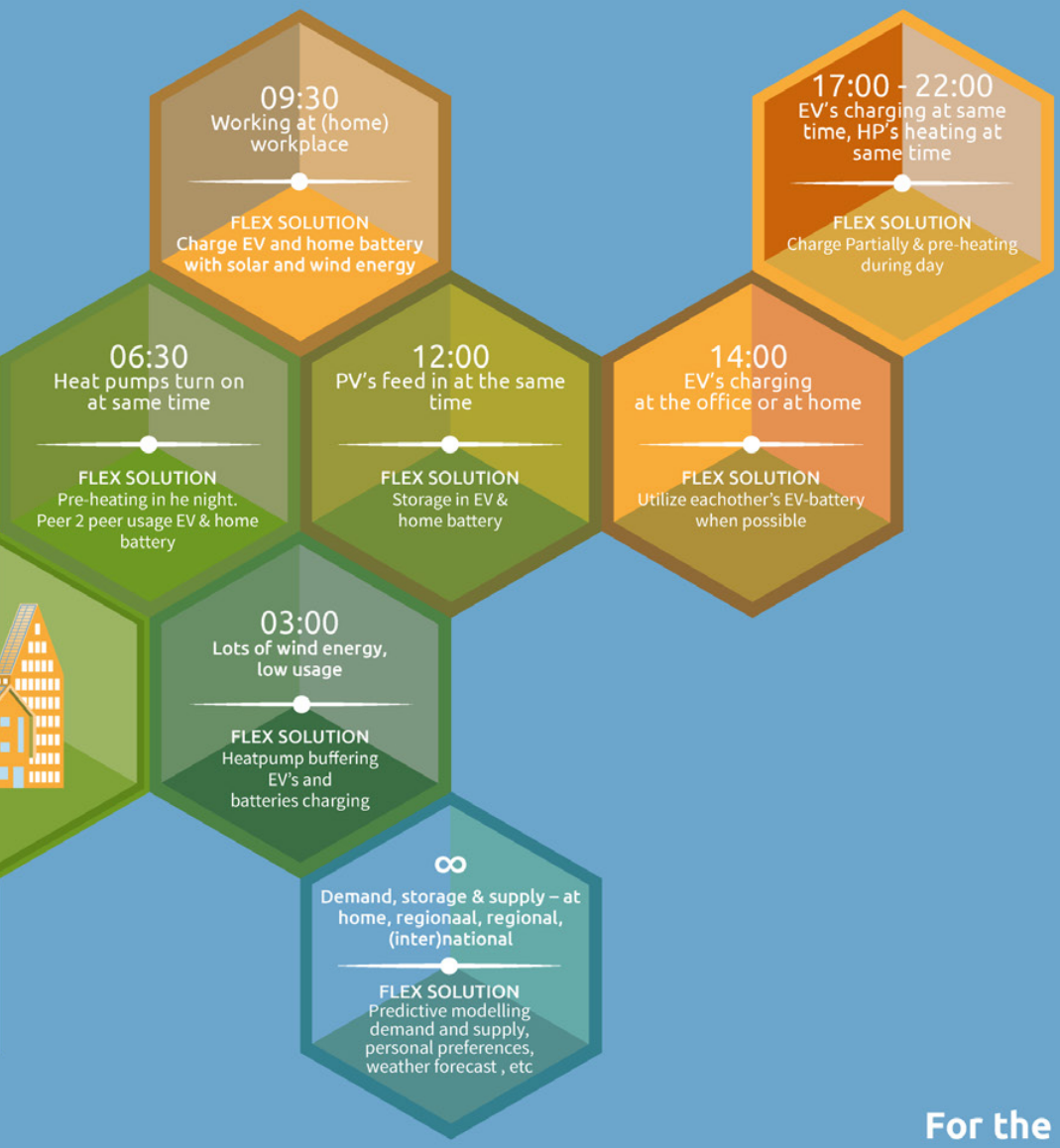
Businesses are not developing HEMS because there is no demand. Consumers are not asking for HEMS because it does not create benefits yet



Government

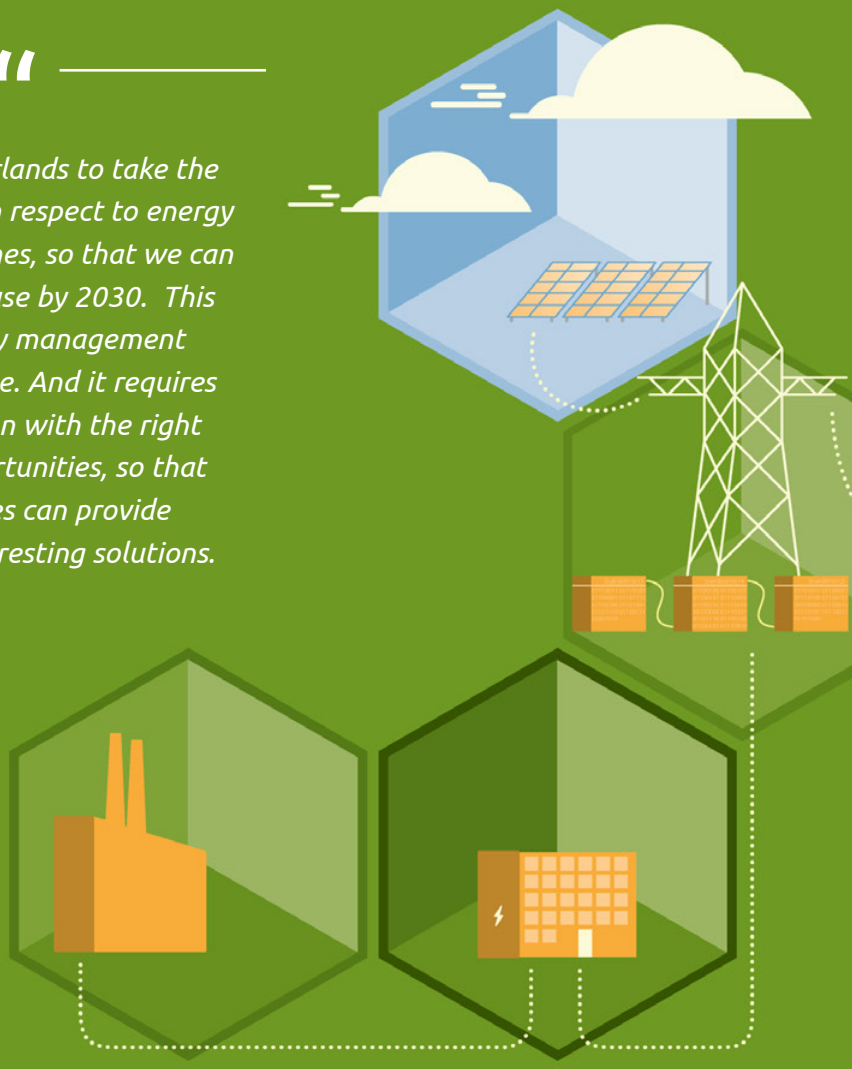
needs to stimulate this

Embrace
Energy Flexibility



For the
Consumers
to encourage energy flexibility

We want the Netherlands to take the right steps now with respect to energy management in homes, so that we can scale smart energy use by 2030. This calls for good energy management systems for the home. And it requires a good market design with the right incentives and opportunities, so that innovative companies can provide consumers with interesting solutions.



CONTACT

elaad.nl • ElaadNL

flexible-energy.eu • FAN

FLEXIBLEPOWER ALLIANCE NETWORK

Elaadnl