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D5.7 – Oulu Monitoring Programme

WP5, Task 5.4

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Abbreviations and acronyms

Acronym	Description
DHW	Domestic Hot Water
DR	Demand response
GDPR	General Data Protection Regulation
KPI	Key Performance Indicator
PED	Positive Energy District
RES	Renewable Energy Sources
SCIS	Smart Cities Information System

Executive Summary

Task 5.4 “Monitoring in Oulu and Groningen” deploys the Monitoring Programmes that were defined in Task 5.3. This is a cross-cutting activity among WP2, WP3 and WP5. Project level KPIs (defined in D5.2) are in the main focus in the monitoring programme. The data sets required for calculating these KPIs are defined in D5.5. The deliverable 5.6 produces guidelines to the monitoring programme, while the detailed monitoring programme is described in D5.7 for Oulu and in D5.8 for Groningen.

This document constructs the deliverable D5.7, describing how to embed and deploy the monitoring procedures and mechanisms in the Oulu PED-demonstration. The main objective of this deliverable is to provide specific guidelines for the monitoring phases and methods in Oulu, including metrics monitoring from each building types, and plan for data quality assurance. The monitoring program guidelines include both quantitative and qualitative data aspects for the indicator based monitoring. Also, the user engagement and interaction in the monitoring program is described.

In this document, the monitoring of quantitative data describes how the monitoring will be implemented in Oulu, and how the data for quantitative KPI calculation is achieved from six demo buildings; four residential buildings, a shopping centre and a school. Monitoring of qualitative data describes how the qualitative data monitoring will be implemented both at the city level and PED level in Oulu. The data sources for qualitative monitoring are the residents of Oulu, the residents of the demo buildings in Oulu, and domain experts, policy-makers or other relevant stakeholders of the city of Oulu. Finally, residents’ engagement and interaction on monitoring describes how the data is provided for the residents of the demo building, and how these residents provide feedback.

1 Introduction

1.1. Purpose and target group

This report constitutes Deliverable "D5.7 Oulu Monitoring Programme" describing how the guidelines of monitoring programme defined in D5.6 are applied in Oulu case. The monitoring programme consists of three different types of monitoring:

Monitoring of quantitative data describes how the data required for quantitative KPIs calculation are achieved. Six different buildings are used as data sources.

Monitoring of qualitative data describes how the data for qualitative KPIs are collected. The data sources for qualitative monitoring are the residents of Oulu, the residents of the demo buildings and domain experts, policy-makers or other relevant stakeholders.

Residents' engagement and interaction on monitoring describes how the data is provided for the residents of the demo building, and how these residents provide feedback.

The application of these phases in Oulu case are described in more detailed in the following sections.

1.2. Contribution partners

Table 1 depicts the main contributions from participant partners in the development of this deliverable.

Table 1: Contribution of partners

Partner nº and short name	Contribution
01-CAR	Peer-review quality control
04-TNO	Main contributor of D5.8 in the case of Groningen PEDs
14-UOU	Resident engagement and interaction
20-VTT	Main contributor in the case of Oulu PED

1.3. Relation to other activities in the project

Figure 1 and Table 2 depict this deliverable relation to other project activities. In this project, data-oriented ICT platforms are developed within both lighthouse cities. The ICT platforms contains at least following building blocks:

1. Data collection framework
2. Databases where data is stored
3. API(s) for getting the data out from the databases

The PEDs and ICT platforms of the lighthouse cities are very different. Therefore, also the data collection frameworks are very different. This document provides the deployment of monitoring programme described in D5.6 (Guidelines for definition of Monitoring Programme) in Oulu.

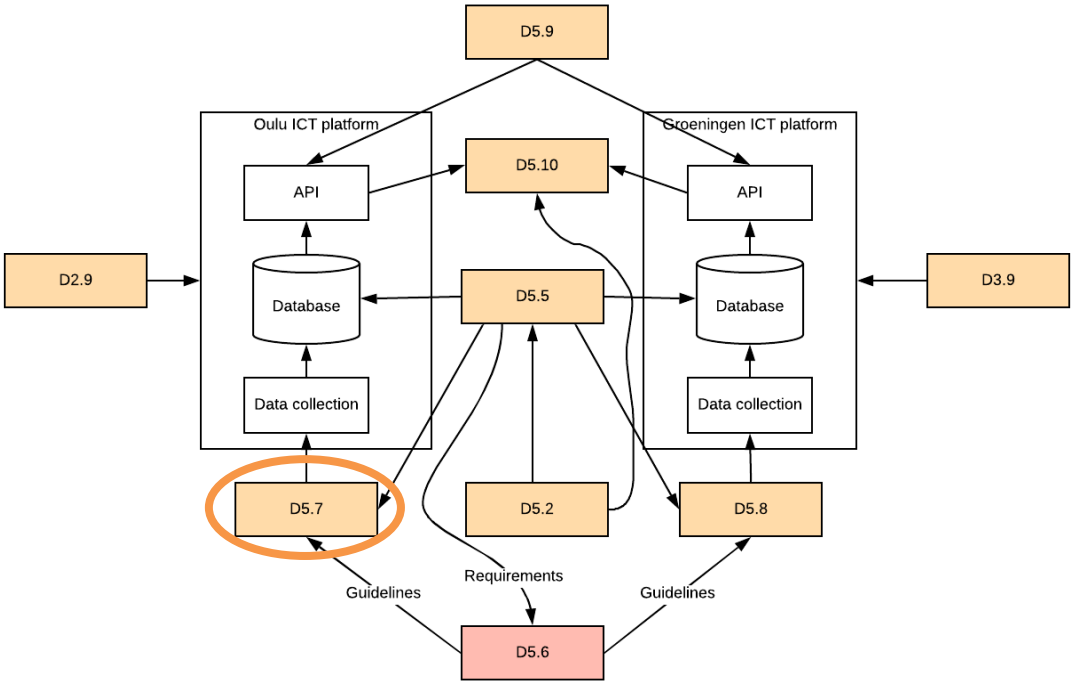

Figure 1: Deliverable relation to other activities in the project

Table 2: Relation to other activities in the project

Deliverable nº	Relation
D5.1	D5.1 describes the definition and calculation of the KPI for city evaluation
D5.2	D5.2 defines project level KPIs that are calculable from outputs of monitoring programmes
D5.3	D5.3 describes the evaluation procedure for PED actions based on KPIs
D5.4	D5.4 describes the city impact evaluation procedure based on prioritized and weighted city level indicators
D5.5	D5.5 describes the collection of data sets
D5.6	D5.6 defines the guidelines for the Monitoring Programmes
D5.8	D5.8 describes monitoring programme of Groningen PEDs in details

2 Introduction of the Oulu demo setup

Oulu is the capital of northern Finland with over 200,000 inhabitants. The demo area in Oulu is Kaukovainio that is a suburb of about 3000 inhabitants located around 3 kilometers southeast from the Oulu city center. The district was built between 1965 and 1974 and it consists of multi-storey apartment buildings on the eastern and southern sides and low terraced and detached houses on the western side. The services of the area include a school, a library, a grocery store and kindergartens.

The demo area consists of six buildings:

- B1: a renovated apartment block, Sivakka1 (by city-owned housing company Sivakka)

  Residential building Sivakka1 is a rental house, currently populated, and includes 56 apartments distributed in seven floors and the basement. The total area is 2,820 m2 and the volume is 8,930 m3. The energy consumption before the renovation is 414 MWh/year (357 MWh for heating and 57 MWh in electricity).

- B2.1: a new rental housing, Sivakka2.1 (by Sivakka)

  Residential building Sivakka2.1 is a new rental building that is constructed (total area 2,654 m2), consisting in 50 apartments distributed in seven floors. It is built according to the latest energy specifications. The annually estimated consumption is 280 MWh (heat + electricity). The residents were able to move in September 2021.

- B2.2: a new rental housing, Sivakka2.2 (by Sivakka)

  Residential building Sivakka2.2 is a new rental building that is under construction (total area 3,618 m2), consisting in 41 apartments distributed in seven floors. It will be built according to the latest energy specifications. The annually estimated consumption is 340 MWh (heat + electricity). The residents are estimated to move in January 2022.

- B3: a new private-owned block of flats under construction, YIT1 (by building company YIT)

  Residential building YIT1 was built according to the latest building code and energy regulations. The building includes 45 apartments distributed in seven floors with an area of 2,932 m2. Annually estimated consumption is 290 MWh (heat + electricity). The first residents moved in at 1st of December 2020.

- B5: a new shopping centre (by Arina)

  New shopping mall was commissioned in October 2018 and was built to meet very low 228.5 kWh/m2yr total consumption. It has a total area of 2,000 m2, distributed in a single floor. Arina has a singular heating and cooling system based on heat pump and geothermal energy, connected to the district heating, with a thermal energy storage tanks (phase transfer liquid) and PV panels in the roof. A special type of low temperature hybrid heat collectors will provide extra heat even in cold winter temperatures. The mall also houses an advanced wireless control system and will have charging points for eCars.

- B6: School building (city of Oulu)

  The so-called Hiirihaukka building in Kaukovainio will be added to the PED area. It is from MAKING-CITY project point of view used for energy education purposes and as a reference example of an ordinary building without any previous special energy efficiency measures installed, until now during the project, when similar heat pump system presented also in other

MAKING-CITY buildings, will be installed. The building complex is a multi-purpose one, so Kaukovainio school is only one part of that. The total gross area of the building is 7209 m2, so for the required about 2000 m2 only a part of the building can be allocated to the Making-City-project. The spaces to be allocated for MC would be the youth service centre, adult education centre, spaces for indoor sports and library. Therefore, the spaces have a good diversity of communal services for citizens and can give a good insight in energy measures of spaces of different purposes. The original construction year is 1970 and there are several in principle similar buildings in Oulu and Finland, thus the experiences are also well replicable.

3 Data quality

In MAKING-CITY project, there are three completely different types of dataset collection:

1) Quantitative data that is collected automatically by ICT systems
2) Qualitative data that is collected by questionnaires, interviews, etc.
3) Open data that is freely available

Data quality attributes are described in Table 3: Quality attributes and their applicability in MAKING-CITY data quality evaluation with their applicability to data quality evaluation.

Table 3: Quality attributes and their applicability in MAKING-CITY data quality evaluation

Quality attribute	Description and rationale	Applicability
Accuracy	The degree of correctness and precision. Ensures that the data/information is error-free, and the value is in consistent form.	Quantitative data collected from demo buildings. Semantic accuracy; data entities must reference a real world correspondent and must have faultless attribute values, synthetic accuracy: structural validity of a dataset, such as compliance with RDF/XML standards.
Completeness	The degree to which data/information is not missing. Verifies that the data/information is sufficient in breadth, depth and scope.	Quantitative data collected from demo buildings. completeness of data within a data set (A/B); A = number of data required for the particular context in the data set, B = number of data in the specified particular context of intended use
Consistency	Implies that two or more values do not conflict with each other. Ensures internal validity.	Data consistency checks for quantitative data collected from demo buildings.
Corroboration	The same data comes from several different sources.	The data is trustworthy when the amount of data sources is adequate in the situation at hand. Applicable for qualitative data and open data.
Coverage/ amount of data	The extent to which the volume of data is appropriate for the task at hand (appropriate volume of data available)	The minimum of two ratios: The ratio of the number of data units provided to the number of data units needed, and the ratio of the number of data units needed to the number of data units provided. Applicable for qualitative data and open data.
Objectivity	The extent to which information is unbiased, unprejudiced and impartial.	The existence of user biases in the information or associated content Applicable for qualitative data and open data.

Relevancy	The extent to which information is applicable and helpful for the task at hand.	The amount of occurrence of relevant key words. Applicable for qualitative data and open data.
Timeliness	The freshness of the data; timestamp.	A timestamp: data set creation date. Applicable for all different kinds of data sets.
Validity	The likelihood that the data in an appropriate format and the values are still valid.	Data syntax and semantic checks; Data set creation date. Applicable for all different kinds of data sets.
Verifiability	The degree and ease with which the data/information can be checked for correctness. The traceability and provability of data/information.	Resource Identifier, Relation, Cross References. E.g. the data source names the actual source of the data, or if it points to a trusted third party source where the data can be checked for correctness. Applicable for open data.

Five star scheme can be used for assessing the degree to which the individual datasets are re-usable:

- 1 star: the data is available on the web in any format,
- 2 stars: the data is available in a structured format,
- 3 stars: the data is available in an open, non-proprietary format,
- 4 stars: Uniform Resource Locators (URIs) are used to identify the data using open standards and recommendations from W3C,
- 5 stars: the data is linked to other people's data to provide content.

The quality of the data in MAKING-CITY project is validated as a part of the system integration and testing.

4 GDPR Compliance

Some of the data that is collected for the monitoring of the PED's is personal data. In addition, information and feedback are collected from the citizens and residents that may include personal data. Contracts with the residents must be done in two cases:

Monitoring the consumption data of the residents in three demo buildings. The residents has to give their consent to the collection and processing of data for the purpose of the MAKING-CITY project. This has been laid down in a participant contract (defined in "Appendix B: Consumer consent" and "Appendix C: Privacy Notice for Research").

Collecting the qualitative data from the citizens and residents, e.g. with the help of the surveys or a feedback mechanism. In the case of feedback data, the "Participant Contract" is adequate. However, the personal data collected with the help of the survey (i.e. a questionnaire) requires a different contract that describes the residents the information about the data processing. Basically, the personal data is not collected with the questionnaires. However, the personal data (e.g. name, e-mail address) is required when prizes are drawn among the respondents that want to participate on the lottery. The personal data is not used and isn't therefore relevant in data processing. The following information is required to be defined to make the data collection GDPR consistent (defined in "Appendix D: Data privacy statement"):

- Time period for storing and processing the personal data
- What data is to be collected and for what purposes
- Legal basis for the personal data processing
- Transfer of information to a non-EU country or international organization
- Information about the rights of the participant
- Information on the right to withdraw consent
- Name and contact details of the Data Protection Officer (if applicable)

5 Monitoring phases of quantitative data in Oulu

This section describes how the guidelines of quantitative data monitoring will be applied in Oulu. The quantitative monitoring consists of the following four phases, as defined by SCIS Technical monitoring guide (SCIS, 2018b):

1. Defining the indicators and monitoring concept
2. Implementing data collection pipeline
3. Metrics monitoring of the demos
4. Voluntary long-term monitoring

Overall picture of monitoring phases is given in Figure 2: Monitoring phases of quantitative data. Next sub-sections shall cover the phases with more details.

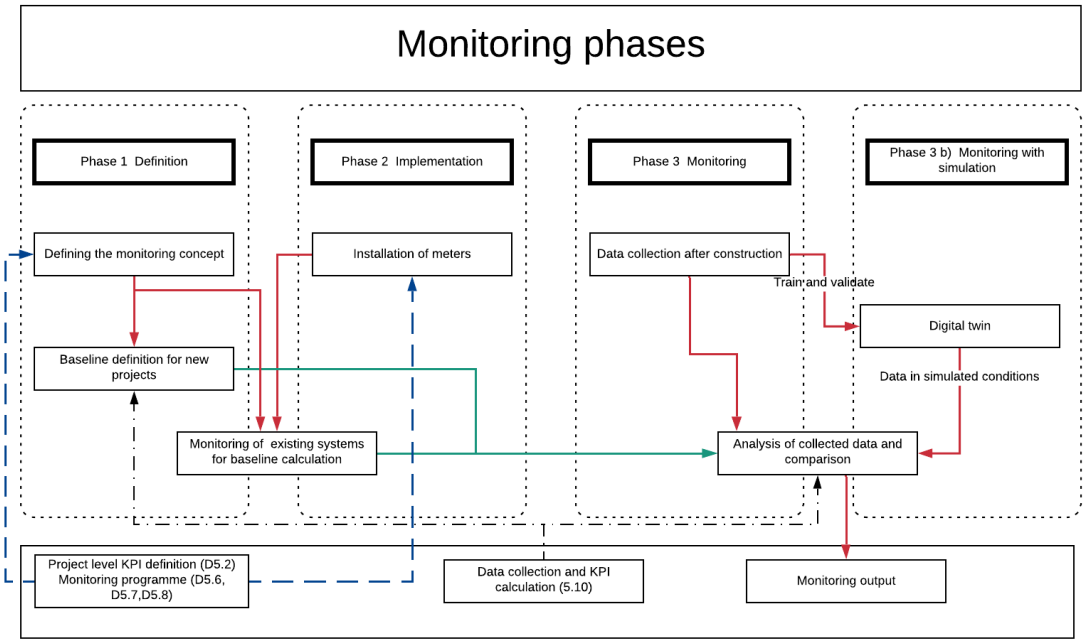

Figure 2: Monitoring phases of quantitative data.

5.1. Phase 1 - Defining the indicators and the monitoring concept

In this step, it is fundamental to identify the requirements and metrics that have be monitored in order to calculate the KPIs. Moreover, all technical (quantitative) KPIs are based on the baseline figures. Therefore, setting a baseline and calculating the baseline performance is essential part of this phase. Exact baseline calculations shall be presented in the deliverable 2.2 (M36) and later in deliverable 5.10. The generic guidelines for the baseline calculation are given in deliverable 5.6.

For quantitative data, the following indicators described in Table 4: Project level indicators have been defined in the deliverable "D5.2 - Project Level Indicators"

Table 4: Project level indicators

ENERGY & ENVIRONMENT		
PED Energy Profile		
Indicator	Unit	Description
E1: Final energy consumption	kWh/month; kWh/a; kWh/(m2month); kWh/(m2a)	Annual final energy consumption divided for all uses and forms of energy (electricity/thermal/gas). **Transportation and public lighting excluded.** Buildings combined to area level. No separate apartments reported. Monitoring on the building level, but **final KPI on PED area level.** Final energy used in buildings defined as in the BEST tables: electricity for lighting, ventilation, space heating and cooling, hot water, for heat: heating, cooling and domestic hot water.
E2: Primary energy consumption	kWh/month; kWh/a; kWh/(m2month); kWh/(m2a)	This indicator corresponds with the primary energy consumed inside the PED boundaries that is the energy forms found in nature (e.g. coal, oil, gas, biomass, nuclear, wind, solar, hydro) which have to be converted (often with subsequent losses) to useable forms of energy. **Excluding transportation and public lighting.**
E3: Energy imported to PED	kWh/15min(/day) ; kWh/month; kWh/a; kWh/(m2month); kWh/(m2a)	The amount of electricity and thermal energy (district heating, gas and other sources) **imported to the PED area** from outside the PED boundaries.
E4: Energy exported from PED	kWh/15min(/day) ; kWh/month; kWh/a; kWh/(m2month); kWh/(m2a)	The amount of electricity and thermal energy **exported outside the PED boundaries** from the demonstration area.
E5: RES production	kWh/month; kWh/a; % of final energy consumption	Amount of **RES production inside PED boundaries**, and share (compared to final energy consumption in the area.) Divided into electricity (solar) and thermal energy (including geothermal, waste/excess heat etc. energy produced with heat pumps).
E6: PED energy balance	kWh/month; kWh/a; (surplus + or deficit -); %	The overall **primary energy balance of the PED** area considering demand-consumption, energy flows, storage, RES.
E7: Energy savings in the PED	kWh/(m2a); %	Total annual **saved primary energy in the PED** compared to situation without any interventions (baseline).
S1: Energy poverty	% of households, or % share of income	Percentage of households by definition, or energy bill as % of total household disposable income.
Environmental effect		
Indicator	Unit	Description

E8: GHG emissions	kgCO2-eq/ (m2month); kgCO2-eq/ (m2a) kgCO2-eq/ (kWh a)	The GHG emissions (converted in CO2-eq.) generated over a calendar year by the same activities included in the primary energy related KPIs inside the PED boundaries.
E9: Reduction of emissions	kgCO2-eq/a; %	**Reduction of CO2-eq. emissions in the PED area** achieved by the project actions and interventions.
MOBILITY		
Mobility related technologies		
Indicator	Unit	Description
M1: Number of public EV charging stations	# of installed stations	Number of EV charging station inside the PED that are available for the public use.
M2: Energy delivered for EV charging	kWh/month; kWh/a; charging time; # of charges	Energy consumption (energy delivered) by the EV charging stations in PED, and if available, the total number of charges, or the total charging time.
ECONOMY		
Economic performance		
Indicator	Unit	Description
C1: Total investments	€/m2; €/kW(h)	How much money is invested in total to PED interventions. Subdivision of the sources (EU funding, (local) government funding, private investment by companies and other private investment.
C2: Payback time	Years	Economic payback period of (selected, most impactful?) investments.
C3: Economic value of savings	€ / saved kWh (or reduced kgCO2-eq)/a	Total investments combined with the output results (in terms of energy savings or reduction in GHG emissions (CO2-eq.)) on a project level, this KPI tells something about the effectiveness per saved amount of (primary) energy / reduced emissions, or contribution into new energy generation.
FLEXIBILITY		
Performance based on flexibility		
Indicator	Unit	Description
F1: System flexibility for energy players	%; kWh; Likert	Flexibility of the whole energy system in PED by means of smart solutions. Demand response management and smart controls for the energy system. **Additional flexibility capacity gained for energy players.** KPI measures the progress brought by R&I activities relative to the new clusters and functional objectives, assessing the additional electrical power that can be modulated in the selected framework, such as the connection of new RES generation,

		to enhance an interconnection, to solve congestion, or even all the transmission capacity of a TSO.
F2: RES storage usage	%; kWh	The combined **usage of energy storage capacity** in the PED area. The aim is to increase energy system flexibility with local energy storages for electricity and heat.
F3: Peak load reduction	%; # of peaks (congestion), duration of peaks and size of peaks; MHDx maximum hourly deficit	The indicator is used to analyse the maximum power demand of a system in comparison with the average power. With the correct application of ICT systems, the peak load can be reduced on a high extent and therefore the dimension of the supply system. E.g., Peak load is the maximum power consumption of a building or a group of buildings to provide certain comfort levels.

This deliverable describes the monitoring procedures only for the metrics that are needed for calculating the key performance indicators. Other possible metrics that will be collected from the demos are excluded from this deliverable.

5.2.Phase 2 - Implementing data collection pipeline

There are three building blocks in monitoring architecture that needs an attention to get robust working monitoring implementation:

1. Energy meters
2. Process reading the energy meters and sending the measurements to a server and
3. A server containing the database where the energy measurements are saved.

The real implementation may be different and more complex, but they most probably contain these building blocks in any case. Data collection pipeline does not work if any of these components fail.

Energy meters

Energy meters are the first part of data collection pipeline. For selecting the proper energy meters to be installed, an attention should be paid that the energy meters meet time and energy resolution specified in D5.5.

Reading process

Reading process reads the meters and sensors and sends them to an external server. In this process, again attention needs to be paid to the meter and sensor reading frequency such that time resolution requirements are fulfilled. It is strongly recommended that the reading process would contain some cache for energy meters such that connection breaks would not cause breaks to the data. Moreover, there may be different reading processes for different energy meters. The reading of the energy meters should be time synchronized well so that the timestamps from different energy meters would be time synchronized as well. The timestamps are recommended to follow UTC time or some other time format where daylight time causes no breaks.

The network protocol between server containing the energy database and reading process should be selected such that it would be fault tolerant.

Server and Database

Finally, the collected data is saved to database in some server either in cloud or in own premises. The data collection pipeline should be monitored in the server such that data breaks would be noted with minimal delay and the reason identified and corrected as quickly as possible.

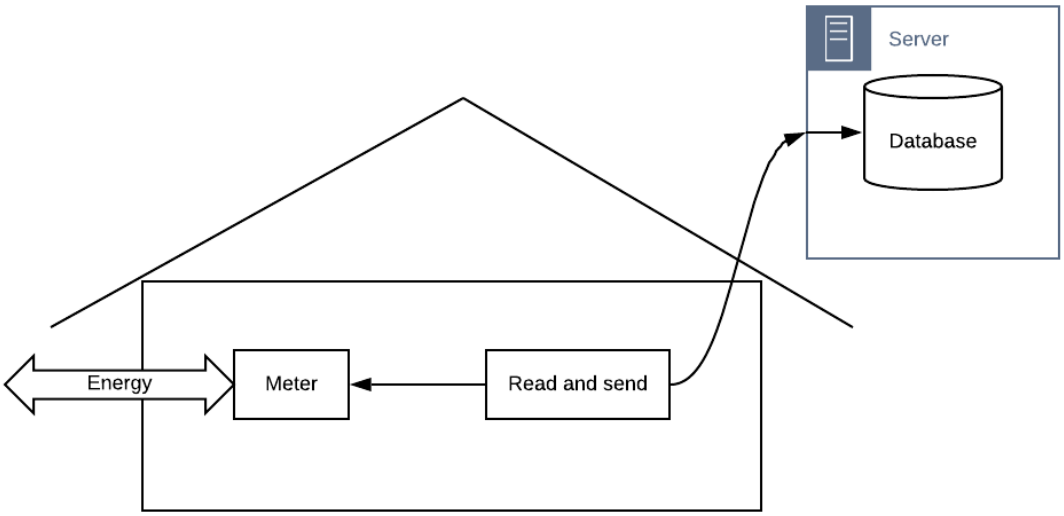

Figure 3: Monitoring building blocks

Baseline

Baseline assessment refers to the procedure to assess the actual situation before the intervention takes place and which will be used to compare the effect of the intervention. This section focuses on guidelines for specific interventions within the energy scope, which are intended to achieve energy savings or to increase the share of renewable energy once the boundary for the analysis is clearly defined.

Baseline calculations differ whether we are dealing with new developments or renovated buildings. For example, when the boundary of the analysis is at an existing building, a baseline refers to the actual situation before the refurbishment, when the intervention relates to improving the energy efficiency or service level of the building. For new building developments, the baseline refers to the business-as-usual practice, which can be derived e.g. from building regulations or by utilizing measured data from same type of buildings.

In these cases, methodologies such as IPMVP (EVO, 2012) can be directly applicable. IPMVP is a best practice methodology commonly used for measuring, computing and reporting savings achieved by energy efficiency projects at end user facilities. This protocol establishes how to perform the evaluation of energy savings by comparing measured consumption before and after implementation of energy actions making suitable adjustment for changes in conditions. The comparison of baseline period and reporting period is carried out by following the general M&V equation:

Savings = Baseline period energy – Reporting period energy +/- Adjustments

The adjustment term shown in the equation should be computed from identifiable physical facts and in this case, proceed to perform an adjusted of the baseline energy.

The baseline is different for new and existing systems. It is important to meter energy consumption before refurbishment in projects that deal with existing buildings and systems. This data is then used for defining the baseline. For new buildings and systems, the baseline is determined based on the energy performance of similar systems representing state of the art or minimal requirements by law, i.e. buildings with similar purposes and sizes or mobility systems in similar districts or cities. The baseline for a project should be defined as follows:

- Refurbishment cases: one year of monitoring of the existing system. The building's energy consumption must be metered before the construction work starts, which will include final energy demand for heating, domestic hot water, cooling, and electrical appliances (kWh/month). In case metering is not possible, data from energy bills can be used to define the status before refurbishment.
- New-built cases: one year of synthetic data reflecting the typical scenario. This data has to be calculated according to regulations, technical guides or similar projects. The calculation can be also simulated as will be done in many cases.

In addition to the baseline, expected energy performance of the system or systems is predefined in planning phase based on simulation, modelling and calculations. This way, later deviations from design values can be detected.

For the calculation of indicators and the assessment of the energy performance different sets of data are needed. These include baseline scenario, design data and monitoring data. The division into these three data sets will allow the comparison between:

- Design data and baseline scenario: improvement compared to the typical solution
- Monitoring data and baseline scenario: real improvement compared to the typical solution
- Monitoring data and design data: comparison of achieved performance against prediction, this can also be defined as a separate indicator (quality of prediction).

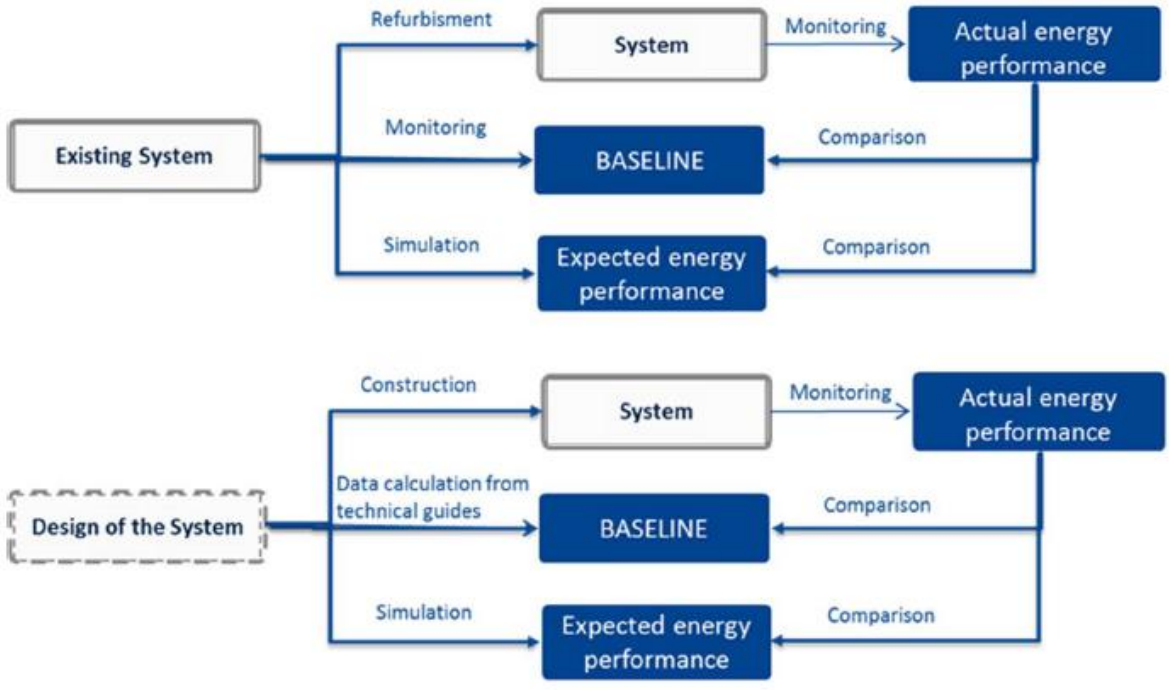

Figure 4: SCIS: Comparison of data on energy performance

5.3.Phase 3 - Metrics monitoring of the demos

Mapping of the metrics on the indicators. Table 5: Metrics for monitored commercial building. and Table 6: Metrics for monitored residential apartment buildings. describe the needed metrics to be monitored from different type of buildings and energy systems included in the Oulu demo, in order to calculate the KPIs.

Table 5: Metrics for monitored commercial building.

Commercial building (Arina shop)			
Metric	Unit	Interval	Remarks
Total electricity consumption	kWh	1 minute	Main meter
Sub meters: Lighting, HVAC, kitchen appliances, compressors, cooler equipment and car heating	kWh	1 minute	All areas
Thermal energy consumption DH	kWh	1 minute	Energy taken from the DH-network
Total thermal need, thermal production, heat pumps?	kWh	1 minute	Total energy need for heating
PV production	kWh	1 minute	
Thermal production	kWh	1 minute	

Table 6: Metrics for monitored residential apartment buildings.

Residential apartment buildings (Sivakka and YIT)			
Metric	Unit	Interval	Remarks
Total electricity consumption	kWh	1 minute / 1 hour	Interval depends on data availability
Net lighting, HVAC and sauna electricity consumption	kWh	1 hour	For common areas only
Total thermal energy consumption	kWh	1 minute / 1 hour	Interval depends on data availability
Thermal energy from DH	kWh	1 minute / 1 hour	Interval depends on data availability
PV production (only Sivakka)	kWh	1 minute / 1 hour	Interval depends on data availability

The abovementioned data is collected both during normal operation and demand response (DR) tests. The demand response tests will be executed during the monitoring phase in order to measure the response of the system to external control commands. This is needed to calculate the following demand-side flexibility related KPIs: F1 - System flexibility for energy players and F3 - Peak load reduction. In practice, the DR test are executed by activating the flexibilities of the buildings as described in D2.6 - Positive District Energy Flows and D2.5 - Smart Energy Systems in Oulu. These DR tests are enough to fully validate the KPI F1. For F3 complementary simulations are utilized in the validation as described in Phase 3.B.

Phase 3. B - Monitoring with simulation

In the Oulu monitoring programme simulations with data-based models verified in the abovementioned demand response test will be used for monitoring the KPI F3 - Peak load reduction in longer time periods. These simulations will complement the monitoring done with real data by enabling evaluation of the KPI F3 with data from longer time periods and different weather conditions.

The core idea with the simulations is that in practice it is difficult and impractical to execute the DR scenarios for peak load reduction for long time periods as there is no strong enough incentives to make it economically feasible. To this end, we will execute limited number of DR events for peak reduction, in order to first validate the machine learning and hybrids models, presented in D2.5, with real measurement data (presented in section 5.3). Once the models have been validated, we can use them to simulate also long periods for demand response and peak load reduction. To make the monitoring with simulation as realistic as possible we will sample errors from the empirical residual distributions obtained during the validation. In this way, the peak load reduction optimization will utilize models that have similar accuracy as in the real world. This makes it possible to realistically extrapolate and analyze the data related to KPI F3.

5.4. Phase 4 - Long term monitoring (and utilization of data)

Relevant data sets collected during the monitoring phase (needed for KPI calculation and evaluation), will be incorporated into the SCIS database. To this end, the relevant data will be collected into the Oulu ICT Platform, including parameters of the KPI and SCIS data specified in D5.2 - Project level indicators and D5.5 - Data sets: Requirements collection and protection. The Oulu ICT Platform will provide open interfaces for accessing this data and the relevant SCIS calculations will be executed in Excel. The details on the Oulu ICT Platform are presented in D5.9 (architecture) and D5.8 (open interfaces). City of Oulu with support from VTT will upload the data into the SCIS system.

6 Monitoring phases of qualitative data

This section describes how the guidelines of qualitative data monitoring are applied in Oulu. Monitoring of qualitative data consists of the following phases:

1. Context definition
2. Selecting the techniques, approaches, and tools
3. Collecting the data
4. Analyzing the data

The four phases are applied at both the city level and the project (PED) level. In addition, the monitoring consists of two iterations that applies the above phases. The first iteration is performed in the beginning of the project with the focus of catching the current status. The second iteration is performed near the end of the project with the focus of catching the development and changes during the project.

Figure 5 describes the overall outline of the monitoring phases. Next sub-sections cover the phases with more details.

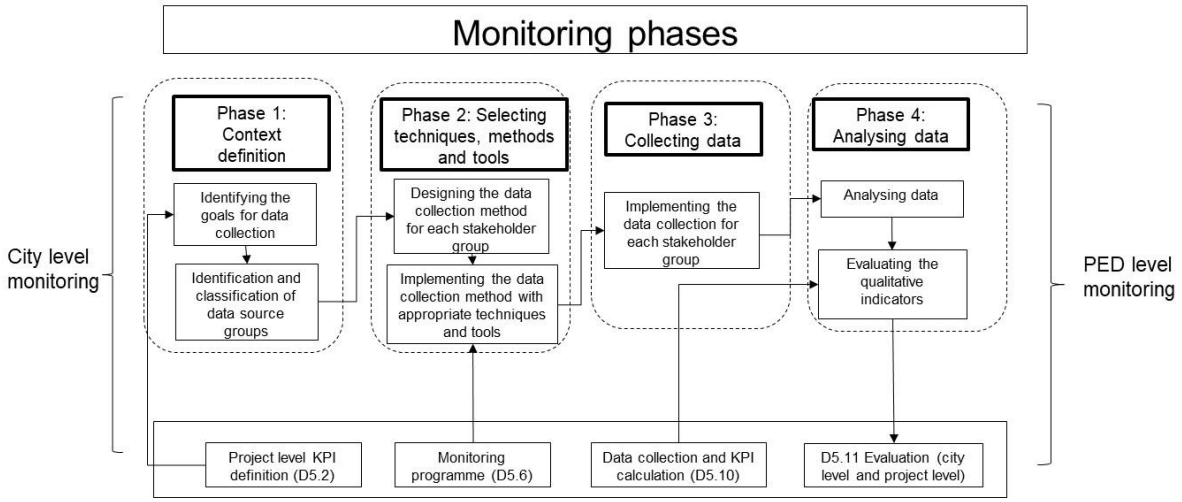

Figure 5: Phases and steps of qualitative monitoring.

6.1. Phase 1 - Definition of monitoring context

City level

Goals: The monitoring of the qualitative data is implemented in two phases.

The purpose of the first phase is to examine the residents' current status, electricity consumption behaviour, and motives for changes in their consumption behaviour. In addition, the purpose is to examine how the residents feel that their city is encouraging them towards healthy lifestyle and providing them data to increase consciousness to climate actions.

In the second phase, the purpose is to examine the concrete/detected changes during the project.

Indicators: Table 7: The city level qualitative indicators describes the defined quality indicators for city level (defined in D5.1 - City Level Indicators) monitoring.

Table 7: The city level qualitative indicators

GOVERNANCE

Initiatives and Strategies of the Public Administration – related indicators	
Smart city factor in a city development strategy	Inclusion and level of detail of smart cities strategies in the urban strategic plans of the city.
Public ICT / Data	
Quality of open data	The extent to which the quality of the open data produced by the city was increased.
SOCIETY AND CITIZENS	
Citizen Engagement and Empowerment	
Citizen engagement/ empowerment to climate conscious actions	Appreciation of the benefits of city actions; Energy empowerment at home, satisfaction, happiness of people.
Encouraging a healthy lifestyle	The extent to which policy efforts are undertaken to encourage a healthy lifestyle.

In addition, the PED level indicators (D5.2 - Project Level Indicators) defined in Table 8: The PED level qualitative indicators are used for qualitative data monitoring.

Table 8: The PED level qualitative indicators

SOCIAL AND RESIDENTS	
Social and resident related indicators	
S1: Energy poverty	Percentage share of energy bill as % of total household disposable income
S2: Consciousness of residents	Increased consciousness of residents of the area on the defined issues (project interventions, energy, environment, climate, personal/ communal consumption, carbon footprint and handprint, etc.).
S3: Resident engagement/ empowerment to climate conscious actions	Appreciation of the benefits of project actions; Energy empowerment at home, satisfaction, happiness of people.

Participants: In the city level, the data sources will be all the residents of Oulu. In addition, the relevant city policymakers and city decision makers, which are familiar with the project and its goals for each PED areas, and are aware of the development of the whole city, are the data sources for 'Smart city factor in a city development strategy' indicator. The rest of the qualitative indicators are applicable for all the residents of Oulu.

PED level

Goals: The monitoring is implemented in two phases.

The purpose of the first phase is to examine the residents' current status, electricity consumption behaviour, residents' awareness of the effect of their own consumption behaviour on climate issues, and the motives and benefits for changes in their consumption behaviour.

In the second phase, the purpose is to examine the concrete changes, the satisfaction of the people and the success of the goals of the project.

Indicators: The defined quality indicators for qualitative research include the PED level indicators (D5.6) defined in Table 8.

Participants: In the PED level, the data sources will be the residents of the monitored buildings. The data collected from these residents is based on their own consumption habits, awareness and everyday life observations.

6.2.Phase 2 - Selecting the techniques, methods, and tools

The qualitative research is implemented using a questionnaire targeted to the residents of Oulu. The questionnaire format is chosen because a high number of responses is desired, and an online questionnaire would be able to reach more people.

In Oulu case, the questionnaire will be implemented as a web-based questionnaire using the Questback Essential (https://www.questback.com/) on-line survey tool, which makes the questionnaire available for residents in several ways via a direct link. The tool enables to present questions based on the answers given (e.g. the "yes" and "no" answers result to different follow-up questions).

The distribution channels for the city-level questionnaire are web pages (City of Oulu, MAKING-CITY project etc.), direct e-mail distribution (if possible) and social media (Twitter and/or Facebook) of VTT and project partners Sivakka, YIT, Arina, the University of Oulu, and the city of Oulu. At PED level, Sivakka will send e-mails to its residents in the demo building. An introduction to the questionnaire ("cover letter") is provided with the explanation of the concept and the purpose behind the questions, and the direct link to the questionnaire is provided to the respondents.

6.3.Phase 3 - Collecting the data

The questions are implemented in Finnish, because not all Finnish people, especially elderly, speak English. The questions include both closed- and open-ended questions. Closed-ended questions typically have a limited set of possible answers. Some of the close-ended questions are multiple-choice questions, whereas some allow only one answer. Both the city level and PED level questionnaires include first general questions about the respondents.

The questions on city level

The questions are related to the following pre-defined indicators (defined in sub-section 6.1).

- Smart city factor in a city development strategy: the status of smart cities strategies in the city's strategic plans
- Quality of open data: the status of the quality of the open data that the city of Oulu provides
- Citizen engagement/empowerment to climate conscious actions: the status of energy consumption at home, and the satisfaction of people energy related issues
- Encouraging a healthy lifestyle: the level at which the city encourages citizens towards a healthy lifestyle
- Energy poverty: the tendencies of saving energy

- Consciousness of residents: the awareness of residents to energy and its relationship with the environment
- Resident engagement/empowerment to climate conscious actions: the motives to engage residents to energy related actions.

The city-level questions for the Phase 1 are represented in Appendix A.

The questions on PED level

The questions are related to the three pre-defined indicators (defined in sub-section 6.1):

- Energy poverty
  - The actions towards energy saving in residents' habits and consumptions
  - Share of energy bill as % of total household disposable income
- Consciousness of residents
  - Residents' current status: energy consumption profile and habits of residents
  - Activity of the residents: how aware the residents are about the development and actions in energy markets
- Resident engagement/empowerment to climate conscious actions
  - Motives of the residents: what are the motives for the resident to participate in energy actions/energy markets

The questions at the PED level can be more detailed than the questions at the city level, and they can also be defined in more case-specific.

6.4.Phase 4 - Analysing the data

Analysing the results

Quantitative methods can be used to analyse the responses to the closed-ended questions (e.g. Yes/NO or numbers from 1 to 5), described as percentages or as numbers (Likert scale). These form the direct value for the results.

The answers obtained from the open-ended questions can be analysed using qualitative data analysis methods, such as the constant comparative method, open coding, etc. For example, content analysis method (Bengtsson, 2016) enables to parse and present data in words and themes, and finally to identify the common characteristics among the responses. Four main stages have been identified (Bengtsson, 2016) that are used here in the content analysis:

- Decontextualization: Familiarizing with the data and broking the data down into smaller meaning units that answer the question set out in the aim.
- Recontextualization: Re-reading the data alongside with the final list of meaning units, checking whether all aspects of the content have been covered in relation to the aim, and letting go of the unimportant information that does not correspond to the aim of the study.
- Categorization: Condensing meaning units and identifying themes and categories that are internally homogeneous and externally heterogeneous.
- Compilation: In qualitative content analysis, a choice can be made between the manifest and the latent level, and the depth of the analysis will depend on how the data are collected. The manifest analysis will be chosen, because it enables to use the respondents' actual words, refer back to the original text and to stay closer to the original meanings and contexts. Regardless of

the form of the analysis, a summary can be presented of themes, categories/sub-themes and sub-categories/subheadings as a table to allow the reader to get a quick overview of the results.

Evaluating the indicators

The evaluation of indicators is implemented with the following steps:

1. Defining the evaluation criteria
2. Forming an evaluation group
3. Defining the input material for the evaluation
4. Evaluating the values for the indicators

Step 1: Defining the evaluation criteria

For the evaluation of the qualitative indicators, evaluation criteria are required to be formed. Tables 9 - 14 describe the defined criteria that are used for the evaluation of each quality indicator.

Table 9 Criteria to evaluate energy poverty

Criteria	Evaluation	Unit
Satisfaction of people	Satisfaction % for electricity price, electricity retailer, electricity devices, electricity taxes (1=not satisfied, 5=very satisfied)	Likert scale
Satisfaction of people on energy distribution price	(1=not satisfied, 5=very satisfied)	Likert scale
Price of energy	Scale from cheap to expensive (1=very expensive, 5= cheap)	Likert scale
Percentage of energy bills of total household disposable income	Five alternatives, % of alternatives	Percent
Activity of people on energy saving	% of given alternatives (1=small activity, 5=very high)	Likert scale

Table 10 Criteria to evaluate consciousness of residents

Criteria	Evaluation	Unit
Activity of people with electricity retailer	(Willingness to change electricity retailer (% of alternatives)) Properties for selection of the electricity retailer (% of alternatives) (1=not often, 5=very often)	Likert scale
Activity of people towards the peak pricing	Alternatives: yes/no/cannot say, % of alternatives (1=not active, 5=active)	Likert scale
Awareness of the content of electricity bill	Scale from strongly disagree to strongly agree (1=not aware, 5=very much aware)	Likert scale
Satisfaction with the access to own consumption information	Scale from strongly disagree to strongly agree (1=not satisfied, 5=very much satisfied)	Likert scale

Willingness to monitor own consumption behaviour	Scale from strongly disagree to strongly agree (1=not willing, 5=very much willing)	Likert scale
Willingness to obtain data	% of given alternatives (1=not willing, 5=very much willing)	Likert scale
Willingness to provide data to companies	% of given alternatives (1=not willing, 5=very much willing)	Likert scale
Interest towards services based on own consumption data	Amount of responses, amount of themes identified (1=not interested, 5=very much interested)	Likert scale

Table 11 Criteria to evaluate citizen engagement/empowerement to climate conscious actions

Criteria	Evaluation	Unit
Willingness to influence the environment through own energy consumption activities	Four scaled evaluation (1=not interested, 5=very interested)	Likert scale
Willingness to change energy provider to a 100% renewable energy provider	Scale: no, maybe, yes (1=not interested, 5=very interested)	Likert scale
Willing to change own electricity consumption behaviour against benefits	Willingness (yes/no).What kind of benefits would like to achieve(% of alternatives) How much decrease in electricity bill to change consumption behaviour (% of alternatives) (1=not willing, 5=very much willing)	Likert scale
Willingness to allow a service/device provider to control heating, air condition or water heater	Scale from absolutely not to certainty (1=not willing, 5=very much willing)	Likert scale
Willingness to receive personal recommendations to change energy usage	Scale from absolutely not to certainty (1=not willing, 5=very much willing)	Likert scale
Willingness to invest in meters, smart devices and systems to achieve some benefits	Scale from absolutely not to certainty (1=not willing, 5=very much willing)	Likert scale

Table 12 Criteria to evaluate quality of open data

Criteria	Evaluation	Unit
Adequacy of open environmental data provided by the city of Oulu	Adequacy of data (yes, not, don't know, % of alternatives)	Likert scale/ percent
Interest /usage of open data provided by the City of Oulu	The usage % of available data (1=low, 5=very high)	Likert scale
Quality of open data	Scale from bad to very good (1=bad, 5=very good)	Likert scale

Table 13 Criteria to evaluate encouraging a healthy lifestyle

Criteria	Evaluation	Unit
Adequacy of possibilities provided by the city of Oulu to support the well-being of citizens	Satisfaction % of people on possibilities (1=not satisfied, 5=very satisfied)	Likert scale
Interest towards well-being actions of city of Oulu	Amount of responses, amount of themes identified (1=not interested, 5=very much interested)	Likert scale

Table 14 Criteria to evaluate smart city factor in a city development strategy

Criteria	Evaluation	Unit *
Smart people	Human-centricity, participation, stakeholder engagement, learning, social and intellectual capital	Likert scale
Smart living	Quality of living, health, safety, education, culture, traffic and logistics, smart solutions	Likert scale
Smart environment	Sustainable resources, environmental protection, pollution and emissions, infrastructures	Likert scale
Smart economy	Innovativeness, entrepreneurship, renewal, global interconnectedness, competitiveness, brand and image, smart specialization, platform/sharing economy	Likert scale
Smart governance	Public services (digitalization), openness and transparency, context-sensitivity, strategic needs, ecosystem, holistic and sustainable development, trust, political decision-making	Likert scale

* Likert scale from not good to excellent (1=not good, 2=tolerable, 3=average, 4=very good, 5=excellent)

Step 2: Forming the evaluation group

For the evaluation of the indicators, a local evaluation group needs to be formed that consist of experts of different partners of the project that has a good knowledge about the local energy markets and the decisions and strategies of the city of Oulu. The group should include domain experts at least from the

city of Oulu and from Sivakka Oy, and the researchers from VTT Technical Research Centre of Finland and the University of Oulu.

Step 3: Defining the input material for the evaluation

Most of the criteria can be evaluated with the help of the results of the survey. However, one indicator, "Smart city factor in a city development strategy", cannot be evaluated from the survey results. For this indicator, the reference material is searched from the city development strategy documentation. Figure 6 describes the "smart city" factor referred in this document.

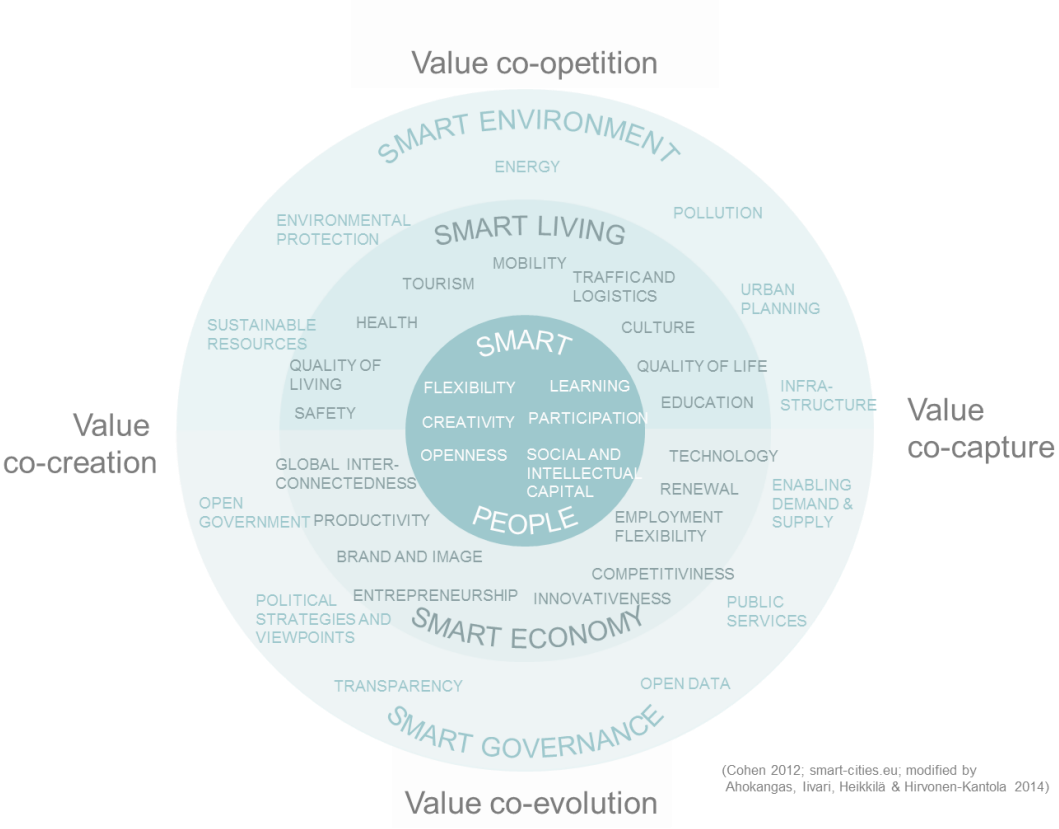

Figure 6 The definition of "smart city".

The applicable documentation for the evaluation can be identified to include the following documents: Oulu City strategy 2026 – The Light of the North[1], Digital Oulu Program (2019–2023) [2] and the City of Oulu Environmental Program -towards carbon neutral Oulu [3].

Step 4: Evaluating the criteria

Evaluation against the results of the survey: The evaluation of qualitative indicators differs from the evaluation of quantitative indicators, sine qualitative evaluation is always more human-centric. The evaluation group is gathered together to evaluate the results of the survey against the evaluation criteria. For each criteria, a value will be evaluated and the value for the qualitative indicator will be formed as a weighted average of the values of the criteria.

[1] Available at: Kaupunkistrategia Oulu 2026 (ouka.fi)
[2] Available (in Finnish) at: Digitaalinen Oulu -ohjelma (2019–2023) (ouka.fi)
[3] Available at: https://www.ouka.fi/oulu/english/environmental-policy

Evaluating the criteria against relevant documents: The criteria of the indicator "Smart city factor in a city development strategy" has to be evaluated by domain experts, policy-makers or other relevant stakeholders against the pre-defined documents. The evaluation is implemented by the evaluation group as in the case of other indicators.

7 Resident engagement and interacting

7.1. Background and motivation

In Oulu, the well-established participatory urban planning processes will be taken advantage of and considered as the baseline also in the integrated energy and spatial planning approach. In addition, the transportation and general consumption reduction are also to be approached. The relevant MAKING-CITY Actions in this point include:

Action 50: Citizen and stakeholder engagement Tenant activities are increased and developed in rental buildings, including tenant meetings, tenant evenings and election of a tenant committee. The cooperation committee that consists of tenant committee gives statements and develops resident activities. Some rental houses already have a volunteer environmental expert who helps residents to monitor their energy, water and electricity consumption and thereby save money and environment. Environmental experts have a key role when implementing new policies and increasing energy consciousness.

Action 51: Education, Co-design and Co-creation in Oulu. A digital web-based user interface is to be developed to involve citizens in their homes and increase their awareness regarding energy issues. The interface is to be available on in-home displays as well as on mobile devices. With the help of the user-friendly interface, the residents participating to the MAKING-CITY project can access their energy consumption, water consumption, evaluate their climate comfort and provide feedbacks on it, as well as information on their environmental impacts.

Action 52: Local toolkit for renewable energy production and storage at the district scale. RES electricity production in the Finnish conditions is based mostly on wind, hydro and biomass, which are the DH system is a good basis with wood-CHP or especially in the future, that completed with heat pumps. These, in turn, are in the best case, controlled (i.e. the timing of the operation is controlled) so that the whole system works optimally. The investments are mainly done by larger organizations. It is however also possible for the individual building owners to invest on e.g. heat pumps, heat storages and PV panels. One good possibility to give information and advice about these actions is on the web pages and leaflets published by the building supervision of the City of Oulu. In that form, the information is again delivered using existing channels, which is favourable in terms of finding the information in a proper place. The other way is e.g. the interface showing the energy status of the MAKING-CITY-buildings. On top of the web interface accessible publicly, the interface allows following the status of the PED even if you are not a participant in the project.

To evaluate the role of consumers in changing the market, consumer engagement and their opportunities to be aware and their possibility to participate in demand response is to be studied. A long tradition of consumer engagement studies circled around the idea of flexible contracts (He et al. 2013), or dynamic pricing to test the reactivity of consumers on the electricity grid for enhancing the smart grid concept as in the European project EcoGrid (Gantenbein et al. 2012). An overview of EU projects highlights the importance of including trust and a set of motivational factors to engage

consumers such as environmental benefits of their actions, control over the bill, or improving their climate comfort (Gangale, Mengolini, and Onyeji 2013).

The specific research includes the involvement of residents to demand response under the influence of different criteria and their impact on energy consumption, whether it is electrical or thermal. MAKING-CITY project will look over a set of four criteria that could influence consumer behaviour:

1. Impact of dynamic environmental impact indicators on consumer behaviour

The inclusion of near real-time environmental indicators on the production of electricity aims at informing the consumers on the status of the environmental load of electricity, regardless of the type of electricity contract they have signed with their electricity provider. This information represents the environmental load on the power network by including all produced and traded power from the network. Multiple choices will be set on which environmental indicator the consumer will be informed about whether it is global warming-related, or the environmental impact on land use issues, any toxicity level increases, or air quality.

2. Impact of dynamic pricing as provided by local electricity providers

Regardless of the type of contract that the consumers have selected e.g. Time-of-Use, Fixed Price, Monthly contract + Variable Price, etc… they will be informed on the evolution of the real-time price and recommendations on the future state of the price on short and long-term. As price is more a rational and concrete indicator (Catlin, Luchs, and Phipps 2017), the change and their impacts on consumers and households economy shall be highlighted.

3. Impact of energy information related to the heat and electricity production from the district heating but also from the local decentralised electricity production, and network congestion.

The PED is a complex energy system where the technology used in the buildings will diversified to reach the target of positive energy district. As such, information on decentralised electricity production from the 50 kW PV-panels shall be reported to the consumers and warn them about the future electricity production of the PV system. Moreover, information on their electricity consumption shall be retrieved to set the electricity intensity usage. Electricity consumption shall also be used for reporting purposes by assessing the impact of consumer behaviour on their energy profile as well as energy consumption levels.

4. Impact of climate comfort on consumer engagement

Climate comfort is another motivational factor that influences consumers. To evaluate the importance of climate comfort on consumer engagement, a set of variables shall be retrieved to the users such as the average temperature of their dwelling, the CO_2 concentration of the indoor air that affect indoor air-quality, the humidity level and the ventilation within the dwelling. The household thermal comfort must be compared with standardised thermal comfort level for information purposes and consider specificities of the households such as the age of the consumers. As suggested in the literature (van Dam, Bakker, and van Hal 2010; Hargreaves, Nye, and Burgess 2013), energy monitors or in-home displays lose their effectiveness after 4 months of activity in the home. Many reasons were found to support this idea, one of them being the fact that the information lacks dynamics and once the consumers have learned their ways, they tend to forget about the monitor and checking it. Therefore, a rotation of feedbacks should occur every 3 months, four times in total. At the end of the 12 months period, consumers will have the choice to choose between the four indicators and have the possibilities to weight the importance of each indicator to form a single indicator of four of them. The trial period will continue throughout the project.

7.2. Implementation of resident interaction in Oulu

In Oulu, residents' engagement and interaction in energy consumption monitoring is examined in one retrofitting building and in three new buildings. One of the most important issues is to detect the influence of represented data on the consumption behavior of the residents; will be residents change their consumption behavior based on available data about the statistics of their own building, or perhaps in some point based on the data about their own consumption. The research consists of three phases:

1. Monitoring of the quantitative data of the demo building.
2. Providing residents the data collected about the energy consumption and the conditions of the building.
3. Collecting feedback from the residents through the qualitative research (survey or a separate feedback channel).

1) Monitoring of the quantitative data

1.1 Data collected on site

Data collected from the apartments include temperature, water, energy and thermal comfort. These are described in more detailed in Table 15: Domain and measurement target.

Table 15: Domain and measurement target

Domain	Measurement
Heat	Indoor Temperature External temperature
DHW (domestic hot water)	Hot water flow meter (remote readings) Cold Water flow meter (remote readings)
Electricity	Energy consumption / apartment
Thermal Comfort	Relative humidity Air flow

1.2 Processed data

Data processed through models such as the near real-time emission factors are implemented into the user interface using the API rest server of the University of Oulu[4]. Data are public and include the emission and power by fuel sources. The emissions are visually retrieved every 3 minutes for the end-users such as colour coding, and are visible from the front page of the interface.

[4] https://app.swaggerhub.com/apis-docs/jean-nicolas.louis/emission-and_power_grid_status/1.1.0

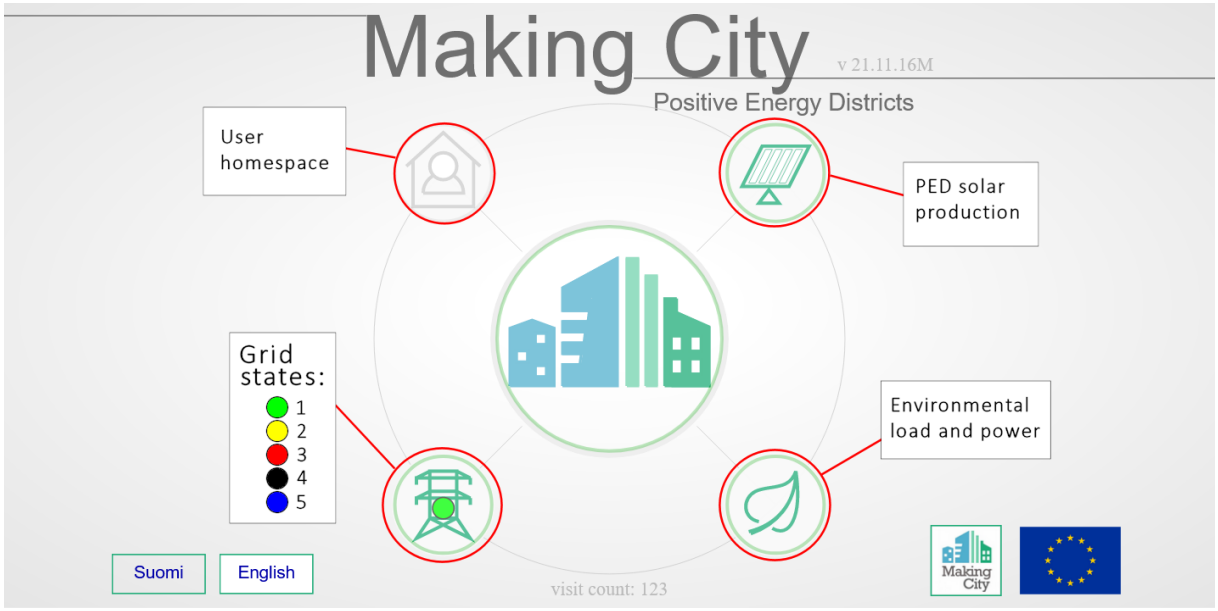

Figure 7: Front page of the interface presented to the tenants

At the front page (see Figure 7), we can find the grid state indicator light and graphical elements, which act as buttons to access more detailed information about grid, PED solar power and environmental load (see Figures 8, 9 and 10).

Different states of the power system - traffic lights: *

1 = Green: Power system is in normal secure state.

2 = Yellow: Power system is in endangered state. The adequacy of the electricity is endangered (serious risk for electricity shortage) or the power system doesn't fulfill the security standards.

3 = Red: Power system is in disturbed state. Manual load shedding has taken place in order to maintain the adequacy and security of the power system (electricity shortage) or there is a serious risk to a wide black out.

4 = Black: An extremely serious disturbance or a wide black out in Finland.

5 = Blue: The network is being restored after an extremely serious disturbance or a wide blackout.

* https://www.fingrid.fi/en/electricity-market/power-system/different-states-of-the-power-system---traffic-lights/

Figure 8 shows latest snapshot of production with different technologies and how much import is needed to match consumption (+export).

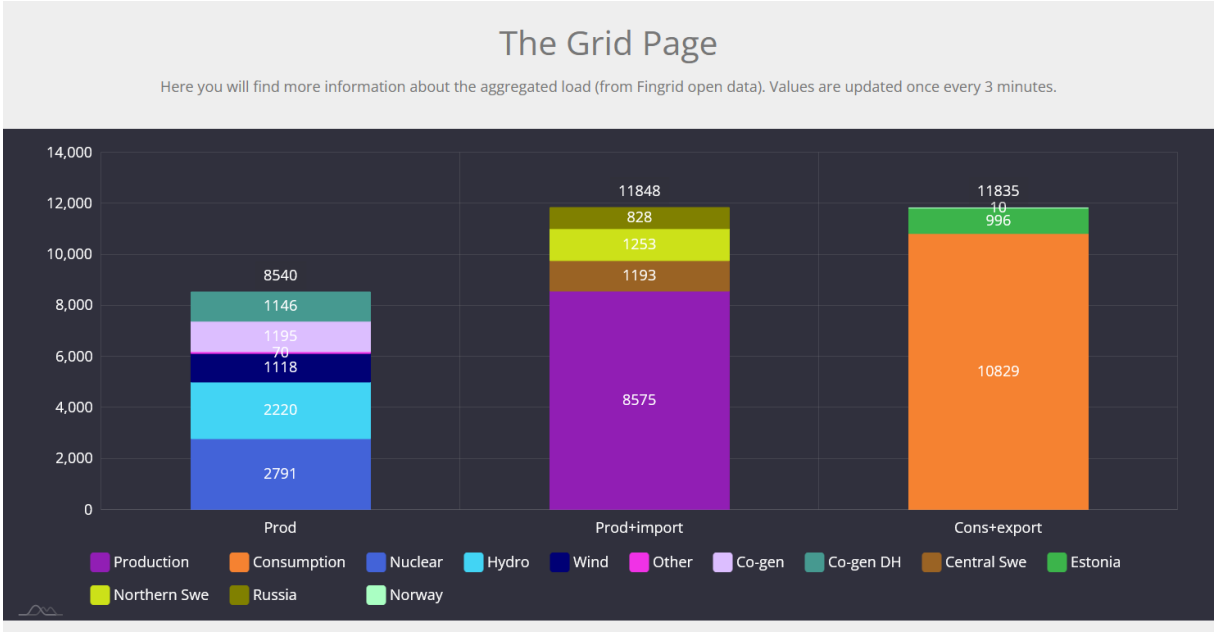

Figure 8: The grid page, production and consumption snapshot

Figure 9 presents the solar page: solar power generation forecast for the next 36 hours. The forecast is updated hourly.

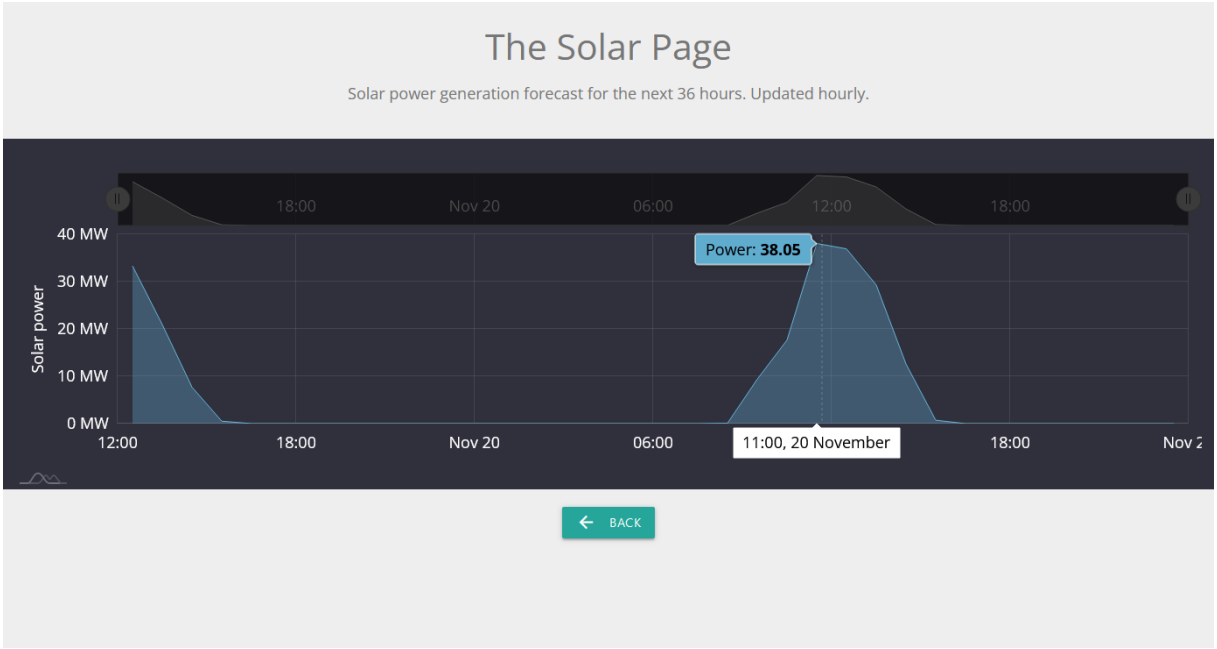

Figure 9: The solar page, forecast for Finland.

Figure 10 presents the environment page that describes the carbon footprint of production and consumption.

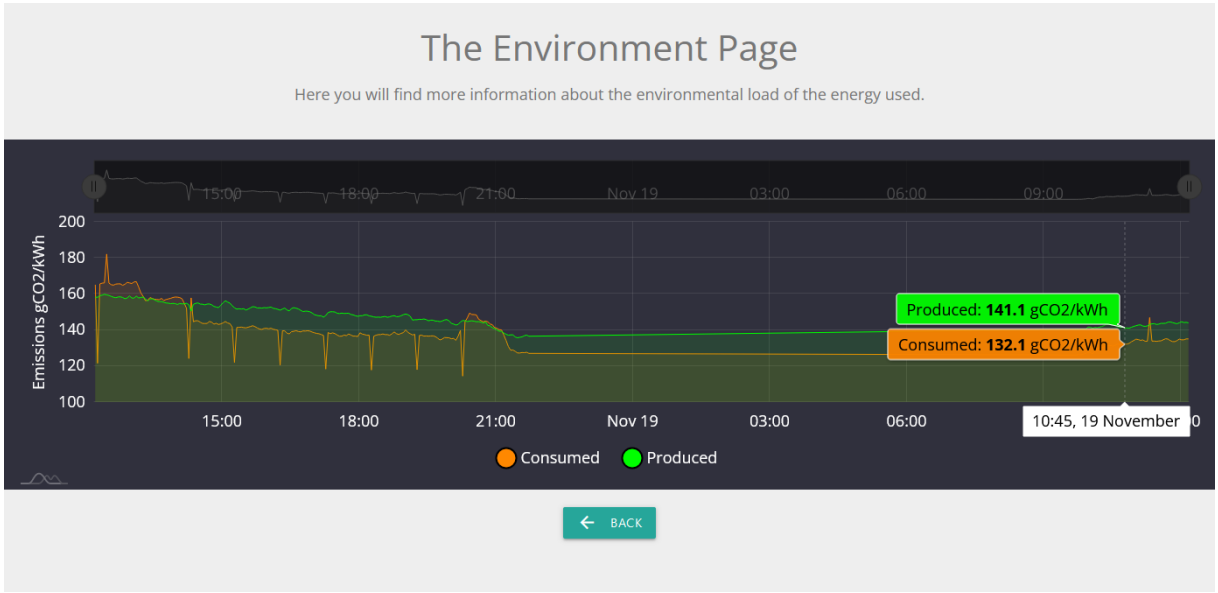

Figure 10: The carbon footprint of production and consumption

2) Providing residents the collected data

Residents can participate and get access to their own apartment data through registering process (described in D2.16 Chapter 7.3 User interface for residents). However, there is also a public view for anonymous users (general public), which will show selected anonymized and averaged building-level data (see Figure 11).

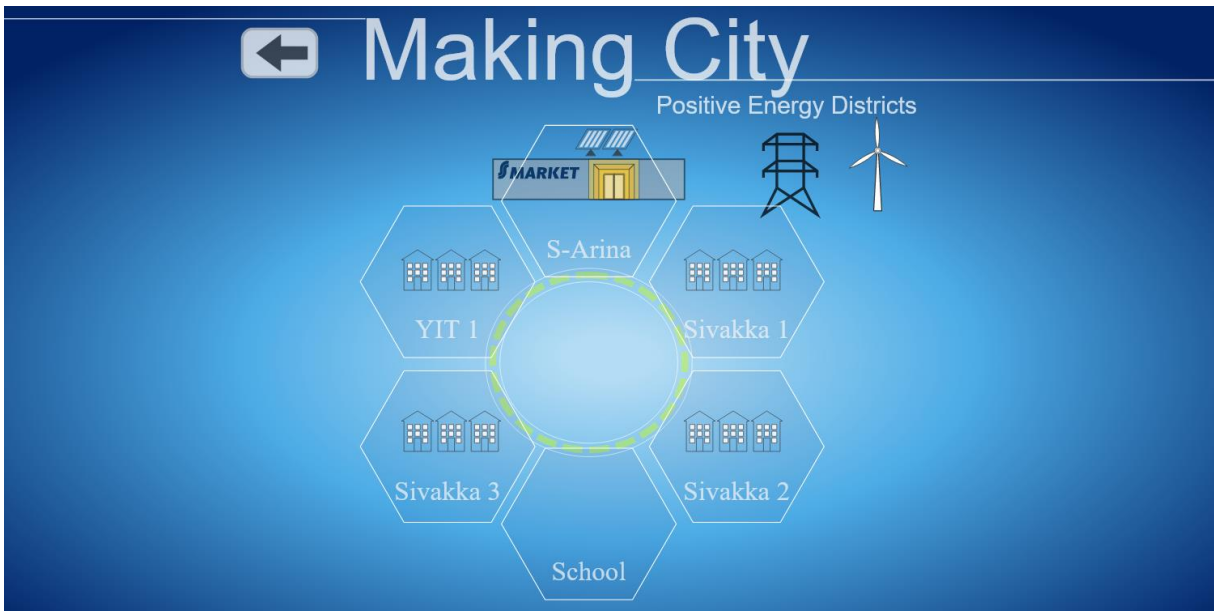

Figure 11: PED area view

Registered users (residents) can view their electricity consumption, water consumption and heating in different time periods. Electricity consumption view also shows money spent if users have given correct prices from their electricity contracts. In heating view users can give feedback using smiley ratings, how comfortable they feel heating or ventilation is (see Figure 12).

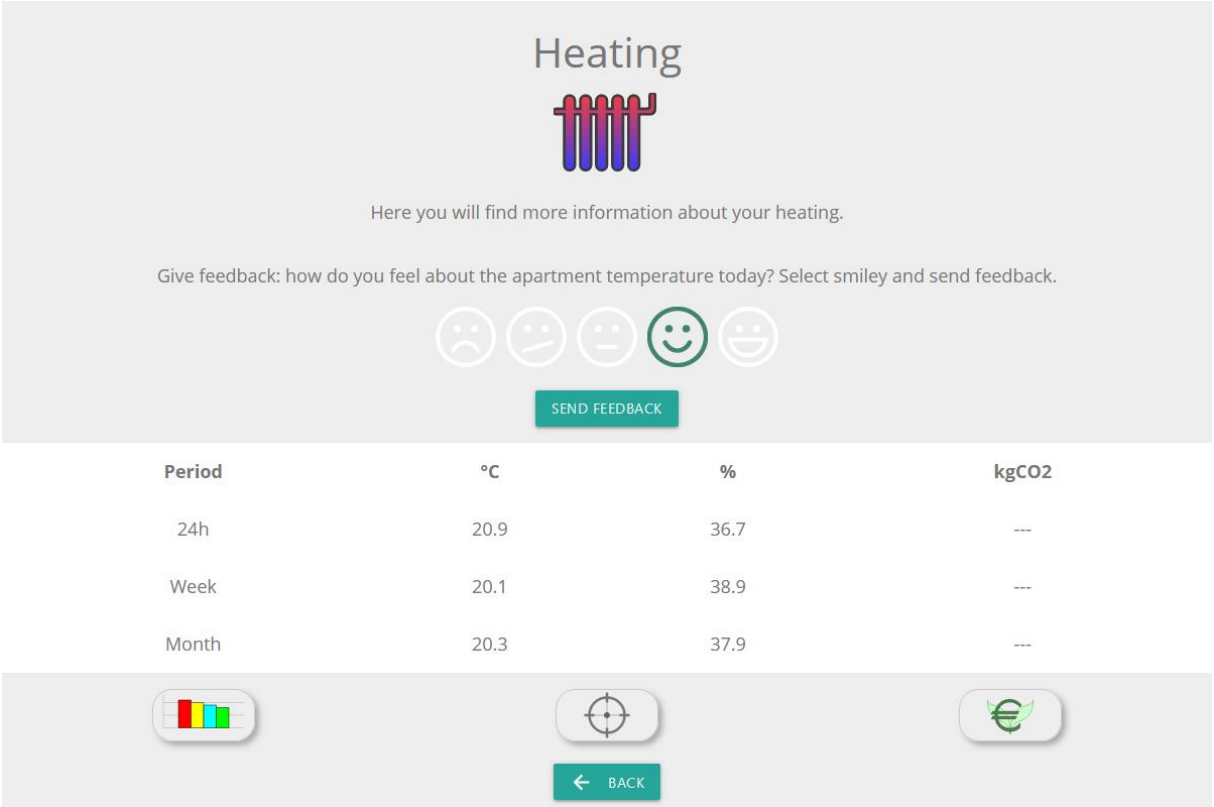

Figure 12: Residents' heating feedback

3) Collecting feedback from the residents

Feedback channel: The residents may be able to provide feedback about the indoor conditions through the feedback inquiry integrated with the user interface. History data can be collected about the satisfaction of the residents to the room temperature, as the residents are able to select the number that reflects their satisfaction (1=not satisfied, 5=very satisfied) through the user interface (see Figure 12). Providing feedback is voluntary. A general feedback channel is still under consideration, where the residents can write free text whenever they want.

Survey: The purpose of the survey is to detect the effect of the data; have the residents changed their consumption behaviour based on the data. The questions of the survey are related to three quantitative indicators (defined in D5.2 - Project Level Indicators):

Energy poverty

- Energy saving habits: has the received data caused changes in residents' habits?

Consciousness of residents

- Data reception: have the residents received / followed the data? How often/frequently?
- Consciousness: do the residents feel that their consciousness on energy and climate has been increased?
- Satisfaction: do the residents achieve any benefits or detect positive effects?

Resident engagement/empowerment to climate conscious actions

- Increase in activity; are the residents more active/aware about energy actions/issues?

- Changes in behaviour: Are there any changes in residents' consumption behaviour and habits based on the received data?

The questions of the survey are consistent with the questions introduced in chapter 6.3. - The questions on PED level.

Conclusions

The purpose of this document is to describe the guidelines and the methodology for implementing the monitoring program specified for Oulu demonstration. The PED area and demo-buildings have been described as well as the quantitative and qualitative indicators that act as the starting point in determination of the monitoring needs.

This report describes the monitoring of both quantitative and qualitative data, and the user engagement and interaction in the monitoring program. Monitoring of quantitative data describes how the monitoring will be implemented and how the data for quantitative KPI calculation is achieved from six demo buildings in Oulu. The monitoring consists of the following four phases; 1. Defining the indicators and monitoring concept, 2. Implementing data collection pipeline, 3. Metrics monitoring of the demos, and 4. Voluntary long-term monitoring. Monitoring of qualitative data describes the four-phased process how the qualitative data monitoring will be implemented both at the city level and PED level. The data sources for qualitative monitoring are the residents of Oulu, the residents of the demo buildings in Kaukovainio (Oulu) and domain experts, policy-makers or other relevant stakeholders of the city of Oulu. The monitoring consists of the following four phases: 1. Context definition, 2. Selecting the techniques, approaches, and tools, 3. Collecting the data, and 4. Analyzing the data. Finally, residents' engagement and interaction on monitoring describes how the data is provided for the residents of the demo building, and how these residents provide feedback. This research consists of three phases: 1. Monitoring of the quantitative data of the demo building, 2. Providing residents the data collected about the energy consumption and the conditions of the building through a user interface, and 3. Collecting feedback from the residents through the qualitative research (survey or a separate feedback channel).

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Appendixes

Appendix A: The questions for the city level qualitative research

Background	
Your age	(one choice) a) under 30, b) 30-50, c) 50-70, d) over 70 years
Your gender	(one choice) a) male, b) female
What is your role as an energy consumer?	(one choice) a) family house owner, b) flat owner, c) tenant, d) other, what?
What is the size of your household?	(one choice) a) single person, b) 2 persons, c) three or more persons
What is your home's electricity consumption/year?	(one choice) a) under 5000 kWh, 5000-10000 kWh, b) 10000 - 20000 kWh, c) 20000 - 30000 kWh, d) over 30000 kWh, e) don't know
What is the type of your electricity contract?	(one choice) a) Fixed price, b) operating tariffs (night/day electricity), c) exchange electricity (market variable price), d) don't know, e) other, what?
Is your home equipped with any kind of smart technology (i.e. can the following be automatically optimized/controlled)?	(multiple choices) a) heating, b) lighting, c) ventilation/air conditioning, d) refrigeration, e) car heating, f) some other, what? g) no controllable devices/systems
What is the *main* heating method of your home?	(one choice) a) direct electrical heating, b) district heating, c) storage electric heating, d) oil/wood /pellet, e) geothermal, f) exhaust air heat pump, g) air-water heat pump, h) air-heat pump, i) other, what?
Energy poverty:	
How satisfied are you with	a) electricity price, b) electricity transfer price, c) your electricity provider, d) your current electricity devices, e) electricity tax in Finland (Likert scale 1…5 for each + cannot say)
Are your satisfied with your room temperature?	(Likert scale 1…5)
Do you pay attention to energy saving in your habits and consumptions?	(multiple choices) a) I turn the lights off when I leave the house, b) I tend to use less warm water, c) I tend to buy energy efficient appliances, d) I invest in thermal insulation, e) I use only little devices/appliances that consume much energy, f) I keep the room temperature sensible, g) I have installed smart meters, h) I use low-energy lighting, i) other, what?
How would you describe the cost of energy in Finland?	(Likert scale 1…5)
How many percentages is your energy bills (electricity and heating) of total household disposable income?	(one choice) a) under 5%, b) 5-10% c) 10-30%, d) 30-50%, e) more than 50%, f) don't know

Consciousness of residents	
Do you follow regularly the news in electricity markets?	(one choice) yes/no
If yes, how?	(multiple choices) a) using a Web app (e.g. sahkonhinta.fi), b) electricity company newsletters, c) general media (e.g. tv, papers), d) other, what?
How often do you change your electricity retailer?	(one choice) a) after few months, b) approximately once a year, c) after couple of years, d) whenever I receive a good offer, e) I tend to keep my reliable retailer longer
What properties is your selection of your electricity retailer based on?	(multiple choices) a) electricity price, b) company brand, c) environmental concerns, d) locality of the company, e) credibility, f) other?
What kind of energy services are you interested in?	(multiple choices) a) automatic heat adjustment service, b) automatic detection of electrical equipment malfunction and related maintenance, c) optimizing own electricity consumption, d) electric car charging service, e) other, what?
Do the variations in electricity price (e.g. the peak pricing) affect your own consumption behaviour?	(one choice) Yes / No / Cannot say
Are you aware of your energy consumption and the content of your electricity bill?	(Likert scale 1…5)
Are your satisfied with the access to the information and its level regarding your own energy consumption and bills?	(Likert scale 1…5)
Would you like to monitor your own consumption behaviour and consumption more precisely?	(Likert scale 1…5)
What data would you like to obtain?	(multiple choices) a) detailed information and statistics on my individual equipment consumption, b) information about the consumption peaks of my home / property, c) predictions about my own consumption, d) information about important events in the market that will affect the electricity price, e) data considering the consumptions of similar types of households, f) data about the environmental effects of my consumption, g) the current data is enough for me, h) other, what?
If you could not be identified from consumption data, what would you be prepared to provide to companies for free use?	(multiple choices) a) data about your heat consumption, b) data about your electricity consumption, c) data about the indoor air temperature in your apartment, d) none of the above mentioned
Companies can develop services based on consumption data if they are allowed to do so. What kind of service would be useful for you?	(open question)

Resident engagement/empowerment to climate conscious actions	
How strongly you feel each one of the following is responsible for the climate change and its effects?	People (residents) (Likert scale 1…5), Government (Likert scale 1…5), Industries/business (Likert scale 1…5), Nature itself (Likert scale 1…5)
Do you tend to improve the environmental situation for your own part?	(one choice) a) I am not interested at all how my consumption affects the environment, b) I tend to choose environment-friendly option when it is profitable for me, c) I always then to choose environment-friendly option when it is possible and sensible, d) I take the environment into account in all my actions)
Would you change your energy provider to a 100% renewable energy provider?	(one choice) a) No, this thing is irrelevant for me, b) May be if it doesn't cause any extra costs for me, c) Yes, even if it would be expensive alternative, d) cannot say
Would you be willing to change your own electricity consumption behaviour (for example, do the laundries or go to sauna at different time) if you achieved some benefits?	(one choice) yes/no / cannot say
If yes, what kind of benefits would you like to achieve?	(multiple choices) a) decrease in electricity bill, b) some service; e.g. automatic heat control, c) supporting the environment through reducing emissions, d) other, what?, e) don't know
IF a selected; how much should the decrease be (€/year)?	(one choice) a) 10-20 €/year, b) 20 - 50 €/year, c) 50 - 80 €/year, d) over 80 € /year, e) cannot say, f) other, what?
If no, why are you not willing to change your consumption behaviour?	(open question)
Would you allow a service/device provider to control your heating, air condition or water heater against some benefits?	(Likert scale 1…5)
Would you like to receive personal recommendations to lower/ change your energy usage?	(Likert scale 1…5)
Are your willing to invest in meters, smart devices and systems to achieve some benefits?	(Likert scale 1…5)
Are you interested in becoming an electricity producer in the future, for example, with the solar panels?	(Likert scale 1…5)
What do you consider as good ways to motivate people to climate conscious actions?	(multiple choice) a) providing people more data about environmental effects of their consumption behaviour b) publishing more visible graphics about total emissions, c) motivating them to use bicycles when going to work, d) enabling them to monitor their own consumption, e) providing them tips how to save energy, f) encourage them to reduce material consumption, g) other, what?

What do you consider as the main barriers why people are not interested/motivated to change their consumption behavior?	(open question)
Quality of open data	
Does the city of Oulu provide enough environmental data available for citizens' usage (for example, the quality of water and air, and the total electricity consumption, etc.)?	(one choice) Yes/no/I don't know
IF yes, what data do you utilize?	(multipe choice) a) Quality of water, b) quality of air, c) data related to traffic, d) data related to energy consumption, e) I don't follow any of the above mentioned, f) other, what?
What is the quality of that data?	(Likert scale 1…5)
What kind of data would you like your city to open?	(open question)
Encouraging a healthy lifestyle	
Does the city of Oulu provide enough possibilities that support your well-being? Please select the alternatives with which you are happy with:	(multiple choices) a) cycle paths, b) running/skiing paths c) sport centers/halls, d) sporting events, e) reasonable prices to city's sport activities, f) health recommendations, g) I am not satisfied with any of mentioned above, h) other, what?
How could your city support your well-being better?	(open question)

Appendix B: Consumer consent

Consumer consent

I confirm that I have read and understood the information sheet and attached privacy notice. I confirm that I fulfil the selection criteria and/or do not have any exclusion criteria mentioned in the information sheet. I have had the possibility to consider all information and ask questions and I have received satisfying answers to my questions.

☐ I hereby consent to **participate in the research**. I have the right to interrupt my participation or leave out from any phase of the research and withdraw my consent at any time without any specific reason and without having to explain the reason.

☐ I hereby consent to **processing of personal data in the research**. I have the right to withdraw my consent at any time without any specific reason and without having to explain the reason.

I have the right to withdraw my consent but I understand that after being published there are practical limitations concerning the removal of personal data.

Signature

_____

Name:

Date:

Appendix C: Privacy Notice for Research

Privacy Notice for Research

In accordance with EU General Data Protection Regulation (2016/679, "GDPR") and applicable national legislation (including Finnish Data Protection Act 1050/2018).

1. Name and duration of the research

Name of the research: MAKING-CITY

Duration of the research: 1.12.2018 - 30.11.2023

2. Controller(s), data protection officer(s) and contact person(s)

Name: VTT Technical Research Centre of Finland Ltd. ("VTT"), Business ID: 2647375-4

Address: Vuorimiehentie 3, 02150 Espoo, Finland

Data protection officer (DPO) of VTT:

Name: Seppo Viinikainen

Address: VTT Technical Research Centre of Finland Ltd., Koivurannantie 1, 40400 Jyväskylä, Finland

E-mail: Seppo.Viinikainen@vtt.fi (DPO) or dataprotection@vtt.fi (DPO, data security, HR manager and legal counsel)

Contact person or responsible research group of the research:

Name: Jari Rehu, Teknologian tutkimuskeskus VTT Oy

Address: VTT Technical Research Centre of Finland Ltd, Kaitoväylä 1, 90571 Oulu

E-mail: jari.rehu@vtt.fi

Other joint registrars:

University of Oulu

E-mail: dpo@oulu.fi

3. Joint controller responsibilities

VTT Technical Research Centre of Finland Ltd is the primary contact point for the registered persons and coordinates the requests of registered persons towards other joint registrars. The other joint registrars (see section 2) are responsible for executing the requests on their own behalf. The data subject can exercise his or her rights regarding the processing of personal data centralized through a contact person: Seppo Viinikainen, VTT Technical Research Centre of Finland Ltd, Koivurannantie 1, 40400 Jyväskylä, Seppo.Viinikainen@vtt.fi. If necessary, the contact person shall forward the contact request of the data subject to the other joint registrars.

4. Personal data categories

Processed personal data categories: Home temperature, humidity, electricity consumption, consumption of hot and cold water, and feedback from the resident.

The data subjects represent persons living in the buildings selected for the study or use buildings in the Kaukovainio district of Oulu.

5. Purpose and legal basis of processing

Purpose of personal data processing: With your consent, VTT will process the collected data for energy-related research on housing conditions and energy consumption. The data is used for research purposes only. Data is not combined with an individual.

Legal basis of processing[5]:

☐ Performance of a task carried out in the public interest

☐ scientific or historical research purposes or statistical purposes

☐ archiving purposes of research data and cultural heritage data

☐ Legitimate interests pursued by the Controller(s) or by a third party

legitimate interest concerned:

☒ Data subject's consent

☐ Other:

6. Data sources

Personal data is received from your apartment through the home automation system, and possibly through the resident's user interface.

7. Recipients or categories of recipients

Personal data will be disclosed to the following recipients:

VTT Technical Research Centre of Finland - joint registrar, processor of personal data

University of Oulu - joint registrar, processor of personal data

8. Transfers outside the European Union or the European Economic Area

Personal data is transferred outside the European Union or the European Economic Area:

☒ No

☐ Not yet known but possible. Mechanism defined and informed on a case-by-case basis.

☐ Yes, on the following basis:

- ☐ Commission adequacy decision
- ☐ Binding corporate rules
- ☐ Commission standard data protection clauses

[5] GDPR Art. 6 and Finnish Data Protection Act 4 §.

☐ Other:

1. **Automated decision making**

Personal data is not used for automatic decision-making.

2. **Retention period of personal data after the research**

☐ Research data and personal data is destroyed after the research.
☒ After the research, research data is retained for 12 months and
  ☐ personal data is anonymised
  ☒ personal data is pseudonymised
    ☐ it contains direct identifiers of the data subject, for the following reason:

Research data is stored in a database maintained on VTT's server.

3. **Protection principles**

In performance of research, research data:

☐ is anonymized before commencing the research
☒ is pseudonymised before commencing the research
☐ contains direct identifiers of the data subjects

Manually processed personal data is pseudonymized and protected in accordance with the practices of VTT's research environment.

Personal data processed in data systems is protected with:

☒ user name
☒ password
☐ multi-factor authentication (MFA)
☐ access control with IP address
☐ user monitoring (log)
☐ access control

Encryption method of data transmission:

☒ in transmission: HTTPS standard, SSL protocol
☒ for data file: user name and password
☐ other, what:

4. **Rights of the data subjects**

The data subjects have the rights listed below, which however may be exempted from and/or not applied on grounds set forth in applicable legislation. Exemptions and restrictions are considered for each case separately.

<u>Further description of data subject's rights:</u>

Right to withdraw consent

If the processing is based on consent, the data subjects have the right to withdraw their consent on which the processing is based on. This shall not affect the lawfulness of processing based on consent before its withdrawal.

Right of access

The data subjects have the right to obtain from the controller confirmation as to whether or not personal data concerning him or her is being processed and access to his or her personal data and information concerning the processing of his or her personal data.

Right to rectification

The data subjects have the right to obtain from the controller rectification of inaccurate personal data concerning him or her. The data subjects have the right to have incomplete personal data completed.

Right to erasure ("right to be forgotten")

The data subjects have the right to obtain from the controller the erasure of personal data concerning him or her.

Right to restriction of processing

The data subjects have the right to obtain from the controller restriction of processing.

Right to data portability

Where the processing is based on the data subject's consent and carried out by automated means, the data subjects have the right to receive the personal data concerning him or her, which he or she has provided to the Controller and have the right to transmit those data to another controller.

Right to lodge a complaint with a supervisory authority

The data subjects have a right to lodge a complaint with a supervisory authority if the data subject considers that the processing of personal data breaches the data subject's rights pursuant to applicable law. In Finland, see Finnish Data Protection Ombudsman contact information: https://tietosuoja.fi/en/contact-information

The data subject can exercise these rights by contacting Controller with information set forth in section 2, preferably by email.

Appendix D: Data privacy statement

Information on data processing

Time of storage and processing of personal data

Personal information will be stored for one (1) month after the end of the questionnaire research, after which the personal information will be destroyed except for the winner of the lottery, whose personal data we will process until the price has been delivered to the winner.

What type of personal information is collected and used

VTT will use the personal information requested from you (name, address, e-mail and possibly telephone number) with your consent to conduct a lottery, which will be conducted among those who have provided contact information for participating in the lottery. If you do not wish to participate in the lottery, you will not be required to provide us with your personal information in order to respond to the survey. Personal information will only be used to organize and contact the lottery to communicate the results of the lottery. The personal information provided for the lottery will not be combined with the answers provided in the survey.

Legal basis for the processing of personal data

Personal data will be processed based on the consent of the participants in the lottery.

Transfer of data to a non-EU country or international organization, and safeguards (if applicable)

Personal data will not be disclosed outside the EU or the EEA and will not be processed for profiling, direct marketing or automated decision making.

Personal data is collected from you via the Questback survey tool, after which it is stored with high security, in which case only employees who have committed to VTT's confidentiality have access to it.

Personal data will not be disclosed to third parties other than the supplier of the survey tool to the extent necessary for the technical implementation of the survey. VTT has a contractual relationship with the supplier of the tool required by data protection legislation, and the supplier does not have the right to process your personal data contrary to what is described here.

Your individual rights

You have the following rights with regard to your personal data: the right to withdraw your consent, the right to access the data, the right to rectify the data, the right to delete data, the right to restrict processing, the right to transfer data from one system to another and the right to complain to the supervisory authority. You can implement your above rights by contacting the registrar using the contact information provided here.

Your right to withdraw consent

You can withdraw your consent to the processing of personal data mentioned here at any time by contacting a VTT contact person.

Data Protection Officer

Seppo Viinikainen, tietosuoja@vtt.fi