

**Louvain School of Management**

# **Smart Homes Technologies: do they really help households to reduce their energy consumption?**

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Academic Year 2019-2020

## Abstract

The aim of this thesis is to define the term of the Smart Home and various notions revolving around it such as the Internet of Things (IoT) or connected objects as well as other more descriptive criteria like the advantages/motivations, disadvantages/obstacles or a resistance to adopting them.

It also focuses on understanding whether it is possible to save energy by having Smart Homes Technologies. To do this, a qualitative study will be carried out by interviewing five individuals with connected objects in their homes as well as five professionals in the field of Smart Homes, digital architecture, and electricity.

A divided opinion on the subject will emerge although it seems that energy savings are indeed visible after the installation of Smart Homes Technologies. The sales argument that Smart Homes would reduce energy consumption would therefore seem to be relevant.

Nevertheless, several questions remain to be raised in future work: do the solar panels and the type of energy used by the household enter into this energy saving? Is it profitable in view of the number of years required to amortize the purchase of Smart Homes Technologies?

## Résumé

Ce travail de fin d'études a pour objectif de définir le terme de la Smart Home et diverses notions gravitant autour de celui-ci comme l'Internet des Objets (IoT) ou les objets connectés ainsi que d'autres critères plus descriptifs tels que les avantages/motivations, les inconvénients/obstacles ou encore une réticence à les adopter.

Il a également pour but de comprendre s'il est possible de réaliser des économies d'énergie en ayant des Smart Homes Technologies. Pour ce faire, une étude qualitative sera réalisée en interrogeant 5 particuliers possédant des objets connectés dans leurs habitations ainsi que 5 professionnels dans le domaine de la maison intelligente, de l'architecture numérique et de l'électricité.

Un avis partagé sur le sujet en ressortira bien qu'il semble que des économies d'énergie soient effectivement visibles après l'installation des Smart Homes Technologies. L'argument de

vente comme quoi les Smart Homes permettraient de réduire sa consommation d'énergie semblerait donc pertinent.

Néanmoins, il reste plusieurs questions à soulever dans de futurs travaux : est-ce que les panneaux solaires et le type d'énergie utilisée par le ménage rentrent en compte dans cette économie d'énergie ? Est-ce rentable au vu du nombre d'années nécessaires pour amortir l'achat des Smart Homes Technologies ?

## Foreword

*I would like to thank all the people who contributed to the realization of this paper.*

*First, I would like to thank my mentor, Nadia Steils, for her guidance, advice, and support throughout this thesis.*

*I would also like to thank the five private users and five professionals who agreed to devote me some of their time by responding my various questions despite these difficult moments. This work would not have been possible without their sharing of experience and collaboration.*

*Finally, I would like to thank my family for their precious advice and support during these last months of study.*

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## Introduction

Intelligent thermostats, connected alarm systems, connected cameras, connected light bulbs, connected television ... All these objects directly connected to our smartphones or tablets are increasingly present in our houses.

In 2018, a survey of 1,000 people conducted by the market research company iVOX revealed that 17% of Belgian houses are equipped with one or more intelligent devices. Only 3% of them control their heating via their smartphone or tablet, but 37% are planning to do so in the future (Vandebeek, 2018).

One year later, another survey conducted by Direct Research and commissioned by Somfy (manufacturer of connected homes) showed that 74% of Belgians with connected solutions bought them to improve their living comfort, such as a pleasant indoor temperature, automated curtains and lighting that switches on/off by itself. 55% also state that they want to invest in eco-friendly habitations to reduce their energy consumption with the main reason being saving money (Eerdeken, 2019).

In this final thesis, I decided to discuss the subject of Smart Home in Belgium: firstly, as a literature review and secondly, as a practical part focusing on energy saving.

First, this paper will briefly explain what a Smart Home is, but also other notions surrounding it such as the Internet of Things (IoT), connected objects or even domestication. The various advantages and disadvantages will be discussed. I will also take an opportunity in this part to discuss the motivations but also a certain reluctance shown by consumers to adopt them. A section will also be devoted to the environmental aspect related to these Smart Homes.

Further to this literature review, there will be a more practical part including a qualitative study composed of ten interviews. Five persons with connected objects as well as five professionals in the field of Smart Home, digital architecture and electricity have been interviewed. The aim of this interview is to find out if private users are satisfied with their connected objects and to understand the reasons that led them to adopt them. However, the focus will mainly be on the energy and money saving aspect to find out if they have reduced their bills. Questions regarding the jobs of professionals have been asked in order to get their

opinion on this possible energy reduction. This will be followed by an analysis of the different interviews based on the comparison between private users and professionals.

Finally, a conclusion will end this work as well as suggestions for future work or research in the field of Smart Homes and connected objects.

## Part 1: Literature review

### Definitions

Imagine pressing a 'welcome home' button on a remote control when you arrive on your driveway and your entrance hall lights turn on. Besides this, your heating or air-conditioner has already taken care to warm or cool your living room. When you enter in your house, your favorite music starts playing. That is what we call a Smart Home!

For Hargreaves, Wilson and Hauxwell-Baldwin (2018), a Smart Home is a "*residence equipped with a high-tech network, linking sensors and domestic devices, appliances, and features that can be remotely monitored, access or controlled, and provide services that respond to the needs of [their] inhabitants*". It is the answer to the customers' demand to integrate smart appliances and systems in the human environment. The main objectives of a Smart Home are to increase home automation, improve energy management, and control environmental emissions.

Available since the 1980s, Smart Homes did not penetrate the market very well due to the lack of powerful microprocessors, inadequate interfaces, and high product cost. In the last years, they receive a lot of attention and are now affordable (Ford et al., 2017).

We can use the Smart Homes objects to replace existing products or in addition to existing ones. We usually do this via smartphones apps, touchscreen interface, a web browser or through digital assistants like Google Home or Alexa from Amazon.

It is assumed that all devices in Smart Homes are connected in one or more Home Area Networks (HAN) (Mongay Batalla at al., 2017). These HANs include:

- One or several high-speed networks which are usually Wi-Fi networks being emitted by a set-top box, mobile devices, gateways, access points...
- Personal networks or ad hoc networks that are created between multiple devices using low-speed connections. This also includes Wireless Sensor Networks (WSN).

At the beginning, Smart Home Technologies (SHTs) were developed for luxury houses. Today, SHTs are sold as *home electronics accessories and devices with the promise of enhancing domestic comfort, usability, security and hobby's whilst simultaneously reducing energy use*

*through optimized home energy management* (Herrero et al., 2018). The Smart Home sector is one of the sectors that will benefit most of the development of connected objects in next years.

We can define the SHTs as the implementation of technology and services through home networking for controlling network-connected home systems and for a better quality of living (Robles & Kim, 2010). The SHTs are a contemporary application of ubiquitous computing that incorporates intelligence and automation into home environment. They are referred as part of the “digital revolution”.

According to Ford et al. (2017), we can classify Smart Homes products into 3 categories:

- The user interfaces (energy portal, in home display, load monitor).
- The smart hardware (smart appliance, light, thermostat, plug/switch, hubs).
- The platforms (web services platform, utility facing web services).

Smart Homes are part of what is called the Internet of Things. The Internet of Things (IoT) is the interconnection between the Internet and physical objects, places, and environments. The IoT refers to a growing number of objects connected to the Internet allowing communication between our so-called physical goods and their digital existence.

However, IoT must be distinguished from connected and intelligent objects. Indeed, the Internet only facilitates connectivity, and therefore ubiquity (the omnipresence of connected objects), where connected and intelligent objects retain their original physical attributes. Elements which make the objects smarter have been implemented on them (Folcher et al., 2017).

According to Porter & Heppelmann (2014), connected objects are defined by three elements: physical components (mechanical, electronic parts...), intelligent components (sensors that identify and measure data and actuators that perform actions based on the data collected) and connectivity components (through a system for transmitting this data). They create the link between 2 worlds thanks to the exchange of data and an intelligence to process them: the physical world of objects and the virtual world. The fact that latter are in direct interaction through the IoT makes them even more smart. Using internet is not systematic for connected

objects. However, connected objects can be frightening because they collect and transmit personal data and information.

According to Chouk & Mani (2016), connected objects have 3 characteristics: connectivity (allowing the exchange of information with the environment), intelligence (allowing autonomous decision-making based on previously captured data) and ubiquity.

It is not possible to talk about Smart Homes without talking about domestication. Domestication requires that users understand 3 types of work (Hargreaves et al., 2018):

- Cognitive: it is about learning about the technology itself and what it can bring to a household.
- Practical: it is about learning how to use this technology.
- Symbolic: it is about constructing the meaning of the technology and the way to integrate it in identities.

### Actors in the development of Smart Homes

The State plays a key role in the development of connected objects and becomes the main actor (Chouk & Mani, 2016). It can express this role in two ways:

- A regulatory role through laws and the creation of control bodies. It must thus ensure that legislation provides guarantees regarding the security, confidentiality, and reliability of connected objects.
- A role of investor in sensitive areas to avoid deprivation of liberty due to the system.

Smart Homes represent the 10<sup>th</sup> priority actions of the European Union in the Strategic Energy Technology Plan (Wilson et al., 2017).

Companies are the second most important actors in this development. Firstly, they must invest in cyber security research. Indeed, connected objects have a rather low level of protection. Companies must work on functional compatibility between connected objects and other equipment. It would therefore be necessary to create a universal system allowing connectivity between different objects. It is also essential to counter the gadget image associated with connected objects (Chouk & Mani, 2016). Finally, the intentions of the

consumers behind their purchases of Smart Homes' products should be understood in order to offer the more accurate and best ones for them.

### Resistance to innovation at the consumers' level

A connected object is considered as an innovation as soon as the consumer perceives it as something new. According to Ram (1987), there are 3 types of factors that explain resistance to innovation: consumer-related factors (motivation, personality, values, etc.), innovation-related factors (complexity, relative advantages, etc.) as well as those related to the mechanisms of propagation of innovation on the market (clarity, credibility, etc.). The consumer expresses resistance to a product when he or she refuses to adopt it, when he or she opposes against change and innovation. Two barriers can explain this refusal: functional barriers (linked to the use, value, and adoption of the product) and psychological barriers (linked to tradition and image). Connected objects are presented as a positive revolution that will be accepted by all, whereas this is not always the case. Here are some examples of resistance factors to connected objects: lack of knowledge of these objects, security, private life, loss of control, price concern.

As Folcher et al. (2017) suggest, the resistance to these connected objects would be lower when they are connected in a house. Consumers fear more connected objects when they are used on their own, and thus not connected to something. This could be likened to the theory of arrangement, which puts forward the idea that the parts of a whole interacting with each other are better than the sum of these parts.

The Smart Homes' landscape evolves quickly, and the adaptation period is not easy.

### Users

For the generation Y (1981 - 1996), technology must represent utility to be considered (Folcher et al., 2017). Those born with the technology, generation Z (from 1997), have fewer expectations in terms of usefulness and have less fear and resistance towards connected objects than the previous generation. When today's generation of students are going to be old enough to have SHTs in their own houses, it will be more available on the market and even more affordable than they are today.

Households having technical skills are more motivated to adopt Smart Homes services and products because they know how to use and control them (Nikou, 2019).

### Advantages - Motivations

Smart Homes have a lot of advantages and create value to improve the comfort and the daily life of today's households.

Firstly, it is a win of time and energy. According to Hargreaves et al. (2018), to save energy and associated costs is important for many users of Smart Homes. Saving energy for the well-being of the planet is currently one of the main concerns of the consumers. Some companies declare that Smart Homes can allow energy savings up to 30% without compromising the comfort at home. What is positive for Smart Homes' users is that they can conserve electricity and, at the same time, save money. Regarding the environmental aspect, Smart Homes present an advantage for energy's savings, but this statement does not make unanimity. It will be developed in the section called "Environment" in page 9.

Secondly, it enables the monitoring of the house when the household members are not present. Alarm systems with cameras, human heat sensors and/or motion-activated sensors allow you to watch what is going on in your home. These alarm systems are often connected directly to the central office of a monitoring company or to your smartphone via an application. Households are motivated by the desire to improve safety at home (Securitas Direct, 2019).

Thirdly, connected objects and, therefore, Smart Homes can improve services regarding health environment (Wilson et al., 2017). It can bring some independence to persons who need an assisted living.

The convenience (Paetz et al., 2011), the affordable prices compared to the 1980s (Ford et al., 2017) and the connected and the refined design of the connected objects are some other motivations to adopt the Smart Homes. The new connected objects are well designed to be an integral part of the different rooms of the house.

Finally, users of Smart Homes have an interest in new technology and home automation. They can therefore enjoy of their commitment with these SHTs (Ford et al., 2017).

## Disadvantages - Obstacles

Smart Homes also have disadvantages and consumers see many obstacles that might refrain them from adopting them.

Firstly, Smart Homes can strengthen the dependence to the connected objects, and it may result in a loss of autonomy especially among children. Indeed, these SHTs reduce the opportunities for the parents, for example, to teach their children how to save energy by turning off the lights or the tap. According to Hargreaves et al. (2018), *SHTs are disruptive for domestic life*.

Secondly, some users are afraid by the potential loss of control of Smart Homes. By control, we talk about the power of set up, repair, customize and control the management of information about connected objects. They fear their inability to handle problems that can arise with SHTs. There is a lack of awareness and knowledge of what constitutes a Smart Home and how to handle it.

When a consumer uses a connected object, he is potentially vulnerable to piracy because of data management and to his expectations in relation with the object. His health is also at risk. It is the same in a Smart Home, even if not all the SHTs are connected to Internet (Mongay Batalla et al., 2017). The powerlessness and the vulnerability fear a lot of consumers.

Nowadays, the data privacy and security are a hot topic. Six goals are covered by the General Security Requirements for Smart Homes Infrastructures: confidentiality, integrity, authenticity, non-repudiation, availability, and authorization (Mongay Batalla et al., 2017). To achieve these goals, we determine 4 measures :

- The application layer: concerns the authentication and key agreement, the privacy protection, and the security education and management.
- The support layer: concerns the secure multiparty computation, the secure cloud computing, and the antivirus security.
- The network layer: concerns the identity authentication, the anti DDos (Distributed Denial of Service), and the Encryption and communication security.

- The perceptual layer: concerns the lightweight encryption, the protecting sensor/actuator data, and the key agreement and physical security.

Smart Homes are at risk in many points and secure management systems should be included. According to Mongay Batalla et al. (2017), *“it is necessary to introduce external actors capable of managing the system introducing security in all layers and ensuring privacy of data, and [...] the network operators are the best positioned to give management support to Smart Homes since they are already present in the houses through home gateways for multimedia delivery”*.

Furthermore, some consumers accuse the public authorities of setting up a mass surveillance system as well as companies wanting to take advantage of the information collected. Some services will only be available when they are connected to a specific object. They fear that some traditional objects will only work with the help of these connected objects (Chouk & Mani, 2016).

Finally, SHTs can be complex to use and to understand. Some of them can take time to be configured and connected at home and often require some technical knowledge to be set up. It is also not always clear why SHTs would be used and how to use them to get the most out of them (Chouk & Mani, 2016).

## Environment

European and national policies have a common goal: reduce the greenhouse gases that contribute to global warming. To meet this purpose, two main issues must be resolved: expanding the supply of renewable energy and increasing energy efficiency (Paetz et al., 2011).

Not all consumers use their appliances at the same time or in the same way. The electricity needed is different for every consumer good. It is therefore difficult to reduce energy consumption and to use sustainable electricity. It is invisible, untouchable, and only consumed indirectly via related activities, like working on a computer (Paetz et al., 2011; Fischer, 2007; Grønhøj & Thøgersen, 2011; Hargreaves et al., 2010).

A solution for reducing electricity consumption and prices is the roll-out of smart metering which is already used throughout Europe (Paetz et al., 2011). The European Union has the ambition to invest 51 billion euros in the next years in smart metering. A variable day- and

night-tariff could be a great idea where consumers will pay a lower price at night when the demand is lower than during the day. Appliances will receive a signal to start when electricity price is lower. But it requires few changes in the everyday behavior and routines of the consumers. Some household activities cannot be rescheduled and cannot take place at another time.

Energy reductions between 5% and 25% are possible. In a study quoted by Paetz & Dütschke (2011), people using Smart Homes' energy monitors are able to reduce their consumption by 7.8% but they are not able to maintain it over a period of 15 months. They have doubt about the real potential for conserving electricity and saving costs as well as major concerns about necessary investments and possible abuse of data. Fear were expressed about time and effort required.

In another study quoted by Ford et al. (2017), we can see that CFLs (Compact Fluorescent Lamps) coupled with smart lighting may allow up to 7% reduction of total electricity consumption of a home.

For Schill et al. (2019), inhabitants' energy consumption can be reduced by using connected lighting and heating, and smart windows. To minimize water usage, plant, sensors, and sprinkler sensors can also be used. By making use of these Smart Homes objects, they come to the designation of "Eco-friendly Smart Home Objects" (ESHO). If someone is concerned about the environmental issues, he will probably have the intention to purchase ESHO. Its concern will depend on some sociodemographic variables such as the age, the gender, the education, the profession, and the income.

94% of Europeans believe that protecting the environment is important and that the main issues are climate changes, air pollution and shortage of drinking water. 87% of them believe that individual consumption has a significant role in the protection of the environment. 35% believe that the most effective measure to resolve environmental problems are the investing in research and development to find new technological solutions (Schill et al., 2019).

However, in the words of Tirado Herrero et al. (2018), *"there is little evidence that Smart Homes Technologies will generate substantial energy savings and, indeed, there is a risk that they may generate forms of energy intensification through pre-warming domestic spaces*

*before residents come home, raising comfort expectations or encouraging the adoption of additional energy-using technologies”.*

## Challenges

According to Mongay Batalla et al. (2017), two rather worrying challenges have emerged:

- The first one concerns the multiple connectivity of the Smart Homes objects to the internet. It is due to the cloud-based management of the IoT systems for data analysis and storage.
- The second one is about the behavior of users who are responsible for configuring their SHTs.

## Part 2: Practical part

Before I began my thesis on Smart Homes, I was convinced that Smart Homes saved energy and, therefore, money. After reading academic articles and writing my literature review, I reconsidered these thoughts because some researchers were questioning the potential energy savings. The fact that energy saving, which is the main selling argument of companies in the field of Smart Homes and connected objects, is not always seen as an advantage in itself jumped out at me. Indeed, several academic articles doubt of this aspect of energy savings.

### Methodology

I therefore decided to interview private users who have connected objects in their houses to see if they were really saving energy and money. They explain me which connected objects they have and their satisfaction of it.

I also decided to interrogate professionals in the sector to get their opinion on the matter of the energy savings.

First of all, I talked about my interview project with my relatives. Then, I posted a post on my Facebook profile in order to reach as many people as possible. This publication helped me to find most of my participants. I also found a contact through Batibouw which is the largest Belgian trade fair for Construction, Renovation and Interior Design for professionals and privates. In total, I interviewed ten people: five private users and five professionals.

## 1. Description of the professionals

In the following table, you will find the workplaces, positions and additional information about the professionals interrogated. Let us note that they all have connected objects at home but at different levels from the thermostat to manage the heat to the connected oven.

<b>PROFESSIONALS</b>	<b>Workplace</b>	<b>Position</b>	<b>Additional information</b>
<b>1<sup>st</sup> professional</b>	Sibelga <sup>1</sup>	Strategy and Innovation Director	He also teaches business planning and financial analysis at Solvay Brussels School. He has a civil engineer background.
<b>2<sup>nd</sup> professional</b>	Son Excentrique <sup>2</sup> and Bezonie <sup>3</sup>	Independent in direct contact with the customers	Son Excentrique works in collaboration with Bezonie only for professionals, not private users.
<b>3<sup>rd</sup> professional</b>	Domestia <sup>4</sup>	Account Manager in charge of the company's commercial relations	Domestia is the 4 <sup>th</sup> firm on the home automation market in Belgium.
<b>4<sup>th</sup> professional</b>	Qbus <sup>5</sup>	Contractor being member of the Board of Directors	Qbus is the number 2 on the Belgian Smart Homes' market.
<b>5<sup>th</sup> professional</b>	AVarchitects <sup>6</sup>	Co-creator of the company who oversees the technical-commercial part.	/

<sup>1</sup> Sibelga is a gas and electricity network operator in Brussels.

<sup>2</sup> Son Excentrique is a sound & light company creating all kinds of events for individuals and professionals.

<sup>3</sup> Bezonie is a control platform that brings together all connected technologies and automation protocols within buildings and living spaces for professional or private use.

<sup>4</sup> Domestia is a home automation system ranging from the management of light points to heating and shutters.

<sup>5</sup> Qbus develops switching modules and software that make the electrical installation of residential and professional buildings intelligent.

<sup>6</sup> AVarchitects is active in in-home cinema, home automation, audio and video multiroom, home control, videophone and internet.

## 2. Description of the private users

The private users I interrogated had very different profiles. In the table below, their different profiles are described regarding their age, their profession, the composition of their household and the types of connected objects they have at home.

<b>PRIVATE USERS</b>	<b>Age</b>	<b>Profession</b>	<b>Household's composition</b>	<b>Number of connected objects</b>	<b>Type of connected objects</b>
<b>1<sup>st</sup> private user</b>	29	Maintenance technician with a background in home automation	2 adults	5	<ul style="list-style-type: none"> <li>- Connected speaker</li> <li>- Connected cat flap</li> <li>- Connected lights</li> <li>- Connected fire alarm with smoke detectors</li> <li>- Connected TV</li> </ul>
<b>2<sup>nd</sup> private user</b>	55	Secretary at the Ministry of the Wallonia-Brussels Federation <sup>7</sup>	2 adults and a 22-year-old girl	5	<ul style="list-style-type: none"> <li>- Connected lights</li> <li>- Connected fire alarm with smoke detectors</li> <li>- Connected security alarm with cameras and motion-activated sensor by Verisure</li> <li>- System to manage the water</li> <li>- System to manage the heating</li> </ul>
<b>3<sup>rd</sup> private user</b>	47	Freelancer working at Sibelga as Project Manager in IT	2 adults and 2 children aged of 14 and 17	12	<ul style="list-style-type: none"> <li>- Honeywell for the heating</li> <li>- Hue lights by Philips</li> <li>- Motion-activated sensor on lights</li> <li>- Indoor and outdoor cameras</li> <li>- Connected doorbell by Ring</li> <li>- Zwave sensor at the doors</li> </ul>

<sup>7</sup> The mission of the Ministry of the Wallonia-Brussels Federation is to implement, after approval by the parliament, the government's policy. It is organized into six major entities, namely the General Secretariat and five general administrations: Education, Culture, Youth Aid, Sport, and Justice Houses.

					<ul style="list-style-type: none"> <li>- Connected smoking detectors</li> <li>- Connected TV</li> <li>- Strip LED by Philips</li> <li>- Hub Homey</li> <li>- Smappee</li> <li>- IFTTT</li> <li>- Connected solar panels</li> </ul>
<b>4<sup>th</sup> private user</b>	Forties	Policewoman	2 adults	2	<ul style="list-style-type: none"> <li>- Indoor cameras</li> <li>- Motion-activated sensor</li> </ul>
<b>5<sup>th</sup> private user</b>	69	Retiree with a background as an electronic engineer in a musical instrument shop and at the Royal Belgian Mint	2 adults	6	<ul style="list-style-type: none"> <li>- Connected shutters</li> <li>- Connected lights</li> <li>- System to manage the heating</li> <li>- Indoor and outdoor cameras</li> <li>- Connected security alarm with cameras and motion-activated sensor by Verisure</li> <li>- Connected solar panels</li> </ul>

## Professionals' opinion

All that will be mentioned in this part concerns the opinion of professionals related to their experience as practitioners and not in relation to their own houses. It is therefore their arguments and opinions that they put forward, for example, when they sell Smart Homes Technologies.

### A. General criteria

#### 1. Advantages and disadvantages of Smart Homes

The two main advantages cited by each respondent are the improvement of the comfort and being able to manage your home automatically and as you wish. By comfort, professionals mean being able to control their homes remotely and manage them as they want but also having a pleasant temperature at home. We can create sequences according to our lifestyles so that interactions are created. The practical aspect is interesting. Being able to install wireless systems is also appreciated.

The participants cite it as an advantage for energy savings, but when analyzing their answers, we could rather say that Smart Homes avoid wasting energy instead of saving it. For example, when a child opens the window in his bedroom, the heating switches off automatically. We have this home automation and the use of this house in a smart way.

Artificial intelligence appears more and more in houses and it will learn how the inhabitants live and what their customs are, and then, it will suggest adjustments to the house herself.

According to one of the participants, from the moment the installation is well done from the start, the houses are much more evolutive and in phase with the rapid evolution of the market. The choice of basic components makes the house upgradeable in the long term. But this advantage is in contradiction with what some participants told me. Indeed, there are a lot of products with different protocols, and often when a consumer commits to a brand, it is quite complicated to change afterwards. Every brand has his own application to control the Smart Home's systems and has therefore his limits. It would be great to assembly all these techniques under one single interface because we have everything at our fingertips on our smartphones, but we still have to switch between different applications. That is where it gets

a bit silly because the goal of a Smart Home is that everything is interconnected to create sequences that consider all the techniques present in the house. The disadvantage is that we have to make a choice from a vast offer and take the risk that our purchase will not be compatible with the future ones.

The disadvantage which was cited in every interview is the security. The systems are of course tested and validated before being sold, but this feeling of insecurity still seems to stay in minds because zero risk does not exist. There is always a risk that someone hacks the system and breaks into the house.

According to the co-creator of AVarchitects, the problem of security is at different levels and not only in the house. First, you have the person you are going to work with to set up the home automation systems: the integrator or the programmer. This person is the weak link because he can go bankrupt or even die at any time, which would mean that your project would fall through. If you do not have the plans and software, you can then start your project again with another company. Then, the second weak element is the possible flying cables outside the house that someone could plug in and see all the frames in your house. Security can also be at the wireless level with Wi-Fi which is not well secured. If passwords are not changed, this gives even easier access to intruders. Three years ago, they conducted tests on the security of connected homes. It is impressive to know that they managed to break into several villas via the surveillance cameras that filmed the alarm on/off keyboards where the residents typed in the code. All this without being a hacker, which means that it would be within the reach of any malicious person. A final security flaw according to AVarchitects is that of insurance. When you build or renovate a house, insurers are starting to pay attention to whether home automation is present in the house or not. They start paying attention because, for example, the repayment in case of fire will be higher if your house is a Smart Home. Insurers are starting to ask for the installation of lightning protection systems and/or extra premiums from customers if home automation systems are present in the house. This is not yet a standard, but it will become one in the coming years.

Connected objects are personal information that may be collected and used for advertising and commercial purposes, such as Google, which has databases about us. There is therefore

a loss of control of his private data. This loss of control and freedom remains a question of choice, whether one is in favor or against it.

With these new technologies, we become dependent and lazy. It can also be difficult for some people to use them, but I will come back to that later in this paper.

Smart Homes systems are 20 to 25% more expensive than traditional non-intelligent systems. It is therefore complicated to have an installation which corresponds 100% to the customer's demand unless he has a lot of money.

## 2. What motivates and demotivates people to adopt Smart Homes

What would motivate consumers to adopt Smart Homes would be for the improvement of comfort and their practical side. The evolutionary and simple side of Smart Homes is also appreciated and plays an important role in the balance when making a purchase.

At Domestia, for the salesman, people are not aware of what home automation could bring them. Saving energy is easily possible by using home automation properly. Just explaining to the consumer that Smart Homes will not only bring comfort but also some energy savings.

According to the director of Sibelga, there is currently no motivation to save energy because there is no incentive to automate and adapt the way one consumes simply because the tariffs have not yet been adjusted accordingly. This interest in saving energy, and therefore money, is low and is not yet part of the consumer's will.

The safety problem would hinder people from adopting Smart Homes. The security systems are obviously tested and validated, but this feeling of insecurity remains nevertheless present. The rather high prices would also prevent customers from buying home automation systems. Domestia's commercial gives us a new barrier to the adoption of Smart Homes. A small number of people show a categorical refusal to buy SHTs due to the magnetic field created around the connected devices. A magnetic field is a health danger. In an electrical circuit, there are 3 wires: earth, phase and neutral. Most home automation systems only cut off the phase, leaving the neutral active. There is therefore always a residential power supply that creates weak magnetic fields. At Domestia, their basic system cuts off the phase and the neutral, which reduces the magnetic field in the house and increases safety for our health. For those

who argue against this, it is therefore possible to buy home automation systems without a magnetic field.

### 3. Profile of persons interested in Smart Homes

People with an interest in Smart Homes would have a young profile (around 30 years old), an affluent socioeconomic profile, having an interest in being more connected in their homes, being interested in new technologies and all gadgets. AVarchitects agrees with the high socioeconomic profile but not on the age range. According to them, purchasing power is directly related to age. The consumers with the most purchasing power are in the 40 - 60 age group.

There are two types of clients: the ones who know exactly what they want and the ones who have heard about the home automation, who want it, but they do not know for what. Among the customers who want home automation, there are those who have the budget and those who do not.

Smart Homes systems are a common choice in new construction and renovations, it is rather rare to install home automation in existing buildings. It remains a niche market. According to a study carried out by Qbus, the Belgian home automation market has little presence. Every year, there are 51,000 new constructions, 27,000 renovations and 7,000 demolitions. In new constructions and renovations, 47,500 install conventional electricity, 24,000 set up pre-domotic systems with smart discounts and 6,500 install Smart Homes' systems.

### 4. Is everyone able to use Smart Homes?

Once again, I got two main opinions from the five professionals:

- Three of them told me that not everyone is able to use them. As with any form of technology, there will always be people left behind and this will be directly related to the level of education, age and social gap associated with the new technology. Some basic IT skills are needed to make all the systems communicate with each other and to fix eventual bugs. You still need to be familiar with modern tools. This is complicated in terms of the use of the different systems and the integration of the different connected objects. The first step is to understand how Smart Homes work, the

information they transmit and the advantages they offer, and then to be able to use them without difficulty.

- Two of them told me the contrary, that everyone has the ability to use SHTs. According to them, manufacturers have facilitated information and instructions for the use of connected products in homes. It is therefore possible to use these home automation systems at any age, regardless of the profession, if we stick to the fundamentals of home automation, which are simple. There is no need to have IT or electricity knowledge. However, it is sometimes necessary to have an assistance, especially if we place some IoT, it becomes a little complicated for aged persons. Some users are do-it-yourselfers and therefore do their own installations.

Let us take the example of the hospital and the hotels. Today, we meet home automation in these places without knowing it and everyone uses without any problem. If we use it unwittingly, it means that we can use it at any age because these places are not reserved for young qualified IT people.

#### 5. Will everyone have a Smart Home in the future?

According to the Director of strategy and innovation working at Sibelga, it will be crucial that all houses are made sufficiently intelligent in the coming years to ensure two elements linked to the energy transition: electric vehicles and new modes of energy production.

In the next 10 years, sales of electric vehicles are expected to boom. One of the reasons for this is the price of fuel, which continues to rise every day, while the price of electric vehicles seems to be getting more and more attractive. Another reason is to meet the CO2 reduction targets set by the European Union. Indeed, most car manufacturers forced themselves to offer a wide range of electric vehicles in order to avoid penalties. Where these electric vehicles are becoming interesting for Smart Homes is in their storage capacity, which is huge and therefore a large consumer of electricity. In the future, more and more people will connect their electric vehicle to their home and that is when consumption will have to be managed in an intelligent way so as not to blow the circuit breakers. We are therefore seeing an interest in being able to control and make intelligent use of the different sources of energy consumption so that we can adjust our consumption according to the different loads we use at home. We will observe a paradigm shift in the way energy is consumed at home.

Currently, technologies are being studied to have the possibility of re-injecting electricity from your electric vehicle into your house. We will be able to use this energy instead of going directly to the grid. Once again, Smart Homes will play a crucial role because we will be able to control our household appliances when our electric vehicle is plugged into our house and injects electricity into it.

The second element linked to the energy transition is the new ways of producing energy due to the nuclear exit and the increase of decentralized production. For decades, we have generated electricity from nuclear, gas and coal-fired power plants. Production was therefore stable, and we knew exactly how much electricity was going to be produced in a certain period of time. So, we were moving from production to consumption. With the objectives of reducing CO<sub>2</sub> and exiting nuclear by 2025, decentralized production such as wind turbines or photovoltaic panels continue to grow. With these new production methods, it is no longer possible to adapt our production to our consumption. We will therefore have to adapt our consumption to our production. In the next 10 years, it will be necessary to consume when there is production. When there is wind or sun and production starts, the appliances in a house will have to consume. It will therefore be essential that all houses are intelligent to respond to these new production methods.

For him, in the next 20 years, it will be a necessity for most people to have a Smart Home. It will be necessary to put in place intelligent management mechanisms for consumption in most households. Let us take the following example. We are in the middle of winter, around 6 p.m. Most of the workers go home and use their appliances. The problem is that in winter, at 6 p.m., there is no sun. The fear of a blackout will then arise in everyone's mind, and that blackout will certainly occur if we do not prepare for it. The prices will then be exorbitant at the end of the day. If we install smart meters, it will be a real advantage because companies will be able to say to their customers "It's time to consume because energy is cheap" or the other way round. This will then allow for energy savings, which is not clear at the moment.

This generalization of Smart Homes will depend on the level of automation of the connected objects. If the user does not have to do anything and the system adapts consumption according to the different periods of the day, most households will have Smart Homes. On the

other hand, if the systems only give information that the inhabitants must interpret, it will be more complicated.

According to the commercial of Domestica, within five years, 80% of the new buildings will be equipped with a home automation system. And 60% will control their homes through their smartphones.

AVarchitects compares Smart Homes to iPhones. These smartphones are still extremely expensive after all these years, but everyone owns one. For the smart homes, it will be the same but at different levels. Some will simply have a Nest thermostat<sup>8</sup> that will allow them to intelligently manage the temperature of their house. Some will add an IFTTT (If This Then That) system so that, for example, your garage door opens automatically when you come within 10 meters of your home. There is no precise definition of what constitutes a Smart Home.

## 6. Home automation in tertiary building

Tertiary buildings such as hospitals, retirement homes, offices, factories, and hotels are increasingly equipped with home automation. There is obviously a huge opportunity to put home automation in such places, it is not useless. Architectural offices have long understood that putting connected technologies in large buildings can meet demands for energy savings in heating and lighting. The volumes of these buildings are multiplied in comparison to that of a house, so management through connected systems is an excellent solution.

We can take the example of production lines. We see more and more detectors to prevent breakdowns and thus avoid shutdowns for hours.

### B. Question of energy savings

This aspect of energy saving is quite sensitive because, during the interviews, I was told that it is an advantage and a motivation to adopt Smart Homes, but when I asked the following question "Do we really save energy and therefore money thanks to Smart Homes Technologies?", the answers were in contradiction with what I had been told before.

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<sup>8</sup> The Nest thermostat is a connected and smart thermostat to manage the heat of your house and therefore, to do energy savings.

1. Is it home automation or the behaviors of inhabitants which play a role in the energy savings?

For two of the participants, it is the coordination between the home automation and the behaviors of the inhabitants, which play a role to reduce the energy consumption. In an ideal world, we would be provided a monthly report of our energy consumption in order to provide us suggestions for improving our daily lives. What is key in this management is the information given by the connected objects that will allow the household to understand its consumption in order to, then, automate the behaviors. Home automation is of interest only if the user understands the issues at stake and acts accordingly. The three other participants think that home automation has nothing to do with the reduction of energy consumption. The education of citizens is a key factor for the energy savings.

2. "Smart Homes will help you to save energy and therefore money": true or false?

We have two ways of thinking regarding the selling argument "Smart Homes will help you saving energy and money".

Firstly, it is a good way to convince potential buyers if they are interested in their personal energy consumption. At Qbus, they measured the before/after installation of a Smart Home system in several houses and they observed a reduction in energy consumption through the use of smart thermostats of 20 to 25% in the residential sector. In commercial buildings, the reduction can be as much as 50%.

In contradiction, this argument of energy savings does not represent the exact reality. Saving energy is often used as a selling point but is rarely a reason to buy. What consumers are looking for are simple Smart Homes systems that think for themselves and whose primary need is often lighting management. Sometimes, companies using this argument do not even believe in it themselves. For the independent working in collaboration with Bezonnia, it is still too early to have a system working perfectly and if it is the case, the reductions are quite small and the client is going to pay a lot of money and will have to wait a lot of years before writing off.

SHTs can bring comfort to the user, but energy savings do not necessarily follow. The reason is quite simple: the appliances that consume a lot of energy are refrigerators, washing machines, dishwashers, electrical hubs, freezers and are therefore not controllable. If a household wants to save energy from these appliances, it is best to buy the most modern and energy-efficient ones. It is also more efficient to change all your traditional light bulbs to LED bulbs which consume maximum 25 watts than to start thinking about turning on the lights less often. The notion of energy saving in the residential sector is also linked to the purchase of household appliances with A+++ labels as well as the proper use of these appliances.

It is therefore almost impossible to make energy savings in the residential sector. One of the reasons for this is the thermal regulation that few people adopt or install correctly. Indeed, in Smart Homes, mechanical ventilation is installed with a heat exchanger that takes the air from one room to heat it and re-injects it into another room. Let us take the example given by the co-creator of AVarchitects. We have 2 rooms where we want a temperature of 19°C and 21°C, respectively. The exchanger will take air at 21°C in the first chamber and will reject it in the second chamber where the requested temperature is 19°C. As the second chamber is heated by the first one, it will stop heating because the 21°C one will have warmed it up. So, there is a small energy impact but not something that will change your consumption. As people do not take this step, they do not save any energy.

### 3. Cancellation of energy savings

The main purpose of this paper is to analyze whether Smart Homes save energy or not, but in these connected homes, we are just adding new devices that also consume energy. Would not the possible energy savings be "cancelled" by connected objects that also consume energy? I have therefore decided to present this reflection to professionals, and I receive quite similar opinions.

One participant does not understand how it is possible to reduce something by adding elements to the installation. For him, reducing our consumption by adding consuming appliances is not very coherent.

The four other professionals explain it in this way. Connected objects are low-energy objects, so they allow you to really reduce your energy consumption without cancelling it. They are

electronic devices and therefore not power devices as they were twenty years ago. All the manufacturers are working on this energy reduction and therefore they create systems that consume very little power. It is not sleeping systems that consume, but it is, for example, the washing machines which do. A connected boiler will not consume much more energy than a conventional boiler that is not connected. Let us take the example of Domestica's basic system. It only consumes 10 watts which is not much.

#### 4. Experience of the family in a Smart Home

In the experience conducted by Paetz & Dütschke (2011), the participating household managed to reduce its energy consumption for 15 months and then return to its initial consumption. I wanted to get professional opinions on this reversal of situation.

When I talked about this experiment during my various interviews, I got several opinions that were quite divergent:

- If after a year and a few months, the energy saved returns to its starting point, it is because, in the end, this rate of saving is not big enough and sufficient for the family to continue to make efforts and live using these new technologies.
- Smart meters in Smart Homes provide information on household consumption. If the inhabitants do nothing with this information, there will be no change in terms of saving energy and money.
- It all depends on how the home automation system is installed and programmed. The residents are part of an experiment, so they try at the beginning. The problem is certainly related to the installation and programming of the system that does not correspond to the habits of the inhabitants.
- The habits of the occupants have changed, which had an impact on the functionality of the family and the system was therefore no longer adapted to the inhabitants.

## Private users' opinion

All participants had connected objects in their homes. Here are a few examples: connected loudspeaker, heating system, alarm and motion detectors, fire alarm, connected lights, indoor and outdoor cameras, door sensors, connected shutters, connected TV, connected bell, etc.

### A. General criteria

#### 1. Satisfaction of their connected objects at home

All private users are very satisfied about their connected objects. For them, everything to do with heating systems, alarms and cameras is very efficient. They of course consider some objects as gadgets like the connected lights of Philips, the connected fridge and hotplate or a connected cat flap. For the independent working at Sibelga, there are obviously gadgets in his house that are not necessary, but his family is used to live with all these connected objects and all the comforts they bring, so they would miss it.

#### 2. Management of their connected objects at home

##### Manage with a smartphone and several applications

The interviewed owners of connected objects all have a smartphone or a tablet that is independent or attached to the wall to manage them. Some have a specific application for each connected object, others have combined them into a single application when possible.

Let us take the example of the application proposed by Chacon. This application is used by the retired person who is passionate about new technologies. He has connected his shutters and heater to a DiO Home box as well as his plugs and remote-control devices. He can therefore manage everything remotely, even when he is abroad.

The Sibelga worker shares his disappointment about the large number of applications needed to manage the Smart Homes. According to him, there are not many solutions that centralize all the applications of the different brands. Some devices communicate with each other while others do not. He uses several services in order to centralize the management of his connected objects:

- The IFTTT (If This Than That) service is used to link different objects so that one action triggers another. For example, if a lamp starts to burn, it sends a notification via a smoke detector to your mobile phone: *if the lamp is burning, then* send a notification.
- The Homey central hub is also a system where several objects can be connected.

### Frequency of use

These SHTs are an integral part of the daily life of these private users. Some of them visit the applications of their connected object several times a day when they are not at home. Others go there at least once a week. Remote control makes sense for these people because some of them have no fixed work schedule and can therefore program and manage their home remotely.

### 3. Installation: done by themselves or by a specialized company?

Some people called in professionals while others carried out the installation themselves by buying the connected objects on the internet. Before purchasing any SHTs, they all do a market analysis by surfing on websites and on forums and by asking quotes to several companies. For many of them, it is not always necessary to buy the most expensive connected objects to have quality.

The secretary working at the Wallonia-Brussels Federation hired two companies for the installation of its management systems: Ores for the heating and water system and Verisure for the security and fire alarm. She is therefore bound by a contract with these two companies to carry out the annual maintenance. The retiree also has the Verisure alarms and is therefore obliged to go through the company for the annual maintenance.

The other private individuals went through the internet to acquire their connected objects. They therefore carried out the installation themselves and have no maintenance to plan annually. It was very easy to install and use from the start.

#### 4. What do they think about Smart Homes and connected objects?

It has a huge interest for disabled persons. For example, people in wheelchairs have the ability to control their house using their voice or an application on their phone.

For the retiree, Smart Homes are awesome. He never thought of it in a negative way.

Two of them had never really thought about it and were therefore a little afraid of all these connections. The secretary at the Wallonia-Brussels Federation sometimes fears that someone hacks the application for the alarm to enter into her house.

Connected objects are still quite expensive even though prices have fallen sharply in recent years. Systems are developing and becoming more open to interconnect with each other.

#### 5. Why adopting Smart Homes Technologies?

Persons having an interest in new technologies are motivated and attracted by connected objects. Direct marketers, specialized publications on the subject and family/friends' advices seem to be adequate ways of selling SHTs. Two of them told me that you have to evolve with your time.

Regarding alarms and security cameras, they are installed in houses to prevent robberies and to be able to see what is going on in the house when you are abroad or at work.

None of them mentioned that they acquire connected objects to save energy.

They all intend to buy more SHTs in the future.

#### 6. Do they find the Smart Homes Technologies easy to use?

The use of SHTs represents different levels of difficulties regardless of the background or the generation.

Today, there are more and more introductory tutorials provided by the brand or available on internet to install and use these new technologies. You do not need IT knowledges to use them. This may be a little more difficult for older people. The problem is that not everyone has a smartphone or a tablet to manage these connected objects.

On the contrary, for the independent working at Sibelga, it is more complicated to install connected objects if you do not have IT basics. That is why he would recommend simple and stable solutions to his heat system to not frustrate people if something is not working.

#### 7. What do they blame on Smart Homes and connected devices?

In the exhibition halls like Batibouw, companies show too much of the flashy side of Smart Homes and not enough of the other facets.

Lack of security remains a problem for participants. When you decide to connect your house, you open all the doors to anyone with bad intentions.

The prices for the network and Wi-Fi remain too high compared to our neighboring countries. The slowness could also be improved thanks to the optic fibre<sup>9</sup> already present in France.

#### B. Question of energy savings

##### 1. Is it home automation itself that reduces energy consumption or rather the attitude and behavior of the inhabitants?

For the maintenance technician with a background in home automation, it is primarily the attitude and behavior of the inhabitants that allows energy consumption to be reduced, and everything which is connected in the house would improve this energy reduction.

In the opinion of the two ladies, we do not really need connected objects to reduce the energy we consume. If the household is attentive, some energy savings can be made.

According to the independent working at Sibelga and the retiree, we cannot count on the inhabitants' behavior because they are not used to rely on tools telling them they are consuming too much. He is convinced that home automation helps to reduce energy consumption.

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<sup>9</sup> The optic fiber is a new technology for connecting to Internet that is fast and provides uninterrupted broadband.

2. Is the selling argument “Smart Homes are going to help you reducing your energy consumption” a good way to convince consumers to adopt them?

According to three participants, it is not the best argument to sell SHTs. The good way of selling it is by saying to the customers that they can handle their house the way they want and that it brings comfort.

For the worker at Sibelga, in the current situation, home automation is still too expensive to sell it as an energy reducer in terms of the real savings which are possible.

One of the participants also wondered whether the selling argument of energy savings is relevant given that there is a commercial purpose behind the sales. He also has doubts about the energy which is consumed by the connected objects that could “cancel” the savings ‘effect but he says that LED is put everywhere so there are small energy savings. For him, saving money makes people flinch.

For the retiree, the selling point of energy savings is good but there are many other arguments.

3. Do they observe real energy savings?

The employee of the Wallonia-Brussels Federation observed energy savings up to 30% following the installation of her connected boiler and connected lights. There are small savings, but, according to her, it is not with a connected system that big savings can be made. Notice that she has solar panels.

The independent saves energy and, therefore, money thanks to the heating system. He observed 10 to 20% savings, but it is the only place where he noticed energy savings, his other installations are more for luxury and comfort. It cost him 1,500€, he did not count the number of years it would take him to amortize his investment but, if he saves 10 to 20% per year, it should be quickly profitable according to him. With the help of the Smappee<sup>10</sup> tool, he can

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<sup>10</sup> Smappee is an all-in-one energy management system used for commercial, industrial and domestic purposes. It collects data about the production of solar energy and the consumption of water, electricity and gas.

measure his consumption and the injection of his electricity. He can observe his consumption but also his production because he has connected solar panels.

The retiree observed a huge reduction of his energy bill: it went from 125€ per month to 5€ per month. He also has solar panels.

#### 4. The experience of a family in a Smart Home (conducted by Paetz & Dütschke in 2011)

For all participants, it is not surprising; it could be compared to the new year's resolutions. If we forget to turn off the lights once, we think that it is not a big deal, but this situation comes repeatedly. There is also a question of human laziness.

The family who participates to the experience has maybe too many connected objects to manage and did not care of it. They did quite effort in the beginning to give up after a while.

## Analysis

Below, you will find a comparative table showing the opinions of professionals and private users according to 5 topics: the ease of use of SHTs, the real energy savings, the sales argument used by companies (SHTs can save energy and money), the role played by home automation and the behavior of residents, the experience of the family in a Smart Home by Paetz and Dütschke (2011).

	Professionals	Private users
<b>Ease of use</b>	<ul style="list-style-type: none"> <li>- <u>Two out of five</u>: everyone can use SHTs regardless of the age, the profession, or the IT skills. Manufacturers work on the ease of SHTs.</li> <li>- <u>Three out of five</u>: everyone is not able to use SHTs. It is related to education, background, age and social gap associated to new technologies. Some IT skills are needed.</li> </ul>	<ul style="list-style-type: none"> <li>- <u>Four out of five</u>: everyone is able to use SHTs. No IT skills are needed but it can be a little more complicated for older people.</li> <li>- <u>One out of five</u>: it is within everyone's reach, but the installation requires a basic IT knowledge.</li> </ul>
<b>Real energy savings?</b>	<ul style="list-style-type: none"> <li>- Using smart meters allows a reduction of 20 to 25% of energy consumption.</li> <li>- SHTs bring comfort but energy savings do not necessarily follow.</li> </ul>	<ul style="list-style-type: none"> <li>- <u>Three out of five</u> observed energy savings after the installation of the SHTs.</li> <li>- <u>Two out of five</u> do not observed energy savings but they do not have systems allowing savings.</li> </ul>
<b>Selling point of energy savings</b>	<ul style="list-style-type: none"> <li>- It is a good way to convince potential buyers, but it is rarely a reason to buy.</li> </ul>	<ul style="list-style-type: none"> <li>- <u>Four out of five</u>: it is not the best argument to sell SHTs.</li> <li>- <u>One out of five</u>: it is a good selling point but not the only one.</li> </ul>
<b>Home automation or behaviors of inhabitants which play in the energy savings?</b>	<ul style="list-style-type: none"> <li>- <u>Two out of three</u>: it is the coordination between the home automation and the behavior of the inhabitants which help to reduce the energy consumption.</li> </ul>	<ul style="list-style-type: none"> <li>- <u>One out of five</u>: it is the combination of both which can help reducing energy consumption.</li> <li>- <u>Two out of five</u>: the behaviors of inhabitants are the only thing</li> </ul>

	<ul style="list-style-type: none"> <li>- <u>Three out of five</u>: home automation has nothing to do with energy savings. It is the education of citizen which is key to reduce the energy consumption.</li> </ul>	<ul style="list-style-type: none"> <li>that play a role in reducing energy consumption.</li> <li>- <u>Two out of five</u>: it is only the home automation that play in the energy savings.</li> </ul>
<p><b>Experience of the family in a Smart Home</b></p>	<ul style="list-style-type: none"> <li>- The energy savings is not enough to continue to make efforts.</li> <li>- Inhabitants do nothing with information given by smart meters.</li> <li>- The problem is related to the installation and programming of the system that does not correspond to the habits of the inhabitants.</li> <li>- The habits of the household have changed, and the system is therefore not adapted anymore.</li> </ul>	<ul style="list-style-type: none"> <li>- It is not surprising, humans are lazy.</li> <li>- The family has too many connected objects to manage and she gives up after a while.</li> </ul>

### 1. Ease of use

We notice that the opinions of professionals and private users are different. They do not even agree between professionals or privates.

In total, six out of ten people, professionals and private users together, find SHTs accessible to any public regardless of age, background or IT knowledge. They just mention that this could be a small difficult for the elderly and that perhaps some help should be provided to them.

For the other four participants, IT knowledge is essential in order to understand and use SHTs.

### 2. Real energy savings

According to one professional, it is possible to reduce energy consumption by 20 to 25% thanks to smart meters which automatically record a household's energy consumption in order to provide the consumer and the utility more detailed information on current consumption in real time. But according to other professionals, this is not the reality. What is

surprising during these interviews is that they all talked to me about reducing energy consumption as an advantage of Smart Homes, but when it comes to the question of real energy savings, this advantage disappears. You can then guess that it is instead used as a commercial pretext even though savings are indeed visible in the households of the private users interviewed.

Indeed, three of the private users observed energy reductions following the installation of connected boiler and connected lights. A reduction of 10 to 15% and 30% in heating for two of them, with an electricity bill going from €125 to €5 for the other. The problem is that the three of them have solar panels to produce their own electricity. Would not it be thanks to these solar panels that their electricity bill would have decreased? One of them has also switched from fuel oil to gas. Would gas be cheaper than fuel oil and therefore affect the bill? These are some questions we have to ask ourselves.

### 3. Selling point of energy savings

In majority, professionals and private users agree about this topic. It is used to sell Smart Homes and is a good way to convince potential buyers, but it is rarely a reason to buy for the private users and it is certainly not the best argument.

When meeting potential customers, they use this selling point of energy savings, so it is surprising that they told me that it is not the best argument to give while they use it.

### 4. Home automation or behaviors of inhabitants which play in the energy savings

Once again, opinions are very different.

The half of them, professionals and private users combined, think that home automation has nothing to do with energy savings. It is only the behaviors of inhabitants who play a key role in reducing the energy consumption. In that case, education of people is very important.

For three out of ten, it is the combination of the home automation and the behaviors of the inhabitants that can reduce the energy consumption.

For only two out of ten, it is only the home automation which plays a role in the energy savings.

## 5. Experience of the family in a Smart Home

As you can see in the table, the reasons of the return to normal of the family after 15 months are different. It mainly concerns the behaviors of the inhabitants and the installation and programming of the SHTs.

## Conclusion

The theoretical part of this thesis led me to ask the following question: « *Smart Homes in Belgium: do they really help households to reduce their energy consumption?* ».

In the light of the various interviews conducted and their analyses, I can now answer this question.

On the one hand, professionals only half believe it when they use this energy saving selling point, which leaves us in doubt as to the reliability of their words. According to them, this is not the first reason why consumers buy this SHTs.

On the other hand, energy savings of 10 to 30% are indeed visible for private users since the installation of their SHTs. These private users have solar panels and have changed fuels (gas instead of fuel oil). Is it really thanks to these SHTs that they have managed to make energy savings or is it thanks to these two totally independent elements that are solar panels and gas?

As far as the inhabitants are concerned, their behaviors and habits play a crucial role in helping to save energy. Educating them is the key to energy reduction. It is therefore essential to teach children the basics in terms of wasting electricity and water because they will become the main actors in their daily actions.

Concerning managerial input, these results allow managers to have the opinion of some individuals using SHTs. It is essential that they know how users feel to adapt their offer and their way of selling. It would be important to present Smart Homes and connected objects in a different way by further developing the benefits with consumers and reducing the gadget and “flashy” side.

Several limitations of this work can be highlighted. First, not all the private users interviewed had fully connected homes. Two of them only had few gadgets that did not enable them to save energy. Their opinions about possible energy savings are therefore not based on observable facts. Regarding the professionals working for companies selling SHTs, they mostly sold me their businesses. They are perhaps less objective about their efficiency.

There is a final limitation to this work. It is still a little too early to do this kind of analysis in Belgium. Indeed, it seems to me that few people have real Smart Homes. For the moment, it is mainly a few connected objects present in houses.

For future researches, it would be interesting to interview more people with SHTs. It would also be relevant to find out if solar panels and gas come into consideration when it comes to reducing a household's energy consumption. Calculating the depreciation of these SHTs would also seem to be important.

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