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D5.6 - Guidelines for definition of Monitoring Programmes

WP5, Task 5.3

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Abbreviations and acronyms

Acronym	Description
DHW	Domestic Hot Water
ESU	Energy Supply Unit
GDPR	General Data Protection Regulation
KPI	Key performance indicator
PED	Positive energy district
RES	Renewable Energy Sources
SCIS	Smart Cities Information System
WP	Work Package

Executive Summary

Task 5.3 aims to define monitoring programme for the project consisting PED level monitoring. Project level KPIs shall be in the main focus in the monitoring programme that are defined in D5.2. The overall guidelines for the monitoring programmes shall be based on the main reference framework; SCIS monitoring guides (SCIS, 2018a, 2018b).

This deliverable communicates the general guidelines for the definition of Monitoring Programmes, and it is targeted for both lighthouse cities. The deliverable produces only guidelines to the monitoring programme while the detailed monitoring programme shall be described in D5.7 for Oulu and in D5.8 for Groningen. Moreover, this document provides some general guidelines for data collection and KPI calculation while they are defined more exactly in D5.2 and D5.5. Both quantitative and qualitative methods are described in this report. An extra care must be paid for proper handling in the collected data. All the GDPR related aspects of collected data shall be covered in D5.5. In addition to the links to other deliverables in WP5, this deliverable has also links to WP2 and WP3 where the ICT platforms implementing the monitoring programme are specified.

1 Introduction

1.1 Purpose and target group

This report constitutes Deliverable “D5.6 Guidelines for definition of Monitoring Programme” which is the first outcome of the “Task 5.3 Monitoring Programme Definition” while the second and last outcomes are individual monitoring programme definitions for Oulu and Groningen.

The intention of the guide is to define a common approach and standardized methodology, which should be applied to all three PEDs in the two lighthouse cities and in all the follower cities. The guidelines provided in this document should ensure that all the datasets defined in D5.5 are collected in reliable way. There are three completely different types of dataset collection in the scope of this document:

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

Quantitative data enables to reach hard facts, such as numbers and percentages, whereas qualitative data enables to describe certain topics in non-quantitative way. Open data can include both quantitative and qualitative data. Methodologies for collecting these data sets are naturally completely different and they are described in independent chapters in this deliverable. Moreover, it should be highlighted that this document quantitative research concentrates for collecting the data sets that are needed directly for calculating KPIs calculation. Therefore, for example collecting sensor data that are used for optimizing energy usage, liveability or energy awareness of citizen are out of scope of this deliverable.

1.2 Contribution partners

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

Table 1: Contribution of partners

Partner n° and short name	Contribution
01-CAR	Contributions to data quality aspects and resident interaction
04-TNO	Defining the monitoring programme with VTT, GDPR issues, peer-review
09-CGI	Peer-review quality control
14-UOU	Contributions to quantitative monitoring and resident interaction
20-VTT	General structure and content of the document

1.3 Relation to other activities in the project

Figure 1 and Table 2 (and later Figure 3: Monitoring phases) 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

This deliverable is focused on the first one. However, the PEDs and ICT platforms of the lighthouse cities are very different. Therefore, also the data collection frameworks are very different. This document provides general guidelines for data collection framework that are defined more exactly in D5.7 and D5.8 separately for both lighthouse cities.

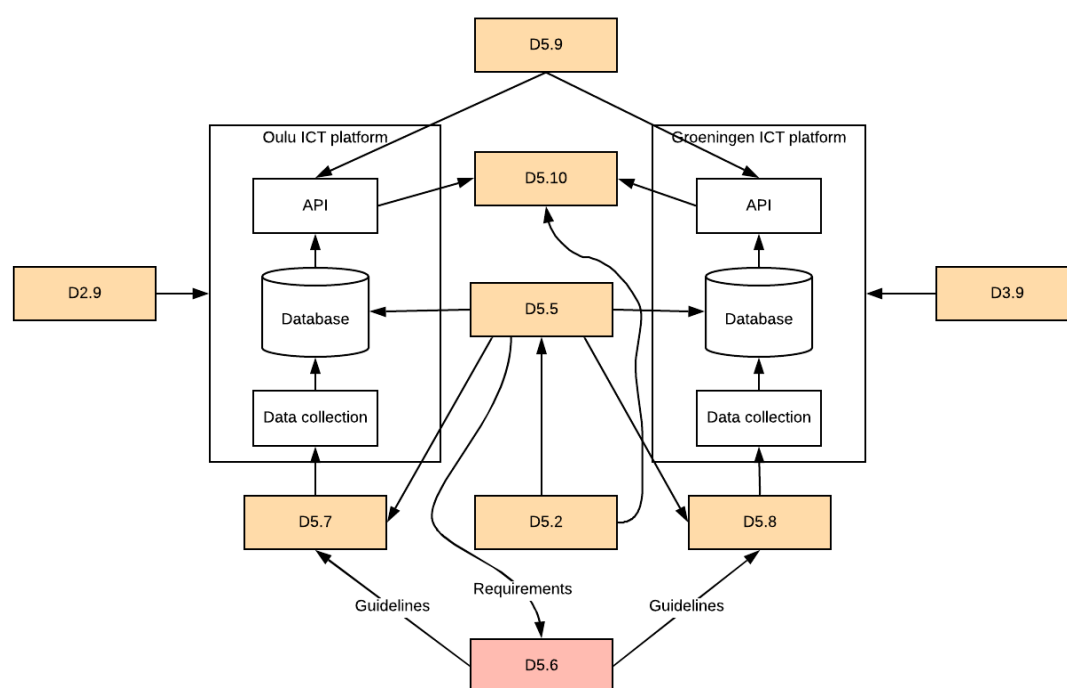


Figure 1: Deliverable relation to other activities in the project

Table 2: Relation to other activities in the project

Deliverable n°	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

D5.7	D5.7 describes monitoring programme of Oulu PED in details
D5.8	D5.8 describes monitoring programme of Groningen PEDs in details

2 Evaluation framework

2.1 Monitoring the actions

MAKING-CITY evaluation framework has been defined to monitor and evaluate the effectiveness of the project actions and interventions, compared to the initial situation, initial objectives and expected results. Robust monitoring and evaluation protocols are being developed and implemented, including a full methodology for the monitoring and evaluation of the project actions and interventions that will allow the introduction of future data after the end of the project.

The main references for developing the evaluation framework and monitoring protocols have been first of all SCIS (KPIs, monitoring guide etc.), but also other recent H2020 funded smart city initiatives including CITYkeys, MatchUP and MySmartLife projects. In the reference projects, KPIs, evaluation methodology and/or monitoring protocols have been implemented in a similar fashion, although there are some deviations mainly due to the differences in the overall project objectives and demo set-ups.

The scope of the MAKING-CITY monitoring protocol is twofold, firstly in order to measure the performance of the actions deployed to reach a validation of PED concept and secondly to evaluate the impact at city level. A set of 20 indicators has been defined for each of these two levels and they can be found in the deliverables D5.1 “City level indicators” and D5.2 “Project level indicators”.

As can be seen in Figure 2: Classification of the defined indicators within the MAKING-CITY evaluation framework, these 40 indicators have been classified in different categories, four in the case of the 20 city level indicators and five categories for the 20 project level ones. In order to evaluate the results and the impact of the project actions at both levels, it is necessary to establish a methodology to obtain the necessary data for calculating these indicators and carrying out the evaluation correctly.

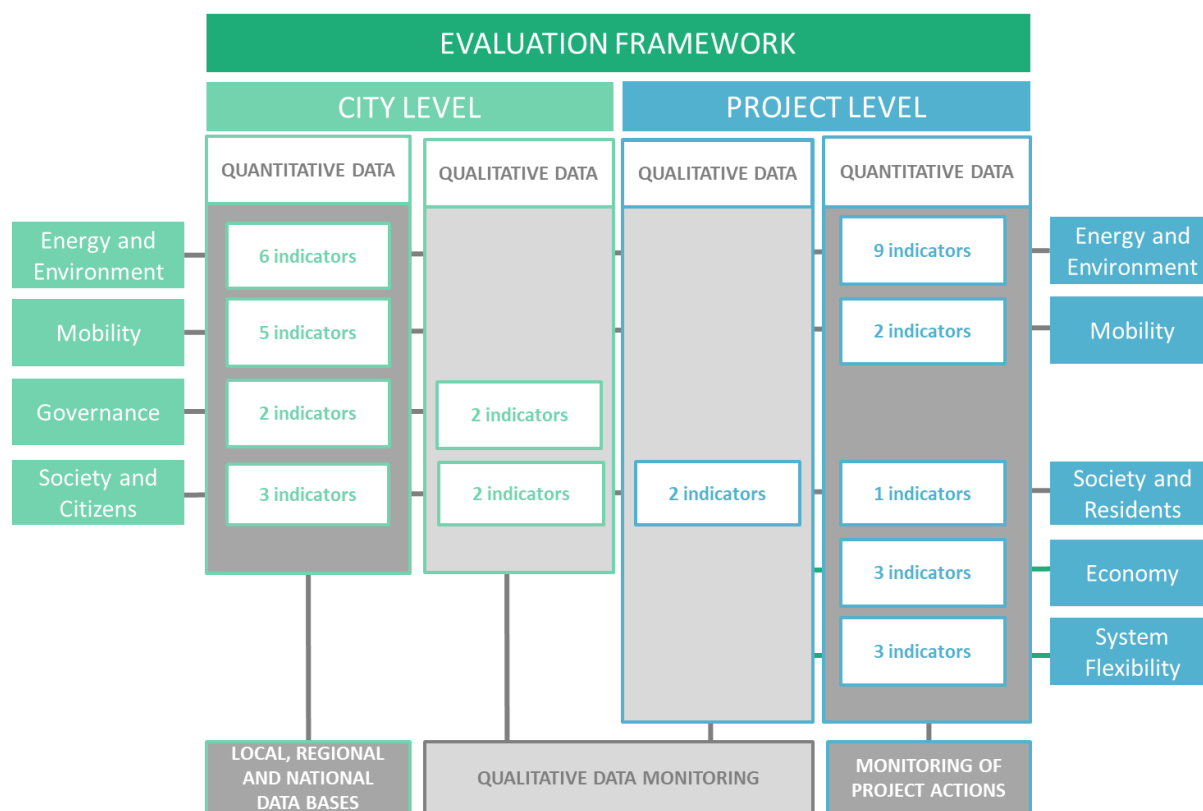


Figure 2: Classification of the defined indicators within the MAKING-CITY evaluation framework

Although most of the indicators defined in the evaluation framework are quantitative, it should be mentioned that six of the proposed indicators are qualitative, so in these cases a specific methodology to obtain this information will be applied. More details about this methodology can be found section 0.

In the case of quantitative data, it is necessary to distinguish the method of obtaining the city level indicators from those of the project level. The city level indicators are obtained from official sources, local, regional, national databases and city plans. The calculation of these indicators in the initial phase of the project has already been carried out and has been presented in deliverable 1.2 “Analysis of existing city plans”. However, in order to calculate the quantitative indicators at project level, it is necessary to establish a protocol for monitoring the actions implemented in the project, which is presented in this deliverable and is detailed for each of the demonstration areas in both lighthouse cities in the deliverables 5.7 and 5.8 (monitoring programmes).

2.2 Ensuring data quality

IoT data can be classified into following groups (Cooper & James, 2009): Radio Frequency Identification (RFID), address/unique identifiers, descriptive data, positional and environmental data, sensor data, historical data, physics models, and command data. In general, IoT data shares four distinct properties (Ma et al., 2013): heterogeneity, inaccuracy, massive real-time data and implicit semantics. The IoT data taxonomy (Qin et al., 2016) classifies the intrinsic characteristics of IoT data into three categories: 1) data generation category consists of velocity, scalability, dynamics and heterogeneity, 2) data interoperation category consists of incompleteness and semantics, and 3) data quality category consists of quality characteristics, such as uncertainty, redundancy, ambiguity and inconsistency.

Data quality is a measure of the condition of data based on factors such as accuracy, availability, completeness, consistency, reliability and whether it's up to date. Measuring data quality levels can help urban city platforms identify data errors that need to be resolved and assess whether the data is fit to serve its intended purpose. Data quality management is a core component of the overall data management process, and data quality improvement efforts are often closely tied to data governance programs that aim to ensure data is formatted and used consistently during and after the MAKING-CITY project.

Why data quality is important? Bad data can have significant consequences for the MAKING-CITY project. Poor-quality data is often pegged as the source of operational snafus, inaccurate analytics and ill-conceived strategies. Examples of the damage that data quality problems can cause include added a bad management of strategic of behavior in building or cities, fines for improper financial or regulatory compliance reporting. A good data quality can help drive operational decision-making and strategic planning by enterprises, business managers, Energy Service Companies (ESCO) and other end users.

What is good data quality? Data accuracy is a key attribute of high-quality data. To avoid transaction processing problems in operational systems and faulty results in analytics applications, the data that's used must be correct. Inaccurate data needs to be identified, documented and fixed to ensure that managers, data analysts and other end users are working with good information. Other aspects, or dimensions, that are important elements of good data quality include data completeness, with data sets containing all of the data elements they should; data consistency, where there are no conflicts between the same data values in different systems or data sets; a lack of duplicate data records in databases; and conformity to the standard data formats created by MAKING-CITY project. Meeting all these factors helps produce data sets that are reliable and trustworthy.

How to determine data quality? As a first step toward determining their data quality levels in MAKING-CITY must assure a surveillance system in order to make data asset inventories in which the relative accuracy, uniqueness and validity of data are measured in baseline studies. The established baseline

ratings for data sets can then be compared against the data in systems on an ongoing basis to help identify new data quality issues so they can be resolved.

The quality assessment metrics are heuristics and designed to fit a specific assessment situation (Pipino et al., 2005). Quality assessment metrics can be classified into three categories according to the type of information that is used as quality indicator (Bizer, 2007). Content-based metrics use information to be assessed itself as quality indicator, whereas context-based metrics employ meta-information about the information content and the circumstances in which information was created or used as quality indicator. Rating-based metrics rely on explicit ratings about information itself, information sources, or information providers.

In MAKING-CITY project, data is collected through monitoring. In addition, freely available data is also utilized. Therefore, three different types of data can be identified:

- Quantitative data; data that is collected through automated monitoring system from the buildings.
- Qualitative data; data that is collected through questionnaires, surveys, interviews, etc. directly from the people.
- Open data; data that is freely available.

Applicable data quality metrics are described in Table 3.

Table 3: Data quality metrics

Quality attribute	Description and rationale
Accuracy	The degree of correctness and precision. Ensures that the data/information is error-free, and the value is in consistent form.
Completeness	The degree to which data/information is not missing. Verifies that the data/information is sufficient in breadth, depth and scope.
Consistency	Implies that two or more values do not conflict with each other. Ensures internal validity.
Corroboration	The same data comes from several different sources.
Coverage/ amount of data	The extent to which the volume of data is appropriate for the task at hand (appropriate volume of data available)
Objectivity	The extent to which information is unbiased, unprejudiced and impartial.
Relevancy	The extent to which information is applicable and helpful for the task at hand.
Timeliness	The freshness of the data; timestamp.
Validity	The likelihood that the data in an appropriate format and the values are still valid.
Verifiability	The degree and ease with which the data/information can be checked for correctness. The traceability and provability of data/information.

Evaluation for open data: In order to improve data interoperability and reusability, Linked Open Data (LOD) principles by Tim Berner-Lee provide many useful tools and schemes to assess and categorize data sources by how useful they are to other digital services. The goal was to judge the quality of data by its accessibility (open data access), by its format and structures and by its interoperability. There are two main types of data principles used to support this target, the FAIR -principle and the 5-star scheme. The first data principle has the acronym FAIR and it emphasizes that in order to data being interoperable, it should be Findable, Accessible, Interoperable and Reusable. In FAIR data is expected to have a stated license for access, thus emphasizing the license agreement in reusability. In FAIR scheme contextual information is also required to improve the reuse of data. The 5-star scheme was introduced by Tim Berners-Lee in 2010 to encourage especially government data owners along the road to good linked data. It focuses less on the license than the FAIR principle and assumes the data is available with open license.

- ★ Available on the web (whatever format) but with an open licence, to be Open Data
- ★★ Available as machine-readable structured data (e.g. excel instead of image scan of a table)
- ★★★ as (2 star) plus open, non-proprietary format (e.g. CSV instead of excel)
- ★★★★ All the above plus, Uniform Resource Locators (URIs) are used to identify the data using open standards from W3C (RDF and SPARQL), so that people can point at your stuff
- ★★★★★ All the above, plus: the data is linked to other people's data to provide context

2.3 GDPR

Some of the data that is collected for the monitoring of the PED's is personal data. The residents have given their consent to the collection and processing of data for the purpose of the MAKING-CITY project. In addition to the contract with the residents, all parties involved in the processing of personal data should sign a data processing agreement.

General Data Protection Regulation (GDPR)¹ is a regulation in EU law on data protection and privacy in the European Union (EU) and the European Economic Area (EEA). According to GDPR, the data collector is obligated to provide at least the following information:

- Who is handling and processing the data.
- Why is the data processed.
- What is the legal basis for the handling.
- Who is the receiver of the data.

The residents have the following rights to their personal data:

- Free access to their own personal data, and the right to transfer data from a system to another.
- The right to correct and supplement their own personal data when they feel that the data is incorrect, defective or inaccurate.
- The right to remove the personal data (the right to be forgotten).
- The right to refuse the usage of the personal data in solely automatic processing.

The data management in MAKING-CITY project is described in more detailed in D9.5 - Data management plan.

3 Monitoring quantitative data

This chapter contains methodologies for real time data collection pipeline. Target in these methodologies is to provide robust pipeline for collecting data sets needed in KPI calculation that are:

- Imported/exported energy for each building for each energy type (electricity, thermal, gas) separately
- Energy produced by each building for each energy type separately
- EV charging energy consumption

Despite of the fact that data collection pipeline guidelines are limited for these data sets, guidelines are general, and they should scale for other data sets as well.

Monitoring programme concentrates on monitoring all the incoming and outgoing energy flows for each building of the district and for the whole district separately. Monitoring must handle all the energy types that flows to building/district at own pipes separately (e.g. electricity from grid or thermal energy from district heating pipes or gas from gas pipes).

These are the main guidelines, but it is natural that in real life there might be deviations from this guideline. For example, it may be possible that not all the buildings can be monitored due to GDPR regulations or some buildings or public infra such as public lighting misses metering. However, if there occur any deviations from this main guideline, all the deviations should be documented.

3.1 Monitoring phases

SCIS Technical monitoring guide defines four monitoring phases (SCIS, 2018b):

1. Definitions
2. Implementation
3. Monitoring
4. Voluntary long-term monitoring

Monitoring concept used in MAKING-CITY shall follow these phases, but it reformulates the third phase to cover also simulation of energy flows that cannot be directly monitored. There are two identified cases which prevents the direct monitoring. Firstly, there may be cases where in some buildings there are no possibility to install meters. Therefore, the performance of these buildings shall be simulated instead of real metering. Secondly, some energy efficient solutions planned to this project are based on intelligent control of energy systems that is not possible to be implemented for the whole monitoring period. Demo specific plans have been described in D5.7 and D5.8.

Overall picture of monitoring phases is given in Figure 3: Monitoring phases. Next subsections shall cover the phases with more details.

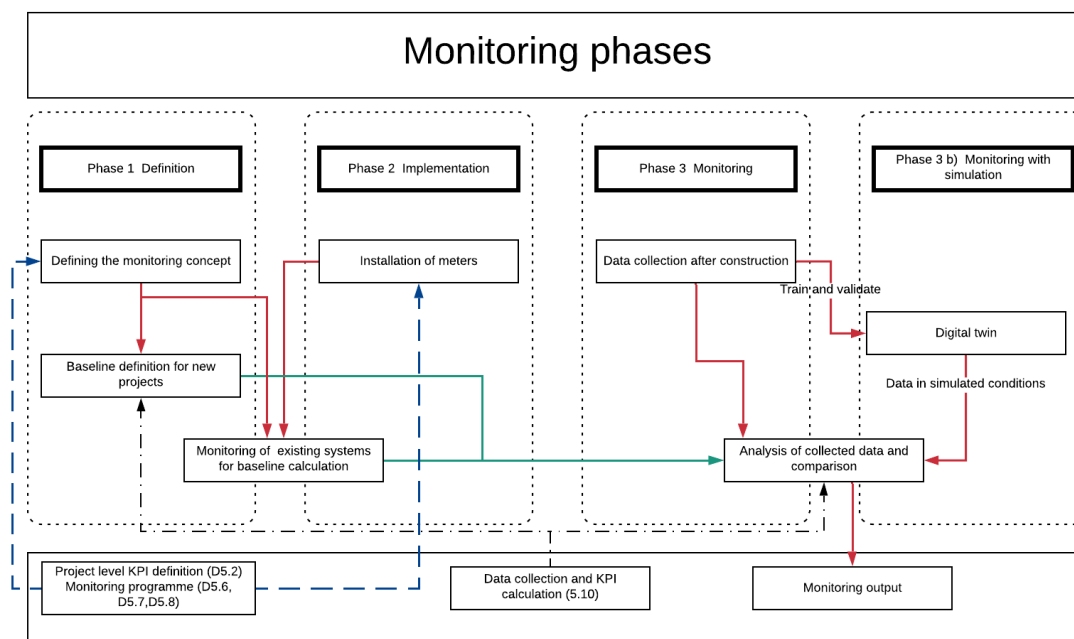


Figure 3: Monitoring phases

3.2 Phase 1 - Defining the indicators and the monitoring concept

In this step, it is fundamental to identify the requirements that are needed to calculate KPIs. Moreover, all technical KPIs are based on the baseline figures. Therefore, setting baseline and calculating the baseline performance is essential part of this phase. Exact baseline calculations shall be presented in deliverable 2.2 (M36) and later in deliverable 5.10. The generic guidelines for the baseline calculation are given in Section 3.2.1.

For quantitative data, the indicators (defined in the deliverable “D5.2 - Project Level Indicators”) are described in Table 4, Table 5, Table 6 and Table 7,

Table 4: Indicators related to energy & environment

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 (described further in the Annex), or energy bill as % of total household disposable income.
Environmental effect		
Indicator	Unit	Description
E8: GHG emissions	kgCO ₂ -eq/ (m2month); kgCO ₂ -eq/ (m2a) kgCO ₂ -eq/ (kWh a)	The GHG emissions (converted in CO ₂ -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	kgCO ₂ -eq/a; %	Reduction of CO₂-eq. emissions in the PED area achieved by the project actions and interventions.

Table 5: Indicators related to mobility

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.

Table 6: Indicators related to economy

ECONOMY		
Economic performance		
Indicator	Unit	Description
C1: Total investments	€/m2; €/kW(h)	The amount of 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 kgCO ₂ -eq)/a	Total investments combined with the output results (in terms of energy savings or reduction in GHG emissions (CO ₂ -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.

Table 7: Indicators related to flexibility

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.

Baseline comparison mechanism depends on two separate issues. First, it depends on whether the building is a renovation building or a new one. Second, it depends whether system can be fully monitored, partially monitored or not monitored at all. If the system can be partially monitored, partial monitoring data is collected to form a simulation model (digital twin) of the system. Then this digital twin is used to simulate the whole monitoring data.

The baseline comparison concepts for each of these cases are shown in Figure 4: Performance validation when all the measures can be monitored. Green lines are present for retrofitting buildings and red ones for new ones. Figure 5: Performance validation when the system can only be partially monitored. Green lines are present for retrofitting buildings and red ones for new ones. and Figure 6: Performance validation if the system cannot be monitored due to missing meters, and simulations / reference cases are used instead. Green lines are present for retrofitting buildings and red ones for new ones..

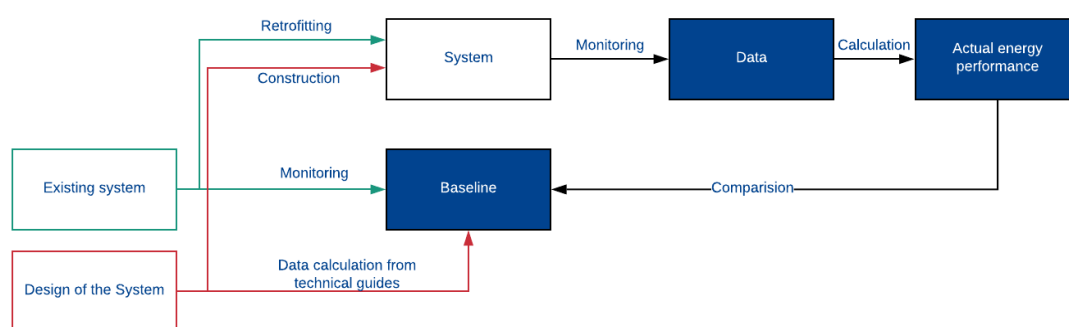


Figure 4: Performance validation when all the measures can be monitored. Green lines are present for retrofitting buildings and red ones for new ones.

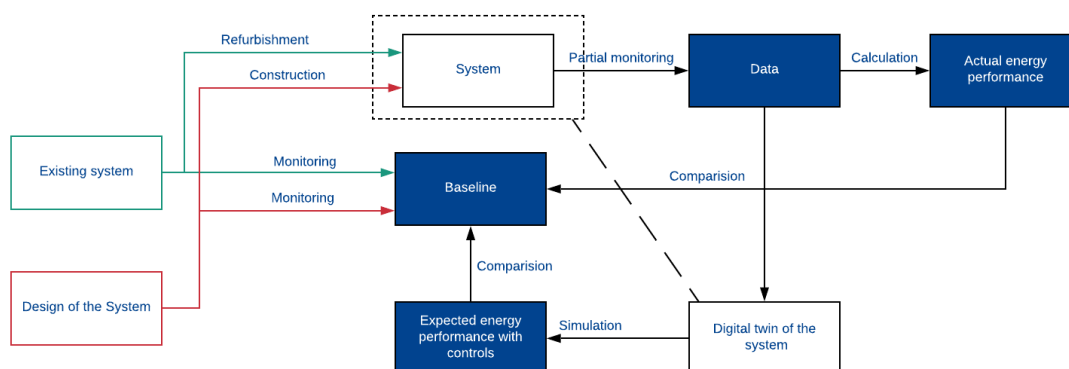


Figure 5: Performance validation when the system can only be partially monitored. Green lines are present for retrofitting buildings and red ones for new ones.

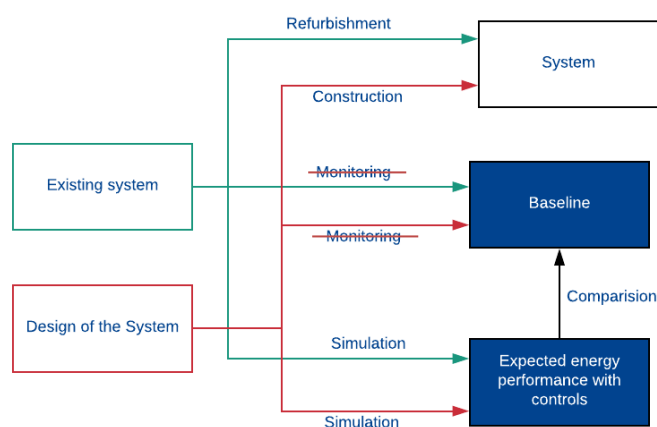


Figure 6: Performance validation if the system cannot be monitored due to missing meters, and simulations / reference cases are used instead. Green lines are present for retrofitting buildings and red ones for new ones.

3.2.1 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.

New buildings

For new building developments, there are no existing data to which against the comparison is made. Baseline shall be determined by the energy performance of similar buildings without implementing the interventions mentioned in the project plan.

Renovated buildings

For refurbished buildings, it is essential to meter all the needed energy performance metrics before any renovation actions are made. In this case, baseline shall be pure metrics calculated from one year before renovation actions without weather corrections.

3.3 Phase 2 - Implementing data collection pipeline

A different approach during phase 2 is applied to new construction and to retrofitting projects:

1. Projects based on existing systems: The monitoring must start before the implementation of measures since real data from the existing system has to be collected for further comparisons for at least one year. Once this data has been collected and the construction and renovation measures start, the next steps are similar to new construction projects. It may also be possible that the requested data to calculate a KPI is available without new data collection pipeline.
2. New construction projects: From the monitoring concepts and requirements previously defined, a plan for the sensor installations has to be prepared, based on the concept definition of phase 1.

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.

3.3.1 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.

3.3.2 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.

3.3.3 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.

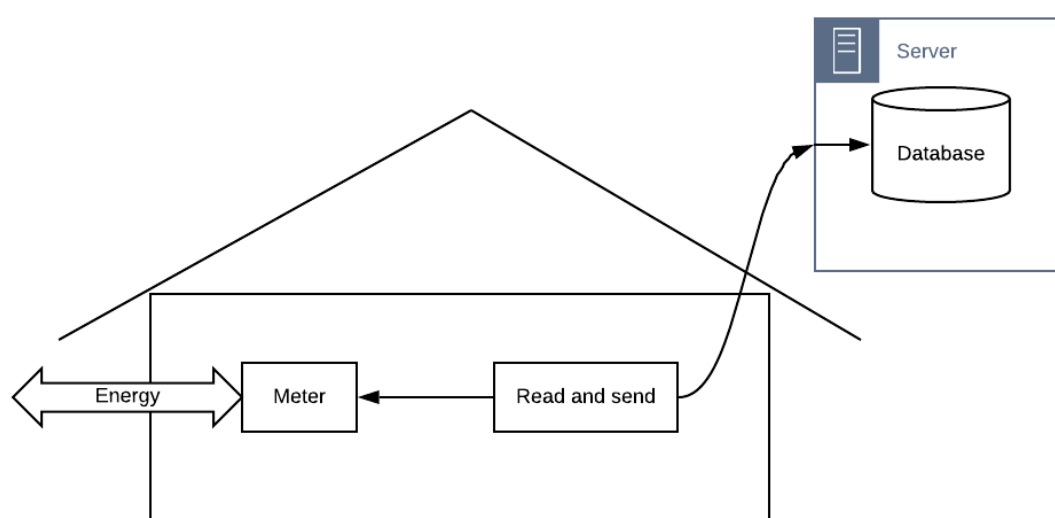


Figure 7: Monitoring building blocks

3.4 Phase 3 - Metrics monitoring of the demos

The objective of Phase 3 is to measure real energy performance of each individual building in the PED area, and the whole demonstration district. For KPIs and evaluation, the energy performance will be monitored for at least two consecutive years. However, there are two cases identified that can prevent extensive direct monitoring:

1. Within some buildings, apartment level monitoring with separately installed metering equipment is not possible without written permission from the residents living in the apartments, due to GDPR etc. regulations.
2. Some advanced energy optimization techniques require dynamic control of energy management system, which is possible to be done only for very limited time period.

These cases must be handled with indirect monitoring. Guidelines for monitoring the indirect monitoring cases are provided in Sections **¡Error! No se encuentra el origen de la referencia.** and 0. The next subsection covers some basic principles on monitoring the monitoring 3.4.1.

3.4.1 Monitoring the monitoring process

As already stated in Section 3.3.3, the whole monitoring process should be monitored to get good quality of data. It is good practice to toggle automatic alarms to database such that if data flow stops to database engineers would get immediate feedback to solve the issue.

3.4.2 Phase 3. B - Monitoring with simulation

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 **Error! No se encuentra el origen de la referencia.**). 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.

Simulating the energy behaviour with digital twin

Target energy behavior can be monitored only partly under the right circumstances. There can be various reasons for the partial monitoring. One reason is that intelligent control is used, and the control is made possible only for limited time instead of the whole two years monitoring period. In case of partial monitoring the final monitoring outcome is simulated using digital twin of the target building or the target district. In this case, the real monitoring time shall be used for training and validating the digital twin. When the digital twin is used, it is crucial the digital twin behaves same way as its physical counterpart. Therefore, an extra high care must be paid to the validation of the digital twin. Following guidelines must be followed when working with digital twin:

1. Validation method must be documented properly
2. Problems in validation and implementation of digital twin must be identified
3. Digital twin must operate only in conditions where its operation is somewhat reliable

These guidelines must be documented with details in Monitoring Programme deliverables D5.7 and D5.8.

3.5 Phase 4 - Long term monitoring

It is recommended that monitoring would be continued also after the project phase. However, due to various reasons it may not be possible. If the monitoring is not continued after the project, the reasons shall be explained in deliverables D5.7 and D5.8 (monitoring programmes).

4 Monitoring qualitative data

Qualitative data is monitored in two levels; city level and project (PED area) level. Both levels consist of two iterations.

Monitoring of qualitative data consists of the following phases (as depicted in Figure 8: Phases and steps of qualitative monitoring.):

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

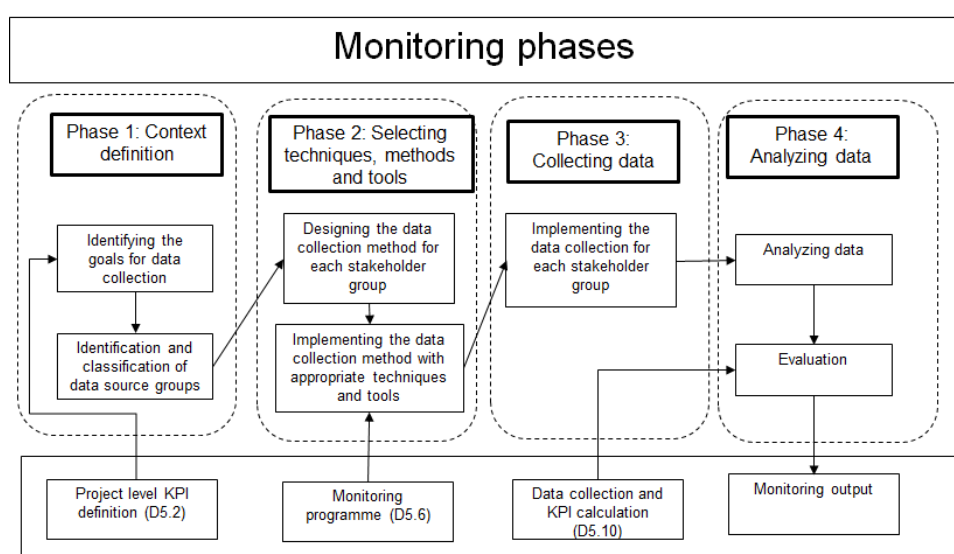


Figure 8: Phases and steps of qualitative monitoring

4.1 Phase 1 - Context definition

4.1.1 Identifying the goals for data collection

For qualitative data, the city level indicators (defined in deliverable “D5.1 - City Level Indicators”) are described in Table 8 and Table 9, and the project level indicators (defined in deliverable “D5.2 - Project Level Indicators”) are described in Table 10.

Table 8: City level indicators related to governance

GOVERNANCE		
Initiatives and Strategies of the Public Administration		
Indicator	Unit	Description
Smart city factor in a city development strategy	Likert scale	Inclusion and level of detail of smart cities strategies in the urban strategic plans of the city. Likert scale: Not at all – 1 – 2 – 3 – 4 – 5 – Very detailed
Public ICT / Data		

Indicator	Unit	Description
Quality of open data	Likert scale	The extent to which the quality of the open data produced by the city was increased. Likert scale: Not at all – 1 – 2 – 3 – 4 – 5 – Excellent

Table 9: City level indicators related to society and citizens

SOCIETY AND CITIZENS		
Citizen Engagement and Empowerment		
Indicator	Unit	Description
Citizen engagement/empowerment to climate conscious actions	Likert scale	Appreciation of the benefits of city actions; Energy empowerment at home, satisfaction, happiness of people. Likert scale: Not at all – 1 – 2 – 3 – 4 – 5 – High engagement
Encouraging a healthy lifestyle	Likert scale	The extent to which policy efforts are undertaken to encourage a healthy lifestyle. Likert scale: Not at all – 1 – 2 – 3 – 4 – 5 – Excellent

Table 10: PED level indicators related to social and residents

SOCIAL AND RESIDENTS		
Social and resident related indicators		
Indicator	Unit	Description
S1: Energy poverty	% of households, or % share of income	Percentage of households by definition (described further in the Annex), or energy bill as % of total household disposable income
S2: Consciousness of residents	Likert scale: No consciousness – 1 – 2 – 3 – 4 – 5 – High consciousness	Increased consciousness of residents of the area on the defined issues (project interventions, energy, environment, climate, personal/communal consumption, carbon footprint and handprint, etc.). Communal consciousness and social coherence are the foundations of a healthy and democratic society (ITU). Civic consciousness is the people's awareness of their civic rights and responsibilities, their role in the community and their involvement in its holistic development, thereby increasing social capital (Ng, 2015). This includes: 1. Personal identity and citizenship: awareness, pride, obedience to the law, equality 2. National identity: respect for the national authorities, belief in the current political system, development of the country

		<p>3. Moral consciousness: being a good citizen in public and private, trusting that others are too</p> <p>4. Ecological consciousness: awareness of the finite nature of resources, thinking about environmental consequences of actions</p> <p>5. Social citizenship: family values and virtues, actively concerned with others at home and abroad</p>
S3: Resident engagement / empowerment to climate conscious actions	<p>Likert scale:</p> <p>No engagement – 1 – 2 – 3 – 4 – 5 – High engagement</p>	<p>Appreciation of the benefits of project actions; Energy empowerment at home, satisfaction, happiness of people.</p> <p>The indicator provides a qualitative measure and is rated on a five-point Likert scale:</p> <p>No increase – 1 – 2 – 3 – 4 – 5 – High increase</p> <p>1. No increase: The project has not increased civic/resident engagement.</p> <p>2. Small increase: The project has increased civic/resident engagement with regards to one of the five factors mentioned.</p> <p>3. Some increase: The project increased civic/resident engagement with regards to two of the factors mentioned.</p> <p>4. Significant increase: The project has increased civic/resident engagement with regards to three of the factors mentioned.</p> <p>5. High increase: The project has increased civic/resident engagement with regards to four or more of the factors mentioned.</p> <p>Note: during the testing phase it will be seen whether it is possible to measure actual impact of projects on civic/resident engagement, or that we may need to rephrase the indicator to just include actions taken by the project to increase civic/resident engagement.</p>

4.1.2 Selecting the sources of data

The relevant data sources, i.e. the stakeholders for the qualitative data collection, must be identified. The stakeholders can be, for example, the residents of the buildings, larger property owners, city policymakers, etc. The classification of the stakeholders must be done, and the required number of stakeholders must be defined for each stakeholder class.

In the city level, the data sources will be residents of the city and 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.

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 habits, awareness and everyday life observations. Also, larger property owners can provide this kind of data in a wider perspective.

4.2 Phase 2 - Selecting the techniques, methods and tools

There are different ways to collect qualitative data. In conversational and collaborative techniques, data is extracted from people's behavior and their verbalized response. The conversational method provides a means of verbal communication between two or more people. The selection of methods depends on

a) the stakeholder class (see Phase 2), b) the amount of responses required, c) the ability to ask predetermined questions.

Surveys enable standardized data collection, ensuring that the same data is collected from each respondent. Surveys can be roughly divided into two categories: questionnaires and interviews.

- Questionnaires: Questionnaires provide an efficient way to collect information from multiple stakeholders quickly. They can force users to select from choices, rate something or have open ended questions allowing free-form responses.
- Interviews: There are three types of interviews - unstructured, structured, and semi-structured. In structured interviews, the analyst uses a predetermined set of questions. The success depends on knowing the right questions, when they should be asked, and who should answer them. In unstructured interview there is no agenda or list of questions. Semi-structured interview is a combination of the structured and unstructured.

Different kind of survey must be prepared for each stakeholder class. In the case of the residents, the questionnaire format is most likely to be chosen because a high number of responses is desired. The questionnaire can include both closed- and open-ended questions. Closed-ended questions have a limited set of possible answers, whereas open-ended questions enable respondents to describe their thoughts and opinions more freely.

The questionnaire can be in different formats:

- Questionnaire in PDF format
- Online form
- Online platform

Different kind of questionnaire must be prepared for other stakeholder class, such as for the residents of the city and city decision makers. If there are only few stakeholders involved, interviews may be the more appropriate choice.

4.3 Phase 3 - Collecting the data

4.3.1 City level data collection

The city level data collection consists of two phases. In the first phase, the purpose is to examine the residents' current status, electricity consumption behaviour, motives for changes in their consumption behaviour, and the effect of an increased amount of available data on consumption behaviour. In addition, the purpose is to examine how the residents feel that their city is encouraging them towards healthy lifestyle and providing data to increase consciousness to climate actions. The questions for the data collection will be defined in more detailed in D5.20 for Oulu and D5.21 for Groningen. However, the questions will reflect the achievement of the project qualitative 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.

Quality of open data: The extent to which the quality of the open data produced by the city was increased.

Energy poverty: Percentage share of energy bill as % of total household disposable income

Citizen engagement/empowerment to climate conscious actions: Appreciation of the benefits of city actions; Energy empowerment at home, satisfaction, happiness of people.

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.).

Encouraging a healthy lifestyle: The extent to which policy efforts are undertaken to encourage a healthy lifestyle.

In the second phase, more compact research is implemented to detect the concrete changes, the satisfaction of the people and the success of the goals of the project.

4.3.2 PED level data collection

The data collection in PED level also consists of two phases. In the first phase, the qualitative data is collected from the residents of the monitored buildings.

Energy poverty

- Energy poverty 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 consumers
- 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/issues
- Consumers' thoughts, attitudes and expectations from the results of this project

In the second phase, the feedback collection is implemented in the later phase of the project, collecting detected and actual results; what are the concrete changes, how satisfied and pleased the people are and how succeeded the goals of the project were.

Energy poverty

- Changes in residents' habits and consumptions

Consciousness of residents

- Detected changes: do the residents detect any results/changes
- 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

4.4 Phase 4 - Analysing the data

Qualitative data quality attributes can be used to evaluate the collected data. The appropriate attributes (defined in Table 3) include accuracy, completeness, consistency, corroboration, coverage and relevancy.

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 qualitative indicators.

All the indicators cannot be measured from the results of the interviews, but they may be based on evaluation of single persons. For example, the value for the indicator “Encouraging a healthy lifestyle” may be based on the estimation of city policymakers based on the results of the project

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.

5 Resident engagement and interaction

The role of interaction with the residents in the MAKING-CITY project is mainly to influence the attitudes of residents and other people about the benefits of energy efficiency and to get them to accept the solutions made in the area's buildings. The main focus of interaction and social inclusion in the MAKING-CITY project area is to

- provide information to residents and other people
- give everyone the opportunity to express themselves
- give residents and other people the opportunity to choose where they participate
- give everyone the opportunity to influence the development of their own living environment as well as their own solutions, for example to increase energy efficiency, reduce adverse effects and reduce consumption, as the MAKING-CITY project aims to do

This point is very close to the user acceptance and the evaluations. Social research before the beginning of building works aims firstly to raise stakeholders' awareness in the necessity of develop and the implement clean technology and measures as well as to provide detailed information about MAKING-CITY Project. Different actions, tailored for different involved stakeholders, have to be performed for achieving this goal.

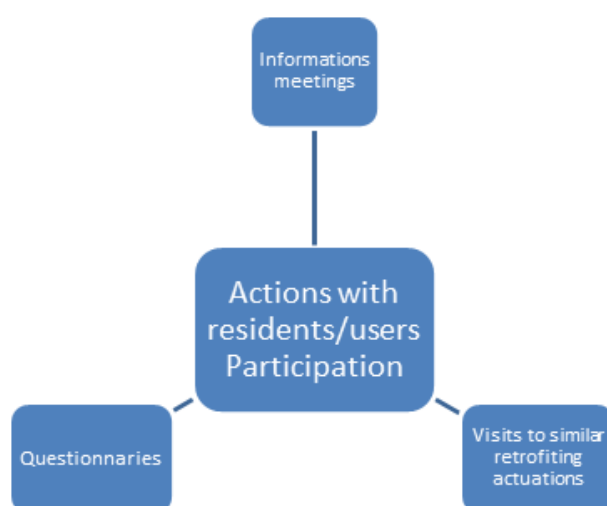


Figure 9: Different actions with residents/users participation

Figure 9 describes the different kinds of actions with which the residents can participate in planning. It is particularly important, during this stage, to give the affected users the possibility to participate in the planning process in order to create a strong identification with the measures that will be implemented and the retrofitting process. At this purpose, meetings with the final users should be organized with the aim of informing them about the project and the innovations brought about by the project itself.

Moreover, questionnaires should be distributed, during the informative meetings or afterwards, to get users/occupants feedback regarding their current living and working conditions, with particular reference to energy consumption, comfort perception and dwelling condition as well as their expectations towards the MAKING-CITY measures. The collected responses are then used to select retrofitting solutions that, at the same energy savings, guarantee greater endorsement by end users.

It would be reasonable to prepare a questionnaire in order to investigate the following aspects:

- User profile
- Dwelling typology
- Energy Consumption
- Comfort Perception
- Conditions of dwelling preservation
- Dwelling and district evaluation

Conclusions

The purpose of this document is to provide general guidelines and the methodology for defining the required steps for the monitoring program. The guidelines are targeted for both lighthouse cities. This report provides general guidelines for monitoring both quantitative and qualitative data, including the overall collection principles and quality assurance of the data sets. Project level KPIs shall be in the main focus of the monitoring programme, while city level indicators have also been considered, which have been defined in D5.1 and D5.2. The data sets required for calculating these KPIs have been defined in more detail in D5.5.

The guidelines for monitoring programme shall be based on the main reference frameworks, namely SCIS monitoring guides (SCIS, 2018a, 2018b). This deliverable produces only general guidelines to the monitoring programme while the detailed monitoring programme shall be described in D5.7 for Oulu and in D5.8 for Groningen. Moreover, this document provides some general guidelines for data collection and KPI calculation while they are defined more exactly in D5.5 and D5.2 and later in D5.10. An extra care must be paid for proper handling in the collected data. All the GDPR related aspects of collected data shall be covered in D5.5. In addition to the links to other deliverables in WP5, this deliverable has also linked to WP2 and WP3 where the ICT platforms implementing the monitoring programme are specified.

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