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mySMARTLife

Deliverable due date: M36 – November 2019

D4.24 Open data and open APIs to the building-level energy savings potential

WP 4, Task 4.5, Subtask 4.5.3

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	D4.24 Open data and open APIs to the building-level energy savings potential
Diss. Level	PU
Status	Working
	Verified by other WPs
	Final version
Due date	30/11/2019
Work Package	WP4
Lead beneficiary	FVH
Contributing beneficiary(ies)	HEL,HEN,VTT
Task description	**Task 4.5: ICT and Urban Platform developments** Energy and district-level components will be developed and up-taken into Helsinki Urban Platform. Currently the Urban Platform consists of over 600 various systems. With Lighthouse, the zone-specific and energy-specific components both to the static open data as well as real-time data (IoT) systems will be implemented. Also, two specific Apps will be developed to demonstrate the value of the new open data and open APIs, and a hackathon will be organised to engage external developers for further data exploitation. - **Subtask 4.5.3**: APIs development to link the domains. Open data and open APIs to integrate and promote the building level energy savings potential will be implemented by FVH in this subtask.

Date	Version	Author	Comment
16/10/2017	0.1	Timo Ruohomäki (FVH)	First draft
17/10/2017	0.2	Pekka Tuominen (VTT)	Chapter 2, 4
3/11/2017	0.3	Timo Ruohomäki (FVH)	Chapter 3
8/11/2017	0.4	Marja Vuorinen (HEL)	Supportive measures
9/11/2017	0.5	Timo Ruohomäki (HEL)	Minor corrections. Ready for review.
9/11/2017	0.6	Mikko Martikka (HEL)	Minor editing. Ready for review.
26/11/2017	1.0	Timo Ruohomäki (FVH)	Final version, ready for submission.
27/11/2017	1.1	CARTIF	Alignment of contents and final review
5/10/2018	1.2	Timo Ruohomäki (FVH)	Review for required additions for M24 submit
29/10/2018	1.3	HEL, HSY	Contribution/review for M24 submit
31/10/2018	1.4	Timo Ruohomäki (FVH)	Minor edit, ready for review.
2/8/2019	1.5	Outi Kesäniemi (HSY)	Updated 5.3, 5.4

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21/10/2019	1.6	Maria Viitanen, Veera Sevander (HEL)	M36 updates
21/10/2019	1.7	Timo Ruohomäki (FVH)	M36 updates
27/11/2019	1.8	Maria Viitanen (HEL)	Minor editing and restructuring (changing places of Chapter 4 and 5)

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Abbreviations and Acronyms

Acronym	Description
API	Application Programming Interface, a set commands, functions, protocols and objects that programmers can use to create software or interact with an external system
BACnet	Building Automation Controls Network, a standard and a communication protocol that allows multiple devices to communicate across building automation system components.
BAS	Building automation system
CityGML	A standard for digital 3D models of cities and landscapes.
GDPR	General Data Protection Regulation
HSY	Helsinki Region Environmental Services Authority is a municipal body, which produces waste management and water services, as well as providing information on the Helsinki Metropolitan Area and environment. The member cities of HSY are Espoo, Helsinki, Kauniainen and Vantaa.
HVAC	Heating, ventilation, air-conditioning and cooling systems services in buildings
INSPIRE	An EU directive aiming to create a European Union spatial data infrastructure for effective functioning of EU environmental policies. At the core of this has been defining common standards for 34 themes of spatial data and creating an access portal. The directive came to force in 15 May 2007 and full implementation is required by 2021.[1]
KNX	A standardized technology for a bus system (a system of building automation control in which every device is connected to every other device).
The Linux Foundation	A foundation supporting open source projects and ecosystems, including (but not limited to) the Linux operating system.
MyData	A Nordic Model for human-centered personal data management and processing based on the right of individuals to access and control the data collected about them.[2]
mySMARTLife	Transition of EU cities towards a new concept of Smart Life and Economy
OAI	Open API Initiative
OAS	Open API Specification
OGC	Open Geospatial Consortium
REMA	Rakennetun Ympäristön Energiamalli, acronym in Finnish language for 'Energy Model of Built Environment'

[1] https://inspire.ec.europa.eu/about-inspire/563
[2] https://www.lvm.fi/documents/20181/859937/MyData-nordic-model/2e9b4eb0-68d7-463b-9460-821493449a63?version=1.0

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REST API	An API that conforms to Representational State Transfer (REST) architecture style, a style defining how a client and a server interact within a service. In REST, the server objects are treated as resources that can be created, modified or deleted by a client command.

1. Executive Summary

This deliverable describes the role of open API's and open data in relation to other actions related to identifying building-level energy savings potential in mySMARTLife Helsinki demonstration cases.

First, the document starts by describing the terms of open data and open API's with their relations to the project activities.

Later on, the document describes the data-driven activities of modelling building stock for evaluation purposes and the various ways to visualize the characteristics of building stock as part of the co-creation and energy advisory activities.

The Helsinki 3D City Model steering group agreed to take an "Energy Atlas" to be their lead pilot, providing a platform that was not available in proposal/negotiation phase. In addition to the building level energy savings potential, heat maps (roofs) and solar and geothermal potential can be added to the 3D-model. Also opening the actual consumption of Helsinki social housing company and adding it to the 3D model will take more time than expected.

2. Introduction

2.1 Purpose and target group

This deliverable provides an overview on data-driven interventions related to the energy-savings potential of buildings in the Helsinki region. There are many avenues in actualizing the energy-savings potential where the data-driven approach can make a difference. This deliverable focuses on the following avenues: defining and communicating the potential for motivating action on a city wide scale, and integrating new energy-saving solutions into building automation systems of individual buildings (driving such technologies further). In the latter case, the methods illustrated here are not restricted to demonstration cases only even though those are the focus of this deliverable.

The three demonstration cases in the project are: 1) Merihaka and Vilhonvuori districts, 2) Kalasatama district, and 3) Viikki Environment house. The following image illustrates the demonstration zones (Figure 1: The Intervention Zones):

Figure 1: The Intervention Zones

2.2 Contributions of Partners

The following table describes the contributions from partners involved with this deliverable (Table 1: Contributions of Partners).

Table 1: Contributions of Partners

Participant short name	Contributions
FVH	Main responsibility of the deliverable.
VTT	Definition of modelling methods
HEL	3D –model, Climate Atlas and supportive measures
HSY	Regional Climate Atlas and Kattohukka.fi

2.3 Relation to other activities in the project

The following table depicts the relationship of this deliverable to other activities (or deliverables) developed as part of the mySMARTLife project (Table 2: Relation to Other Activities).

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Table 2: Relation to Other Activities

Deliverable Number	Contributions
D4.1	Baseline report describes the starting situation of the actions.
D4.11	Practical applications for the urban platform defined in D4.11 Chapter 3 Energy renaissance (link to supportive measures)
D4.2	Comprehensive perspective to energy renaissance activities
D4.4	Report on implementation and performance of innovative smart system appliances and control

3. Open Data and Open APIs

3.1 Definitions

By definition, open data is “data that can be freely used, shared and built-on by anyone, anywhere, for any purpose” (James, 2017). When having a closer look at the mentioned elements of the definition, more detailed requirements can be defined.

Free use means legal openness, being able to get the data, building on top of it and sharing it further. In order to accomplish all this, suitable license terms have to be adopted on the data. For anyone to be able *to share and build-on* the data, the data must be technically open: there should not be any technical barriers for using the data. As an example, if the data is provided printed on paper, it is very difficult to process it further. The same can apply to file formats: a closed, complex file format with no public documentation and restrictive license terms can make the data unusable even though it is machine-readable in theory.

As addition to the legal and technical requirements, there are also some operational requirements related to open data, especially in a public organization. First of all, opening the data should be included in the document management workflow: data is by default open if there is no any specific reason to keep it private. Naturally, there are various reasons why some data must remain private, such as data being related to an identified person. Secondly, published data must be found: the existence and location of data source should be publicly known. It is recommendable that the city, municipality or government body keeps a well-maintained public data catalogue that provides a collection of useful data sets, tagged with keywords and other metadata to improve findability. Finally, the open data should be provided in a way that it is understandable. The structure and meaning of the data in question has to be described and documented, providing adequate level of context and backgrounds. Data that cannot be interpreted in the same way its creator intended remains useless.

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While open data often refers to government information which has been made available to the citizens, other types of organizations and citizens themselves can also publish open data.

Open API is a term often referring to the work of Open API Initiative (OAI), which is an expert group working under the governance structure of the Linux Foundation. The OAI focuses on creating, evolving and promoting a vendor neutral description format.

The OpenAPI Specification (OAS) defines a standard, programming language-agnostic interface description for REST APIs, which allows both humans and computers to discover and understand the capabilities of a service without requiring access to source code, additional documentation, or reverse-engineering through the inspection of network traffic. It is expected that a consumer could understand and interact with the remote service with only a minimal amount of implementation logic (Open API Initiative, 2017).

3.2 Privacy requirements

The General Data Protection Regulation (GDPR) includes a specific definition regarding what data is considered as personal data and should be managed accordingly. The official enforcement date for the new regulation was May 25th 2018 which makes the GDPR compliance a key requirement on data management of the mySMARTLife project.

According to the GDPR, any data that can be associated with a natural person directly or indirectly by a specific identifier is personal data. Identifiers defined in the article 4 can be a name, an identification number, location data, an online identifier or to one or more factors specific to the physical, physiological, genetic, mental, economic, cultural or social identity of that natural person.

This means that when a sensor providing its location information is situated in a person's apartment for example, the sensor data can be personal data and needs to be treated accordingly. However, a common misunderstanding is that the data collection and processing would always require an informed consent of those persons whose data is being used. The Article 6 of GDPR directive defines six ways how the processing of personal data can be lawful. As an addition to the consent, grounds to use the data may include a contract in which the data subject is a party, a task is performed in public interest or the processing of the data is necessary for the purposes of legitimate interests. As an example, data collection for maintenance purposes is a legitimate interest of the facility manager. In the service design however, special attention needs to be put on the transparency of data collection and processing towards the data subjects no matter which criteria is used to prove the lawfulness of the data collection.

It should however be noted, that the GDPR have also specific requirements for the clarity of language when data is collected related to children of the age below 16 (or 13). In addition, the Article 22 defines the

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conditions related to automated individual decision-making, including profiling. This may require attention in cases where personal profiles are to be created to control conditions.

The urban platform is a generic data platform and data hub for any kind of data. Therefore it has to be assumed that the data can include information that falls into the category of personal data according to the GDPR. This will cause some technical requirements such as encryption of data, being able to allow the citizen to decide what for the data is being used (cf. MyData principles) and logging relevant actions in order to support auditing requirements and providing proof of the given consent (Trunomi, 2017).

3.3 Relations to other initiatives

Open Data and Open APIs have numerous relations with other projects in both Horizon2020 and European Regional Development Fund projects. While parallel development is not always an issue and can even lower the risks related to technology development, findings from the related initiatives have been studied and adopted when relevant.

In order to improve interoperability and ease the re-use of the developed work, a decision has been made to implement the SensorThings API from OGC, Open Geospatial Consortium, to the Helsinki Urban Platform. The urban platform should also be capable of providing ready data for 3D city models, thus support for CityGML version 3.0 is expected to be implemented when the new standard is approved.

The INSPIRE directive establishes and infrastructure for spatial information in Europe to support Community environmental policies, and policies or activities which may have an impact on the environment. It entered into force in May 2007. The directive addresses 34 spatial data themes needed for environmental applications, with key components specified through technical implementation rules. The technical implementation relies on the ISO/TC211 standard collection of both spatial characteristics and observations. This provides a semantic interoperability framework for sensor metadata and observation data. While the project is not expected to provide new INSPIRE datasets, the platform capabilities developed will enable Helsinki and other cities in the future to support the data themes of the directive.

The Urban Platform concept has been defined in the ESPRESSO project with the support of EIP-SCC. It has been further refined in several Horizon2020 projects, including Synchronicity and Select4Cities.

4. Data-driven Services

4.1 Helsinki 3D Map and city open data services

In mySMARTLife project, the city of Helsinki had a goal to open several energy-related datasets linked to the city 3D-model and as open access data (Figure 2: Screenshot of Energy and Climate Atlas and Figure 3: Planned and executed Public Energy Data Sets). The goal of offering this data has been to increase the knowledge of possibilities to increase energy efficiency and renewable energy production especially in renovation stage to help to reach the city's ambitious climate goals. There are several recognized international experiences that show that open energy data motivates all stakeholders to do action when relevant information is available.

The benefits for different target groups related to the overall goal to improve energy efficiency of buildings are:

1. Data increases **building owner**'s interest on the performance of their buildings when they can compare their consumption and renovation need and they can see the potential for energy improvements.
2. Data supports especially **smart and clean technology related businesses** when the building stock's energy related data can be found easily and used for business purposes. For example, businesses can estimate if a potentially upcoming roof renovation can be combined with a solar panel installation.
3. **Investors** can get better access on the information of building stock, which eases making the financial decisions related to energy renovation projects.
4. Data and 3D energy models help **city planners** to concentrate their efforts on the most promising areas in terms of energy saving outcomes when all the data can be processed simultaneously.
5. Better knowledge and understanding of the situation of the residents can develop the **real estate management sector** to improve their work as responsible actors.
6. **Housing market** is able to incorporate information on features such as the energy performance and renovation history of the buildings.

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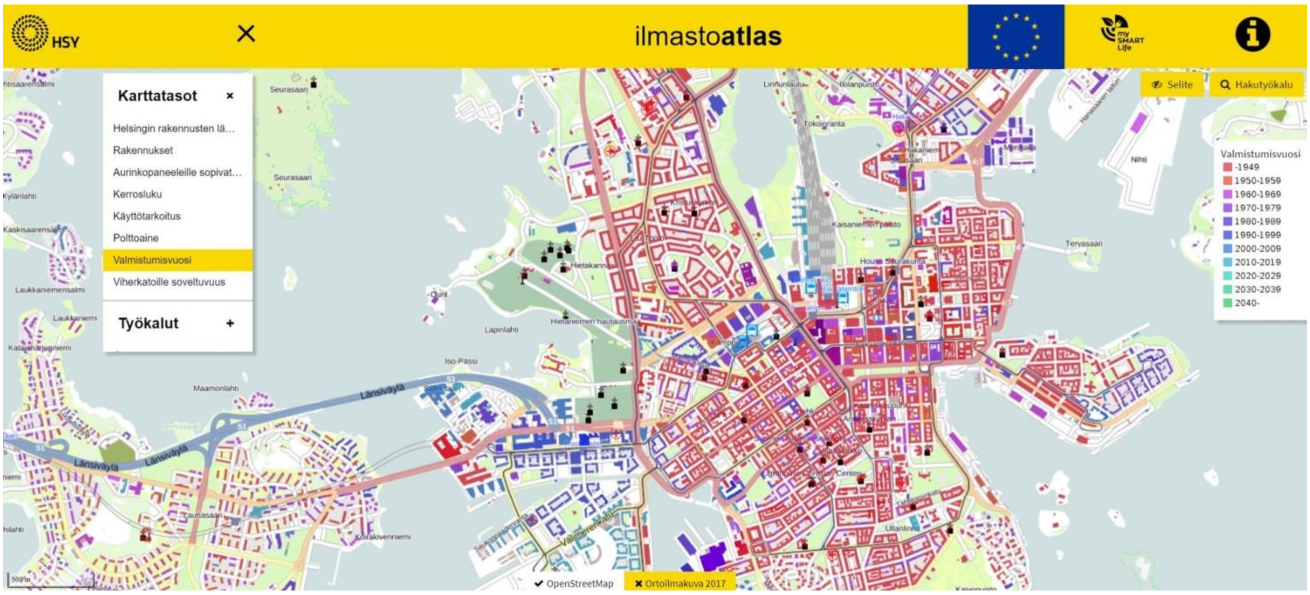

Figure 2: Screenshot of Energy and Climate Atlas

Data	Source	Will be published	Challenges
1. Building renovation history	Facta building registry	Feb 2018	Some old data in paper format
2. Hekan apartment buildings heat, electricity and water consumption	Heka Ltd.	Feb 2018	
3. Energy certificate registry	www.energiatodistusrekisteri.fi	2018?	Building ID's needed
4. Public service buildings consumption	HEL Buildings and public areas div.	End of 2018	Energy monitoring renewed
5. Calculated energy consumption of all buildings	VTT	Feb 2018	
6. Calculated energy saving potential in one area (Merihaka)	VTT	Feb 2018	
7. Heat loss images of Helsinki's roofs reanalysis	HSY, kartta.hsy.fi	Feb 2018	Don't fit directly in buildings
8. Large scale waste heat potential of buildings	Metropolia study	2019	Preliminary study done, needs more accurate info
9. Solar energy potential and visualization	HSY+3D, kartta.hsy.fi	Feb 2018	
10. Thermal imaging of facades in one neighbourhood (Merihaka)	HEL environmental services	Winter 2018	Right weather needed (cold+dry)

Figure 3: Planned and executed Public Energy Data Sets

4.2 Challenges and solutions during collection of energy data in 3D energy and climate atlas

Collecting the data for the Energy and Climate Atlas implied several challenges, and an equal amount of innovative solutions to overcome these challenges were devised during the project. To begin with, city's "Facta" building registry was used as a main source of information. The registry covers all basic data of buildings. This information is mainly collected to store the legally demanded information for building permits. However, in order to provide up to date information on buildings' energy performance, this registry was not sufficient. This was due to the fact that not all renovations that have an impact on building's energy performance need a permit. Due to that, not all energy retrofits are included in the registry rendering the data incomplete. Some of the renovation-related data in Facta registry connected with energy performance could be found, but the data was in various formats and could not be directly sorted by energy features. This data was tailored into common format with various search functions.

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Waste heat data was collected on buildings and the estimates for large waste heat sources was found. But it was noticed that the data is not accurate enough to give even generalized data on waste heat potential of buildings on building level, as there are so large differences at building level depending on buildings technical features, so more careful studies (like energy audits) should be made to include the waste heat potential on the map.

Heating modes of buildings were also collected from Facta building registry. It was found that the changes of heating modes have not always been registered. In fact, in most of the cases only the original heating mode has been available to be included into the 3D Atlas. It has been estimated that the data represents about 25% too many oil heated buildings, which in reality have been transferred into district heating or geothermal heating. It is being studied how this can be fixed in future (an interactive fix made by building owners or automatic fix made with geothermal borehole map could be some options).

All the energy audit data is published in the National Energy certificates registry (ARA). The registry shows the energy performance of buildings, but as a registry it is quite new. Only about 10% of buildings' energy certificates were found in the register. The registry will be completed in the coming years. What is more, the information presented in the energy certificate registry is quite varied. Some certificates cover much more information than others, such as suggested energy efficiency measures for example. There was also a problem that not all buildings could be mapped with an address due to a missing buildings ID. What is more, the buildings with less than 10 residents are not included due to privacy legislation, so the data covers mainly blocks of flats, commercial buildings and service buildings.

As a part of the mySMARTLife project, VTT produced several datasets. One was an estimation of energy consumption of all buildings in city area. There are many studies on the issue and Helsinki has a lot of data on buildings' energy consumption by age class. These were used to improve the accuracy of the estimations.

VTT also made an energy renovation potential and cost efficiency analysis of 1970s and 1980s buildings in Merihaka area. Actual consumption and building data collected during mySMARTLife project was used as one source for the analysis. The results were included in 3D City Model.

City-owned HEKA Ltd. rental apartments gave district heating, property electricity and water consumption data of 2015 and 2016 on building level. It took some time to collect the data from the database of Heka Ltd. In some cases, the consumption data was generalized for more than one building. These instances included cases where there is only one energy meter for 5 separate buildings (usually the buildings were of similar age class). A few outliers were taken out from data (measurement error). In the end, it took some time to modify and combine the data, building IDs and addresses in right format (excel) so that the data could be used in the 3D City Model. As mentioned, the buildings that have less than 10 flats are not included.

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4.3 The Regional Climate Atlas

In previous EU-funded projects HSY has produced the following datasets including all buildings in Helsinki:

1) Solar power potential: solar irradiation on the roofs, suitable locations for PV installations and estimated yearly electricity yield
2) Roof heat loss thermal map
3) Green roofs: existing (built and spontaneous) and potential

These datasets listed above are freely available through HSY open data interface and can also be utilized e.g. by the Helsinki 3D City Model or other spatial services.

In mySMARTLife project, as a part of Helsinki Urban Platform, HSY has implemented a web map tool, the Regional Climate Atlas that features climate change and energy efficiency datasets on a map. This 2D application presents energy and climate related open data in Helsinki and in the surrounding metropolitan area. It focuses on city wide datasets and works side by side with the 3D City Model. The data covers the Helsinki Region (cities of Helsinki, Espoo, Vantaa and Kauniainen), and the data is also available via API for further use. The Regional Climate Atlas was built using open source web mapping platform “Oskari” (oskari.org). It is easy to use and open for everyone. It features building-level energy data such as yearly solar power potential and green roof potential. It also features basic building information such as building age, fuel used in heating, number of floors, floor area, volume, and building purpose of use. Also, calculated energy consumption per building type provided by VTT was converted to building-level spatial data by merging the values to each building, using the building type and year of construction.

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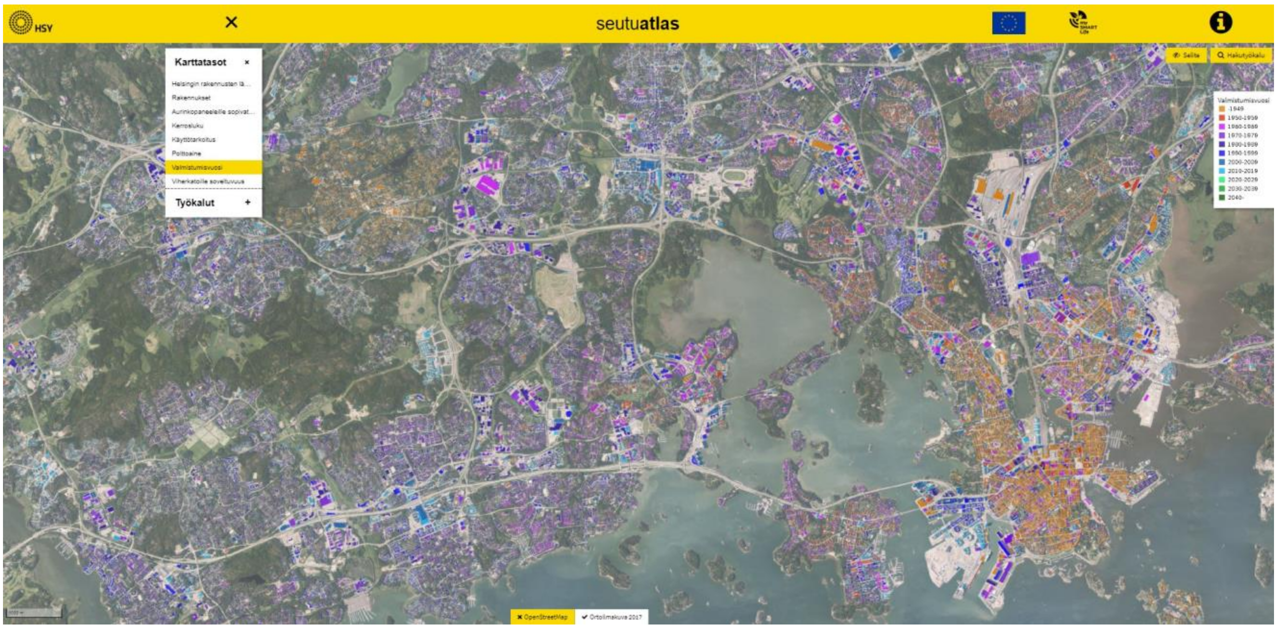

Figure 4: An overview of the Regional Climate Atles, "Seutuatlas"

4.4 Kattohukka, a building heat loss visualization tool

“Kattohukka”, a building heat loss visualisation tool, was launched in April 2018 as a part of the Helsinki Urban Platform, a collection of smart city related data and services. It is an easy-to-use web-based map service that visualises thermal losses from the buildings in Helsinki. The heat loss map is an open data interface, and the service is available to everyone.

Kattohukka features a thermographic map acquired on a clear, cold winter night. The map shows the surface thermal radiation measured from each roof using a thermal imaging camera on 30 cm pixels.

In Kattohukka, the user first answers a few questions about the shape and material of the roof, and whether the space directly below the roof is heated. After answering, the user can see a legend explaining the colors in terms of roof insulation quality. The user can also switch the view from thermographic map to an aerial image to check the details of a roof. The service can be used by property owners as well as companies when planning renovations. Currently the tool is further developed with new features added, based on customer feedback.

The web page also includes information on building heat losses and tips on how to improve energy efficiency. Kattohukka was designed by the Helsinki Region Environmental Services Authority HSY and implemented by Kairo Design Agency Ltd. The tool Kattohukka (in Finnish) can be found at https://www.kattohukka.fi/.

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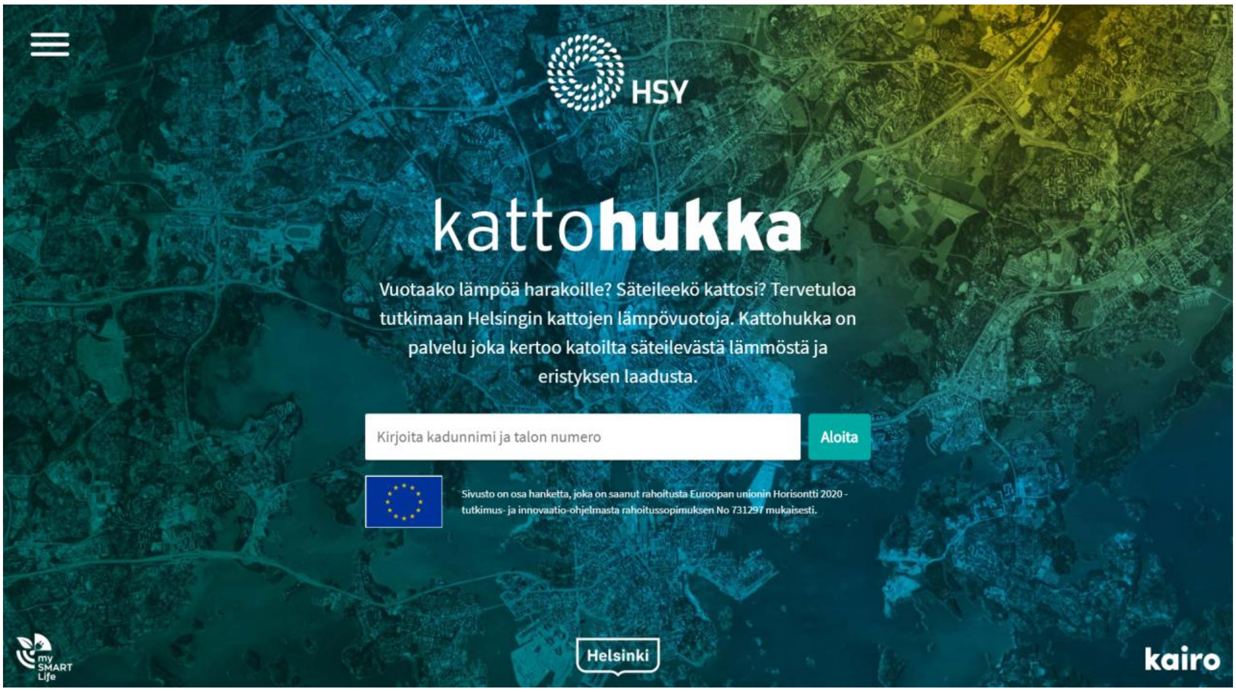

Figure 5: Screenshot of HSY Kattohukka.fi tool

4.5 Using Modelling for Studying Energy Use in Building Stock

Both the 3D Map and the Climate Atlas services are linked to REMA calculation model developed by VTT. The REMA tool was created for information management and for evaluating the impacts of repairs to be made to individual buildings and the building stock as whole.

The model will help to analyse a variety of technological scenarios, evaluating factors such as the technological potential for reducing carbon dioxide emissions from the building stock. The tool has also been used to outline cost impact scenarios for the most effective measures.

The REMA model uses as inputs the energetic properties of each building type and sub-type (see Figure 6

Figure 9). For existing buildings, the combined living area of the type is included and a linear annual decrease in that area over time due to demolitions or abandonment. For new buildings, a linear increase in the amount of each particular building type is assumed over time until it is replaced with a newer building type. In this case, REMA is used to provide a reference level of energy efficiency for buildings of various type and age that can then be visualized in a map view. REMA is also used to produce forecasts of energy savings in the building stock with energy improvements included in renovations.

The building stock is slow to renew, so decisions concerning the energy efficiency of buildings have long lasting implications. REMA helps to choose the appropriate measures for buildings built in various decades and using various methods to improve their energy efficiency and reduce their carbon dioxide

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emissions. For example, the impact of improving the external shell of a building or changing the heating system on carbon dioxide emissions may vary enormously.

The REMA model can support the owners of major real estate properties, building management companies, contractors and the city authorities in planning an energy strategy for the buildings under their management. This can mean things such as renovation plans, decisions concerning new buildings and installation of integrated energy infrastructure such as heat pumps or solar panels.

As an energy model, REMA can be categorized as a bottom-up model of energy use in the building stock. In the context of the building stock, top-down methods estimate energy use in buildings based on variables that pertain to the whole buildings sector. Bottom-up methods, on the other hand, calculate the total sum of energy consumption in the building stock based on limited distinct categories of buildings and their respective sizes and energetic properties, sometimes called archetypes. In REMA, buildings are categorized as shown below. (Tuominen et al. 2014).

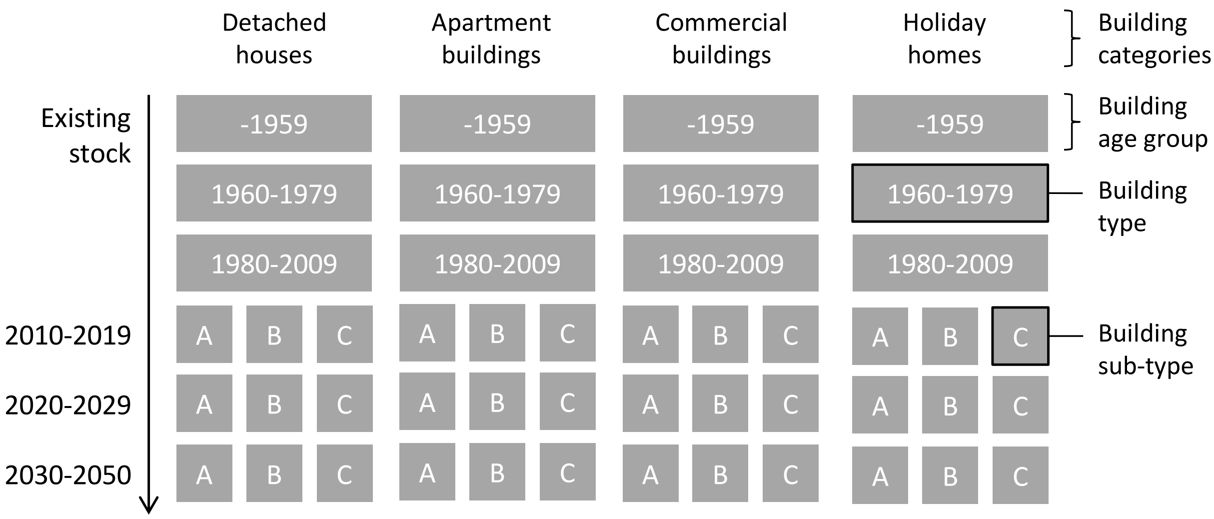

Figure 6: Existing and future building stock categorized

In the figure above, building age refers to all building types of the same age, whereas building type only refers to a certain category of building of a certain age.

Energy models of the building stock use different types of inputs depending on the type of the model. Different strengths, weaknesses and capabilities result from the choice of modelling approach. For instance, the level of detail in the model can vary greatly depending on the selected methodology, which is also true for the inputs required. Typically input data includes information such as physical properties of the buildings, number of occupants, appliances and equipment in use, historical energy consumption,

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climate conditions and economic variables. This information can be very detailed or rely on aggregated values such as averages.

Bottom-up models contain varying amount of detail concerning the composition of the energy consumption totals. They can be based on the energy consumption in different end uses, individual buildings or groups of buildings. These data are summed using the representative weight of each category of energy consumption in the sample. (Tuominen 2015)

In REMA, future developments are estimated using annual rates of new construction, renovations and removals from the building stock. This approach can be used to create varying scenarios for the development of the building stock and its energy use. Typically the REMA model can be used to support the owners of major real estate properties, building management companies, contractors and the city authorities in planning an energy strategy for the buildings under their management. This can mean things such as renovation plans, decisions concerning new buildings and installation of integrated energy infrastructure such as heat pumps or solar panels. More advanced analysis is possible by adding a dynamic layer to energy modelling allows creating scenarios that develop on their own according to modelling parameters to find optimum solutions (Tuominen et al. 2017) or by analyzing the cost-effectiveness of proposed energy efficiency measures (Tuominen et al. 2015).

4.6 Supportive measures

Participation and interaction have been important activities for the city of Helsinki in the past, and attention to these areas has increased even more recently due to the organisational reform and the new city strategy. The new forms of civic participation, defined as city activism or urban activism are also taken in account.

Between the city of Helsinki and local businesses the cooperation in climate-related matters has been organized in the form of climate partners network. It fosters cooperation to reduce emissions that affect the climate as well as the cooperation to make companies smarter. More detailed and more actual data will help the businesses to meet their goals in the future.

The new city strategy seeks to make Helsinki the world’s most functional city, to ensure sustainable growth and to provide good everyday life for all its residents. New strategy includes the goal to render Helsinki carbon neutral by 2035. Helsinki aims to reduce emissions by 60 per cent by 2030. The city has also started a major digitalization programmes by first appointing a Chief Digital Officer in late 2018.

Smart, liveable and carbon neutral city can be achieved in collaboration between citizens, decision-makers and businesses. City 3D model with its energy data aims to help achieving these new goals.

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4.7 Utilising the 3D model in energy advising

The 3D model and its possibilities to visualise energy saving potentials are demonstrated in the mySMARTLife project. The visualisations can be utilised in planning and decision making by different stakeholders such as property owners, management companies, contractors and city planners.

As mentioned in Chapter 4.2, the energy data of building performance and characteristics is added to the city 3D model. The model provides a reference level when comparing the performance of one's own building with a computational performance of a similar building in the model. One can also get an estimate of for example solar power potential of the buildings.

In order to find out the best use cases for the 3D model and the energy related data in energy advising it is necessary to know the needs of residents concerning energy issues. City of Helsinki has a lot of experience in how to engage and involve people as explained in D4.1 Baseline report, Chapter 7 Identification of existing actions for citizen engagement and their success rates.

During the mySMARTLife project, a series of info evenings and workshops have been organized in Merihaka area as part of Action 32 Smart District-Level Energy Renaissance Strategy and Action 40 Implementing Energy Advisor, as described in more detail in D4.4 Chapter 3. These events were organized to find out more about the needs of the residents, to provide knowledge, and to also find possible ways to utilise the 3D model.

A survey was conducted regarding the 3D model and its use at the Lähiöfest festival (suburban living festival) in Helsinki on the 30th of October 2017 amongst the festival visitors. The results (25 answers) showed that most of the respondents had never used the model before but would most likely be using it in the future, e.g. to visualise energy savings or to compare building performances.

As a part of the co-creation efforts, a living lab space was set up in the Kalasatama district in 2015 as part of the Smart Kalasatama project. The space has attracted people living in the neighbourhood to participate in planning events. From 2015 to 2017, a total of 76 events and larger workshops have been organized with over 2.300 people participating. The space and approach have also interested visitors as the Kalasatama activities have been demonstrated to over 1.300 visitors during that time.

4.8 Threats and opportunities in opening city service building data

Threats and opportunities of opening the building related data of service buildings were examined as a part of the action of improving the Helsinki Urban Platform with building-level open data.

The City of Helsinki has worked systematically since 2009 to facilitate access to public information for use by the citizens and the private sector. Open data can be used to enable transparency in public

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administration, create new digital practices and present opportunities to software developers designing new consumer products. This work has made Helsinki a model city for open data.

Helsinki Region Infoshare (HRI) is an open data service that offers free-of-charge data related to Helsinki and its neighboring municipalities. The data can be utilized by citizens, developers, reporters, companies, universities, schools and research institutes, as well as by municipal decision-makers and employees.

Helsinki has invested in new modern open API based smart building management platform called Nuuka. Nuuka system is part of the ecosystem when Helsinki is achieving high targets related to carbon neutrality by 2035 and being an international trendsetter in the energy efficiency, improving and maintaining the good indoor air conditions and involving the users of the buildings to achieve these goals.

So far, thousands of data points are found in the Nuuka-system. Data points are associated to single property, building or room. As base data there is a lot of stationary building specific data such as location, purpose of use, year of construction, property manager, etc. as well.

The majority of data points contain information about the energy consumption of public service buildings. Hourly based consumption data is available for almost 1700 buildings. Energy consumption data is received as Ediel messages and presented hourly based for each source of consumption (electricity, district heating and district cooling). On-site energy production is also measured and monitored in the system.

There are pilot projects going on in which some of the buildings / rooms are equipped with additional data points. Data is collected via building automation systems, sensors monitoring indoor air quality factors, energy sub-metering and user experience application. All the data mentioned is already integrated straight to the Nuuka data platform to be available for explaining the actual indoor air quality, energy consumption and overall user satisfaction as well as well-being in the building.

Approximately 15 buildings are integrated to data platform via building automation system providing additional data points regarding process data of building equipment as well as indoor air quality data. In addition, there are also a couple of buildings equipped with user satisfaction application providing user experience data straight to the data platform.

In the future it may be possible to control building automation system to adjust for e.g. ventilation and heating of the premises automatically by means of room specific indoor air quality factors such as (CO_2 (ppm), TVOC (ppm), particulates (PM2,5 & PM 10), pressure differential over the building envelope, humidity (%) and temperature (°C).

In the project, the data content of Nuuka was analyzed by experts in terms of validity and security in relation to opening the data. Also, as a part of the project, a workshop for city employees and different stakeholders working with energy, ICT and open data related issues were carried out. The

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recommendations for proceeding with the opening of the building related data were represented as an outcome of the project.

Recommendations for the open building related data content are to open 1) the basic building data excluding GDPR sensitive data, as well as 2) the main meter energy consumption data. According to the recommendation generated in the project, the indoor air quality data as well as the user experience data are not valid enough to be opened so far.

The next step will be creating a test API of building related data according to the recommendations. In that project, the data content is to be opened and the frequency of updates may be determined in the detail.

5. Viikki Environment House Data Integration

5.1 Overview

The Viikki Environment House represents a typical office building with a modern, BACnet based building automation system managing the HVAC systems. The electrical system is controlled using building automation based on the KNX system. Before the project, there was no link between the HVAC systems and the electrical systems. The electrical systems were split into three subsystems: lighting controls (KNX), electrical metering system (Mittrix) and local production and storage (Siemens). In mySMARTLife, the HVAC and the electrical systems were integrated to improve the manageability of the system, render it more reliable and introduce a possibility for additional energy efficiency tweaks. The following diagram illustrates the integrated system following the actions of the project (Figure 7).

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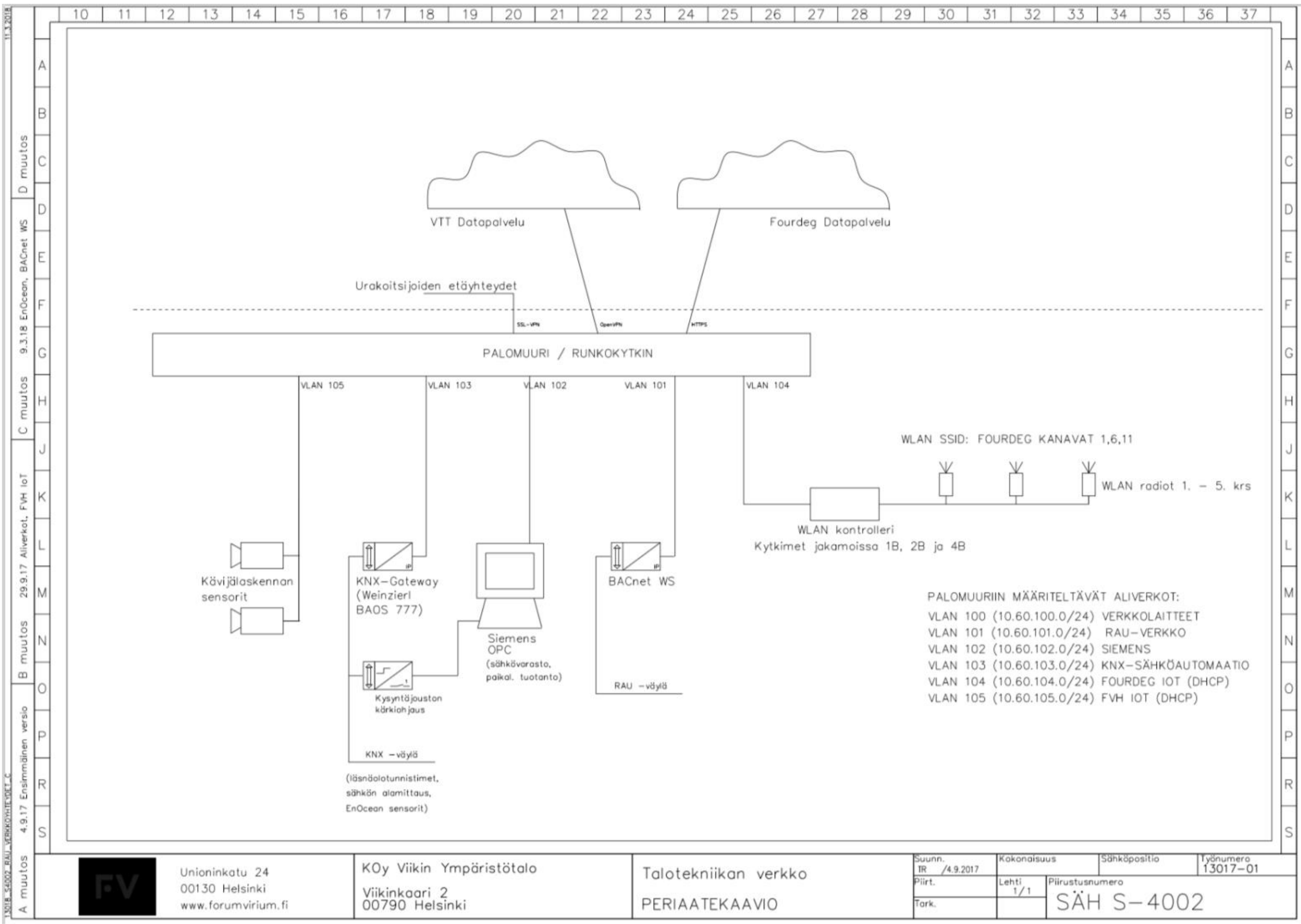

Figure 7: Viikki IoT Connectivity

5.2 HVAC Systems

The HVAC automation in Viikki is managed with Trend building automation system. The building automation field bus runs BACnet protocol and the building has about 2.000 data points in total. As part of the project, a BACnet Web Service -device was installed on the data bus, allowing external reading and writing on any data point values. The web service is connected to the VTT data platform over a VPN tunnel. The following picture shows the new IO -device cabinet containing both BACnet and KNX gateways.

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Figure 8: Viikki Building Automation Gateways

5.3 Electrical Systems

As mentioned in the overview, the electrical metering systems were not earlier integrated with the building automation system. As part of the project, the electrical submeters are to be connected into KNX bus so that the meter readings can be externally read using the new KNX REST interface. The existing Mittrix system will thus be made obsolete because of the open data approach. The open API for KNX is based on Weinzierl BAOS -protocol and it is available through VPN tunnel externally for the VTT data platform. Within the next few months a connector will be created to transform this proprietary protocol into SensorThings API, following the data model selected on the project.

5.4 Smart thermostats

In Viikki Environment House, every room has been equipped with Fourdeg’s electronic wireless radiator thermostats, in short, smart thermostats. There are c. 240 in the building. These can be controlled both

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manually and via a Wi-Fi connection. They enable both energy saving and increased user comfort by providing individualized conditions. The latter aspect is developed further by another project partner, VTT. They have tested their Human Thermal Model concept that aims to define an individualized preference model of the user defined by human comfort set point values with which the conditions can be adjusted to best suit them. In addition, the thermostats have provided a test bed for district heat demand response trials that are based on temperature adjustment requests provided by Helen. (These solutions are described in more detail in the mySMARTLife Deliverable 4.22)The installation demanded extending the Viikki Environment House Wi-Fi so that it can incorporate new IoT devices, such as the thermostats.

5.5 Data Visualizations

The Viikki Environment House case brings important lessons for improving building automation system interoperability especially in systems geared towards sustainability. When building has some own energy production, for example, the issue of integration with the traditional building automation system becomes important to solve. In the meanwhile, it is also important to keep the users apace with the improvements. When building automation systems take up more functions to handle smartly to ensure good conditions while saving energy, they may become more opaque for the users of the buildings. To facilitate the understanding, and also prompting smart behavior of users and visitors, the project studied how to visualize the energy use and production of the building.

To this end, concepts for visualizing the energy data for Viikki Environment House were produced with service design. A service design project investigated the best ways to present the data. The visualization concept was designed to be replicable on other public buildings as well.

Service design was employed as a method to create concepts for visualizations of the actual energy consumption and indoor climate data related to Viikki Environment House and later for other buildings hosting the city units and facilities. The target for visualizations is to motivate building users and visitors to behave in more sustainable way as well as showcase what progress is being made by the city and/or the building unit in saving energy. The outcome of the service design consists of three main elements complemented with various sub-elements.

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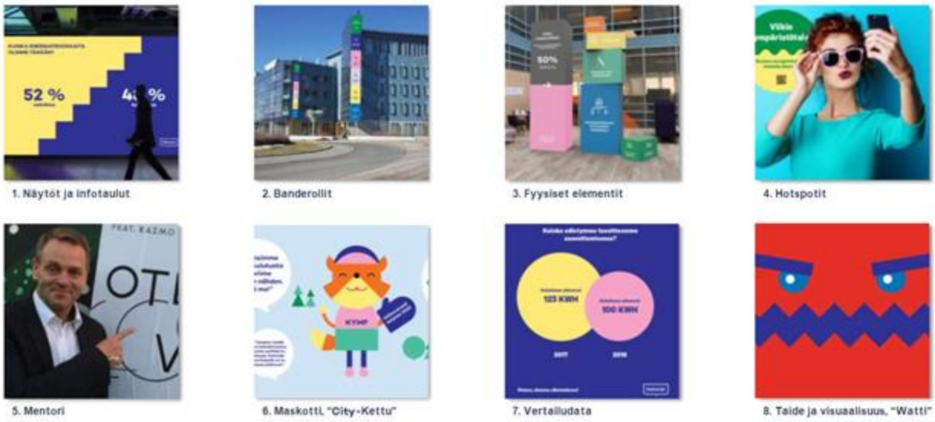

Figure 9: Energy saving visualization elements presented as a result of service design process

One of the main elements of visualizations is lobby screen showing simple but informative graphics generated by on-line energy and indoor climate data system via open API (see Figure 9, left upper corner). Topical and up to date tips for saving energy and cutting down emissions at the time can be shown at the screen. Another main element is touch screen application / webpage with graphics and navigation including information of energy consumption, renewable production and emissions at the level of building, portfolio, Helsinki organization or whole city region. Application can be published at the separate screens in public areas or organization's intranets, Helsinki webpages, etc. Application can also be used for communications and educational purposes. Physical elements for public spaces or showrooms are the third part of the main visualization elements (Figure 9, third image from left, upper row). Those can be, for instance, collection of boxes in different size as pieces of furniture with the purpose of showing physically and touchable the relative proportions of each source in City's yearly energy consumption or emissions.

All three main elements can be coupled with sub-elements like virtual feature called "Watti" who is able to react on energy consumption peaks by showing unhappy face and giving a tip how to decrease the peak consumption right at the time. Famous person as a sustainability mentor or gentle mascot dedicated to promote sustainability by communicating both can be added to virtual elements as well as physical spaces. Energy and indoor climate visualization concepts will be demonstrated at several public buildings during the year 2019.

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6. Conclusions

The current report provides a description of data-driven activities of modelling building stock for evaluation purposes and the various ways to visualize the characteristics of building stock as part of the co-creation and energy advisory activities.

REMA model is presented as a valuable tool to analyse a variety of technological scenarios, evaluating factors such as the technological potential for reducing carbon dioxide emissions from the building stock. This tool, developed by VTT, has also been used to outline cost impact scenarios for the most effective measures. Typically the REMA model can be used to support the owners of major real estate properties, building management companies, contractors and the city authorities in planning an energy strategy for the buildings under their management.

The planned and implemented actions have already resulted to a clear view on the requirements of data and API's in order to set up the monitoring mechanisms. The data to monitor the impact of the project is getting ready and will be ready to be visualised on the existing city services, such as the Energy and Climate Atlas. The workflows and quality of data will be improved in the upcoming years of the project. Facility owners will be encouraged to open more data, thus leading to a more complete understanding of the energy consumption of buildings. The project includes several activities related to identifying the energy savings potential from a sensor-level to the simulations. After the project, the city will have a better tool to both manage their own initiatives and influence the citizens to act locally.

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7. References

City of Helsinki. 3D City Information Model. http://www.hel.fi/3d

James, L.: Defining Open Data. Open Knowledge International. https://blog.okfn.org/2013/10/03/defining-open-data

Open API Initiative. OpenAPI Specification. https://github.com/OAI/OpenAPI-Specification

Trunomi. GDPR Portal. http://www.eugdpr.org

Tuominen, P., Stenlund, O., Marguerite, C., Pardo-Garcia, N., Grahn, E., Huvilinna, J., Iglar, B.: CITYOPT planning tool for energy efficient cities. International Journal of Sustainable Development and Planning, Vol. 12, 2017, pp. 570-579.

Tuominen, P.: Assessing energy efficiency potential in the building stock: Method for estimating the potential for improvements and their economic effects. Doctoral Thesis, Aalto University, 2015.

Tuominen, P., Reda, F., Dawoud, W., Elboshy, B., Elshafei, G., Negm, A.: Economic appraisal of energy efficiency in buildings using cost-effectiveness assessment. Procedia Economics and Finance, Vol. 21, 2015 pp. 422-430.

Tuominen, P., Holopainen, R., Eskola, L., Jokisalo, J., Airaksinen, M.: Calculation method and tool for assessing energy consumption in the building stock. Building and Environment, Vol. 75, 2014, pp. 153-160.

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