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my SMART Life

Deliverable due date: M36 – November 2019

D4.3 New predictive and adaptive control algorithms and monitoring of performance, smart demand control system

WP4, Task 4.2

Transition of EU cities towards a new concept of Smart Life and Economy

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Project Acronym	mySMARTLife
Project Title	**Transition of EU cities towards a new concept of Smart Life and Economy**
Project Duration	1st December 2016 – 30th November 2021 (60 Months)
Deliverable	D4.3 New predictive and adaptive control algorithms and monitoring of performance, smart demand control system
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Status	☐ Working ☐ Verified by other WPs ■ Final version
Due date	30/11/2019
Work Package	WP4
Lead beneficiary	VTT
Contributing beneficiary(ies)	HEN, HEL, FVH, FOU
Task description	**Subtask 4.2.3 Innovative BEMS and Smart Control Demonstration of heat demand response at apartment level** (VTT: 5 PM) Description: In Merihaka/Vilhonvuori and Kalasatama High-Performance residential buildings with waste heat recovery and an optimised control system for the district performance and user comfort. The solutions include smart meters and smart building automation systems with demand side management possibilities. The solutions enable demand side management both in heating and electricity use. In addition, the automation has interactive and visual user interface. The automation can use both temperature and human comfort set point values (HTM). The advantage in human comfort set point values is that it takes into account adaptive comfort aspect increasing users' well-being and making possible to save energy. Together with HTM also predictive algorithms are used for optimised energy and peak power use. HEN will lead this task, together with HEL, FVH and VTT. Other Partners participating: HEL (3PM), FVH (0,5PM), HEN (5PM)

Date	Version	Author	Comment
06/04/2017	0.1 - 0.3	Mari Hukkalainen (VTT)	Structure of the report and allocation of writing work
02/10/2017	0.4	Tapio Toivanen	SAL input
11/10/2017	0.5	Timo Ruohomäki (FVH)	Updates on Chapter 4
19/10/2017	0.6	Kristiina Siilin, Pekka Takki (HEN)	HEN inputs
27/10/2017	0.7	Marja Vuorinen (HEL)	Section 3.4
27/10/2017	0.8	Mari Hukkalainen, Zarrin Fatima, Kalevi Piira, Pekka Tuomaala	Integration of partners inputs, checking the overall deliverable and unifying the style of the contents. Synchronisation with D4.4.

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16/11/2017	0,9	Mari Hukkalainen (VTT), Timo Ruohomäki (FVH)	Finalisation of the interim version. English version of the appendix 1 from Timo added.
27/11/2017	1.0	CAR	Alignment of contents and final review

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Abbreviations and Acronyms

Acronym	Description
BACnet	Building Automation and Control Networks
BEMS	building energy management systems
CIM	Common Information Model
DH	District Heating
DR	Demand Response
DSM	Demand Side Management (DSM)
GDPR	General Data Protection Regulation
HTM	Human Thermal Model
IoT	Internet of Things
KNX	Konnex
mySMARTLife	Transition of EU cities towards a new concept of Smart Life and Economy
UI	User Interface

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1. Executive Summary

This deliverable describes the innovative building energy management systems (BEMS) and smart control strategies demonstrated in Merihaka/Viihonvuori (Zone 1) and Viikki Environment House (Zone 3) in Helsinki. Predictive algorithms have been defined for apartments to achieve optimization of the heat demand response. The implemented solutions are based on Demand Response to optimize energy usage and simultaneously employ VTT's Human Thermal Model (HTM) to ensure wellbeing and comfort of the users.

In Merihaka, Salusfin's Demand Response solution will be installed in 167 apartments. The solution expects to achieve 10 – 25% energy savings through smart heating management and user control. This system is responsible for managing room level temperatures and hence, for the whole apartment. Here the concept of heat demand response is essential as it leads to either increasing or decreasing the amount of heat supplied to the home and is dependent on the measurements of the smart thermostats. The details are used as inputs for the heating algorithm to adjust the temperature.

In Kalasatama, the demonstration actions focus on paving the road for up taking the smart home and energy solutions in new buildings. The required change is pushed among others through the terms for the plot assignments in the Kalasatama area. These terms target to ease the implementation of the smart solutions, and the discussions are on-going to replicate these terms to be used in all districts in Helsinki.

In Viikki's Environment House, the objective is to demonstrate that momentarily increasing or decreasing the indoor temperature can lower the cost of district heating and reduce peaks in heat demand. The room temperature is kept stable with the help of smart thermostats. The Cloud server operated by Fourdeg utilizes hourly price signals from Helen and adjusts the temperature accordingly during office and non-office hours. Each thermostat in the room operates individually and performs the DR functions when necessary. The actions revolve around the idea of making the user more aware of energy usage and enabling the users to not only maintain their comfort level using HTM, but to also reduce energy consumption at the same time.

According to the initial plans of the tasks related to this deliverable, most of the predictive and adaptive control algorithms will be ready in the current established due date, month 12. However, the monitoring of their performance and especially, the smart demand control systems that need some adjustments, lead to a need for more time to fully guarantee the quality of the deliverable and the delivering of top-quality results.

Considering that an Amendment was requested in September (month 10) and that the process of negotiation and approval can still take several months, it was agreed with the Project Officer to submit an interim report at the original due date, including the description of most of the algorithms. In this

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Amendment, a new due date in month 36 is requested to provide not only the final design of the performance of these algorithms but even some insights from those already deployed.

This deliverable will be updated and detailed later in M36, when the actions have been implemented. This version describes the overall situation as known before the implementation of the demonstration actions.

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2. Introduction

2.1 Purpose and target group

This deliverable describes innovative building energy management systems (BEMS) and smart control strategies that have been demonstrated in Merihaka, Kalasatama, and Viikki Environment House located in Helsinki. Predictive algorithms have also been defined for the optimization of the heat demand response at an apartment level. The algorithms are based on the earlier background knowledge of the Finnish partners. The results are targeted at experts and researchers interested in practical applications of demand response.

The work reported here is related to Task 4.2 focusing on Smart Homes Deployment. There is also a strong focus on Subtask 4.2.3, which aims to develop innovative BEMS and smart control demonstration of heat demand response at an apartment level. The demonstrations have been performed in **Zone 1**: Merihaka and Vilhonvuori (Action 4) and **Zone 3**: Viikki Environment House (Action 7). The solutions include smart meters and smart building automation systems with demand side management possibilities. The solutions enable demand side management in the use of both heating and electricity. Additionally, the automation system has an interactive and visual user interface. The automation can utilize both temperature and human comfort set point values based on VTT's Human Thermal Model (HTM). The advantage in human comfort set point values is that it takes into account adaptive comfort aspect, which increases the users' well-being and leads to potential energy savings. The HTM is used together with predictive algorithms to optimize energy usage.

2.2 Contributions of partners

Table 1 shows the contributions of the partners for this deliverable. VTT will lead the deliverable while HEN will lead Task 4.2.3 together with HEL, FOU, SAL and FVH.

Table 1: Contribution of partners

Participant short name	Contributions
VTT	Lead of the deliverable, main writing responsibility. HTM in Merihaka (Section 3.4 and 5.2). Kalasatama: requirements for smart homes (Section 4.1).
HEN	Lead of the task 4.3.2, which is reported in this deliverable. Section 3.2: Demand response concept. Section 3.3. Electricity demand response in Viikki.
FOU	Demand response development in office building: Section 5.1.
SAL	Demand response development in an apartment building in section 3.1. Figure and inputs to section 3.3.

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HEL	Inputs to Kalasatama, Viikki and Merihaka actions.
FVH	Section 4.2 Kalasatama: smart homes. Appendix 1. terms for the plot assignment

2.3 Relation to other activities in the project

Table 2 depicts the main relationship of this deliverable D4.3 to other activities and/or deliverables developed within the mySMARTLife project, which should be considered for further understanding of the content.

Table 2: Relationship to other activities in the project

Project activity	Contributions
D4.1	Provides the overall baseline for the Helsinki demonstrations
D4.2	Describes retrofitting actions and actions implemented in new buildings. The described demand response solutions (Action 4) complement Action 1
D4.4	This report D4.3 is closely followed by D4.4, which describes the implementation and performance of innovative smart system appliances and control algorithms, BEMS and smart control in Helsinki demonstration

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3. Adaptive control strategies in apartment buildings

3.1 Introduction to smart thermal control strategy at apartment level

The smart thermal control strategies have been developed in the Action 4: **Demonstration of heat demand response at apartment level at Merihaka/Vilhonvuori.** In addition, the smart homes will be connected to the IoT platform as highlighted in Actions 47 and 48. In Zone 1 Merihaka/Vilhonvuori, a total of 167 flats will be provided with a system comprised of smart thermostats connected to the district heating with the help of IoT and cloud-based intelligence to load balance the network. Data will be used to study more transparent and usage dependent cost sharing in heating. At the moment, the costs of heating are sent to the housing company and each apartment (dwelling) pays an equal share. Neither the residents nor the dwelling owners have economic incentives that could lead to reducing the heating costs.

Smart home/away functionality and smart management of electricity consumption concept is designed with the residents as part of the demonstration implementation, as these are expected to lower the total energy consumption. Dwelling implementations together are expected to lower the total energy consumption by 10-15 %.

The demonstration efforts are expected to lower the total energy consumption by 10-25% and may be achieved by:

1. Technical implementation
   - Precise and smart heating controls
   - Remote heating controls
   - Machine learning and ventilation/window open features
   - Scheduling and optimization
2. User behaviour
   - Fully utilizing solution features (e.g. dynamic heating control, absence temperature drop)
   - Having motivation to utilize the solution’s capabilities
   - Knowing cost related information? effect of increased cost awareness
   - Understanding the ease of use

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3.2 Demand response concept

The building mass is used as a heat storage to balance district heating consumption peaks. A system level diagram is illustrated in Figure 1. Apartment level heating is managed and controlled by a smart heating management system. The heating control system uses smart thermostats in apartments to manage room level temperatures.

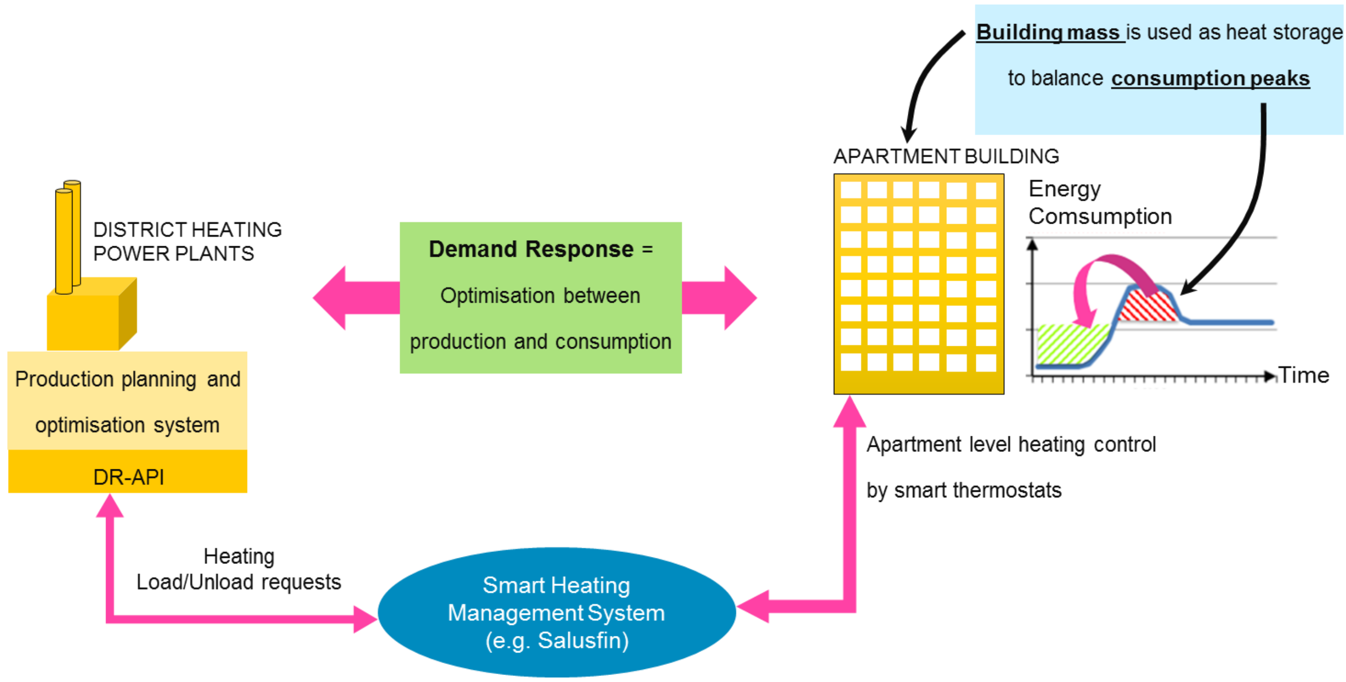

Figure 1: System diagram (figure from Helen)

District heating production is continuously planned and optimized. The production planning system is based on heating upload and unload requests (i.e. heating consumption increase or decrease requests) that are sent to the smart heating management system. These requests are provided hourly as illustrated in Table 3. The heating management system uses these requests as inputs for heating management algorithms. The heating in the apartment is either increased or decreased as shown in Figure 2.

Table 3: Load/Unload requests

HOURS	WEEKDAY	HOURS	WEEKEND
0-3	NORMAL	0-4	NORMAL
3-6	LOAD	4-7	LOAD
6-9	UNLOAD	7-10	UNLOAD
9-15	NORMAL	10-16	NORMAL
15-18	UNLOAD	16-19	UNLOAD
18-24	NORMAL	19-24	NORMAL

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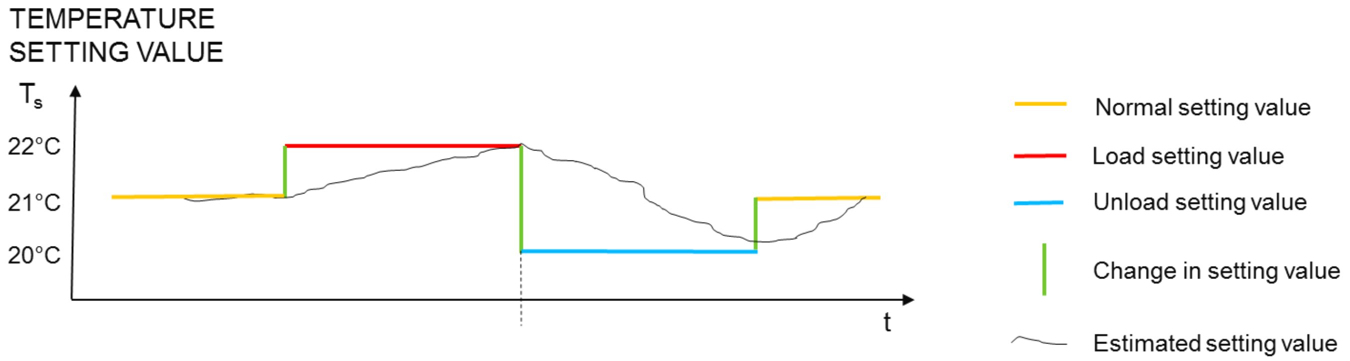

Figure 2: Temperature setting values

3.3 Relationships and contracts for thermal demand response (Hannu/HEN + Tapio)

Salusfin operates the Demand Response (DR) platform for district heating. Helen is the platform concept owner and makes agreements with the housing association and operator (i.e. Salusfin). Salusfin takes the head load requests from the interface developed by Helen. Based on the agreement, Salusfin adjusts heating and keeps the ambient temperature between an agreed high and low boundary. Salusfin optimization service can provide heat to the apartment prior to DR temperature drop.

Demand Response-contract is a contract between the housing company and energy company (Helen Oy). The contract will define the terms and conditions of the housing company participation in district heating demand response functionality (Figure 3).

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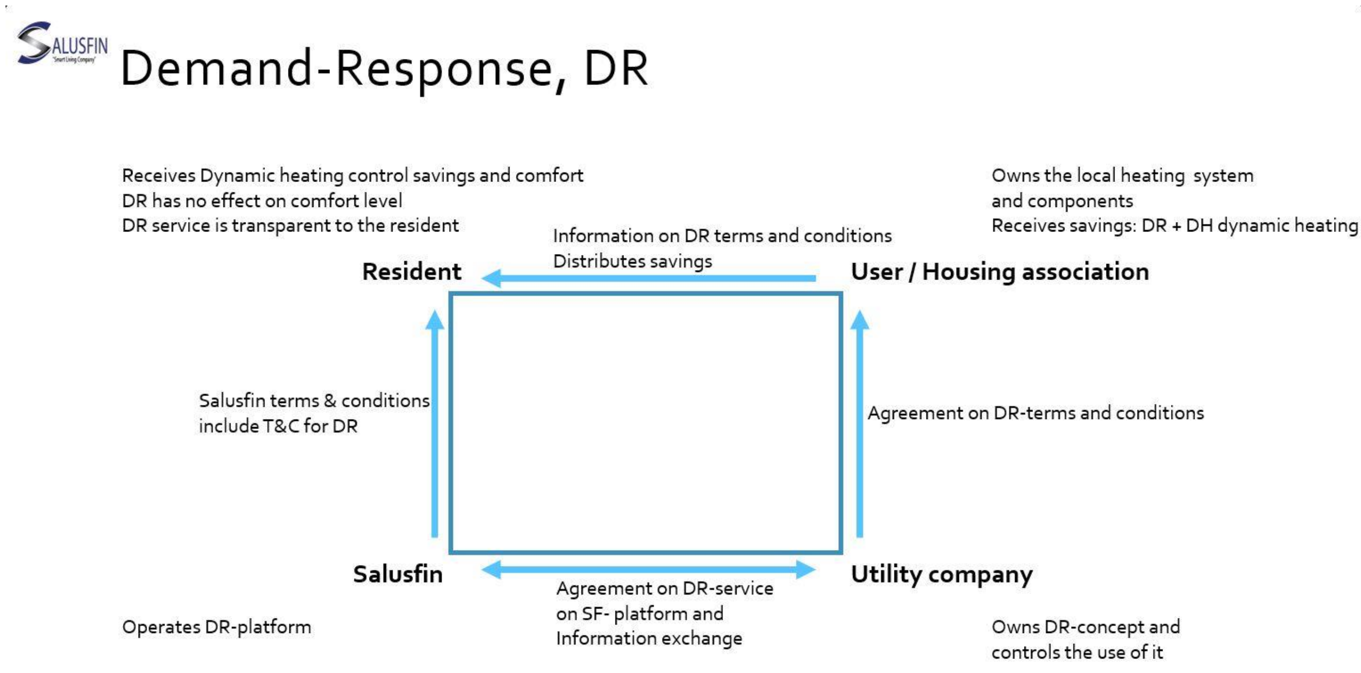

Figure 3: Contractual relationships between residents, housing associate, utility company and the technology provider (figure by Tapio Toivanen / Salusfin Oy)

3.4 Evaluation of thermal comfort with Human Thermal Model in Merihaka

In Merihaka, VTT's HTM model will be used to analyse the thermal comfort of the building in two test apartments. These two apartments were chosen based on voluntary participation to the research, where the residents promised to offer their data for making the HTM analysis. HTM will not be used here as a control algorithm. HTM and its use is explained in more detail in Chapter 5.2

The HTM analysis requires setting up some additional input needs:

1. Measurements needed for the HTM model:
   - Indoor air temperature
   - Indoor air humidity
   - Significantly differing temperatures for surfaces (window, radiator, a wall)
   - Optional (not applied in this demonstration action): average air flow velocity at the areas which are often occupied and surface temperatures for all walls
2. Geometry of the apartment

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- Room dimensions (width, length, height)
- Windows' sizes and locations
- Radiators' sizes and locations

3. Information about the human, using one of these options:
    - Option A: basic information: year of birth, gender, height, weight, the level of muscularity
    - Option B: body composition analysis by using either VTT's measurement or commercial scale, which shows the weight of skin, fat, muscles, bones, viscera and brains.

This information will be used for assessing individual thermal conditions (individual thermal sensation and individual thermal comfort as shown in Figure 4 and Figure 5) at different times in the analysed room/apartment by using VTT's HTM model. The results will be reported anonymously. The collection of the personal data requires a legal agreement between VTT and the people participating in the test.

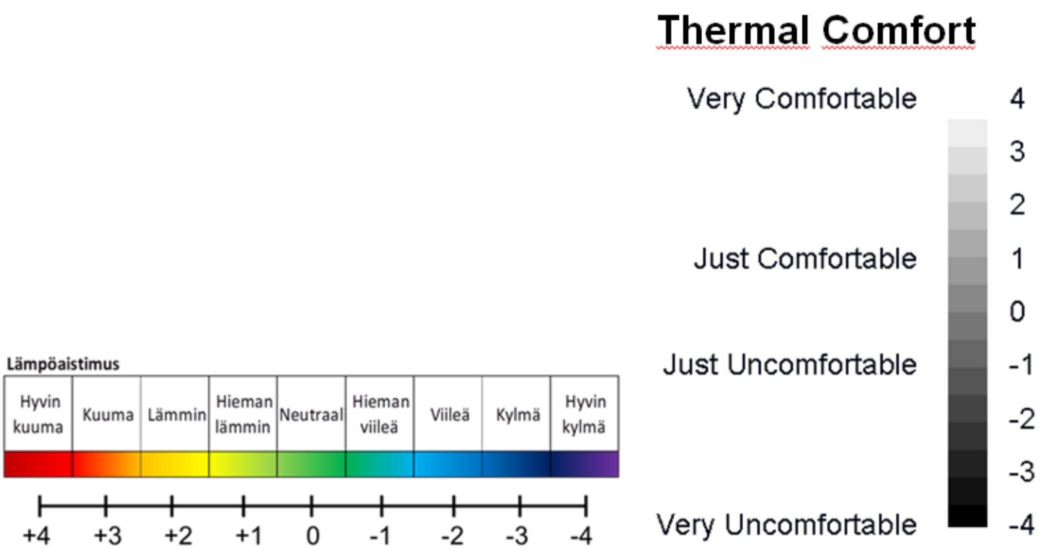

Figure 4: Thermal sensation scale (left) and thermal comfort scale (right)

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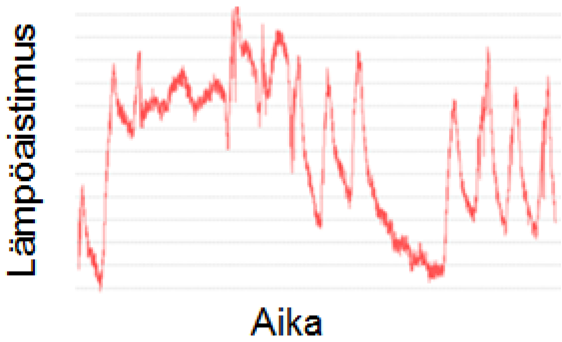

Figure 5: Thermal sensation (lämpöaistimus) with respect to the time (aika)

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4. Smart home solutions in new buildings

Requirements for smart home solutions in new buildings

Requirements for smart home solutions in new buildings are enforced as a part of the urban planning by defining specific requirements in the terms for the plot assignment at the Kalasatama area. The earlier version of these requirements are assessed and refined as a part of MySMARTLife demonstration actions. To upscale the implementation of the smart home solutions, the revised requirements were introduced to the city's areal development managers in September 2017 and they are considering extending these requirements to all areas in the City of Helsinki.

The regulations require the planning and using smart building solutions, including smart meters and smart building automation systems with demand side management possibilities. The solutions enable demand side management both in heating and electricity demand. The revised regulations are included in the Appendix 1.

4.1 Requirements for performance monitoring (Timo Ruohomäki)

The key technical requirements for the performance monitoring are open REST API's for the energy data andcompliance with CIM standard (IEC 61968) for demand management. It is also required that the building automation systems are based on widely used open standards, such as BACnet or KNX. In both cases, the API requirements can be fulfilled with a gateway product that shall keep the costs at a reasonable level. The performance monitoring is based on monitoring the basic attributes of HVAC and electrical systems.

For the Common Information Model (CIM) interface, the following profiles are expected to be implemented:

- MeterReadings
- MeterReadSchedule
- GetMeterReadings
- EndDeviceEvents
- EndDeviceControls

The electrical systems are expected to be designed in a way that different types of consumption are grouped together. The different types of consumption are defined as follows:

4. Lighting

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5. Wall outlets
6. Kitchen outlets, stove and oven
7. Housekeeping: laundry machine, dryer, dishwasher
8. Cooling devices: fridge and freezer
9. Sauna heater
10. Direct heating devices
11. Storage heating devices
12. Water heating
13. HVAC
14. Cooling devices
15. Electrical vehicle charging

The units of measurement for electrical systems are load and cumulative energy. The measurements are made separately for each of the three phases for each apartment. It is also expected that the electrical loads can be controlled.

Temperatures are measured both inside and outside the building and also for each apartment. Domestic hot water consumption is also measured.

During data collection and performance monitoring, especial attention is given to ensure privacy and security of information. The interfaces must be implemented in a way that the information is safe from network threats. At times, certain data attributes may fall into the category of personal data according to the upcoming General Data Protection Regulation (GDPR).

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5. Demand response in an office building

5.1 Predictive and adaptive control algorithms for optimized demand response

The Viikki Environmental House is a demonstration area for heating Demand Response (DR) in an office building. The main objective is to show that decreasing or increasing momentary indoor temperature in rooms can lower the cost of district heating (DH). The target is to cut peaks and fill gaps of the heating demand curve without jeopardizing the indoor comfort of the employees. Digital thermostats, which keep the indoor temperature of the room stable, contribute to an increase of thermal comfort in the Environment House.

Heating Demand Response has been studied in Finland since 2003 (Kärkkäinen et al 2004). In this project, the maximum heat load of a concrete building was reduced for 2-3 hours by 20-25% in average. The authors concluded that the building mass has a large storage capacity and the air has a correspondingly a small one. In this study, load shedding, i.e. deliberate control of consumption, was fulfilled with time-based control devices which are restricted in flexibility

Johansson and Wernstedt (2007) have studied real-time implementation of load control. A residential area in Karlshamn, Sweden was the subject of a pilot test where demand side management (DSM) was implemented in the form of agent-based load control (Wernstedt et al., 2007). It is concluded that direct load control is imperative in order to attain desirable levels of response. With predictive heating demand response, load shifting can be practiced when the district heating (DH) company requires it, i.e. when the marginal costs of DH are high or during an outage (Salo 2016).

A similar approach is taken in the Environment House in Viikki. The cloud-server operated by Fourdeg (FOU) receives a price signal from HEN for each hour of the day. For the first test period, an indoor temperature shift range of 1°C is allowed. Hence, the temperature can shift between 20-22°C during office hours and 18-20°C during non-office hours depending on the price signal. Since the temperature perception of the consumers is frequently asked, the shifting range can be adjusted according to the feedback.

The employees can adjust the smart IoT thermostats and their default temperature. They are advised to adjust the cooling blocks, installed in every room of the Environment House, to the winter mode i.e. 23°C. Additionally, the ventilation time and the thermostats' heating time are adjusted so that the rooms are heated up before the ventilation is in full mode.

Each thermostat operates independently to maintain comfort and performs the DR actions when needed. The heating DR in each room is automatic and the aim is to utilize the maximum DR capability without compromising comfort. This is assessed by analysing the total energy load during DR activities and the valve position of each radiator thermostat. Consumer satisfaction is ensured through the feedback form.

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Three external temperature sensors are deployed on each floor of the building. They measure the indoor air temperature variance and the information can be utilized in real-time to adjust the target temperature of the radiators.

5.2 Human Thermal Model based control

The automation can use both temperature and human comfort set point values, based on VTT's Human Thermal Model (HTM). The advantage in human comfort set point values is that it takes into account adaptive comfort aspect increasing users' well-being and making possible to save energy. Together with HTM, predictive algorithms are also used to optimize energy and peak power use. HTM based control will be implemented in three office rooms in Viikki Environment House.

HTM is based on true anatomy and physiology of the human body and it estimates human body tissue and skin temperature levels. The human body is divided into sixteen different body parts: head, neck, upper arms, lower arms, hands, chest and back, pelvis, thighs, lower legs and feet. Each body part is further sub-divided typically in four realistic tissue layers (bone, muscle, fat, and skin) by concentric cylinders. The functional tissue layers are also connected to adjacent body parts by a blood circulation system, which has been used for physiological thermoregulation of the whole body. (Holopainen, 2012).

The thermal sensation and thermal comfort estimation methodology by Zhang (2003) has been integrated in HTM, allowing much more detailed thermal sensation and thermal comfort index estimations than for example, Fanger's commonly utilized methodology.

Needed parameters for HTM based control can be divided to external and internal parameters Figure 6.

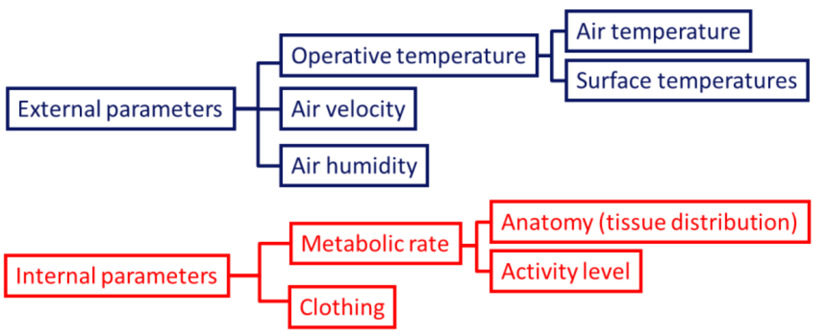

Figure 6 External (space-related) and internal (occupant-related) boundary conditions influencing human thermal sensation and thermal confort (figure by Pekka Tuomaala, VTT)

External parameters are air temperature, air humidity, air velocity and surrounding surface temperatures (e.g. window, radiator, chilled beam, external wall, internal wall, floor, ceiling, etc.). In the Viikki case, only indoor air temperature is included in the existing BACS based measurements, and therefore, complementary measurements will be installed. These complementary measurements will include only the

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most relevant measurements including air humidity and surface temperatures of window, radiator, chilled beam, and external and internal wall. Air velocity can be expected to stay constant in a occupied zone and the internal wall surface temperature is expected to be almost the same as floor and ceiling temperatures. In addition, HTM needs inputs of the room geometry (width, length, height), windows' sizes and locations, and radiators' sizes and locations.

Internal (occupant-related) parameters are related to the occupant's clothing and metabolic rate. Metabolic rate depends on individual anatomy (amounts of different tissue types) and activity level. Individual anatomy will be calculated by measuring a voluntary test person's body composition. Default office worker values for activity and clothing level will be used if up-to-date user feedback is not available (see chapter 5.4). Human related parameters are collected as follows:

- Option A: basic information: year of birth, gender, height, weight, the level of muscularity
- Option B: body composition analysis by using either VTT's measurement or commercial scale, which shows the weight of skin, fat, muscles, bones, viscera and brains.

The HTM control works in steps. Internal (human related) parameters are given to the model as base inputs and the external (measured) parameters are updated to the model e.g. every 5 minutes. Based on the updated measured, HTM calculates the new control set value for the thermostats based on the optimal individual thermal sensation value. This control set value is then read and updated from VTT's cloud by Fourdeg's system to the thermostat e.g. every 15 minutes.

5.3 Electricity demand response

Regarding electricity consumption, production and storage, Viikki Environment building has smart control and optimization algorithm for the energy system provided by Siemens. The electrical energy storage at Environment building is Siemen's SieStorage which is controlled and optimized by DEMS, distributed energy management system. DEMS is used for local optimization of the assets installed in Environment building, mainly controlling the operation of the battery energy storage system (BESS). In addition to BESS, DEMS enables the control of the electric vehicle charging, solar production, elevators energy consumption and peak powers as well as the air conditioning and lighting at the office. The smart control of the DEMS optimizes the different assets and provides flexibility. For example, the BESS can provide market driven services to the transmission system operator (TSO) Fingrid when the resources are connected and aggregated via DEMS by Helen, the utility company and service provider. In terms of demand response, the BESS is also capable to reduce the load to the grid by discharging the battery to correspond the office's consumption. Other loads in Environment building, such as the air conditioning and lighting, can also participate to demand response.

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6. Conclusions

This deliverable describes the innovative building energy management systems (BEMS) and smart control strategies demonstrated in Merihaka/Viihonvuori (Zone 1) and Viikki Environment House (Zone 3) in Helsinki. Predictive algorithms have been defined for apartments to achieve optimization of the heat demand response. The implemented solutions are based on Demand Response to optimize energy usage and simultaneously employ VTT's Human Thermal Model (HTM) to ensure wellbeing and comfort of the users.

In Merihaka, Salusfin's Demand Response solution will be installed in 167 apartments. The solution expects to achieve 10 – 25% energy savings through smart heating management and user control. This system is responsible for managing room level temperatures and hence, for the whole apartment. Here the concept of heat demand response is essential as it leads to either increasing or decreasing the amount of heat supplied to the home and is dependent on the measurements of the smart thermostats. The details are used as inputs for the heating algorithm to adjust the temperature.

In Kalasatama, the demonstration actions focus on paving the road for up taking the smart home and energy solutions in new buildings. The required change is pushed among others through the terms for the plot assignments in the Kalasatama area. These terms target to ease the implementation of the smart solutions, and the discussions are on-going to replicate these terms to be used in all districts in Helsinki.

In Viikki's Environment House, the objective is to demonstrate that momentarily increasing or decreasing the indoor temperature can lower the cost of district heating and reduce peaks in heat demand. The room temperature is kept stable with the help of smart thermostats. The Cloud server operated by Fourdeg utilizes hourly price signals from Helen and adjusts the temperature accordingly during office and non-office hours. Each thermostat in the room operates individually and performs the DR functions when necessary. The actions revolve around the idea of making the user more aware of energy usage and enabling the users to not only maintain their comfort level using HTM, but to also reduce energy consumption at the same time. Human Thermal Model (HTM), developed by VTT, plays a role as it is based on the preferred human setpoint values to fully ensure the user's wellbeing. The HTM is used together with predictive algorithms to optimize energy use.

This deliverable will be updated and detailed later in M36, when the actions have been implemented. This version describes the overall situation as known before the implementation of the demonstration actions.

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Appendix 1. Kalasatama smart energy systems - Terms for the plot assignment

KALASATAMA SMART ENERGY SYSTEMS

PLOT ASSIGNMENT STIPULATIONS

1. Introduction

This document defines the plot assignment stipulations that the local authority has required and the private developer must commit to. As addition to the **mandatory requirements**, some **recommendations** are also being made for consideration.

The requirements are based on the European Union energy efficiency guidelines, national recommendations for building lifetime changeability and market trends that are related to the smart energy systems.

In the construction project, special attention should be put on the facility as an entity so that the energy efficiency goals can be met on electricity, heat, heated water, cooling, water consumption, air conditioning and ventilation. It should be however noted that the energy efficiency is monitored on apartment level and the smart energy systems are supposed to provide the homeowners and tenants new opportunities to utilize the new, data-driven services that are based on metered energy data.

The implementation of these stipulations involves several areas of planning and subcontracting in a construction project. Such areas are HVAC, building automation, plumbing and piping plans, electrical and telecommunications cabling systems. It is vital that this is noticed as early as possible in the planning phase in order to avoid overlapping and extra costs in designs and installed systems.

Chapter 9 applies only on commercial space and offices.

2. Open Interfaces

REQUIREMENT 2.1:

All building automation systems must be implemented in a way that allows later addition of API from the Internet. The API specification must be open and based on common standards.

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With the API it is expected that new business opportunities and services are enabled and significant cost savings are achieved on system level. The systems must be implemented in a way that pseudonymised data and interfaces are made available using common open data licensing terms. In such case the license terms used in the Helsinki Region Infoshare –service must be adopted. IN addition, the interface must allow serviced provided by third parties, where the person living in an apartment gives consent for the service provider or research partner to use her own data (MyData). The system design and implementation must follow the European Union General Data Protection Regulation (GDPR) requirements.

Any data that can be associated with a person and is to be made public must be anonymised according to current legislation (currently Tietosuoja-asetus 2016/679, with later updates). The data is anonymous if any personal characteristics and indirect identifiers included in the data together will only refer to a group of people and a single person cannot be recognized with a reasonable effort.

REQUIREMENT 2.2:

The building automation system must be equipped with a bidirectional CIM –interface for external services and controls that is compliant with IEC-standards 61968-9 and 61968-100. The following profiles must be implemented: MeterReadings, MeterReadSchedule, GetMeterReadings, EndDeviceEvents, EndDeviceControls.

REQUIREMENT 2.3:

The building automation system (BAS) and electrical automation system must allow bidirectional (monitoring and control) connection to other systems within the building using a commonly used, open standard protocol or interface. As addition to open standards so called industry standards are accepted if they are widely used and well documented. By widely used it is meant that the devices using the technology are provided by at least hundreds of vendors.

REQUIREMENT 2.4:

The communication protocol used in the home automation system to connect sensors and actuators must be commonly used and based on open standards. As addition to open standards so called industry standards are accepted if they are widely used and well documented. By widely used it is meant that the devices using the technology are provided by at least hundreds of vendors. It must be possible to add sensors and actuators from different vendors to the same system.

REQUIREMENT 2.5:

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All the observations and status information (on/off) must be available and accessible remotely from standard CIM- or BAS interface in order to enable smart services relying on energy data from dwellings and households.

REQUIREMENT 2.6:

The home automation system, the devices connected and their objects must be controllable from standard CIM- or building automation system interface in order to enable third party services using energy data. The interface is also utilized to provide services related to smart grid demand response.

REQUIREMENT 2.7:

The Internet connection to CIM –interface and the outbound Internet traffic from building automation system must be implemented in a secure way and must be based on VPN tunneling with proper firewall.

RECOMMENDATION 2.8:

The network design of building automation system should be part of the cabling system design. It is not recommended to connect such systems to a network that is operated by a tenant of a dwelling or commercial space.

3. Building and home automation

REQUIREMENT 3.1:

The usage and control operations of electrical appliances in a dwelling must not depend on the Internet connectivity.

REQUIREMENT 3.2:

The log of metering-, control- and status information events of the automation systems must be stored locally for at least ten days.

REQUIREMENT 3.3:

Every apartment must have a home/away –switch that controls at least electrical loads related to presence of a tenant.

RECOMMENDATION 3.4:

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Home/away –switch is capable of controlling the HVAC in order to lower the temperature and control ventilation.

RECOMMENDATION 3.5:

The ventilation of an apartment should be controllable via home automation system.

REQUIREMENT 3.6:

Electrical loads are grouped in switchboards based on load types as follows:

Load type 1: **Lighting**

Load type 2: **Wall and floor outlets in rooms**

Load type 3: **Cooking: Kitchen countertop outlets, stove and oven**

Load type 4: **Housekeeping: washer/dryer outlets, dishwasher**

Load type 5: **Refrigeration**

Load type 6: **Sauna heater**

Load type 7: **Direct heating devices (e.g. radiant panel heaters, towel dryer, band heaters)**

Load type 8: **Storage heating (e.g. underfloor heating)**

Load type 9: **Water heaters, boilers**

Load type 10: **Air ventilation devices**

Load type 11: **Cooling devices**

Load type 12: **Vehicle chargers and heating devices**

Grouping is not required for loads that don’t exist. As an example, heating devices may be part of district heating or cooling systems.

REQUIREMENT 3.7:

Of all the electrical loads, power and energy must be measured. As addition to this, the sum power and energy of all the loads combined is measured separately on each three phases. Dwelling or space specific measurement of electrical power and energy must be measured directly.

REQUIREMENT 3.8:

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The electrical loads must be controllable and the status information of control must be available.

REQUIREMENT 3.9:

Room temperature must be measured on each dwelling or commercial space.

REQUIREMENT 3.10:

Outside temperature must be measured.

REQUIREMENT 3.11:

Consumption of the cool and heated water must be measured on each dwelling or commercial space.

REQUIREMENT 3.12:

All the observations must be provided as an aggregated, hourly average and as a single observation point.

RECOMMENDATION 3.13:

The naming convention for data points should follow the instructions provided in appendix 1. In case of the electrical automation system the naming convention depends on the common practises for that particular technology. The aim for this recommendation is to make sure, that during that programming changes later on can be provided by any certified contractor or programmer and not just the one who delivered the original programming.

4. Usability of building and home automation systems and other technical requirements

RECOMMENDATION 4.1:

A typical latency from CIM –interface to controlled device is less than three seconds.

REQUIREMENT 4.2:

Measuring observations and the timestamps of events in the interface must be in the UTC –time. If user interfaces (HMI) are provided as part of the system, timestamps there must be shown in local time.

REQUIREMENT 4.3:

The clock time used by the system must have accuracy within +/5 seconds to actual, local time.

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RECOMMENDATION 4.4:

Automation system should have an internal error diagnostics and it can be connected to an external monitoring system.

RECOMMENDATION 4.5:

In order to provide uninterrupted control and monitoring service for the building, the control bus, automation server and network devices are connected to an UPS system that provides at least 30 minutes of power supply in case of blackout.

RECOMMENDATION 4.6:

Local storage of log and configuration files is provided with a backup storage and automated backup routines.

5. Electrical vehicle (EV) charging

REQUIREMENT 5.1:

The parking standard for the area is extended with a mandatory requirement to equip at least 1/3 of parking spaces with an EV charging option.

REQUIREMENT 5.2:

Every parking space assigned for EV car parking must have a 3 x 16 A electrical power supply.

REQUIREMENT 5.3:

EV parking space must have cabling to support at least 16A of continuous power supply. The cabling must be terminated to a charging device that is compliant with SESKO SK69 and that has a SFS-EN 62196-2 Type 2 car charger socket.

REQUIREMENT 5.4:

The electrical system supplying power to the parking space must be designed to support EV charging or the area must be provided with electrical conduits that the cabling (according to 5.2) can be later extended with low effort. The SESKO 69 –instruction must be followed.

REQUIREMENT 5.5:

In order to extend the number of parking spaces with an EV charging function later on, the parking spaces must be equipped with corrosion resist electrical conduits that are large enough to fit the required cabling. As addition to the electrical cabling (according to 5.2, 5.3) there may be data

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cabling requirements for smart chargers. The electrical cabinets must be large enough to provide room for such later extensions, including devices for smart controls of charging.

REQUIREMENT 5.6:

The cumulative electrical energy consumption of a charging unit of every parking space must be measured on hourly basis.

REQUIREMENT 5.7:

The instantaneous active power must be measured (or average active power with less than 1 minute aggregation time) of each of the phases separately.

RECOMMENDATION 5.8:

In case of parking space being shared, measuring and authentication must be for each charging event separately.

6. Demand-side management

REQUIREMENT 6.1:

The following load types mentioned in chapter 3.6 must be remote controllable using the CIM-interface in order to provide loads to the aggregators: direct heating devices, sauna heater, storage heating devices, vehicle chargers and heating devices, refrigeration, air condition and ventilation devices, water heaters and cooling devices. A prerequisite for such remote controlling function is an agreement and consent from the occupier of dwelling unit, who must have an opportunity to decide which loads can be controlled and to what extent.

RECOMMENDATION 6.2:

Electrical loads shall be available for the grid company (Fingrid) through an appropriate local automation system in order to be used as a frequency-controlled reserve.

RECOMMENDATION 6.3:

The control-event in demand-side management process and the resulting state of controlled action should be logged with a timestamp on a local storage. Such events together with their timestamps should be transferrable through CIM –interface for audit purposes. The information should include average power five minutes before and after the control event.

7. Heating and water supply systems

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RECOMMENDATION 7.1:

The maintenance manual of the building should include the following recommendation: After four years has passed since the building was taken in use, the heating curve should be adjusted to match with the building so that the indoor temperature remains on set level throughout the heating period.

RECOMMENDATION 7.2:

The outdoor temperature sensor that controls the heating system automation must be placed on the wall facing the North. It must not be placed on the roof. Sun must not shine directly to the sensor during the heating period. The sensor must be protected from direct rainfall. The sensor location on the wall is to be chosen so that no external source (e.g. air duct, door etc.) of heat affects it. Cabling route through the wall must be made in a way that it doesn't leak heat from inside.

RECOMMENDATION 7.3:

The heating distribution system should be equipped with automation that allows the setting of activation threshold level based on the outdoor temperature. The heating should be switched on when the 48-72-hour average of outdoor temperature is lower than the threshold level set on to the automation system. The heating should be switched off when the 48-72-hour average of outdoor temperature is higher than the threshold level set on the automation system. In new apartment buildings the set level of heating activation is typically from 5 to 10 degrees Celcius.

REQUIREMENT 7.4:

When de-icing of driveways is installed, the system must be based on hydronic heating instead of electric.

RECOMMENDATION 7.5:

The water pipelines should be equipped with automation-controlled valves in each dwelling.

8. Renewable energy

REQUIREMENT 8.1:

The space reserved for electrical cabinets must be large enough for later extension with renewable energy devices.

RECOMMENDATION 8.2:

The electrical cabinets of dwellings and other spaces must have enough expansion room for later additions of devices and conduits for renewable energy applications.

REQUIREMENT 8.3:

The energy production utilities that are synchronized with the grid must be compliant with VDE-AR-N 4105 standard.

RECOMMENDATION 8.4:

Devices for distributed energy production should be connected to building automation system in order to accomplish remote control functionality using the CIM –interface.

RECOMMENDATION 8.5:

The electrical cabinets where energy production devices are connected should be equipped with energy meters that has a field bus connection to the automation system. There should be separate metering for each type of production.

9. Commercial and Office Spaces

REQUIREMENT 9.1:

The requirements of dwellings must be followed on commercial and office spaces when reasonable.

RECOMMENDATION 9.2:

When placing and designing the electrical cabinets it should be noted, that the commercial spaces can in the future be divided or merged together with light walls according to the typical layouts of the apartment floors.

REQUIREMENT 9.3:

The waste heat of large cooling devices of commercial spaces should be recovered either locally or transfer to district cooling system.

RECOMMENDATION 9.4:

The heating and cooling system should be implemented as hydronic underfloor heating. The pipe layout design should allow later addition of a reversible heatpump.

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Appendix 2: Data point naming convention

In order to improve interoperability between systems and usability of the systems, data point and position labels must have a common naming convention. The following example is highly recommended in case there is no specific reason to use either naming convention.

Data point label must be globally unique, as an example:

HE.123456789A.TK01.TE20@A105

The data fields in the example above are the following:

Location code (city)	HE = Helsinki
Building Code	123456789A
Subsystem type	TE = air handling unit
Subsystem number	01 = First device in the building
Device type	TE = thermostat unit
Device number	20 = sequential number within subsystem
Location code	A105 = Room code in architectural layout

The building code is a unique identifier maintained in the Finnish Population Information System (VTJ-PRT) in its Building and Dwelling Register (BDR). The code has 10 characters and always starts with 1. Its last character is an error-detecting code.

In the example above the key data fields are separated with dot.

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