SMART
ENERGY
EFFICIENT
HOUSING

Let´s get started on the Smart Home Journey!

STRONGHOUSE

Interreg
North Sea Region
Stronghouse
European Regional Development Fund

EUROPEAN UNION

SMART HOME MANUAL

A guide to smart living

LET´S GET STARTED ON THE SMART HOME JOURNEY!

Presented by

atene KOM

Agency for Communication, Organisation and Management

Be part of the community

https://northsearegion.eu/stronghouse/

Stronghouse3

Interreg NSR Stronghouse Project

SMART HOME MANUAL

SMART RESIDENTIAL BUILDINGS & SMART HOMES

This manual addresses people who are interested in starting a Smart Home Journey and all municipalities aiming to develop a local strategy to increase new constructions or speed up the renovation of the housing stock with the components of Smart Residential Buildings and Smart Homes.

Table of Contents

INTRODUCING OUR VISION OF A SMART HOME JOURNEY

New technologies did not enter our homes as fast as they, for example, revolutionized our cars.[1] Our car tells us when the next service check is due, that another vehicle or a person is in the blind spot, or it can even park itself! But what about the buildings we live in and spend a large part of our life in?

With the declaration of the COVID-19 pandemic in early 2020, for many, their homes also became their daily headquarters. An annual analysis in 2020 by GFK – Growth from Knowledge (the leading German market research institute) showed[2] that consumers invested significantly in their homes and es-

1 Cédric Locqueneux, Le guide de la maison et des objets connectés - Domotique, smart home et maison connectée, Eyrolles, 2016

2 Julia Richter, GFK Press release Smart Home: Consumers show growing interest in voice-controlled products, March 18, 2021

pecially in smart appliances at this time. Not only Smart Entertainment & Office products experienced growth but also the Smart Small Domestic Appliances (SDA) and Smart Health Sector with +41 per cent. For example, the category Smart Cooking grew by +71.5 per cent. The measures implemented to contain the pandemic did not only speed up the modernisation of home furniture and equipment but also enhanced the use of voice control to interact with smart products. For instance, in 2020, voice-controlled products experienced a 61 per cent growth in sales.

On their journey to design their home with more comfort and safety, people also take criteria concerning sustainable resource use and energy efficiency into account. The need to save energy combined with long-term economic advantages motivates many homeowners or real estate project developers to design or renovate using components of Smart Homes and Smart Residential Buildings. The price stability of energy (gas, fuel, coal, electricity) has been disrupted by the COVID-19 crisis: beginning with a historic plunge in global energy consumption in the early months of the pandemic, the prices of many fuels have been driven to their lowest levels in decades.[3] However, with the exceptionally rapid global economic recovery, the prices have rebounded strongly, partially due to a weaker-than-expected increase in supply. Additionally, the energy-related effects of the Russia-Ukraine war are pressuring many households to address the problem of energy efficiency. While the ambition to tackle climate change by renovating their homes is the motivation of a small minority, cost reduction via energy saving is an important aspect of this consideration. Remote controlling and automation are key aspects and can help to reduce, in the long run, the energy needs and costs of households (not only for homeowners but also for tenants). Further, the digitalisation of numerous services such as health care or administrative documents – which the pandemic containment measures amplified with the use of COVID-19 tracking apps and contactless interactions – is now also actively reaching older generations. This offers the possibility to develop new home standards, not only for future home buyers' generations

3 Fernández Alvarez, Carlos. 2021. What is behind soaring energy prices and what happens next? https://www.iea.org/commentaries/what-is-behind-soaring-energy-prices-and-what-happens-next

such as Millennials and Generation Z but also rethinking the standards of homes for elderly persons that, for instance, enable them to comfortably and safely live in their own homes for longer.

Using various Personas[4], the Stronghouse Project synthesized the different targets or user groups of energy renovation and also their motivations as well as triggers to start out on the Journey to energy efficient housing. In our manual, we elaborate on the Smart Home concept as the right trigger for some of the elaborated Personas. You can learn more about the Personas tool and look at the Stronghouse examples in Course 3 of our free e-learning series.

Check it out!
If you have further interest in creating different personas, take a look at our e-learning course.

Stage 3 - Becoming Interested: Drive the Message Home

https://rise.articulate.com/share/7xXI-nI_VdoIRSY_99IKb2Q4VVKt55Fs#/

The Smart Home appliances could be a trigger for more than one of the Personas and can be summarized under four categories.

| Climate/environmentally aware:

- eager to save the climate, and reduce the energy demand

| Health/comfort lovers:

- searching for solutions to improve their health, comfort, and well-being: security, a stress-free environment, and ambience are important
- providing the best for the people around him/her
- an elderly person needing assistance

| Economical pragmatic:

- add value to your home that results in lower utility bills, whereby the financial investment would pay off in the end

| Tech-savvy:

- enthusiastic to explore new techniques and novel technologies in a broad field
- occur in a range of middle-income groups regardless of age, and consist of both young people with technical affinity and older people who are passionate about technology

4 'Personas' is a widely used tool for the development of (commercial) digital services that addresses challenges by defining multiple target groups for the use of extremely complex digital technologies to provide intuitive, easy-to-use solutions for end users. The behaviour analysis of target profiles facilitates a more specific interaction with – and gathering information on – consumer groups.

Furthermore, the Stronghouse project identified nine different stages on the Journey to energy efficient housing (Figure 1). It describes the process of generating and potentiating an interest in energy efficient living which, over time, is transformed into active financing and optimisation of processes resulting in installations. The added value of this process is expressed in the experience gained, which can be shared to initiate further projects.

This manual shows how the Smart Home sector fits stages 1 to 5 of the Journey to Energy Efficient Housing, focusing on stages 3 and 4 elaborated by the Stronghouse project. We strongly believe that the Smart Home concept and appliances can help customers to become aware (Stage 2), interested (Stage 3), and active (Stage 4) in a low-threshold way. We are convinced that Smart Home appliances are a good shortcut in the Journey to Energy Efficient Housing since it enables homeowners to experiment with the benefits of retrofitting measures within a short period and with lower investment costs in comparison to traditional measures. We assume that at the end of a Smart Home Journey, a majority of homeowners would be eager to pursue the journey with more extensive measures, and by doing so, taking already known steps of the Journey to Energy Efficient Housing from the Stronghouse Project. Another assumption is that by including Smart Home devices during the Energy Efficient Journey, homeowners will become more interested in the overall process of the topic of energy efficient renovation (ref. Figure 2).

Figure 1 The Journey to Energy Efficient Housing - Stronghouse Project © atene KOM 2023

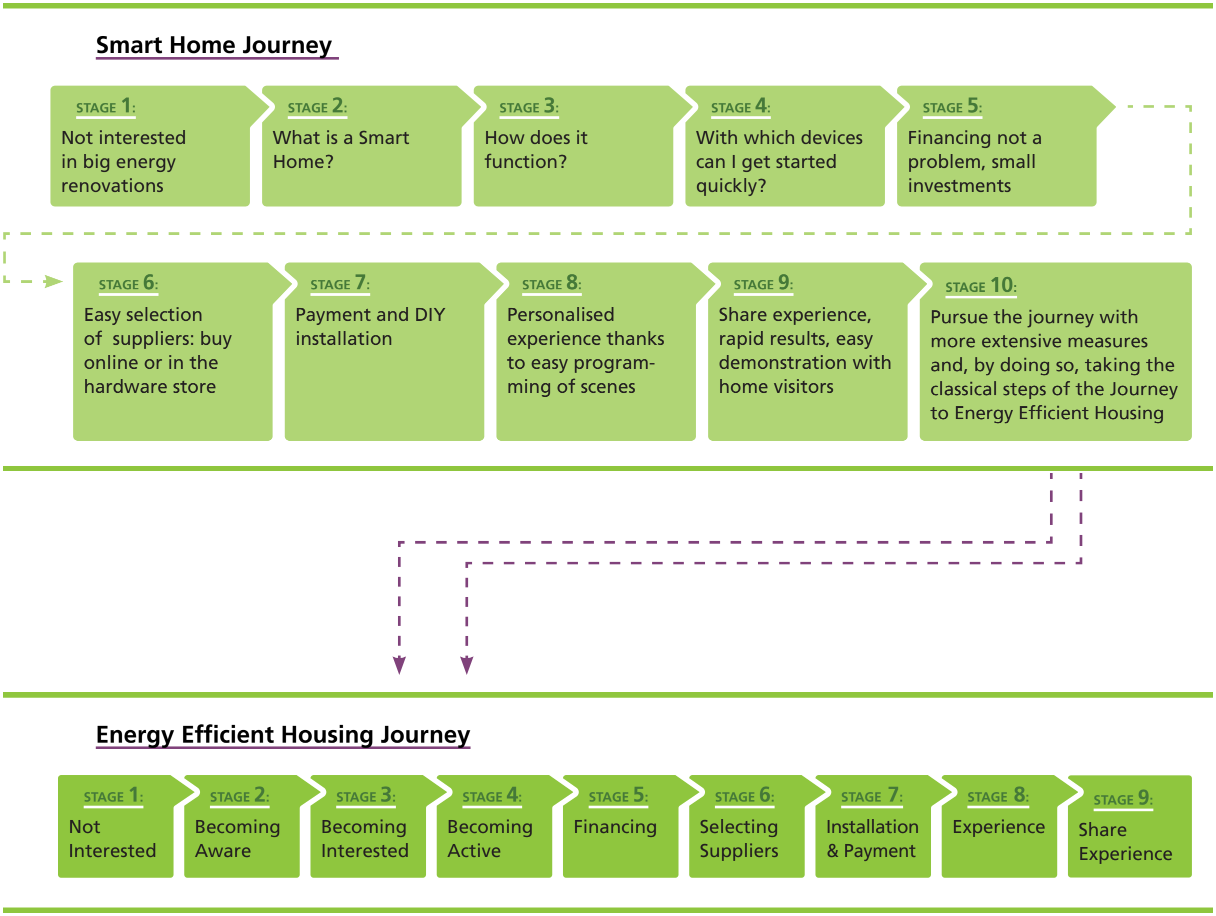

Figure 2 Smart Home Journey – a way to encourage homeowners to embark on the Energy Efficient Housing Journey
© atene KOM 2023

MANUAL USER GUIDE

This manual provides an overview of the Smart Home concept and the components of a Smart Residential Building with regard to technology and applications for daily life. While doing so, the Smart Home concept is also addressed as a way to improve the energy efficiency of residential buildings and illustrates the numerous financial incentives currently available in the countries of the North Sea Region. Finally, this manual presents the main discussions, debates, and trends around Smart Residential Buildings and the concept of Smart Home to show the potentials but also the risks for homeowners and municipalities by integrating these technologies into their private spaces (ref. chapter 3.6).

HOW TO DEFINE SMART RESIDENTIAL BUILDINGS & SMART HOMES

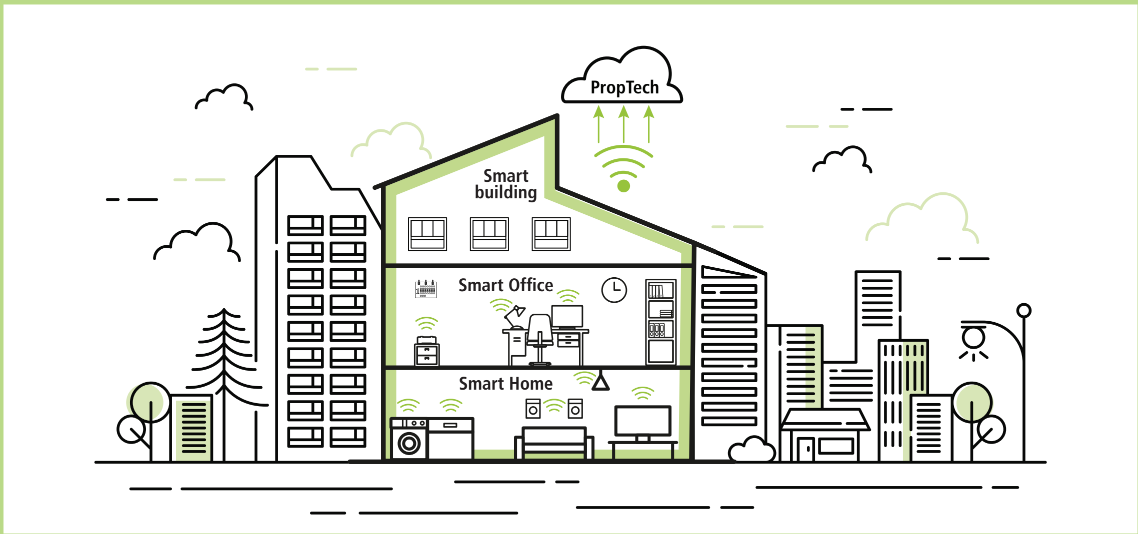

Figure 3 Classification of smart living and working spaces based on https://kiwi.ki/lexikon/smart-building/

In the broad field of the building sector, there are specific concepts and notions related to the smart construction or renovation of buildings. Since this manual is about housing and focuses on households, it will closely examine and deepen the notions of the Smart Home and Smart Building. While the differences between these two concepts are rather poorly differentiated, one main distinction is that a Smart Building refers to the digitalisation of an entire building whereas the term Smart Home rather describes the digitalisation and interconnection of home appliances, which can either occur in an entire building (like a detached house) or a unit in a residential building[5] (ref. Figure 3). In addition to Smart Homes and Smart Buildings, Smart Office and PropTech should also be mentioned for the sake of completeness, whereby these terms are often used synonymously since they describe concepts and components to digitalise real estate properties, which thus excludes them from further consideration in this manual.

Smart Buildings

The Smart Building describes the automation and centralised operation of classical functions such as heating, cooling, lighting, shading, and security technologies (esp. fire alarms). Thanks to the implementation of numerous sensors, it is also evolving towards responsiveness and prediction. As a result, for instance, your building could recognize a water leak before the first signs and damages are even visible. Smart Buildings, especially new constructions, are not only energy efficient and more sustainable but also tend to evolve towards energy positivity thanks to renewable energies and their own energy production. This is a relevant motivation for owners and investors to decide on Smart Home appliances, even if the smart technology increases the regular construction costs as, from a long-term perspective, the result would be more profitable. Apart from the improvement of energy utilization, comfort and safety are the other main goals.

5 https://kiwi.ki/lexikon/smart-building/

Figure 4 The aspects of Smart Homes
© atene KOM 2023

Smart Homes

The Smart Home, ideally located in a Smart Building, reaches a certain level of automation of classical functions and, beyond this, further evolves to learn from the daily routine and behaviours of the occupants and adapts to each specific household. This is made possible by bringing information technology (IT) into the electric system (a smart infrastructure), by cross-linking the Smart Home appliances and electronic devices, and finally programming scenarios and triggers (through a Smart Home hub). A home is smart when it does not need your active intervention to effectuate simple tasks such as turning off the heating while your bathroom window is open. This is the key difference from Smart Home's prior concept theorem of the last decades.[6]

6 Home automation (in the 1970s), intelligent Home (1980s), Ubiquitous Home (1990s) in Seo, Bae, Choi & Choi.

1 THE COMPONENTS OF A SMART HOME

1.1 Smart Home Technology

Smart Home Technology relies on communication and IT by using sensors, actuators, and triggers which are briefly described in this section. In subsequent sections of the manual, several devices and technologies are listed and described in scenarios to illustrate the effectiveness of Smart Home technologies concerning energy efficient living.

Smart Home Hubs

Hubs are the most essential tools and the heart of a Smart Home, which generally cannot operate without a hub (ref. chapter 1.2). Hubs facilitate control over a Smart Home and the different devices inside and outside of the house such as thermostats, smart speakers, or smart lights, which can be automated and connected. It also allows devices to trigger actions from other devices. The central unit takes over the control of all connected devices, which thus eliminates the need to use several apps or to directly control each device, whereby a hub can also take the form of software running on a computer.[7] The Smart Home hub is often referred to as a bridge or gateway and is, for example, the interface to voice assistants such as Alexa, Siri, or Google.

Hubs are therefore more than simply a remote control that functions via switches or smartphone apps. With the right software, they can be an interface that uses real-time data based on individual behavioural specifics or processes.[8] Depending on the intensity and complexity of the personal programmed scenarios, the Smart Home hub will need to be able to use scripts in addition to graphical representation. This could be interesting for tech savvies (ref. Personas), who have the knowledge of and are interested in achieving peak performance in their Smart Homes. Examples of free software hubs include Home assistant (running on Python), OPenHab (running on Java), and domoticz (running on C++) these can be used to create your own Smart Home network.[9]

Sensors/Actuators

Sensors are an integral element of a Smart Home's equipment as an installation with sensors is what makes the intelligent perception of a home through linked devices possible in the first place. As with sensory organs, sensors cover various areas of perception. Ranging from simple smoke detectors to the measurement of brightness, air quality, temperature, wind, and rainfall, all the way to motion sensors and the status of

7 Chai, Wesley. Shea, Sharon. 2020. Definition Smart Home hub. https://www.techtarget.com/iotagenda/definition/smart-home-hub-home-automation-hub

8 ref p. 5-f Wang, Pan et al. 2018. A Smart Home Gateway Platform for Data Collection and Awareness. https://arxiv.org/pdf/1804.01242.pdf

9 2022. Smart Home Hubs and Gateways – Beginners Guide. https://stevessmarthomeguide.com/smart-home-hubs-guide/

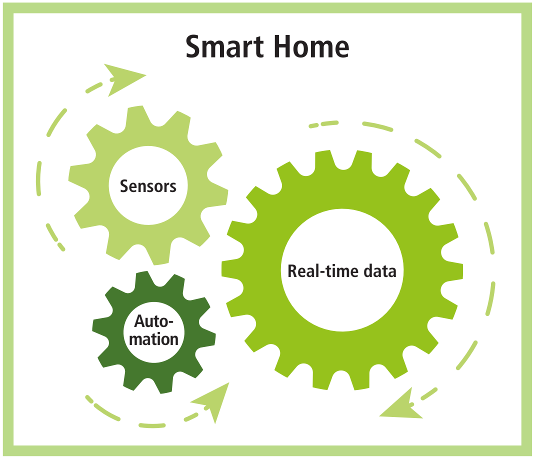

Figure 5 Mechanisms of action for Smart Home implementation
© atene KOM 2023

whether windows and doors are closed, sensors capture all desired or undesired events in the home. A central idea in the field of Smart Home development is the recording of occupants and objects in a home, whereby even a smartphone can act as a sensor by tracking the position of the owner. This in turn can be used to cause actuators to react in certain ways.[10]

Actuators are the second important component required for the controlled functioning of a Smart Home. An actuator is a collective term for devices that perform an operation after receiving a signal.[11] For example, if a sensor registers that the sun is rising, it will send a trigger to the actuator, which is connected to the blinds and can respond to the signal from the sensor by raising them. Similarly, the detection of poor air conditions by sensors enables automatic ventilation by opening the windows, as long as they are equipped with the required actuators. To refer back to the previously mentioned smartphone as a sensor, through the combination with actuators in the lighting system,

10 Crandall, Aaron. Cook, Diane J. 2011. Tracking systems for multiple smart home residents pp. 2-4

11 https://dictionary.cambridge.org/dictionary/english/actuator

the light can be switched on or off depending on the presence detected in the room. These are just a few examples to illustrate the importance of sensors and actuators in Smart Homes and only show the simplest possible combinations of these elements.[12]

Triggers

It has already been clarified that **sensors** form a basic system structure together with the **actuators** via the central control unit. However, Smart Home systems are capable of much more than just reacting to simple environmental influences since by using triggers and scenarios (ref. chapter 2.3), far more complex system structures can be established. Like domino stones, triggers initiate further functional chains that lead to certain automation processes. There are different types of triggers including time, voice control (Alexa, Siri, Google Assistant, Cortana, Bixby), cloud-based voice control (that acts like a digital switch), and logical associations (if, and, or, then)[13]. A scenario can automatically be started by the Smart Home hub or via the smartphone app/web interface of the Smart Home hub. A predefined trigger, which for instance initiates the scenario for a working day, might be started when the sensor of the front door, in combination with the time of day and the positioning of the smartphone, registers that a person is leaving the house for work. Hence, it can be said that each scenario relies on an individual trigger and, as a result, a predefined scenario can be initiated that turns down the heating and switches off all the lights.

12 ref. Bertko, Chris et al. 2017 p. 23

13 ref. Bertko, Chris et al. 2017 p. 29 f.

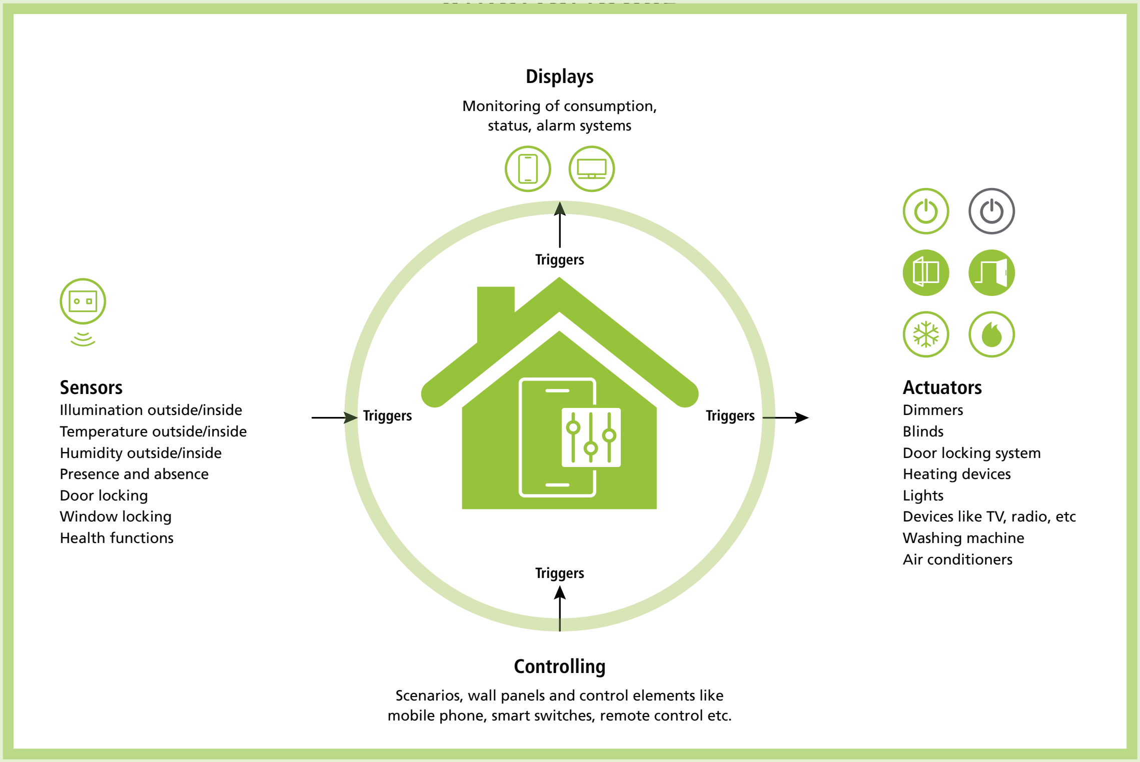

Figure 6 The key elements of a Smart Home
based on Bertko, Chris et al. 2017 pp. 27

1.2 Infrastructure

Basic infrastructure is needed to equip buildings with smart technology, and several options are available for this. In this context, a basic distinction must be made between wired and wireless systems that allow devices to be linked and interact with each other. Especially in the case of a new building or the renovation of a house, it should be considered at an early stage whether a cable system should be installed. However, it is also possible to retrofit a building or to equip it completely with non-wired systems.

Wired – Smart Home

Wired systems are not only used in Smart Homes but also in larger complexes such as airports and stadiums. Wired systems are also interesting for residential districts that are going to become connected Smart Buildings. The advantage of wired technologies is that they are only slightly vulnerable to faults and are characterised by low energy consumption. This makes them particularly relevant for low emission buildings. Since the systems can differ significantly in their installation and function, in the following, an overview of common systems and their operation is provided. Furthermore, the most common advantages and disadvantages of these technologies are illustrated.

Table 1 Differences of wired systems © atene KOM 2023

Wired systems	How it works	Advantages	Disadvantages
Binary Unit Systems, Electrical Bus System (EBS), European Installation Bus (EIB), Konnex (KNX)[14]	Parallel wire connection beside regular power cables Can already be combined with power cables in new buildings	Error-free function and controlling of lighting as well as heating/ cooling Wide product compatibility as Konnex is compatible with products from more than 400 manufacturers	Small data transmission rate of 1MB/s is sufficient for lighting and temperature
Loxone[15]	Centralized wires connected to the electrical power box Wires must be installed separately from the regular power grid	Stable and secure running system	Only runs on Windows systems Expensive and elaborate installation process Difficult to install new devices
Powerline/ DigitalStrom[16]	The control unit needs a connection to the electrical power box Luster clamps can be installed behind plug and switch covers No new power grid installation is necessary High-security performance through low pass filters	Easy and cheap installation DigitalStrom allows the control of up to 7,936 devices[17]	Only limited control via smartphone

14 ref. Bertko, Chris et al. 2017 pp. 38-39

15 ref. Bertko, Chris et al. 2017 pp. 40-42

16 ref. Bertko, Chris et al. 2017 pp. 42-45

17 ref. https://help.digitalstrom.com/hc/en-us/articles/360008977554-How-many-deviced-can-be-connected-within-a-digitalSTROM-installation-

Wireless – Smart Home

Since not every resident in a flat owns the property and thus might not be allowed to install new cables as required, the installation of a Smart Home using radio systems is a good option for rented properties or already existing buildings. However, in relation to the EIB and KNX systems, there is no common radio standard for Smart Homes and thus well-known radio systems such as Bluetooth and WLAN are often utilised. Generally, it can be said that, up to now, there has been a general lack of a uniform radio system language that is designed for utilisation in the Smart Home sector and radio systems frequently do not function safely and reliably.[18] Especially the interferences from other transmitters, as well as walls and doors, can partially limit the functionality of devices that operate at higher frequencies. WLAN systems tend to have a reduced transmission range as they operate at frequencies between 2.4 and 5 GHz. However, the significant advantage of radio systems is that they are relatively cheap to install and can be flexibly retrofitted. Furthermore, radio-based sensor systems are suitable for saving energy, as they can last for years on one battery charge, whereas cable systems require permanent access to the power grid.[19] Like in the previous chapter, the following section provides examples of different systems to highlight the different functions and advantages as well as disadvantages of their safety architecture.

18 ref. Lib.net. Smart Home Radio Standards Overview – Comparison. https://www.libe.net/smart-home-radio

19 ref. Bertko, Chris et al. 2017 p. 47

Table 2 Differences of wireless systems © atene KOM 2023

Wireless Systems	How it works	Advantages	Disadvantages
WLAN[20]	A router and a good internet connection are required WLAN systems operating at frequencies of 2.4-5 GHz	High transmission rate Fluent work with lighting systems	High energy demand due to high frequencies Limited operation range, especially when there are walls and doors High energy demand is unsuitable for sensor systems Can get overloaded with many devices that are connected
433 MHz Radio Systems[21]	Can be set up with systems such as Home wizard that support linking between devices through a gateway[22]	Long-distance communication possible up to 100 m Low energy demand	Same frequencies can cause accidental triggers of other devices Less secure due to the non-encrypted monodirectional transmission rate and lacking return channel No smart communication between devices supported
Proprietary Systems	Closed systems that only allow interaction with producer devices	Frequently uses secure two-way communication	Systems can mostly be connected with manufacturers' devices Limited device arsenal of the manufacturer can reduce the use of the Smart Home and its efficiency

20 ref. Lib.net. Smart Home Radio Standards Overview – Comparison. https://www.libe.net/smart-home-radio

21 ref. Bertko, Chris et al. 2017 pp. 50-51

22 ref. Bertko, Chris et al. 2017 pp. 52-58

1.3 Smart Data

To design Smart Homes, it is fundamental and indispensable to collect data about all processes that need to be controlled. However, data in its raw and original form is not usable for homes and requires the transformation of 'data' into 'smart data'[23] by using technological interfaces, or the linking of data to generate knowledge about situations and behaviour patterns. An example of this is a thermostat that collects data on temperature conditions. This process should already be done in such a way that this data can be used for further processing steps so that an intelligent added value emerges from it. In the case of temperature data, the case would involve transmitting the data to radiators that realise an increase in temperature, which subsequently leads to the downregulation of the radiators to remain at a constant room temperature. Hence, to increase the value of data for optimizing the Smart Home, all devices must be able to communicate with each other and exchange data, thereby becoming part of the Internet of Things (IoT).[24]

The collection and use of private data represent a longstanding and much-discussed subject in today's society which is frequently viewed with suspicion by the population. The negative public opinion on sharing private data and the lack of trust in companies to handle private data appropriately are challenging for the sector.[25] This can also be seen in a study by Bitkom from 2020, which reveals that 33% of the consumers surveyed are afraid of misuse of their personal data while a further 24% are afraid of an invasion of their privacy through the use of IoT.[26] Furthermore, the interoperability and the

23 ref. Smart Data: Describe data that is set in a context to other signals and patterns, by intelligent algorithms. https://www.netscout.com/blog/what-smart-data-how-does-it-help

24 ref. Odunlade, Emmanuel. 2022, What makes a Smart Home smart? A guide to protocols and applications. https://www.wevolver.com/article/what-makes-a-smart-home-smart-a-guide-to-protocols-and-applications

25 ref. 15 BVDW, Deloitte. 2021. Faktencheck Consumer IoT. Das Internet der Dinge im Alltag deutscher Konsumenten. https://www2.deloitte.com/content/dam/Deloitte/de/Documents/technology-media-telecommunications/Consumer_IoT_2021_Deloitte.pdf

26 ref. Bitkom. 2020. Smart Home Studie. https://www.bitkom.org/sites/main/files/2020-09/200922_studienbericht_smart-home.pdf

wide variety of providers are obstacles to the use of IoT-based technologies.[27]

How is Smart Home Data used?

To facilitate understanding, the fields of action in a Smart Home can be divided into the categories of security, energy, and comfort. To have a functional Smart Home, certain data from these areas must be linked and shared, whereby the type and amount of data that is collected depend on the Smart Home class. These classes are defined by the technological equipment according to the size and composition of the household. As a result, five stages of Smart Homes can be hierarchised, ranging from homes that are equipped with at least one intelligent device up to attentive homes that can permanently record all the locations of people and objects inside and regulate as well as adjust the technology based on the information provided.

Table 3 Clustering of Smart Home types based on https://www.academia.edu/3174090/Smart_homes_past_present_and_future

Smart Home types	Description
Basic Smart Homes	Residence with at least one intelligent device that can act in a smart manner
Communicative Homes	Residence with several objects that are capable of communicating with each other and exchanging information
Connected Homes	Residences that have access to services and information across the internal network as well as interactive control of internal home systems
Learning Homes	Residences that anticipate user patterns and activities by recording and internalising evaluations
Attentive Homes	Residences that are capable of recognising presence and absence, and are always aware of object positions inside the home

27 ref. 9 BVDW, Deloitte. 2021. Factcheck Consumer IoT. Das Internet der Dinge im Alltag deutscher Konsumenten.

Furthermore, elderly and disabled people require separate and individual adaptations in terms of safety and accessibility.[28]

So much for the theory. Let us take a closer look at the different uses of data in Smart Homes and why it is sometimes necessary to collect data. While data collection in the area of energy and heat efficiency is mainly achieved via sensor networks that adjust illumination and room temperature by using physical or pre-set data, there are systems that collect much more personal data. This especially applies in the case of comfort products such as Smart Home assistants in which all collected data converge.

A further example of data-collecting comfort products is vacuum cleaner robots that create floor plans of homes to perform their tasks. While this is useful for choosing the ideal path for cleaning and avoiding obstacles it also gathers information about the hygiene and living conditions of the house's occupants.[29] In addition, while data from smart devices such as intelligent fridges may indicate if a person is running low on supplies this data can also be used to determine shopping habits and eating behaviours. Smart beds provide information about sleep quality, duration, and bedtimes. All this data concerning individual consumer habits and needs has tremendous value for third parties and companies.

How can the collected data be used to identify consumers' needs and accelerate the innovation process?

Assistance devices such as Alexa, Google, or Siri collect and analyse voice patterns, research requests, and various other types of information. This data is often necessary to improve human-machine communication and help the interface work better as a smart system.[30]

28 ref. Spoor, S.M. 2016. How can data generated by smart home devices help identify consumer needs? pp. 3-4

29 ref. Preis, Dan. 2017. Smart Home Data Collection: Are Companies Going Too Far? https://www.makeuseof.com/tag/smart-home-data-collection/

30 ref. 2021. What data do smart assistants collect about us? https://blog.online-convert.com/what-data-do-smart-assistants-collect-about-us/

2 APPLICATIONS AND PURPOSES

Applications and the installation of devices make it possible to individually expand the controllable area of homes, as well as to create various application possibilities that make everyday life easier and can also save time and energy. The range of products and applications is diverse and multi-layered, which is why the focus of this section is on **technical monitoring, smart lighting, the use of smart switches**, and the **smart readiness indicator**.

2.1 Technical and Energy Monitoring in Smart Houses and Buildings

Technical monitoring is the heart of an intelligent home. It allows the building to reflect and act by itself, by creating a virtual perception of temperature, humidity, lighting conditions, movements, air quality, the position of objects and other elements. As already shown in point 1, sensors and actuators record all this data. Monitoring tools usually work according to the pull principle in which monitoring tools request data from a device that is being controlled. This requires the devices to be set up in the IoT and for them to be online and accessible at all times.

However, this is not so easy to do, as most sensors and controllers in the Smart Home area are on standby mode to reduce energy consumption and therefore need to be activated occasionally to determine and send a data value. But this comfort also consumes energy, and even if it is only between 5 and 10 watts, it adds up very quickly for many devices over time. It is therefore necessary to weigh up in advance how many devices constantly need to be in the IoT and it is also necessary to monitor the energy usage of these devices. By means of monitoring tools, it is also possible to reduce energy consumption with the help of triggers (ref. chapter 1.1.3), for example, the shutdown of a television can be initiated as soon as the trigger registers – based on the voltage – that the device has switched to standby mode. This form of energy monitoring can be used to determine, control, and display the power consumption of all devices with a history. Table 4 provides an overview of the adaptive devices and features that can be added to make your home smarter and monitor your ‘four walls’. To design a Smart Home efficiently, it is essential to evaluate the functionality as well as the cost-benefit in detail in advance.

Table 4 Overview of Technical Monitoring Smart Devices © atene KOM 2023

Heating / Cooling	Smart Thermostat
	Monitoring and developing heating and cooling schedules Compares and detects if windows are open or if the homeowner is absent Can save approximately 10–15% on heating costs Can be installed in houses as well as flats Refers to weather reports Registers the number of people in homes Goal: regulate energy use and heating Can be used with: • Air Source Heat Pump • Water Source Heat Pump

Ventilation	Smart Air Con (AC)	Smart Vent	Smart AC Controller
	Able to cool separate rooms and is configurable by timesheets Possible appliances are: • Window-based option • Portable AC • Central AC Existing AC can be upgraded via infrared sensors to be smart Intelligent AC systems are costly but improve the efficiency of energy use	Adjusts ventilation rates and regulates temperature by room Provides information about air quality Minimises the total energy consumption of the ventilation system	AC can be controlled via remote control or applications Adaptable schedule by location based on georeferencing

Lighting and Sensors	Sensor-controlled Lights	Smart Light Switch	Smart Bulbs
	Control the light depending on the presence in the room Controlled by movement or with a smartphone	Possible to turn existing lights and ceiling fans into smart devices With voice control or a smartphone Permanent way to have smart lighting	Can be controlled with voice command or a smartphone Can generate ambiences or warning signals by changing colours Goal: save money, energy efficient

Energy Management Systems	Solar Energy	Smart Grid	Energy Storage	Energy Monitor
	Photovoltaic moni-toring: solar panels installed on a roof or placed in free space turns solar energy into electricity. The monitoring enables to calculate the annual energy use for prices or the adaption of the consummation. Solar thermal energy: turns solar energy into heat (heating, hot water); the solar thermal collector is mostly placed on the roof and energy is then transported to the heating	Intelligent energy network that can be controlled via applications Balances supply and demand between the system components Simplified integration of different energy sources, into the grid and lowers the cost/ energy Tracks utility energy consumption and controls the flow of resources being used (water, electricity, natural gas)	Smart energy storage systems communicate with all systems/ storages, e-chargers, house automation components heating and light) A central energy source for electricity and warm water	Monitors energy use at home There are two types of monitors: • Handheld screens that work with a separate unit clipped to the electricity meter • Wall-attached screens that are connected to the electrical grid It allows for the prevention of costly repairs, conserves energy, and saves money

Entertainment: Multi-Room-System

Audio

- Control the light depending on the presence in the room
- Controlled by movement or with a smartphone

Smart TV/Home Cinema

- With Smart Home automation, the home cinema is integrated into the smart hub
- Several rooms can be controlled
- Includes speakers, projectors, and receivers
- Works via automation protocols

Security / Sensors

Smart Door Lock

- Operate via Bluetooth and applications, which makes keys obsolete as doors can be opened via smartphones or access cards
- Alternatively can operate via Zigbee or Z-Wave signals

Security and Alarm System

- Two-way intercom systems as well as camera and video system
- Door and window sensors
- Presence simulations
- Panic and emergency buttons and alarms

Smoke Detector

- Wireless or with an app function that can directly be connected to the fire department in case of an accident

Sensor

- Motion/noise detector
- Water/humidity sensor
- Automatic blinds/ lights

Garden

Irrigation, Mowing Machine and Lighting

- Smart sprinklers/irrigation system
- Weather stations
- Smart soil sensors
- Automated lawn mowers
- Outdoor entertainment
- Outdoor lighting

2.2 Lighting Example

To better illustrate the range of elements listed, Smart Lighting is discussed in more detail in this chapter. Turning on the lights in Smart Homes is not limited to flipping a switch, and not even to the presence of a power cable in the wall. With hand gestures, wireless wall switches, remote controls, motion detectors or a voice command, it is possible to turn the light on and off at will and from anywhere. At the same time, smart light bulbs and devices facilitate constantly adjustable illumination, such as changing brightness levels according to the time of day. This not only increases living comfort but also saves energy through intelligent switch-off functions.

However, Smart Lighting can do much more because light not only illuminates a room but can also provide additional atmosphere through coloured light and could even be used for visual status signalling. With adjustable light colours, it is possible to visualise danger signals or a poor room climate and it can also serve as an orientation aid to mark escape routes as well as to avoid stubbing one's toe on the way to the toilet at night. So-called RGB luminaires are used for this purpose, whereby RGB stands for the primary colours red, green, and blue. With these colours, it is possible to cycle through 16 million different colour tones. When all three colours are switched on at the same time, a cool white light is produced. High-quality LED strips have an additional white channel for this purpose and are thus called RGBW. Such LED light strips can be used as indirect lighting.

2.3 Smart Switches and Scenarios

Imagine you just press only one button, and your home awakes and comes alive. Scenarios make everyday life in a Smart Home much easier and contribute many ways of saving time and energy while providing comfort in your daily routine. Connected to Smart Switches and movement sensors, Scenarios unfold their full potential. A simple application example would be a Scenario in which the light is automatically switched on when entering a room and switched off when leaving. Such scenes are especially ideal for the entrance area. Furthermore, with Smart Switches, it is possible to send your whole home into a goodnight mode, for example, and turn off all lights, as well as lowering the heater temperatures overnight. Moreover, with a remote switch at the entrance, all appliances can be turned off and devices such as the vacuum cleaner robot can start doing their chores after everyone has left the house. These are just a few of the possibilities that are concealed behind the pool of Scenario techniques for Smart Homes. The influence ranges from superordinate functions to micromanagement of individual appliances. According to calculations, in this way an intelligent home control system can achieve average savings potentials between 8 and 19 % for heating and domestic hot water.[31]

Consumption Monitoring

Such scenarios are not only useful for controlling electricity and heating but are also suitable for regulating water consumption. Looking to the future, water is a vital resource that needs to be conserved. Smart shower heads, for example, help to generate an overview of showering behaviour and water consumption by connecting via Bluetooth, which allows consumption behaviour to be reconsidered and water consumption to be reduced. In addition, a traffic light system can indicate the current water consumption using changing light signals (green, blue, red) on the shower head while the user is showering.

31 https://www.ibp.fraunhofer.de/content/dam/ibp/ibp-neu/de/dokumente/sonderdrucke/bauphysik-gertis/6-einsparpotenziale-intelligente-heizungsregelung.pdf

2.4 Smart Readiness Indicator

What does the smartness of a building refer to? To provide an answer to this question and to somehow assess the smartness of a building and the ability to integrate related technologies in the building unit, a rating system was needed in all European Union (EU) countries. In 2018, such an instrument was introduced at the European level within the framework of the revision of the Energy Performance of Buildings Directive (EPBD)[32].

Within the revised EPBD, the potential of smart technologies is highlighted, and a so-called Smart Readiness Indicator (SRI) is described and proposed for implementation on the national level. This SRI evaluates the technological ability of a residential building to interact with the user and the supply grid as well as to regulate its operation in an energy efficient manner. The use of smart meters, the integration of charging stations for electric mobility, energy storage systems, and energy management systems are essential requirements that are included in this assessment. The technology that is already installed and the existing infrastructure for possible expansions are put to the test. The indicator is intended to provide building owners, tenants, and investors with practical guidance on the extent to which existing or newly constructed buildings meet contemporary technological requirements.

For existing buildings, the SRI assesses a building or a building unit concerning its capacity to:

- optimise energy efficiency and overall in-use performance,
- adapt its operation to the needs of the occupant, and
- adapt to signals from the grid (energy flexibility)[33].

In general, and looking at the residents in the housing stock, the SRI aims to raise awareness and increase trust in the value of building automation systems.

The methodology for calculating the SRI is based on the assessment of smart-ready

32 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L0844&from=EN

33 https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficient-buildings/smart-readiness-indicator/what-sri_en

services that the building has or could use within nine technical domains, i.e.: heating, cooling, hot water, ventilation, lighting, dynamic building envelope, electricity, electric vehicle charging, monitoring and control.

For a given building, all smart-ready services are assessed by the indicator against the following desired impacts of smart buildings:

- energy efficiency,
- maintenance and fault prediction,
- comfort,
- convenience,
- health, well-being, and accessibility,
- information to occupants,
- energy flexibility and storage.[34]

The application of the indicator for buildings is optional for the EU-Member States, meaning the SRI is a voluntary joint EU instrument. It should be adapted to the specific local framework conditions and thus be tested and rolled out in various EU countries. Against this background, the European Commission provides support and advises the member states and the regions that are implementing the SRI.[35]

34 https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficient-buildings/smart-readiness-indicator/what-sri_en#smart-ready-services

35 ref. https://smartreadinessindicator.eu/sites/smartreadinessindicator.eu/files/sri_summary_2nd_interim_report.pdf

3 SMART BUILDINGS AND ENERGY EFFICIENCY

In the previous chapters, several technologies and systems, as well as utilisation mechanisms, were described that can help to increase energy efficiency in homes. Technical monitoring and scenario-based optimisation in the use of low energy houses are illustrated in the further chapter using various examples. When planning a new building, it is considered how the ecological footprint can be minimised and how a sustainable source of energy and heat can be tapped that the house can fully cover. This part should raise awareness concerning additional methods for creating Smart Homes that are energy efficient. To illustrate this concept, several examples will be presented in the following that deal with the topic of resilient and energy efficient housing, while examining different scales of housing, and the potential for supporting these efforts with the implementation of Smart Home technologies.

Zero Energy Homes

What are the main characteristics of zero energy homes? While existing buildings undergoing retrofitting mostly do not eliminate all losses of heat and energy, newly constructed zero energy houses are built to be very energy efficient in combination with Smart Home technologies from the very start. Zero energy homes are not an identical construction type but are classified into different house types. The spectrum ranges from low energy buildings to total net-zero energy buildings, which may also compensate for the grey energy produced during the construction process. A fully net-zero energy home requires the use of a closed system for heating and cooling, ventilation, hot water supply, operating energy and support services. Low energy buildings have so far shown that at least a net-zero balance in the area of heat is achievable.

The central element of zero energy homes is not that all the energy and heat consumed is recovered to the same extent every day, but rather that the consumption and production balance each other out across the annual net balance. The use of Smart Home technologies is thus especially useful for measuring and monitoring energy production and consumption. Further steps in the development process of zero energy homes are the reuse of grey energy, which also includes the resources and lifetime cycles of buildings and powering of mobility technology through energy surpluses. To achieve the goal of a zero energy home, the use of smart technologies is a positive factor in reducing overall energy and heat consumption. The following chapters present examples of smart technologies in residential buildings and related initial successes in the field of energy efficiency.

3.1 Smart Home on a District Level Retrofitting: Quarter Jena-Lobeda

The Smart District in Jena-Lobeda demonstrates the next dimension of a Smart Building complex by showing how already existing buildings can be retrofitted in a smart way. The project was realised in existing prefabricated buildings that were constructed in 1983 and consisting of tree-building complexes with a total of 246 flats. Within the framework of the renovation process, fibre optic connections with a transmission rate of 1 GB per second were integrated into each flat, as well as new windows and electrics. Additional installations of photovoltaic panels on the balconies and the roofs pave the way for achieving increased energetic independence for the complex. Furthermore, the joints of the building were thermally re-insulated. The entire renovation process with its Smart Home appliances contains transferable solutions for comparable architecture and is therefore a model for other refurbishment projects.

In Jena-Lobeda, the residential units are equipped with smart technologies. In addition to various applications within the flats, the residential environment is also included. Services such as presence-independent delivery of shopping, medicines, and packages, the local availability of car-sharing services, e-charging stations, and bicycle garages, as well as the allocation of a local telemedicine room, where consultation and basic diagnoses can be arranged, comprise the foundation for a smart neighbourhood with an enhanced quality of living. In terms of construction and space, attention is also being paid to an integrative neighbourhood design by creating communal spaces that can be booked digitally as needed to strengthen the social network. A digital neighbourhood platform will also promote the exchange of information between tenants.

The flats contain the central elements of Smart Homes. In addition to a fibre-optic internet connection, intelligent heating control, controllable light sources, and sockets to reduce energy consumption, the flats are also equipped with sensors to measure humidity to determine the optimal ventilation options and security is enhanced by video and intercom systems.[36] Further, the integrated central control and smart switches allow individual control and promote the reduction of energy use.

Figure 7 Smart District Jena-Lobeda
© Stadtwerke Jena GmbH, Kuckkuck Fotodesign, GRAFIKERorg.de

36 Smartes Quartier Jena Lobeda. https://www.smartes-quartier.de/

Figure 8 Central control device
© Stadtwerke Jena GmbH, Kuckkuck Fotodesign, GRAFIKERorg.de

3.2 Smart Home on a District Level, New Construction: Future Living Adlershof

Similar to the above-described Smart Quarter Jena-Lobeda, the project 'Future Living Berlin' is also an intelligent housing quarter. In this case, however, the quarter has been newly constructed in the district Berlin-Adlershof, which is one of Germany's largest science and technology locations. The main features of the residential quarter are the barrier-free, age-independent, multicultural inclusive approach that offers optimised living conditions across all stages of life, whereby especially the smart and sustainable approach to the design and equipment of buildings, flats, infrastructure, and the residential environment is pioneering and very future-oriented.

The following topics are addressed in Future Living Berlin:

- Demographic change, Design for All,
- Smart Home and Smart Building for comfort, safety, and support,
- New forms of mobility,
- Novel energy concepts via local energy production and use,
- New sharing approaches,
- Smart facility management for smart residential buildings.[37]

During project development and the construction/design phase, the initiator of the project, the housing company GSW Sigmaringen, paid particular attention to ensuring that the neighbourhood was developed as an open and common area, despite the extensive technical installations. At the same time, they succeeded in creating affordable housing in the German capital which is even below Berlin city's rent index. With an open attitude towards all nationalities, the GSW places a high value on offering warnings, instructions, and information through integrated control panels in all flats in as many languages as possible. These panels allow the residents to control several functions of their accommodation, such as lighting, the opening and closing of blinds, or the room temperature, which is capped at a room temperature of 23 degrees as a result of the primal purpose of the low energy heating system. Hence, while a personalisation of the basic functions is possible for users, the cooperation of the building management is required for the processing of the building's complex system to ensure long-term functionality in this project.

Smart and energy efficient supply systems such as the approximately 600 photovoltaic panels, 17 air-heat pumps, and the use of efficient heat recovery systems in combination with battery storage of 156 kWh are some examples of relevant components in a new sustainable building complex. The project also sets relevant standards in the area of

37 Presentation Birgid Eberhardt, GSW Gesellschaft für Siedlungs- und Wohnungsbau Baden-Württemberg GmbH, 09.11.2022

climate adaptation using green roofs and sufficient seepage areas to withstand future extreme weather events. As a harmonious system from the individual residential unit to the entire neighbourhood complex, efforts were made to match everything both architecturally and technically. One unique example is the keyless locking system of the complex in connection with the automatic lift system, which starts moving as soon as the flat door is opened and practically 'picks you up'.

In retrospect, the project developer noted that smart technologies are still not easily integrated and connected within the different construction trades, as there were problems with the coordination of different crafts, and it turned out that different systems are not completely interoperable. This shows that there is a need for further projects in which the integration of smart technology in the construction of residential buildings and quarters is implemented as this could lead to the development of standardised processes with improved technical applications.

Figure 9 Future Living Berlin Bird's Eye Visual © Panasonic

Figure 10 Future Living Berlin © GSW

3.3 Smart Homes as New Resilient Building Projects: Autonomous Building for Citizens – The ABC Project in Grenoble

An iconic project in the context of sustainable building development is the ABC project realised in the city of Grenoble in France. The project was completed in 2020 by the developers Linkcity and Bouygues Construction South-East. With an investment of 10.8 million euros in building costs, it was possible to build up to 72 dwellings, of which 20 are designated for social housing while the rest of the 42 dwellings are on an intermediate cost level. It is unique due to the fact that the building complex is designed to be self-sufficient in terms of energy and water as well as in terms of establishing an optimised waste management system. The pillars of this project are the construction materials that were selected, the implementation of a circular economy by the infrastructure technology (water use and treatment, solar energy) and the behavioural aspects, including the implementation of smart devices in each flat to change and reduce the daily energy consumption.

The project is divided into the areas of autonomy, buildings, and citizens, thereby giving it the name ABC. The autonomy area (A) focuses on the recovery of rainwater, energy, and recycling. On an area of 1,130 m², a total of 688 PV modules work and store the energy in battery systems. Thermal energy is even recovered from the grey water and the battery systems. The water is collected and treated via the roof surfaces and should thus reduce consumption by one-third. In order to be as energy efficient as possible, all kitchens are certified with A+++ label installations.

In the area of building (B), the focus is on sustainable construction. With low-carbon concrete and insulation made of Weber cork, which is obtained from sustainable organic cultivation, the ABC Grenoble project is committed to a high level of sustainability. In particular, the implementation of a life cycle analysis shows that these buildings have been planned all the way through from construction to deconstruction.[38, 39]

The last fundamental pillar on which the project is built is the citizens (C) and it focuses on inclusion and the development of social dynamics. For this purpose, several offers are created, such as opportunities for involvement in workshops, gardening, or the organisation of activities in designated community rooms. Especially shared gardening is an intentional concept that was considered from the very beginning to strengthen the community. Even though the basic project was completed at the end of the construction phase in 2020, sociological surveys and assistance programmes were implemented in 2021 to further integrate vulnerable people. A final evaluation of the data is still ongoing.

38 https://sustainablecitybyfrance.org/realisations/abc-autonomous-building-for-citizens-2/

39 https://youtu.be/czEESaIFUlw

3.4 Smart Homes for Owners: Energy Efficiency – Demo Unit (Flanders)

The global energy demand is growing and so is the need to use energy and heat more efficiently. As an example of a potential strategy to increase the energy efficiency of building units, it pays off to look at the climate goals of Flanders. There, efforts are being made to reduce the emission of greenhouse gases in the Flemish Region by up to 2.3 megatonnes of CO_2 by 2050.[40] The long-term strategy for achieving this target is to increase the energy efficiency of buildings. In parallel, digital technologies are used to reduce heat and energy consumption. The overarching goal is that by the year 2050, even the oldest building will be comparable to newly constructed buildings in terms of energy efficiency. With the support of the energy labels from A to F, all residential buildings should save up to 75% on the EPC scale:[41]

- Energy performance of the building envelope (roof, facade, woodwork and glazing, floors),
- Compactness (volume and building's surface area of heat loss) and orientation, especially in the case of reconstruction or new construction,
- Energy carriers (natural gas, fuel oil, electricity, etc.) and heating techniques.

On the EPC scales used with energy labels (A to F), this corresponds to label A. This objective is further differentiated according to the housing typology. At the same time, a shift will be made towards sustainable heating. To achieve this long-term objective by 2050, two equivalent tracks were defined under the Renovation Pact: the implementation of a package of measures and the achievement of an energy performance indicator.

The Demo Unit aims to demonstrate the consequences of energetic renovation on energy consumption to homeowners in the neighbourhood. The Demo Unit is equipped with a thermostat and sensors and is actively monitored. The workers at the Demo Unit

40 ref. p. 4. Vlaamse Regering. 2020. Long-term strategy for the renovation of Flemish Buildings. https://acash.org.pk/wp-content/uploads/2021/03/beflanders_ltrs_2020_en.pdf

41 ref. pp. 9-11 Vlaamse Regering. 2020. Long-term strategy for the renovation of Flemish Buildings. https://acash.org.pk/wp-content/uploads/2021/03/beflanders_ltrs_2020_en.pdf

can simulate the consequences of different behaviours on energy consumption: for example, the windows stay open for three hours, or a new and large electronic device is being used.

The Demo Unit workers can also temporarily monitor individual homes in the neighbourhood to identify intensive energy consumption. Thanks to sensors, they can evaluate the energy consumption in real-time and then after two weeks to one month develop plans with the tenants or homeowners to indicate how to adapt their behaviour to reduce their global energy consumption.

Figure 12 Demo Unit verzonken Kasteel © City of Roselare

3.5 Thermo Scans and Retrofitting Coaches

The reduction of heat and energy losses in houses represents an important aspect in the design of Smart Homes because these can only regulate the saving of energy and heat to a certain extent. Old buildings and historical buildings in particular usually reveal enormous losses of energy and heat due to their weak substance and outdated technology. Possibilities to reduce the impact of these are, for example, thermo scans on the ground, with drones or planes, which can reveal deficiencies in thermal insulation. The Stronghouse Partner IGEMO developed a strategy with volunteers conducting thermo scans on the ground for free. In case of deficiencies in thermal insulation, retrofitting can turn out to be a costly aspect although, in the long run, it is a meaningful investment. This requires the advice of a retrofitting coach who can develop a sustainable retrofitting strategy on the basis of the thermo scans and further calculations.

Each property will receive an A-certificate by 2050. From 2023, due to new obligations imposed by the Flemish government, it is mandatory to retrofit homes with an energy certificate E or worse to label D within five years. There are also new obligations for new constructions. In order to achieve this task, the needs of local residents are first determined. Then, if possible, a follow-up project such as renovation advice (group sessions) commences. If a particular measure is required, group purchases can be started, without obligation (for example for wall insulation, roof insulation, solar panels, home batteries, and heat pumps). The offer is provided so that people can rely on a renovation coach to help them make a renovation plan, find contractors, and apply for subsidies.

Another practical example of this is the city of Münster, which has thermal-scanned the entire city in a large-scale project to offer citizens free advice on retrofitting options and subsidies for their homes.[42]

42 Thermographic scan Münster. https://smartcity.ms/thermografiebefliegung/

3.6 Discussions, Debates, and Trends

In this chapter, we have listed the main discussions, debates, and trends under the categories of strengths, weaknesses, threats, and opportunities concerning Smart Buildings and Smart Homes.

As we explained in the other chapters, Smart Homes are not only about more comfort, entertainment, and security but also about the house (or a building) technical services, which function more effectively and economically.

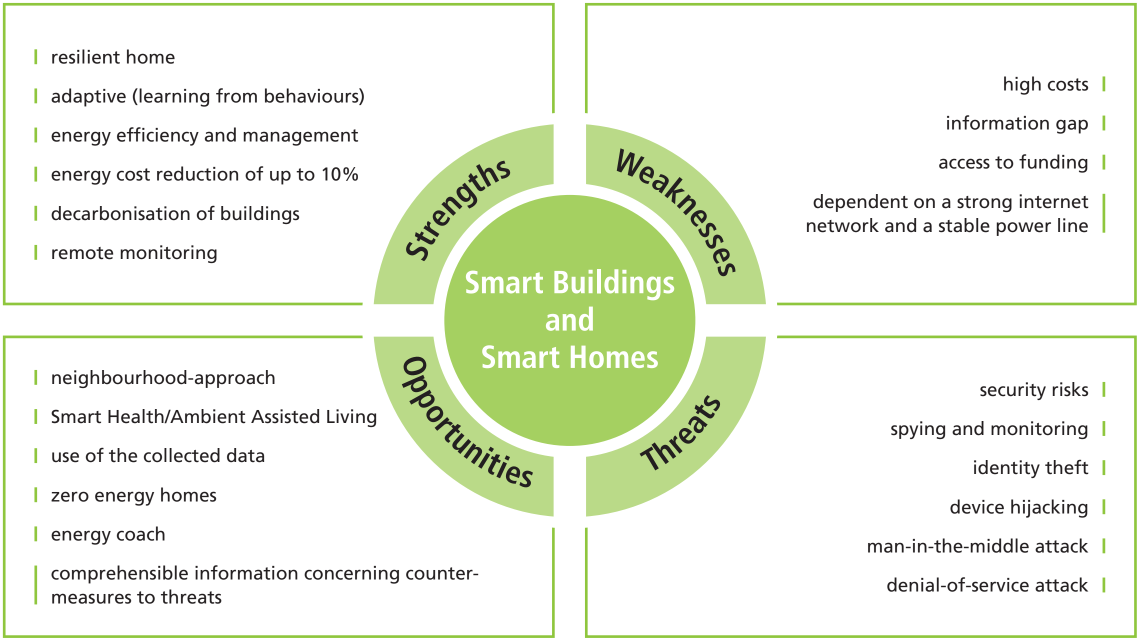

Figure 13 SWOT – Smart Buildings and Smart Homes © atene KOM 2023

TREND 1: SMART HEALTH/AMBIENT ASSISTED LIVING (AAL)

According to the German Federal Statistical Office, approximately 22 million people over the age of 65 will live in a single household in the year 2030. The major problems that this demographic group faces include the weakening of body functions in old age, as well as hearing and vision impairments. The atrophy of muscles and bones in old age can easily lead to accidents, which are partly registered too late in single households and can cause serious health damage or even be fatal. Through the use of Ambient Assisted Living technologies, it is possible to enable older and physically impaired people to live safely and independently in their homes. Through the use of light and sound it is possible for visually or hearing-impaired people to move freely in their homes or, for instance, to be informed when the doorbell is ringing.

Another example of this could be equipping a Smart Home with a door lock containing an emergency button or fire alarm, which would allow ambulance services to enter the home in the event of an accident or cardiac arrhythmia. Smart technologies can also be used to detect an accident or heart attack in a single household. Systems such as 'Capfloor'[43] are able to register if someone has fallen and, in combination with an emergency call system, independently call for help. Systems such as the 'SonicSentinal'[44] also help to recognise health problems or potential injuries at an early stage by analysing cries or unusual sounds and to initiate medical assistance. Concrete plans for age-appropriate housing are already being implemented in Europe, such as the Urban Age Project. Cities such as Helsinki and Santander as well as the Belgian region of Flanders are implementing pilot projects to enable age-friendly housing and to promote the participation and integration of older people.[45]

43 https://entwickler.de/eclipse/capfloor-wenn-der-fussboden-zum-touchscreen-wird

44 https://www.idmt.fraunhofer.de/de/institute/projects-products/projects/sonicsentinel.html

45 https://www.urbanage.eu/

TREND 2: ENERGY COACH

A Smart Housing Journey can, for example, start with an energy coach. If you are interested in the concept but not sure how to implement and finance the energy renovation of your building or house, engaging an energy coach is a very good start. The energy coach will work with you to see what you can do to reduce your energy consumption, including through simple (behavioural) measures and will explore options with you for generating sustainable energy. Further steps in the field of energy coaching should therefore be the extension of the portfolio in terms of Smart Housing applications, which will also reduce energy consumption.

A good example of how to implement it in your community comes from Drenthe. The Drents Energie Loket, supported by the province of Drenthe and inspired by Stronghouse, has trained 50 extra energy coaches. In Drenthe, the energy coaches are volunteers providing information without commercial purpose in their municipality.

TREND 3: THE STRONGHOUSE NEIGHBOURHOOD-APPROACH

Apart from the discussions related to the advantages and disadvantages of Smart Buildings and Homes, one of the biggest remaining challenges is how to raise awareness among homeowners and local authorities. Because citizens and especially local communities will play a crucial role in the energy transition, it is important to tackle the information gap between the various governmental initiatives (on the EU and national level) and individuals. The Stronghouse approach thus aims to motivate and empower homeowners – individually and on a neighbourhood level – to invest in energy renovation/retrofitting their homes. Thanks to the neighbourhood approach, it is possible to organize the necessary scale and drivers to invest.

The Stronghouse Project develops, adjusts, and redesigns measures that enable homeowners to invest, organize scale, and gain access to services and products. It also tries to strengthen regional small and medium-sized enterprises (SMEs) and make the local market more interesting and dynamic.

MORE ABOUT THE STRONGHOUSE APPROACH

Take a look at our free e-learning, in which you will find answers to your questions!
https://northsearegion.eu/stronghouse/stronghouse-e-learning-courses-lets-get-started/

Do not hesitate to contact atene KOM GmbH or the other Stronghouse partner, we would be happy to support you and your community on your Smart Housing Journey.

WEAKNESS: WHAT HAPPENS TO MY SMART HOME IF THERE IS AN INTERNET OUTAGE OR POWER CUT?

Most of the smart devices (for example smart locks, garage openers, and some cameras) are also battery-powered, so they can keep working as usual even if there is a power cut lasting a few hours, and only the remote capabilities will not work since they rely on the internet or a connected hub. Without an active internet connection, it really depends on the choice of your smart hub and devices as some of them do not need an internet connection whereas others will turn to 'dumb' which means that you will have to activate and regulate the device (light switcher, heat thermostat…) yourself. If, for example, the locking system should fail in the event of a power cut, it should also be possible to carry out a manual override.

ILLUSTRATION OF POSSIBLE THREATS AND COUNTERMEASURES

One of the most important features of a Smart Home is that it should function securely and reliably. Digital end devices as well as Smart Home elements are a potential target for digital attacks from outside, whereby especially wireless and internet-based devices are vulnerable because of their connection to the world wide web which creates loopholes for cyber attacks or malware that could infiltrate systems. In addition to the theft of personal data, the safety of residents can also be affected. The following Figure 14 illustrates the dangers involved and how best to protect oneself against them.

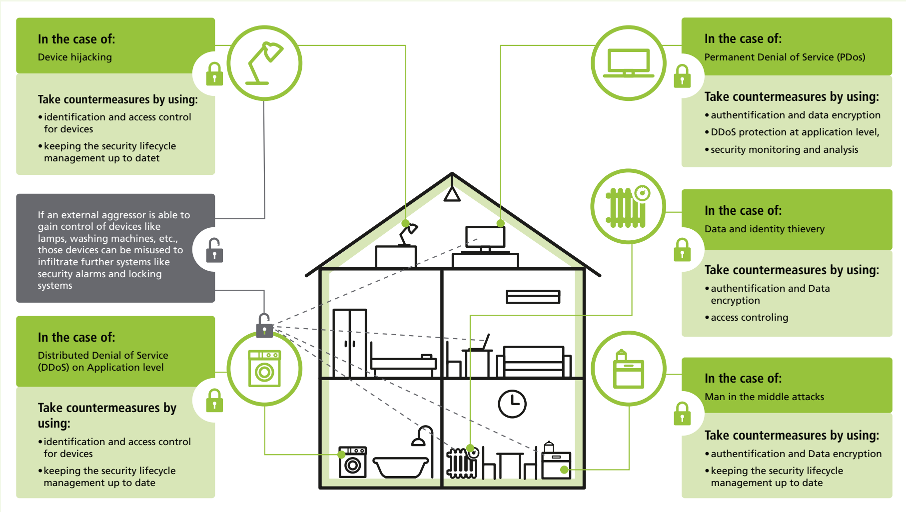

Figure 14 Possible threats and countermeasures based on https://www.rambus.com/iot/smart-home/

Common threats in Smart Homes include Distributed Denial of Services (DDos) and Permanent Denial of Services (PDos) attacks. These are rapid attacks on security gaps in device software to cause damage to the hardware of a system (PDos) or to slow down or overload a system (DDos) through a constant flood of connection requests, messages, and data packets.[46, 47] As in the general handling of security on digital devices, many dangers can already be mitigated by using strong passwords and security accesses, as well as data encryption. Furthermore, it is essential to regularly update the software to prevent security gaps.

Furthermore, an encrypted and secured Smart Home network also makes it more unlikely that man-in-the-middle attacks can be carried out. This form of cyber attack involves simulating or intercepting users' communications with other parties, which can be used to intercept personal data as well as passwords and access data.[48] This can even lead to identity theft, as well as provide attackers with opportunities to hijack devices and gain access to the residence. For this reason, emphasis should be placed on regulated access control and identification of Smart Home systems to avoid such occurrences. Just as windows are fundamentally not burglar-proof, neither are Smart Home technologies. Although security technology such as cameras or door sensors enables better control, it is impossible to guarantee a 100% level of security.

Data safety and further data usage

The public discourse on Smart Homes is mixed and often reveals the two sides of digitalisation processes in the home environment. On the one hand, networked technologies in homes simplify everyday life, save time, energy, and money and thereby make life easier. On the other hand, many users of these tools sacrifice a great deal of their privacy and reveal almost all of their private data to digital assistants.

The most important thing when dealing with this information is that it must be

46 https://howdoesinternetwork.com/2012/permanent-dos

47 https://www.techtarget.com/searchsecurity/definition/distributed-denial-of-service-attack

48 https://www.imperva.com/learn/application-security/man-in-the-middle-attack-mitm/

anonymised and should only be used to increase the efficiency of the home system. A further issue is the linking of data from different systems because if this does not happen, a home cannot be intelligent by definition.[49] This is also in line with the needs and wishes of the consumers. However, as the local storage on these media is often limited, data is not stored locally. Instead, they are often stored on the servers of the producers.[50] Especially smart speakers such as Alexa, Google, and Siri collect a great deal of personal data, such as name, time zone, phone number, as well as the location of devices and computers and your IP address. Even acoustic models of voice characteristics are being generated[51] and while these data sets are used by producers to improve the performance of the units and make them smarter they also have the potential of being misused. Not only personal information is being gathered in Smart Homes and can be used for further purposes but also the data generated from a Smart Home can be set in a bigger context, like in form of a Smart Building using 'crowdsourcing'[52] methods.

For example, using sensor data collected on the outside temperature and wind velocities around Smart Homes, it is possible to make much more precise weather forecasts for a specific area if the data from several Smart Homes can be linked with each other. Smart Homes could retroactively be linked to weather stations to enable intelligent ventilation of the houses or, for example, to prevent storm damage. There is also the possibility of linking Smart Homes with public services. For example, an on-demand emptying of intelligent waste bins that display the fill level could be arranged with the municipal cleaning companies.[53]

49 Fingas, Durch Roger. 2022. Smart home privacy: What data is collected, and how is it used? Android Authority https://www.androidauthority.com/smart-home-privacy-3065661/

50 cf. Price, Dan. 2017. Smart Home Data Collection: Are Companies Going Too Far? https://www.makeuseof.com/tag/smart-home-data-collection/

51 Alex. 2021. What data do smart assistants collect about us? https://blog.online-convert.com/what-data-do-smart-assistants-collect-about-us/

52 The activity of getting information or help for a project or a task from a large number of people, typically using the internet. https://www.oxfordlearnersdictionaries.com/us/definition/english/crowdsourcing

53 Agrawal, Jyot. 2018: 3 Ways How Businesses Can Use Data from Smart Homes. https://datafloq.com/read/3-ways-how-businesses-can-use-data-from-smart-home/

The future use of personal data, especially concerning health status, is particularly interesting for insurance companies. A dystopian aspect, however, is that a completely transparent view of health data, consumption, and exercise behaviour poses the risk that people with unhealthy lifestyles will no longer be able to insure themselves or find jobs, as they represent a loss for the insurance companies or employers from an economic point of view.[54] However, it should be borne in mind that detailed information on the state of health also enables appropriate treatment in the event of an emergency.

54 Hearn, Patrick. 2021. Smart home technology needs to be more private to handle personal health https://www.digitaltrends.com/home/smart-home-technology-must-defend-personal-health-data/

4 FINANCING FOR SMART RESIDENTIAL BUILDINGS AND SMART HOMES

How can more Smart Homes be created? As described in the previous chapter, both developing and constructing new building complexes or quarters as well as renovating existing homes are possible. Including Smart Home technology in building projects will very likely raise the cost compared to building projects without such technology. However, the investment is likely to amortise after a certain period of time due to more energy efficiency. Still, an upfront investment is needed. This chapter describes the current funding trends on the European level and lists examples of German funding opportunities as an example for national funding.

4.1 Examples of EU Funding

The European Union has recognised the building sector as an important lever to activate on the way to become the first climate neutral continent by 2050 as stated in the European Green Deal – one of the main priorities of the von der Leyen Commission.[55] Smart Home has not been established as its own topic of funding. Currently, this topic is dispersed among several strategic topics related to either energy efficiency or digitalisation.

EU Renovation Wave

A 'Renovation Wave for Europe – Greening our buildings, creating jobs, improving lives' is a key initiative to boost energy renovations of both public and private buildings by presenting available EU funding solutions. On the policy level they will

- include direct investment opportunities
- activate private investments
- foster research and innovation
- address market barriers and technical assistance

While this initiative includes also topics related to the decarbonisation of heating and cooling as well as energy poverty, one important focus area in this context is the energy efficient renovation of worst-performing buildings. Therefore, it is worth thinking about modernizing the technology within these buildings and making them smart if comprehensive renovations of the building fabric are necessary.

European Local Energy Assistance (ELENA)

This facility provides technical assistance for projects in energy efficiency, sustainable housing and sustainable transport. The grant support aims at triggering private investments in these three fields. Among the supported investment programmes are initiatives from both the public and private sector with a budget above 30 million euros.

55 https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en

Overview of national support measures

As the EU funding opportunities do not address homeowners directly in the energy and smart renovation of their homes, the EU provides an overview of support measures provided by the Member States. As the list is only updated every three years, the overview is not always up to date or complete.[56]

The following chapter, provides an overview of exemplary national funding options from Germany.

4.2 Examples of German Funding

Federal funding for efficient buildings (BEG)

This funding refers to several funding programmes that support the optimisation of energy efficient and renewable energy systems as well as heating systems and the insulation of building envelopes and combines them into a single programme under the guidance of the German Ministry of Economy and Climate Protection (Bundesministerium für Wirtschaft und Klimaschutz, BMWK), with a funding rate of 20%, except for heating systems, which can be funded with up to 45%. Furthermore, it includes the use of optimised systems technology. In addition, construction supervision and technical planning by experts can also be subsidised. The BEG itself is divided into three sub-programmes. First, the BEG WG for residential buildings. Secondly, the BEG NWG for non-residential buildings, and thirdly, the BEG EM for individual measurement projects. In addition to private individuals and homeowners' associations, municipalities as well as cooperatives and institutions under public law, and other legal entities under private law, including housing cooperatives, are also eligible to apply.

56 https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficient-buildings/financing-renovations_en

Federal funding for efficient buildings, residential building – credit

The KfW-Bank (Kreditanstalt für Wiederaufbau), Germany's leading promotional bank, provides funding for the construction and purchase of energy efficient houses, as well as for the complete renovation of monuments or buildings that are particularly worthy of preservation. With a view to climate-friendly construction or renovation, the KfW-Bank supports private individuals such as owners, landlords, and tenants, as well as companies, municipal enterprises, freelancers, social organisations and associations, cities, districts, and all legal entities under private law. Divided into several performance classes, depending on the type and age of the buildings, this results in different loan amounts of up to 120,000 euros. This value can also be increased to up to 150,000 euros if the building achieves a new efficiency status with sustainable energies and is certified for this.

Energy and resource-saving neighbourhood development and renewal

A holistic approach to the development of energy and resource-efficient housing is offered by the Deutsche Bundesstiftung Umwelt (DBU). The spatial location and interconnectedness of the neighbourhood as well as the existing physical-technical, natural, social, economic, and building-cultural conditions and requirements are to be considered. In concrete terms, neighbourhood renewal is to be carried out with highly efficient CHP plants, local heating networks, and structurally integrated plants for the generation, storage, and use of renewable energies. In addition to funding individual and cooperative projects, companies and associations must contribute only 50% of the project costs while universities are subsidised by up to 100%.

Ownership financing BW – additional funding for energy efficiency

Institutions such as the L-Bank in the state of Baden-Württemberg provide additional funding programmes for the energy efficient refurbishment of old buildings. The funding aims to optimise the energy efficiency of old buildings and monuments according to the specifications of the BEG. There are two credit options for this. The first is the 'Rehabilitation Plus and Monument' loan with a limit of 120,000 euros, and the second is the 'Individual Measures and Measures' package with a financial limit of 50,000 euros. In addition to renovating a building yourself, it is also possible to purchase a secondary building after the renovation. To receive the funding, it is necessary to involve an energy advisor in this project.

Age-appropriate conversion

In addition to the opportunities for energy efficient buildings, the development of age-appropriate and barrier-free buildings is an important segment of housing promotion. Therefore, KfW offers a loan of up to 50,000 euros in the form of a loan with an interest rate of 1.47% p.a. The aim is to reduce barriers and increase living comfort and protection against burglary. The loan can also be combined with other funding programmes and can furthermore be used for the acquisition of a newly renovated property as well as certain building-related operating and drive technology, such as control technology for heating and lighting, doors, roller shutters, and windows. It is therefore an opportunity for private individuals, regardless of age, to prepare for ageing or immobility. In addition, these loans can be used by homeowners' associations, housing associations, housing cooperatives, property developers and cooperatives, as well as public institutions.

Barrier reduction – investment grant

A similar programme to the previously mentioned 'Age-appropriate conversion loan' is the 'Barrier reduction investment grant', which is also provided by KfW. It includes several options for funding modernisation and barrier-free extension projects in a range from funding area 1 to funding area 7. To summarise the investment process, there are two ways to receive funding. Firstly, individual measures to reduce barriers, which can be subsidised with up to 50,000 euros per housing unit with a personal contribution of

10%. Secondly, for a standard house suitable for the elderly, for which the personal contribution is calculated at 12.5%. The subsidy is tailored to private individuals regardless of age, as well as to owners of a detached or semi-detached houses, first-time buyers, and condominium associations.

Modernization of rental and cooperative apartments and owner-occupied housing

This modernisation funding is provided by the state of Mecklenburg-Vorpommern and serves to improve the housing quality of rental and cooperative flats as well as owner-occupied housing with the overarching goal of stabilising the housing market and supporting the urban redevelopment process. The funding is provided, in particular, for the installation of Smart Home components and burglar-resistant security systems as well as building-integrated charging and wiring infrastructure for e-mobility. The requirement for a grant is that the target property is a residential building which is at least 10 years old and is part of the Mecklenburg-Vorpommern state development programme. The funding is capped at a maximum of 104,000 euros per residential unit and a minimum of 20,000 euros, with an own contribution of at least 20%.

As it was shown, Smart Home technologies shouldn't be underestimated about their use for sustainable and energy efficient buildings, as well as their improvement to increase the living quality. If you may have further Question, how to start your own Smart Home journey please contact us and our Stronghouse team.

5 INDEXES

Glossary

Actuator
An actuator is a device that produces motion by converting energy and signals supplied to the system.

Ambient Assisted Living
The generic term for various technologies that support people in need of care in managing their everyday lives inside and outside their own four walls.

Data Encryption
Data encryption is a way of translating data from plaintext to ciphertext. Users can access encrypted data with an encryption key and decrypted data with a decryption key.

Decarbonisation
Decarbonisation refers to the shift of an economy, especially the energy economy, towards a lower turnover of carbon.

Low Pass Filter
In electronics, a low pass filter allows signal components with frequencies below its cut-off frequency to pass through almost unattenuated. They are used to protect networks against high frequented signals.

Demographic Change
Demographic change describes the changes in population size and structure caused by changes in birth rates, death rates, and by migration.

Design for All
Design for All is a concept for planning and designing products, services and infrastructures with the aim of enabling all people to use them without individual adaptation or special assistance.

Device Hijacking
When a legitimate device is hijacked for the purposes of carrying out fraud, that device is known as a hijacked device.

European Green Deal
The European Green Deal is a package of policy initiatives that shall support the aim of making the EU become the first ‘climate neutral bloc’ by 2050.

Grey Energy
Grey energy describes the total amount of energy required over the life cycle of a product, from the extraction of resources to their degradation through recycling. It also describes the energy that is derived from fossil fuels.

Home Assistant
Home assistants are home automation devices designed to be the central control system in a Smart Home or Smart House.

Identity Theft
Identity theft is the crime of making use of another person's private information and data without the knowledge of the victim.

Man-in-the-Middle
A man-in-the-middle attack is a form of attack that is used in computer networks. The attacker stands either physically or logically between two communication partners, has complete control over the data traffic between two or more network participants and can view and even manipulate the information at will.

Monitoring
Monitoring is the supervision of processes. It is an umbrella term for all types of systematic recording, measurement or observation of an operation or process by means of technical aids or other observation systems.

Parallel Wire Connections
Parallel wire connections are additional wires combined with power cables that allow the transfer of small Data packages to envelope communication between devices.

PropTech
Short for 'Proprietary technology'. The term describes any combination of processes, devices, or systems that are the property of a business or individual.

Resilience
Resilience describes the successful process of individuals when adapting to challenging situations and experiences by flexibility and adjustment of behaviour.

Return Channel	Return channels are used in Smart Home devices to double-check and confirm commands in order to increase the security of the network and prevent misleading signals.
Sensors	A sensor converts the physical quantity to be measured into an electrical quantity and processes it in such a way that the electrical signals can be easily transmitted and further processed.
Security life-cycle Management	Security life-cycle management refers to the coordination of spare parts management, technical communication, service field management and product support to maximise uptime at the customer site.
Smart Building	Smart buildings are digitalised and virtually connected buildings. The related technical building equipment and automation processes allow to save energy, increase user comfort and ensure safe operations.
Smart Data	Smart data are data sets that have been extracted from larger data sets according to certain structures by means of algorithms and receive meaningful information.
Smart Home	A Smart Home is a home equipped with lighting, heating, and electronic devices that can be operated remotely by smartphone, computer or further control elements.
Smart Home Hub	With a Smart Home Hub it is possible to connect different smart products to a home. This makes it possible to operate them via a central device.
Smart Meter	Smart meters are gas, water or electricity meters that receive and send data digitally and are integrated into a communication network for this purpose.

Smart Office A Smart Office responds to modern forms of work and cooperation as well as to the needs of hybrid working culture. It uses smart technologies that may improve comfort and productivity of the employees.

Trigger A trigger is the activation of a sequence of events that can have a cascading or predetermined effect on other processes.

Voice Assistant A voice assistant is a new type of product marketed by companies like Apple, Amazon and Google based on natural language speech recognition. They enable a search to be performed with a voice command entered by the user and information to be retrieved using speech synthesis.

Zero Energy Homes A zero energy home is a standard, that describes a building producing sufficient renewable energy to meet its own annual energy consumption.

List of Abbreviations

BEG	Bundesförderung für effiziente Gebäude / Federal Support for Efficient Buildings
BUS	Binary Unit Systems
BMWK	German Federal Ministry for Economic Affairs and Climate Action
DBU	Deutsche Bundesstiftung Umwelt / German Federal Environmental Foundation
DDoS	Distributed Denial of Services
EIB	European Installation BUS
ELENA	European Local Energy Assistance
EPBD	Energy Performance of Buildings Directive
EPC	Energy Performance Certificate
CHP	Combined Heat and Power
IoT	Internet of Things
KNX	Konnex
PDoS	Permanent Denial of Service
SDA	Domestic Appliances
SME	Small and Medium Enterprises
SRI	Smart Readiness Indicator

List of Tables

List of Figures

About atene KOM

As an experienced partner, atene KOM supports the public sector in the development and implementation of projects in the areas of digitalisation, energy, mobility, health and education.

Together with municipalities, districts and companies, we develop the infrastructure for the future. Our goal is to strengthen the regions: With partners in Germany and across Europe we are working on future projects such as the digitalisation of rural areas. We develop smart mobility concepts for local and long-distance transport and intelligent strategies to promote energy transition.

In doing so, we support our partners with around 500 experts from the fields of administration, IT, law, business, education, communication, urban/regional development and geoinformation systems with customised solutions for complex tasks.

Proximity to our customers is important to us: We are present at eight locations in Germany as well as in Brussels, Kyiv and Tirana.

Imprint

atene KOM GmbH

Agency for Communication,
Organisation and Management

Invalidenstr. 91
10115 Berlin

Tel. +49 (0)30 / 60 98 990-0
Fax +49 (0)30 / 60 98 990-99

info@atenekom.eu
www.atenekom.eu

Authors:

Claire Piqueret Rose
Hendrik Doktorczyk
Britta Schmigotzki
Johanna Varanasi

Published in 2023

LET´S GET STARTED ON THE SMART HOME JOURNEY!

Get in touch!

Stronghouse Project Partner
atene KOM GmbH
Invalidenstraße 91
10115 Berlin

Britta Schmigotzki
Project Manager
Phone: +49 30 22183-3101
Email: b.schmigotzki@atenekom.eu
www.atenekom.eu