Deliverable D1.2: Integrated draft of the methodology

Public Document

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Disclaimer

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Glossary

Acronym	Meaning
ECM	Energy Conservation Measure
P&P protocol	Plug and Play protocol
M&V	Measurement and Verification
TPC	Technology provider cluster
ESCO	Energy Service Company
EPC	Energy Performance Contract
FM	Facility Management
KPI	Key Performance Indicator
FLBCT	Feasibility Level Business Case Tool
DMP	Data Management Platform
LCP	Life Cycle Platform
NESM	Non-Energy Savings related Measures
DCF	Discounted Cash Flow
BCT	Business Case Tool

1 Executive summary

The StepUP project methodology is developed to support improving the efficiency of deep renovation projects. The present public deliverable D1.2 includes the description of the StepUP renovation methodology in its current development stage. The report brings together the results developed in the StepUP project so far and integrates them into the overall renovation process.

The **Introduction chapter** describes the underlying principles guiding the methodology development, the main target audience and purpose of the process description (it primarily aims to provide a guideline for future project owners and project managers who want to implement the project approach). This chapter also includes the feedback collected from within the consortium and through StepUP related workshops about the StepUP approach towards renovation.

The European Commission published on 14 October 2020 a new strategy to boost renovation called "**A Renovation Wave for Europe – Greening our buildings, creating jobs, improving lives**" to incentivize investments in renovation and support the implementation of efficient methods and technologies. **Chapter 3** aims to describe the contribution of the StepUP approach toward the goals and methods described in the strategy.

Chapter 4 includes the summary of the scope and boundaries of the applicability of the methodology. The StepUP project methodology is optimized for **specific building types**, which have distinct **stakeholder groups** who are supporting / benefitting from the project. The StepUP methodology can also be fully implemented in renovation projects where the **StepUP P&P technologies** (industrialized technologies developed within the StepUP project) can be deployed. The methodology also includes **KPIs** – metrics that help evaluate the overall improvement from the renovation – that are specific to deep energy renovation projects.

Chapter 5 of the report presents the five renovation phases: Feasibility, Preparation, Design, Implementation and Operation phases. A project starts with the **Feasibility phase** where a simple assessment is carried out to determine if the renovation for the selected building is feasible. Then during the **Preparation phase** all project related information is collected (including 1 year of monitoring data, occupancy and user behaviour information, building geometry and parametric data etc.) which results in a calibrated simulation model that will support the design of renovation. In the **Design phase** the renovation options are developed and assessed. Additionally, a business case is developed that presents the costs and potential savings of the different renovation versions. It also proposes a plan for financing the implementation of the different measures, mainly utilizing the concept of iterative renovation process (where the savings from each renovation cycle can finance the implementation of the next measure). Based on the developed design the renovation measures are carried out during the **Implementation phase**. After project handover the performance of the newly refurbished building is closely monitored during the **Operation phase**. Finally, the **next renovation cycle** can start according to the business case. This means that the project information is updated and the design can be started for the new measures to be implemented. For each phase of the renovation their goals, necessary inputs, expected outcomes, expected duration and process is detailed.

Chapter 6 summarizes all the tools that are developed to enable the use of certain functions of the StepUP methodology:

- The overarching tools, that support the overall process, or multiple methodology phases:
  - **Data management platform** – provides a suite of online visualisations and analysis tools to inspect the performance of the building before and after the renovation
  - **Life Cycle platform** - a suite of integrated tools to facilitate communication and track the renovation project stages, including the capability to assess the potential performance of ECMs ahead of deployment

  - **Stakeholder engagement strategy** - a guideline for involving the typical project stakeholders in all stages of the renovation process
  - **LEAN project delivery guidelines** - guideline for implementation of LEAN project delivery methods in industrialized renovation projects.
  - **Technology provider clusters** - clusters of third-party technology producers which are able to be integrated into the technologies developed by StepUP
  - **Monitoring data collection protocol** - Protocol for the building related monitoring data acquisition framework and infrastructure
  - **SmartEPC** – a guidance to integrate the StepUP method into the existing enhanced smartEPC methodology for Maintenance and Energy Performance Contracting
- The phase-specific tools that are used for supporting a specific activity in one of the five methodology phases:
  - **Feasibility phase business case tool** - Preliminary and basic financial evaluation of the renovation project showing a rough estimate of the energy savings potential of a building or project and the related financial requirements
  - **Technology applicability checking tool –** a tool that provides a checklist to assess whether the technologies developed in the StepUP project can be applied to a building
  - **IES model setup guidelines** – a guide to develop an accurate physics-based model of the building ahead of the design stage
  - **IES model calibration guideline** – a tool to move from a physics-based model of the building to a digital twin, used to evaluate the potential performance of various ECMs
  - **Business case tool** - provides the business case, focused on the financial evaluation, of the design option selected during this design phase
  - **P&P protocol** - Defines specifications for integration of StepUP technologies with third party solutions and product characteristics
  - **P&P envelope installation guidelines** - Installation Guideline of the P&P envelope modules
  - **SmartHeat installation guidelines** - Installation Guideline of the P&P heating system modules
  - **M&V guideline** – a guide to prepare for Measurement & Verification starting from the design phase, until its implementation after the renovation of the building

This report is intended to be distributed publicly, aiming to collect feedback on the described process, the tools under development from its potential future users. Based on the feedback to be collected, the StepUP methodology and supporting tools will be updated and finalized at the end of the project. Chapter 7 describes the proposed process to collect the most useful and relevant feedback by defining who it should be collected from, collection methods and main communication channels.

2 Introduction

The StepUP project methodology is developed to support improving the efficiency of deep renovation projects. The methodology builds upon the feedback from pilot application so far, previous project experiences, assessment of existing literature and targets achieving the main goals of the StepUP project. It is now published as a public report to go through a validation and review process within the consortium, with various external stakeholders, and the scientific community.

The methodology focuses on delivering an operable, iterative process for design, monitoring and installation planning of renovation actions, and includes metrics to set targets and priorities for continuous verification.

The renovation methodology development was based on implementing best practices. Furthermore, some innovative design and implementation principles, approaches are also included, like:

- **data driven approach** – the lack of information before designing a renovation usually leads to poor design assumptions and high performance gap. To solve this StepUP proposes to include detailed and long-term data collection methods to generate a sound base for design and for continuous Measurement & Verification (M&V) of the renovation
- **iterative process** - a core concept of the StepUP project is a new iterative approach to renovation, which leverages big data to generate a continuous improvement of the building performance, aligning renovation investment planning to value investment in commercial buildings and lowering financial barriers for residential and public buildings through implementing the renovation in cycles.
- One of the most important concepts related to the assessment of the renovation solutions is the '**multiple benefits**' of renovations concept (also called non-energy benefits or co-benefits), which include those positive social, financial and environmental impacts, as the results of energy efficiency improvements. An energy renovation project is not always attractive and beneficial for the stakeholders/investors, if they are only focusing on the energy and energy cost savings. However, there are other non-energy benefits, which can make the ECMs valuable for the stakeholders, such as improved thermal comfort, reduced GHG emission, reduced maintenance cost etc. This concept is mainly used during the development of the project assessment metrics, the StepUP KPIs.

A first draft of the methodology was developed for the pilots. In the first year of the StepUP project, the most relevant parts of it were applied on the pilots to collect preliminary feedback. Also, the main principles of the methods were discussed within the consortium and with select external parties.

Based on the collected feedback and then adding the new information from the progress of the project the methodology was updated and included in this public report.

This version of the StepUP renovation methodology primarily aims to provide a guideline for future project owners and project managers who want to implement the project approach. It also intends to be informative for other renovation project stakeholders or interested parties who are responsible for or interested in specific activities during a renovation. The assumption is that professionals who are familiar with the construction industry and the renovation market, but not familiar with sustainable solutions and deep energy renovations can understand the concepts presented in the report.

2.1 Summary of first year of feedback

In the 1 year period after releasing the first draft of the StepUP methodology within the consortium and for the pilots, the following main feedback was collected:

- the iterative nature of the methodology should be highlighted in the methodology as the StepUP methodology should fit into the new EU legislative framework (The Renovation Wave) – see the details in **Chapter 3**.
- the methodology must be focused on explicit energy conservation measures (ECMs) and specific building types
- during the pilot scheduling it was concluded that 1 year of pre-design monitoring is time consuming, but fundamental and this should be highlighted in the methodology
- LEAN project delivery principles are very useful for renovation projects, beyond the construction phase
- commissioning is an important part of renovation and practitioners must be addressed by the methodology

During the first 18 months period of the project, the main source of feedback collection from external sources was the Technology provider clusters, where the feedback was mainly collected about the technology integration, but the process indirectly affects the methodology as well. The *Technology Provider Cluster* approach (TPC), as part of the StepUP project, aims at involving relevant stakeholders potentially able to integrate the StepUP system with specific third-party technologies. This approach has been practically implemented through *ad-hoc* workshops and meetings in Italy and in Spain, during the first year of the project. Albeit these first meetings were focused on putting the basis to create the TPC network and actively engage the technical stakeholders, considerable feedback on the StepUP methodology have been collected. Specifically, it emerged the importance of having a clear and accessible protocol in order to conform to the standard parameters defined within the project: the Open P&P protocol will perform this function, and will be released as a public deliverable of the project. It is also described briefly in **Chapter 6.2.6**.

Another key topic is the preparatory work needed to integrate a third-party technology into the StepUP system: this includes the necessity of considering specific setups for the system that must be foreseen for a smooth integration of additional technologies (e.g. cabling housing, connections, etc.). In order to accomplish this multifaceted task, due to the considerable variety of fields and products to be potentially integrated, a smooth communication flow between the key stakeholders intervening in the process must be granted throughout the entire duration and across all the different phases of the renovation project. In particular, to ensure a better integrability and interoperability of third-party products with the StepUP system, it emerged how crucial is to have a clear understanding of the entire process since the very early phases of the renovation project.

One last output emerged from the TPC approach, during the first year of the project, is a suggestion regarding the definition of the methodology: in fact, the TPC stakeholders highlighted how important would be to have a range of standard case studies for their product - generally speaking, for areas of product - to be integrated into StepUP. In addition, the methodology should be flexible enough to ensure the feasibility of tailor-made intervention for specific and not-standardizable renovation projects.

3 Contribution toward the Renovation Wave strategy

The **European Green Deal strategy**[1] has been published by the EU Commission in December 2019 with the overarching target to make the EU's economy sustainable. It identified the renovation of the existing building stock as a key initiative to drive energy efficiency in the construction sector, therefore the Commission is targeting the doubling of the renovation rates in the next ten years. To pursue this ambition, the Commission published on 14 October 2020 a new strategy to boost renovation called "**A Renovation Wave for Europe – Greening our buildings, creating jobs, improving lives**".[2]

The Renovation Wave strategy states that 85-95% of buildings in the EU are expected to still be standing in 2050 and renovating them is essential to reducing emissions and energy use. The strategy aims to renovate 35 million inefficient buildings by 2030 to reduce emissions by at least 55% and to build the foundations for a climate neutral Europe by 2050.

The Renovation Wave proposed the following lead actions to support the achievement of the identified renovation targets:

- Strengthening information, legal certainty and incentives for renovations
- Reinforced, accessible and more targeted funding
- Increasing capacity and technical assistance
- Creating green jobs, upskilling workers and attracting new talents
- Creating a sustainable built environment
- Placing an integrated, participatory and neighbourhood based approach at the heart of the renovation wave
- The New European Bauhaus: matching style with sustainability

These actions are identified to break down the many barriers to renovation with policy instruments, funding and technical assistance. Several components of the proposed actions closely relates to the methodology and solutions that are being developed in the StepUP project.

- The strategy identified the insufficient information on actual energy consumption profile of buildings and on the potential benefits of renovation as a significant barrier against wider scale renovation. To break down this barrier the strategy proposes strengthening information, legal certainty and incentives for renovations. Within this action the EPC framework will be updated to include energy performance metering technologies and the extension of energy audit requirements are also proposed. The StepUP renovation methodology is based on accurate building information that closes the performance gap between the real and modelled energy uses. To reach this, the methodology includes a detailed monitoring system installation guide (**Chapter 6.1.6**) and a process for creating digital twins that represent the real building energy consumption (**Chapter 6.2.4**).
- According to the strategy "deep renovation is not always achievable in one go. It is therefore important to create better conditions for staged renovation." The same principle is reflected in the iterative renovation methodology where the initial renovation iterations are determined through a business case and then carried out in the renovation cycles.
- Regarding financing of renovations the strategy identified the lack of mainstream financing products as a barrier. In support of the same goal the StepUP project aims to develop Smart EPCs as innovative energy performance contracting solutions.
- The Renovation Wave also indicates that wider scale technical assistance is needed for project owners, especially for individuals or small local authorities as they don't usually have the expertise and resources to find the most optimal solutions. The StepUP decision making support tools aim to provide expertise for residential building owners and municipalities.

[1] https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en
[2] https://ec.europa.eu/energy/topics/energy-efficiency/energy-efficient-buildings/renovation-wave_en

- The strategy promotes the development of industrialised technological solutions for renovations as they can increase quality and reduce costs and duration of works. Within the StepUP project two industrialised technologies are being developed for renovations and Technology provider clusters are established to integrate different types of energy conservation measures.

The Renovation Wave strategy identified three priority areas for policy and financing where immediate action is necessary as they offer huge potential for increasing renovation rates, while delivering large energy savings and healthier and more comfortable buildings for citizens:

a) tackling energy poverty and worst-performing buildings;
b) renovating public buildings, such as administrative, educational and healthcare facilities and
c) decarbonising heating and cooling.

Most of the priority areas are also in line with the targets of the StepUP project. The scope of StepUP includes offering renovation methodology for public buildings and piloting the developed solutions in an educational facility. Also, one of the technology solutions under development is a heating system integrated with renewables for decarbonisation.

4 Scope of StepUP project

The goal of this chapter is to give an outline about what kind of projects can implement the StepUP methodology, and who would benefit from it. The StepUP project methodology is optimized for **specific building types**, which have distinct **stakeholder groups** who are supporting / benefitting from the project. The StepUP methodology can also be fully implemented in renovation projects where the **StepUP P&P technologies** (industrialized technologies developed within the StepUP project) can be deployed. The methodology also includes **KPIs** – metrics that help evaluate the overall improvement from the renovation – that are specific to deep energy renovation projects.

4.1 Building types

The StepUP project targets the existing building stock of the EU to offer a new methodology for implementing more affordable and efficient deep energy renovation projects. The core concept of the StepUP project is a new iterative approach to renovation, which leverages building data and physics simulation to generate a continuous improvement of the building performance, aligning renovation investment planning to value investment in commercial buildings and lowering financial barriers for residential and public buildings.

To demonstrate this approach, the project will target three diverse ownership structures which represent a significant size of the European market:

- **multi owned residential buildings** (i.e. apartment blocks)
- **public non-residential buildings**: various typical building functions are included that are usually not going through regular commissioning (school, academic, public services, office and administration buildings, etc)
- **private office rental buildings**

4.2 Main beneficiaries

There is a large set of potential stakeholders with diverse interests in energy renovation projects. Their identification is crucial in the methodology in order to assess how they can support the renovation process, and what are the outcomes they expect from the project. Therefore, the point of departure is to make a list of the possible stakeholder groups who in general have a role in construction projects, such as financing bodies, design & construction team, building users etc. This process can be done by literature review, and by analysing stakeholder mapping of other energy renovation projects. This categorization contributes to classify the stakeholders in the following steps.

The **main stakeholder types** identified in typical renovation projects are:

- Facility Manager
- Public & Statutory Bodies
- Building Owners
- Building Users
- Community
- Project Management
- Design Team
- Construction Team
- Technology Providers, Third Party P&P providers
- Financing bodies
- Commissioning Team
- Deep Renovation Manager - The new methodologies, tools and technologies developed by the StepUP project means that new stakeholder type should be defined, who can cover the additional services and expertise needed: a methodology expert who can support the

various stakeholders throughout the iterations to achieve successful project delivery, in smaller project can also take over the project management tasks.

4.3 StepUP P&P technologies and ECMs

P&P technologies that are developed within the StepUP project are the backbone of a StepUP renovation process. If the P&P technologies are not selected as solutions to be implemented in a project, some parts of this methodology are not applicable (e.g.: P&P protocol, technology implementation guidelines).

Also, the StepUP renovation methodology works with a predetermined set of energy conservation measures (ECMs) that can be analysed via the software solutions of the project. These set of ECMs cover all the commonly used solutions and the innovative solutions developed in StepUP as well.

- **Technological ECMs**: Technological ECMs represent the interventions that need physical installation in the building. Their installation typically needs permits, therefore a design team should be involved and needs installers who are specialized in each technology. The list of technology ECMs in this project only include the solutions that can affect the Key Performance Indicators determined for the project. Typically these can be: envelope insulation solutions, efficient lighting, heating, cooling, ventilation systems etc.
- **Operational ECMs**: Operational ECMs refers to interventions which do not affect the building fabric or require extensive construction works to be carried out. In general, these are minor adjustments to existing structures and systems which can be undertaken in most cases by inhabitants and building users directly, or require limited technical intervention while still maintaining most of the functionality of the building. Operational ECMs in principle do not require construction permits or disrupt building operations. When technical work is required, it is limited in scope to what is commonly called retrofitting. Examples of operational ECMs include: interventions on the heating systems (installing valves on radiators, adjusting heating setpoints, changing setpoints by zone/occupancy), ventilation (adjusting air supply temperatures, ventilation rates based on schedules / air quality), lighting and power (relamping, turning off plug loads at night, daylight controlled lighting) and cooling systems (modulating setpoint based on outdoor temperature, chiller sequencing, use of shading to reduce solar gains)

The full list of ECMs applicable in the project will be finalised for **Deliverable 1.3**, the final methodology report.

4.4 KPIs

The Key Performance Indicators (KPIs) developed for the StepUP project represent the financial, energetic and qualitative values of the project, and are intended to help evaluate the overall improvement from the renovation. These metrics determine the boundaries of the analysis that can be performed for the renovation design, meaning that the project initiator can use the StepUP methodology to investigate the effects of the proposed renovation by only the metrics included in the KPI list.

Categories

Social
Environmental
Financial

MULTIPLE BENEFITS	INDICATORS	SUB-INDICATORS	CALCULATION METHOD
Increased well-being	Thermal Comfort	Summer comfort without cooling	Quality category (I-IV) according to EN 15251 based on operative temperature and outdoor running mean [°C]
		Thermal comfort in heating- and in cooling season	Percentage hours outside comfort range (according to ISO 7730) [%]
	Visual Comfort	Availability of daylight	spatial Daylight Autonomy (sDA)
	Acoustic Comfort		Indoor A-weighted sound pressure level (day and night) [dB]
	Indoor Air Quality	Ventilation effectiveness (in mechanically and naturally ventilated spaces)	ventilation rates based on EN15251
		Humidity level	the number of hours, when humidity levels are outside threshold reference values
		CO_2 concentration	indoor - outdoor [ppm]
	Wellbeing / productivity *(this KPI derives from the aforementioned comfort+IAQ KPIs)*		3 level scale (improved, same, decreased) based on the effect of the 4 comfort and indoor quality indicators.
	Absenteeism *(this KPI derives from the aforementioned comfort+IAQ KPIs)*		3 level scale (improved, same, decreased) based on the effect of the 4 comfort and indoor quality indicators.
Reduced maintenance cost	Maintenance, Repair, Replacement and Refurbishment costs		Yearly Maintenance & Operations Fee
			Frequency of repair/refurbishment/replacements activity [number/year]
Reduced installation cost	Installation Costs		cost of installation including all new materials and disposal of discarded elements [€/m^2]
Increased energy cost savings	Average Yearly Energy Savings kWh		Periodic (e.g. annual) energy consumption (per energy type)
	Yearly Energy Savings € (Non-Indexed)		Periodic (e.g. annual) energy consumption (per energy vector)+base year currency
	Yearly Energy Savings %		Design energy consumption kWh divided by baseline energy consumption kWh
Increased revenues from rent/sale	Change in Value of Property		3 level scale (improved, same, decreased) based on the effect of maintenance and cost savings
Reduced staff/tenant turnover	Staff or Tenant Turnover		% of regular, full time employees leaving employment in a given year per division/department/team
Reduced disruption of energy supply risk	Flexible Energy Capacity		Flexible energy capacity [%, kWh] / Number of Load shift hours and peak load curtailment due to thermal storage
Less disruption of operational hours	Installation Speed		Installation speed of m2/day
Improved air quality of ambient air	Global Warming Potential		Operational CO2 emissions [$kgCO_2$ eq/m^2 year]
	Renewable Energy on Site		Renewable energy ratio [%]

Figure 1: List of Key Performance Indicators

5 StepUP renovation process

This chapter describes the 'storyline' of a StepUP renovation process: what are the goals and steps of each phase. It is an update of the first version of the methodology that was released internally one year ago, revised taking into account the 1 year of feedback from the pilots and consortium members.

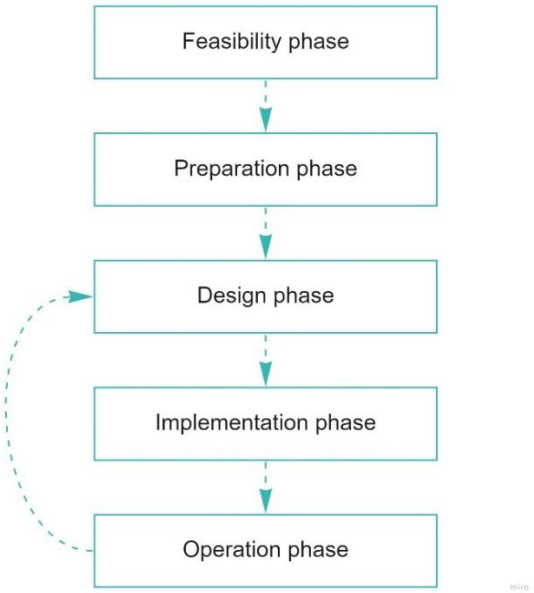

Figure 2: StepUP methodology phases

Figure 2 shows the **five methodological steps identified for a renovation project**. A project starts with the Feasibility phase where a simple assessment is carried out to determine if the renovation for the selected building is feasible. Then during the Preparation phase all project related information is collected (including 1 year of monitoring data, occupancy and user behaviour information, building geometry and parametric data etc.) which results in a calibrated simulation model that will support the design of renovation. In the Design phase the renovation options are developed and assessed. Additionally, a business plan is developed that presents the costs and potential savings of the different renovation versions. It also proposes a plan for financing the implementation of the different measures, mainly utilizing the concept of iterative renovation process (where the savings from each renovation cycle can finance the implementation of the next measure). Based on the developed design the renovation measures are carried out during the Implementation phase. After project handover the performance of the newly refurbished building is closely monitored. Finally, the next renovation cycle can start according to the business case. This means that the project information is updated and the design can be started for the new measures to be implemented.

In the next chapters each phase will be described with the following details:

- goal of the phase
- necessary inputs to start the activities in the phase
- the outputs provided at the end of the phase
- estimated time to go through the steps of the phase
- description of the process

The following descriptions of each phase also mention the tools that are developed for StepUP to use throughout the implementation of the methodology, but do not go into detail about their description. The details will be included in the next chapters.

5.1 Feasibility phase

Goal of the feasibility phase:

- Decision on project applicability
- Decision on project feasibility

Inputs necessary:

No inputs necessary for starting the phase

Outputs provided:

- preliminary and basic financial evaluation, a rough estimate of the energy savings potential of a building or project and the related financial requirements
- financial Key Performance Indicators (KPI) – energy savings potential, total required investment amount, energy savings, CO_2 savings, Payback Time (the investment amortisation period from energy savings)
- basic building data

Time

The critical path for calculating the expected duration of this phase is highlighted on Figure 3.

The duration of the Feasibility phase is flexible. The basic data collection can be achieved with a building walkthrough. For the feasibility study the ECM data collection can take a longer time, but the feasibility calculation is a straightforward, short process. The checking of the applicability of StepUP technologies can be done during the walkthrough. The time for decision making for pursuing the renovation depends on the urgency of renovation, the availability of funding and the willingness of the project initiator.

In summary the Feasibility phase process can take up to 1-2 months of time.

Process description

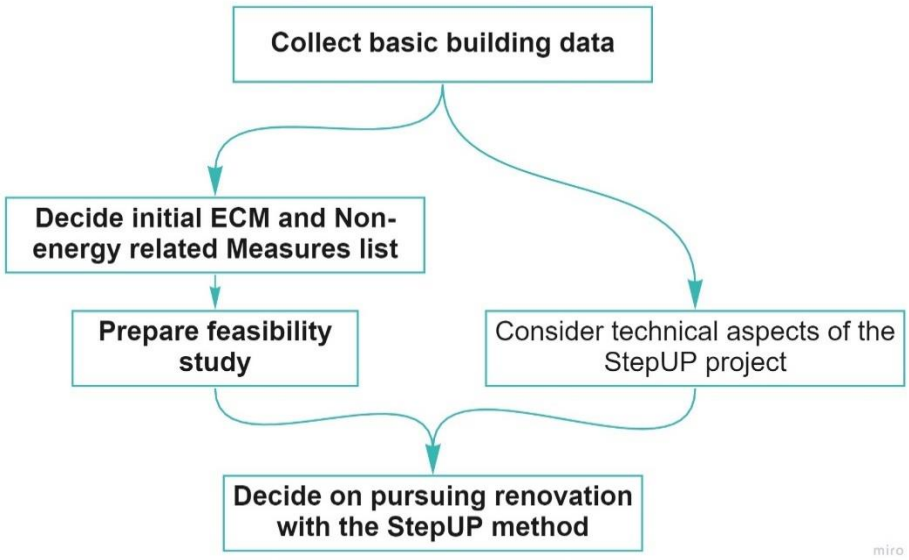

Figure 3: Feasibility phase flowchart

The first phase – the Feasibility phase - focuses on the initial action in every renovation project, which is the **decision-making for pursuing the refurbishment of a building**. This decision is usually preceded by a feasibility study where the cost-effectiveness and the co-benefits of pursuing refurbishment is considered based on a simple data collection.

The first step to be taken in this phase is a **basic data collection** about the building targeted for renovation. The necessary data for this phase can be collected during a site walkthrough:

- for the feasibility analysis: simple geometry, type of electrical and mechanical systems, energy bills of previous years, existing building conditions, systems, structures that need to be renovated
- for the technology applicability investigations: compactness of the façade, window-façade ratio, load bearing capacity of façade, modularity of the façade, existence of roof overhang; amount of area where thermal storage and heat pumps can be placed, heat pump compatibility with existing system, heat distribution system compatibility with SmartHeat output temperature, load bearing capacity of roof, amount of space available for PV on southern facing roof

Based on the current energy consumption and the condition of the structures and systems in the building and **initial list of ECMs and Non-energy related measures** can be determined. For each measure their investment value and potential energy savings or co-benefits should be also determined.

The potential energy savings can be assessed for a package of measures:

- by a simplified simulation model – with a simple geometry and basic knowledge on the type and age of mechanical and electrical systems a simplified simulation model can be developed. Its results include information on potential CO_2 emissions, cost, and energy savings of the intervention. The simulation method can also include the investment risk, which can be calculated based on the uncertainty of the simulation model and the range of savings that can be expected to be achieved.
- by hand calculations – if the preparation of a simple model is not possible, then the potential CO2, cost, and energy savings for the different measures can be estimated with traditional methods based on previous project experience or information from Technology Provider Clusters (**Chapter 6.1.5**)

Using this data, the **feasibility calculations** can be started with the Feasibility Level Business Case Tool (**Chapter 6.2.1**). As a result, this calculation provides a preliminary and basic financial evaluation of the renovation project's expected or required investment in Energy Conservation Measures and the resulting benefits.

In addition to the feasibility of the project, it also needs to be decided **if the full-scale StepUP renovation method is applicable for a project** or it can be only partially applied: the main StepUP P&P technologies have a few technical constraints in their applicability (e.g.: space requirements for the heating system, limitations of the modular façade system). Based on the data collection, the technology applicability checklist (**Chapter 6.2.2**) can determine if the technologies fit the project.

After studying the applicability and feasibility of the renovation, the project initiator can decide on pursuing the renovation with the StepUP approach.

The following table summarises all necessary steps to achieve the goal of this stage.

Task	Initiator	Participant	Method	Related StepUP tool
Collect basic data	Owners, Project management	Owners, Project management	Site survey, Collecting plans	N/A
Consider technical aspects of a StepUP project	Owners, Project management	Owners, Project management	Desk study	Technology applicability checklist
Decide initial ECM list	Owners, Project management	Owners, Project management	Simple energy modelling, hand calculation	-

Prepare feasibility study	Owners, Project management	Owners, Project management, Financing bodies	Desk study	Feasibility Level Business Case Tool
Analyse Project Financial KPIs	Owners, Project management	Public & Statutory Bodies	Decision making	-
Decide on pursuing renovation with the StepUP method	Owners, Project management	Owners	Decision making	N/A

Table 1: Steps of the Feasibility phase

5.2 Preparation phase

Goal of the phase:

- Define and involve the stakeholders of the project
- Define the goals of the project
- Collect and organize all data needed for the design phase
- Set up the initial project schedule

Inputs necessary:

- basic building data (collected in Feasibility phase)

Outputs provided:

- Stakeholder involvement strategy
- Calibrated simulation model
- Initial project schedule

Time

The critical path for calculating the expected duration of this phase (highlighted on Figure 4) is related to the monitoring activities. The time from defining stakeholders until installing the monitoring system can take up to 3-6 months. After the installation of the system, at least a year of monitoring data should be collected to develop the calibrated simulation model.

In summary a minimum of 1,5 years duration can be estimated for this project phase.

Process description

After the decision has been made that a refurbishment will be pursued by the project team the Preparation phase should start. The **goal of this phase is to collect all information, develop the initial scheduling and involve the project stakeholders** that is necessary to start the design.

As the first step the StepUP project initiation will be started by **setting up the supporting StepUP platform** and its components (Data management platform (Chapter 6.1.1); Life Cycle platform (Chapter 6.1.2). All collected information can be then stored on the platform, and shared among the stakeholders.

The preparation phase also includes the **first stakeholder engagement activities**. First, the relevant stakeholders are defined, then the first contact is established with them. Based on the needs and priorities of the different stakeholders **the main goals of the project are determined**. (From the managerial perspective, the benefits of stakeholder engagement include capturing knowledge, increasing ownership of the project by users, reducing conflict, encouraging innovation and facilitating spin-off partnerships. According to the ethical perspective stakeholder engagement can enhance inclusive decision making, promote equity, enhance local decision making and build social capital. Finally, the social learning perspective sees the benefits of stakeholder engagement in the creation of a common forum, where stakeholders could reflect upon their own values while learning about each other. It is also a forum for

increasing awareness, changing attitudes and affecting behaviours.) The project goals are expressed in the **prioritising of the StepUP KPIs**.

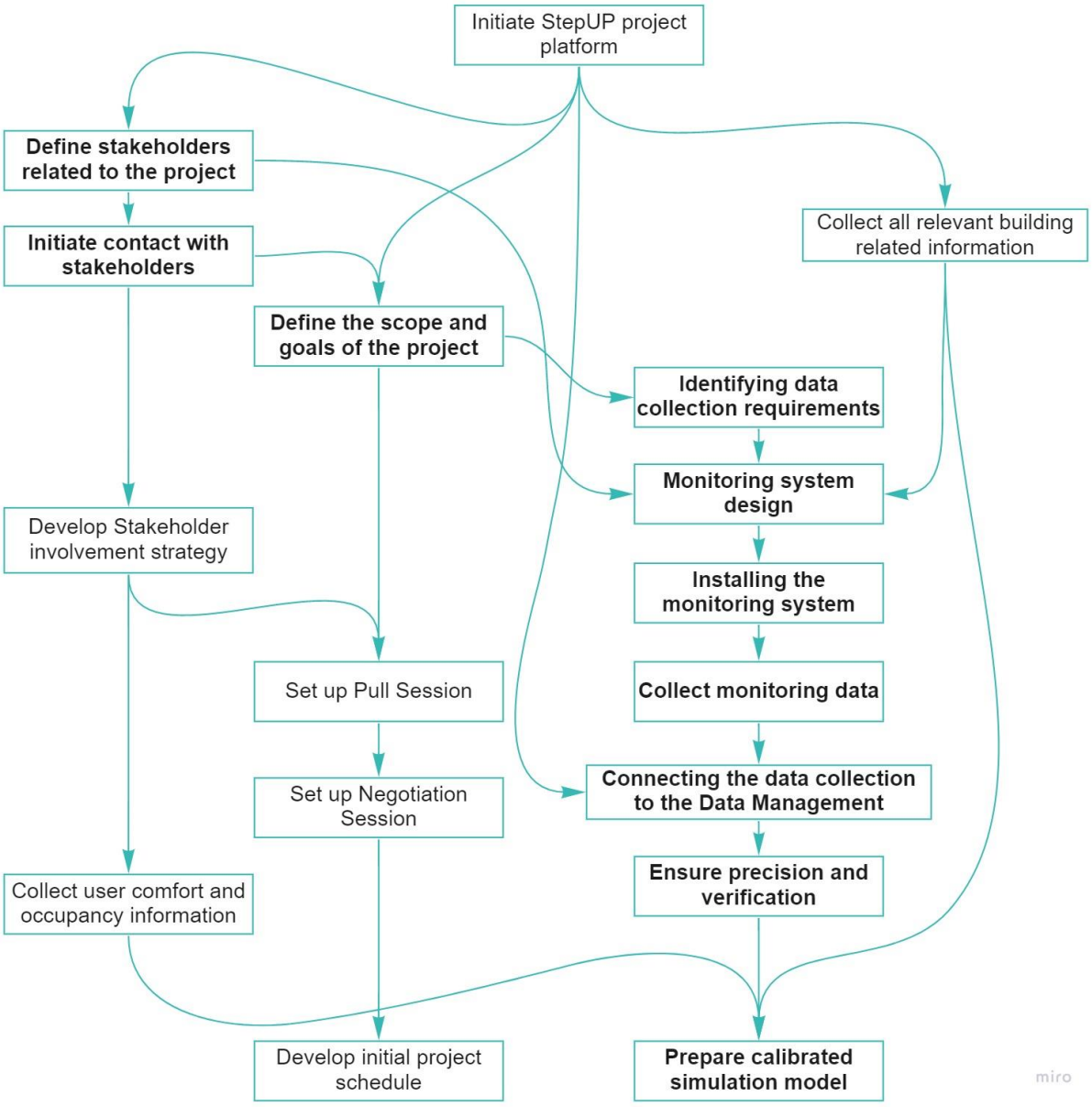

Figure 4: Preparation phase flowchart

For further involvement of the stakeholders it is recommended to **customise the Stakeholder engagement strategy** (**Chapter 6.1.3**) to the needs of the project and based on the initial interest of the identified stakeholders. The first step of the Strategy is to collect user comfort and behaviour data, through surveys of interviews.

Using the identified goals for the project and involving the main stakeholders **the initial project scheduling** can start with conducting Pull and Negotiation sessions **using the LEAN project delivery guidelines** (**Chapter 6.1.4**). The initial project schedule can contain detailed preparation and design phase timelines, and assumptions for the implementation phase. This schedule will be followed and later updated in the next project phases.

One of the information that also needs to be collected in this phase is **the building geometric data** and all relevant parameters of the building structures. This information then can be used for the monitoring system design and the development of the simulation model.

Using the priority KPI list defined by the stakeholders and the initial ECMs proposed in the Feasibility phase the **monitoring data collection** requirements can be determined, then the system designed and installed. The incoming monitoring dataflow should be connected to the Data Management System. Through the data analytics functions of the DMS the precision and verification of the raw data can be ensured (see further details on the Monitoring data collection protocol in **Chapter 6.1.6**).

As a final step in the Preparation phase, using the collected user comfort and behaviour information, the geometric data, the building parameters and at least 1 year of monitoring data, the **simulation model can be built and calibrated**. To guide this process the IES model setup guidelines (**Chapter 6.2.3**) and calibration guidelines are available (**Chapter 6.2.4).**

The following table lists all necessary steps to achieve the goals of this stage.

Task	Initiator	Participant	Method	Related StepUP tool
Initiate StepUP project	Owners, Project management	StepUP Deep Renovation Manager	Setting up StepUP platform	-
Define project stakeholders	Owners, Project management	Owners, Project management	Desk study	Life Cycle Platform
Initiate contact with stakeholders	Owners	Owners, Building management, Building users, (Public / statutory bodies, Community & civic society)	Workshop	Life Cycle Platform
Define project scope, and goals	Owners, Project management	Owners, Building management, Building users, (Public / statutory bodies, Community & civic society)	Workshops, Focus groups	Life Cycle Platform
Pull session	Project management	Owners, Building management, Building users	Workshop	LEAN project delivery guidelines
Negotiation session	Project management	Owners, Building management, Building users	Workshop	LEAN project delivery guidelines
Develop initial project schedule	Project management	Owners, Building management, Building users	Workshop	LEAN project delivery guidelines
Collect all relevant building related information	StepUP Deep Renovation Manager	Owners, Building management, Building users	Site survey, Collecting plans, User survey / interviews, BIM modelling,	Life Cycle Platform
Install monitoring system	StepUP Deep Renovation Manager, Project management	Material, solution and infrastructure providers	Site installation	Monitoring Data collection protocol

				Data Management Platform
Collect monitoring data	StepUP Deep Renovation Manager, Project management		Collect historical and streaming data	Data Management Platform Monitoring Data collection protocol
Conduct pre-refurbishment measures	StepUP Deep Renovation Manager, Project management	Design Team	Analyse historical data for any existing operational issues	Data Management Platform Monitoring Data collection protocol
Prepare as-built simulation model	StepUP Deep Renovation Manager	Design team, Facility management	Energy simulation	Life Cycle Platform
Run as - built simulation	StepUP Deep Renovation Manager	Design team, Facility management	Energy simulation	Life Cycle Platform
Calibrate the model based on measurement data	StepUP Deep Renovation Manager	Design team, Facility management	M&V methods	Life Cycle Platform

Table 2: Steps of the Preparation phase

5.3 Design phase

Goal of the phase:

- Diagnostic of the current state of the building
- Define refurbishment scenarios
- Identify and analyse ECMs by assigning value to ECMs and estimate their impact on key aspects
- Rank the different scenarios by their performance (measured in KPIs), cost, savings
- Decision-making between the options
- Detailed design of the selected scenario

Inputs necessary:

- initial project schedule
- feasibility analysis
- calibrated simulation model
- stakeholder engagement strategy

Outputs provided:

- Detailed design
- Updated project schedule

Time

The critical path for calculating the expected duration of this phase is highlighted on Figure 5.

To get from the building analysis to the decision making between the analysed scenarios takes a minimal amount of simulation computational time, so length of the period only depends of the speed of the data provision and decision-making from designers (~min. 1 month to 3 months.

The permit design preparation and the installation drawings preparation time mainly depends on the complexity of the selected renovation solutions (4-6 months in average).

Process description

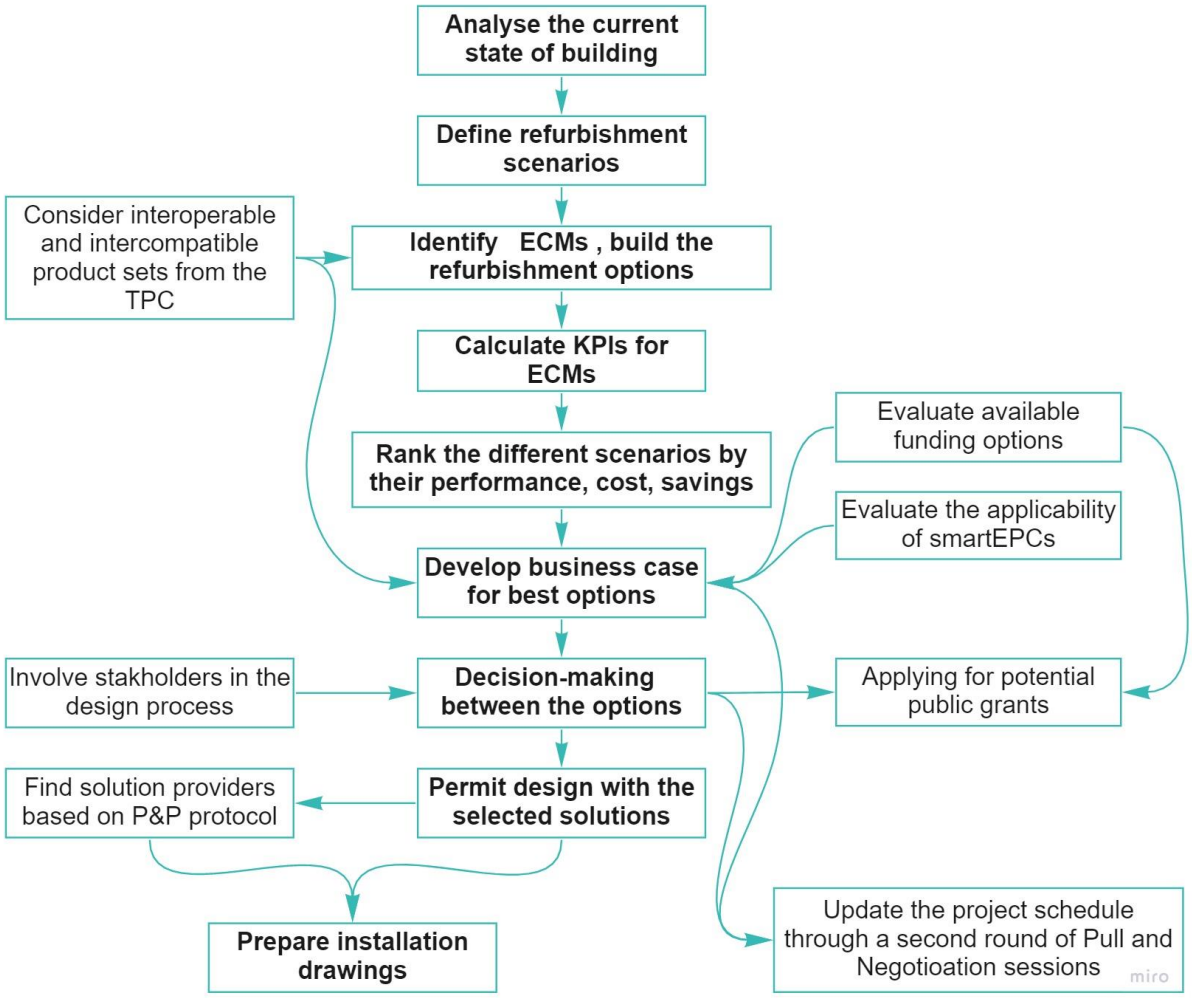

Figure 5: Design phase flowchart

The Design phase includes a data driven refurbishment design, which starts with the **analysis of the current state of the building**. The analysis with the calibrated simulation model should show the low performing areas and systems of the existing building. Then different refurbishment scenarios can be proposed that can correct the identified inefficiencies.

The StepUP renovation methodology can be applied in its most advanced form if the proposed renovation scenarios include envelope insulation and the update of the heating system.

For each scenario the KPIs are calculated to show their performance. For the most suitable options the **business case can be developed** with the Business Case tool (**Chapter 6.2.5**). This tool is focused on the financial evaluation of the design options selected. It aims to support the building owners or project owners in assessing whether an investment in the selected StepUP refurbishment scenario makes sense from a financial performance point of view. It can also include available funding options and then can propose the optimal number of iterations through the selected ECMs can be implemented.

The **different options can be ranked by priority** areas based on performance, costs or savings potential. Taking into account the energy, comfort and cost savings potential and other non-energy related benefits of the different scenarios the project stakeholders can influence the

design by selecting the scenarios most beneficial for their needs. Ideally, the final option for refurbishment will be chosen through a consensus-based approach.

The final renovation option can be developed into a permit design. This will be further detailed by finding solution providers based on P&P protocol (**Chapter 6.2.6**), including the P&P envelope solution and the SmartHeat system, into **installation drawings**.

Using the results of the decision making between the renovation options and the proposed iterations for installation the project team can **update and further detail the project schedule** (by using the scheduling methodology described in LEAN project delivery guidelines, described in Chapter 6.1.4) to include the details on the implementation stage as well.

The following table lists all necessary steps to achieve the goal of this stage.

Task	Initiator	Participant	Method	Related StepUP tool
Analyse the current state of building	Deep Renovation Manager/Design Team	Building users, Owners	Energy simulation	Life Cycle platform
Define refurbishment scenarios	Deep Renovation Manager/Design Team	Owners, design & construction team, MSI providers	Energy simulation	Life Cycle platform
Identify ECMs, build the refurbishment options	Design team	Design team	Energy simulation	Life Cycle platform
Calculate KPIs for ECMs	Deep Renovation Manager/Design Team	Design team	Automated calculation	Life Cycle platform
Rank the different scenarios by their performance (measured in KPIs), cost, savings	Design team	Design team	Participatory design	Life Cycle platform
Develop business case	Owner, Project management	Owner, Project management, Design team		Business Case Tool
Decision-making between the options	Design team	Owners, Design team	Participatory design	Lifecycle platform Stakeholder engagement methodology
Find solution providers based on P&P protocol	Design team	design & construction team, MSI providers, 3rd Party P&P solution providers		P&P protocol
Prepare installation drawings	Design team	MSI providers, 3rd party P&P solution providers		P&P protocol
Update project schedule	Project management	Owner, Project management, Design team		LEAN project delivery guidelines

Table 3: Steps of the Design phase

5.4 Implementation phase

Goal of the phase:

- Conduct the procurement
- Implement renovation measures

Inputs necessary:

- installation drawings
- building permit

Outputs provided:

- renovated building

Time

The procurement period depends on the local (national) regulations and the type of the owner. In public projects most of the time public procurement is necessary, which has prescribed administrative times.

The length of implementation phase mainly depends on the complexity and level of prefabrication of the selected renovation solutions. As the goal of the project is to use industrialised solutions that need minimal on-site modifications, the construction timeline can be minimised.

Process description

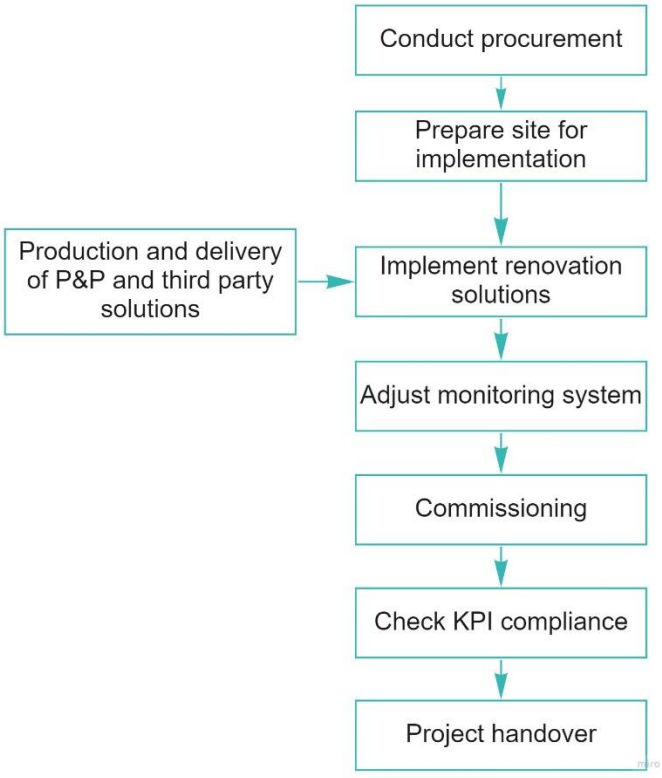

Figure 6: Implementation phase flowchart

The project implementation phase starts with the **procurement process**. During the production and delivery of the procured technologies the site can be prepared for the implementation. The construction team **implements the renovation solutions**, which can be guided by the installation manuals for P&P envelope (Chapter 6.2.7) and the SmartHeat system (Chapter 6.2.8).

The implementation process is guided by the established **project schedule** and the LEAN construction support methodology.

After the technologies are installed, the monitoring system also may need adjustment to include the metering of newly implemented technologies (e.g.: PV production metering).

Using the building and monitoring data visualized through the Data Management Platform the **commissioning** team can conduct an inspection that helps to identify problems, and can make sure the building is operated as expected at design phase by checking KPI compliance.

At the end of the implementation phase the project is handed over to the owner and facility management.

The following table lists all necessary steps to achieve the goal of this stage.

Task	Initiator	Participant	Method	Related StepUP tool
Conduct the procurement	Construction team	Construction team, Owner		Lifecycle platform
Continuously follow up on project schedule	Construction team	Construction team		Lifecycle platform
Adjust monitoring system	Construction team	Construction team		Monitoring data collection protocol
Implement renovation solutions	Construction team	Construction team		Installation guidelines
Involve the stakeholders on the scheduling of the implementation	Project manager	Construction team, Users		Lifecycle platform
Monitoring KPI compliance	Construction team	Construction team		Data Management Platform
Commissioning	Project management, Owner	Construction team, 3rd Party P&P providers		Lifecycle platform
Project handover	Project management, Owner	Construction team		Lifecycle platform

Table 4: Steps of the Implementation phase

5.5 Operation phase

Goal of the phase:

- monitoring the performance of the refurbished building
- optimize operations, adjust performance
- preparation for the next refurbishment cycle

Inputs necessary:

- renovated building
- monitoring data

Outputs provided:

- Updated business case

Time

The operation phase time is defined by the business case, where the duration of each iteration is determined.

Process description

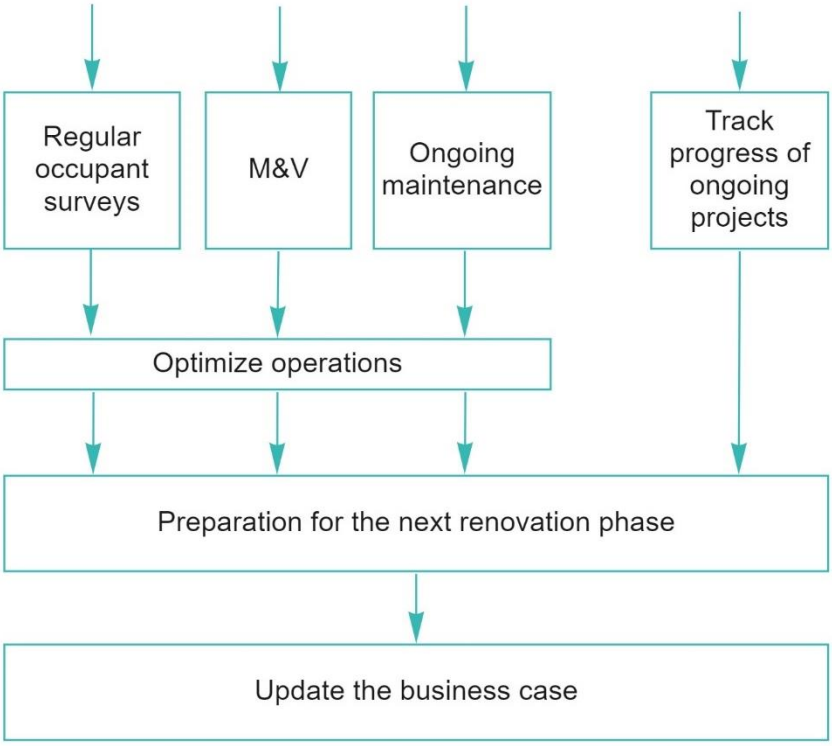

Figure 7: Operation phase flowchart

The operation phase consists of several continuous or regular activities. One of the main elements is **tracking the progress of ongoing activities**, where the basic task of the facility management is to keep track of monitoring data and the ongoing maintenances. Stakeholders can also visualise ongoing projects to track progress towards their targets, via custom visualisations and dashboards. This could be high-level KPIs, e.g. kg of CO2 reduced, kW of energy saved, etc. Also, there are other energy efficiency related continuous activities:

- **Ongoing maintenance**: Based on continuous monitoring of building performance & operational costs and the required schedule for equipment inspection and change, the maintenance of the building can be planned and performed efficiently
- **Measurement and verification** (M&V): the process where the Facility management (FM) needs to evaluate the operational savings & identify any issues as they occur to ensure, and check if the ECMs are performing as intended (see details in Chapter 6.2.9)
- **Regular occupant feedback**

Based on M&V and occupant feedback activities the **operations can be optimized**. This is supported by the Data Management Platform dashboards where user complaints/feedback and monitoring data can be visualized. Also, this platform provides continuous monitoring of Measured vs. simulated data & alarms based on operation limits, alerting if the building is not performing as intended.

The end of the operation phase includes the **preparation for next iteration** (updating simulation models, recalibration based on monitoring data). The business case can also be updated with output from revised calibrated model.

The following table lists all necessary steps to achieve the goal of this stage.

Task	Initiator	Participant	Method	Related StepUP tool
Ongoing maintenance	Facility management	Facility management		-
Regular occupant surveys				Lifecycle platform
Monitoring the performance of the refurbished building - M&V	Facility management	Owner, Users, Facility Management, MSI providers, 3rd Party P&P providers		Data Intelligence tool
Optimize operations	Facility management	Owner, Users		Data Intelligence tool
Preparation for the next refurbishment phase	Owner	Design team		Lifecycle platform
Update the business case	Owner	Design team		Business case tool
Track progress of ongoing projects	StepUP Deep Renovation Manager	Public and Statutory Bodies	Data visualisation	Lifecycle platform

Table 5: Steps of the Operation phase

6 Tools to support the StepUP renovation process

This chapter includes the description of the supporting tools and guidelines that are developed within the project. The tools can be grouped into two categories:

- overarching tools, that provide support during all phases of the StepUP methodology
- phase-specific tools, that support actions in specific phases of the methodology

Each tool / guideline is summarized in the following paragraphs with the following content:

- summary table with information on the main function, target audience, relevant phase and related StepUP report
- why the tool exists, how it helps its users
- how to use it
- summary of the method described in the tool
- necessary inputs, expected outcomes
- what is the innovation in the tool / guideline (if applicable)

The complete tools and guidelines are either included in a public or a confidential deliverable. For each of these a link is provided where the users of this methodology can access detailed information on the relevant tool. The details of some tools are included in confidential deliverable. The publication of the tools as an appendix of the final methodology report from these confidential deliverables are determined by the consortium on a case-by-case basis, as they may be covered by intellectual property laws. These confidential documents are mainly about the implementation development, but public factsheets for key info will be prepared on these. There is a small number of tools that are not included in other deliverables, so they are also covered in this document of the final methodology report in the Appendices.

Figure 8 lists the overarching and phase-specific tools and shows how they are connected to the different phases of the StepUP methodology. The figure also indicates the tools' confidentiality or the links to other deliverables where detailed information is available.

The **overarching tools** are described in the following chapters:

- Data management platform (**Chapter 6.1.1**)
- Life Cycle platform (**Chapter 6.1.2**)
- Stakeholder engagement strategy (**Chapter 6.1.3**)
- LEAN project delivery guidelines (**Chapter 6.1.4**)
- Technology provider clusters (**Chapter 6.1.5**)
- Monitoring data collection protocol (**Chapter 6.1.6**)
- SmartEPC (**Chapter 6.1.7**)

The **phase-specific tools** are described in the following chapters:

- Feasibility phase business case tool (**Chapter 6.2.1**)
- Technology applicability checking tool (**Chapter 6.2.2**)
- IES model setup guidelines (**Chapter 6.2.3**)
- IES model calibration guideline (**Chapter 6.2.4**)
- Business case tool (**Chapter 6.2.5**)
- P&P protocol (**Chapter 6.2.6**)
- P&P envelope installation guidelines (**Chapter 6.2.7**)
- SmartHeat installation guidelines (**Chapter 6.2.8**)
- M&V guideline (**Chapter 6.2.9**)

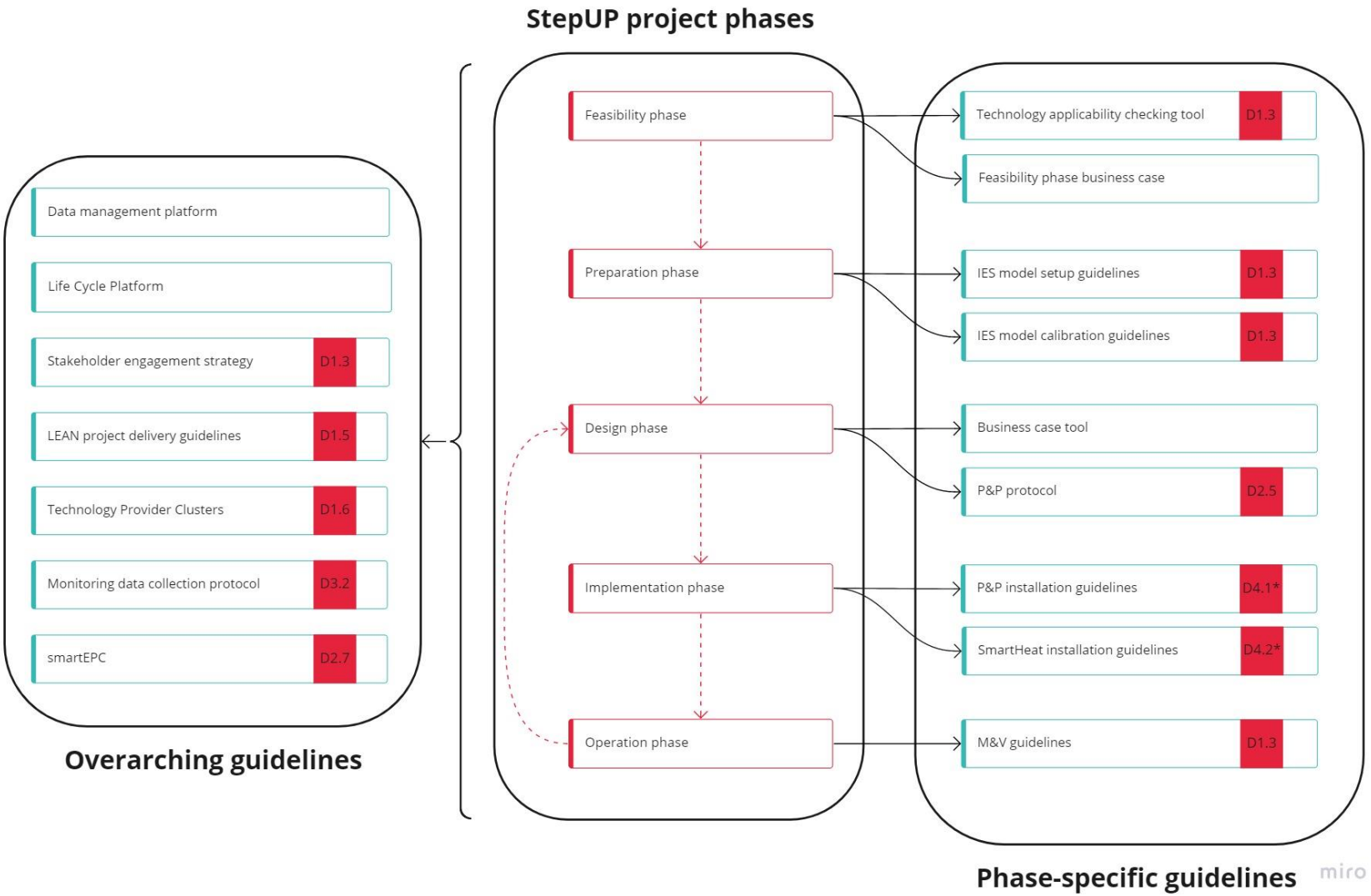

Figure 8: Step UP tools and guidelines connected to the different methodology phases

6.1 Overarching tools

6.1.1 Data Management Platform

	DATA MANAGEMENT PLATFORM
Function	The Data Management Platform (DMP) is a suite of interconnected tools to store, analyse, exchange and visualise historical and streaming data on the performance of the building, together with processed feedback from building occupants.
Target audience	Design team, building owners / managers, commissioning team, building users
Relevant phase	Overarching tool across all phases the renovation process
Link	Deliverable D3.4 (confidential report)

Table 6: Summary information about the Data management platform tool

The core of the **Data Management Platform** (DMP) is the software iSCAN by IES, a cloud data gathering and analysis platform which allows to store building and sensor-related information. iSCAN is a cloud software able to gather different typology of data such as xml, csv, SQL and to enable communication from various sources such as MQTT, ScadaClient, InfluxDB, Pi servers among others. The tool allows possibility to carry out **advanced data management and analysis**. It can easily manage store and visualise building management system (BMS) data, allowing to analyse the real operations of a building ahead of renovation and after the implementation of ECMs. The data is also made available to a variety of dashboards, in different formats depending on the type of end user, to allow them to inspect the building performance and gain useful information to undertake optimal actions on the building operations. To be able to deploy the DMP, a continuous data collection is needed, according to the specifications foreseen by the Data Infrastructure Requirements for the StepUP Methodology (**Deliverable D3.2**; see also **Chapter 6.1.6**).

A number of innovations are expected within the StepUP project to fully enable the methodology, mostly focussing on the development of default analyses to detect common issues of existing buildings and to carry out Measurement and Verification (M&V) procedures, as outlined in the dedicated M&V guideline (see **Chapter 6.2.9**). These presets will facilitate the identification of the highest efficacy ECMs, in particular those that pertain to building operations, and allow to track the performance of ECMs after their deployment. Similarly, a set of dashboard templates will be deployed for different phases and users in the renovation process envisaged in StepUP, such as for example visualisations for facility management (including alarms and user feedback), and building users (focussed on comfort and operational guidance).

6.1.2 Life Cycle platform

	LIFE CYCLE PLATFORM
Function	The Life Cycle Platform (LCP) is a suite of integrated tools to facilitate communication and track the renovation project stages, including the capability to assess the potential performance of ECMs ahead of deployment.
Target audience	Deep Renovation Manager, Design Team
Relevant phase	Overarching tool across all phases the renovation process
Link	Deliverable D3.5 (confidential report)

Table 7: Summary information about the Life Cycle platform tool

At the core of the LCP resides **state of the art, physics-based modelling**, provided by IES through the Virtual Environment (VE) software. The model is transformed into a **Digital Twin** by taking real-life data from the actual building (handled by the DMP), filling gaps with AI and Machine Learning to become an operational model, i.e., an accurate representation of the building at any point in time. This model can then be used to design the renovation solution in a much more accurate way, drastically reducing the performance gap that is a commonly experienced issue in renovation. Furthermore, it will generate an accurate baseline before renovation, which can be used to undertake M&V processes. To be able to create a Digital Twin that can be used within the LCP, both data and a building model are required, according to the model calibration guidelines presented in Chapter 6.2.4.

To enable the StepUP methodology, the Life Cycle platform will allow to test via the Digital Twin a variety of ECM combinations to identify an optimal set of interventions, exploring how their application in time will increasingly **improve the building performance towards decarbonisation**. The LCP will also include guidance on how to follow the various steps of the methodology, guiding users through stages, tools, and procedures to deploy at each moment in time. This interaction with the renovation process steps will be carried out in a collaborative cloud environment, where multiple users can provide information and carry out analyses shared with other members of the renovation team.

6.1.3 Stakeholder engagement strategy

	STAKEHOLDER ENGAGEMENT STRATEGY
Function	The stakeholder engagement strategy is a guideline for involving the typical project stakeholders in all stages of the renovation process
Target audience	Building owners, developers, Project management
Relevant phase	Overarching tool across all phases the renovation process
Link	Initial version in Deliverable D1.2 (public report) Final version in Deliverable D1.3 (public report)

Table 8: Summary information about the Stakeholder engagement strategy guidelines

In traditional renovation projects the project initiator (usually the building owner) defines what they want and need, and then proceeds to realise them by instructing the necessary experts to

develop solutions to the defined needs. However, several building types include many other stakeholders, who use the buildings day by day, frequently differently than the project owner and have different priorities in the building operations. A traditional stakeholder management, that only builds on information sharing on a need-to-know basis can lead to dissatisfaction with the results and negative impacts on the projects budget and schedule. A constructive stakeholder involvement process, which **addresses the needs and priorities of all stakeholders**, involves them in the decision-making process can result in creative solutions and mutually beneficial outcomes.

The StepUP Stakeholder management strategy provides **a guideline for project management teams and building owners about the best methods to inform, consult, involve or collaborate with all project participants**. It includes a guide for identifying stakeholders, determining their needs and priorities and what kind of opportunities or threats they represent and identifying the best type of engagement methods.

The strategy also provides practical information about existing engagement methods and how to implement them to renovation projects and building types in the scope of StepUP project. The engagement methods are also assessed to show in which phase of the StepUP renovation project they are the most effective.

Appendix 1: Stakeholder Engagement Strategy describes the detailed strategy.

6.1.4 LEAN project delivery guidelines

LEAN PROJECT DELIVERY GUIDELINES	
Function	Practical guideline for implementation of LEAN project delivery methods in industrialized renovation projects.
Target audience	The guideline is orientated to all the stakeholders involved in a deep renovation industrialized process.
Relevant phase	Overarching tool across all phases the renovation process.
Link	Initial version in Deliverable D1.5 (confidential report) Final version in Deliverable D1.6 (public report)

Table 9: Summary information about the LEAN project delivery guidelines

This tool is a **practical guideline for implementation of LEAN construction** in industrialized renovation projects.

Lean philosophy is applied in all types of services related industries. LEAN Philosophy could be defined as a strategy for companies to achieve excellence:

- by creating value (from the customer's perspective)
- by creating a culture of continuous performance improvement and working to eliminate all waste of resources and time
- by creating high quality, stable processes and emphasizing respect for people throughout the organization

LEAN Construction consists of applying the LEAN philosophy to the construction sector. Its main idea is to go from planning activities to planning resources in order to reduce efforts, time and unnecessary materials. Its basis is the active collaboration of all the stakeholders to avoid waste.

In this guideline not only construction activities are included, but also activities related to monitoring, analysis of different economic scenarios and the manufacture or fabrication of the P&P technologies and third-party solutions.

The guideline implies a new and innovative approach of current LEAN methodologies, not only for the application of LEAN construction in renovation process but also for the **integration of the entire construction process** (selection, design, monitoring, business model, production, construction, validation) in the methodology.

Besides, it contributes with key guidance to implemented LEAN Construction methodology in industrialized renovation processes, which is an important challenge for the implementation of new LEAN techniques.

6.1.5 Technology provider clusters

TECHNOLOGY PROVIDER CLUSTERS	
Function	Establishing clusters of third-party technology producers which are able to be integrated into the technologies developed by StepUP. The final objective is to create a network groups of producers who can rely on the StepUP system to offer turnkey solutions across Europe.
Target audience	The key stakeholders are large technology producers and innovative SMEs developing high-tech products.
Relevant phase	The TPC approach would potentially affect the Feasibility, the Design, the Implementation and the Operation phases
Link	Initial report in D2.1: Report on progress of pilot third party clusters (confidential report) Final report in D2.2: Roadmap for the generation of technology clusters (public report)

Table 10: Summary information about the Technology Provider Clusters development tool

The end aim of the establishment of Technology Provider Clusters is to generate a new market service for renovation, delivered by interconnected providers of intercompatible and interoperable products. The Technology Provider Clusters aims at **establishing a network of producers of technologies potentially able to be integrated into the StepUP products**. The principal need that the TPC cover regards the interoperability and intercompatibility of products and technologies with the StepUP system. The intention is to create the basis for any third-party to access the StepUP technology.

The TPC approach is initially based on the Spanish and Italian areas and it will be focused on feedback collection from the involved stakeholders, through specific workshops and meetings. Later it will be scaled-up at a European level.

The success of the TPC approach relies on **the active engagement of third-party technology providers**, aiming at structuring and standardizing the potential technology integration provided by third parties.

The main innovation of the TPC is to establish a framework able to be scaled-up in order to develop ground-breaking technologies as a result of the integration of third-party technologies with the StepUP system.

6.1.6 Monitoring data collection protocol

MONITORING DATA COLLECTION PROTOCOL	
Function	Protocol for the building related monitoring data acquisition framework and infrastructure
Target audience	StepUP Deep Renovation Manager, Project management
Relevant phase	All phases of the StepUP project
Link	Deliverable D3.2 (public report)

Table 11: Summary information about the Monitoring data collection protocol

The Data Collection Protocol is closely related to all phases of the StepUP renovation methodology. It has been conceived to **deploy efficient long-term data acquisition systems** with the main goals of:

- establishing the initial baseline building model required by the StepUP methodology,
- minimizing building performance gap between predicted and actual measured performance and
- carrying out a continuous commissioning for any corrective or follow-up actions after the implementation of the ECMs as well as the optimization of operations.

For all of this, the data collected needs to be connected to the Data Management Platform and will be available for design development of energy conservation measures and to calibrate the baseline model.

Figure 9 shows the connection points between the data collection steps and the StepUP methodological steps.

The main result of the Feasibility phase is the early business case that proposes a preliminary list of ECMs based on a quick expert assessment of the existing building and its operations. At the beginning of the Preparation phase the goals and priorities of the renovation project are determined, which can be translated to the selection of the most relevant KPIs for the project. This two information (preliminary list of ECMs and the high priority KPIs) serve as the basis for identifying the data collection requirements.

When the data collection requirements are determined, and the necessary geometric data collected, the monitoring system design is carried out. This consist of deploying a set of meters, sensors and communication networks for energy and IEQ monitoring, as well as the occupancy behaviour monitoring. The occupancy monitoring is based on the understanding of the stakeholders of the building and supported by the stakeholder engagement strategy, especially the early-stage occupant comfort and behaviour surveys and interviews.

The installed monitoring system is then connected to the StepUP Data Management Platform. As the last step in the StepUP Preparation phase, the monitoring system is calibrated, and the data accuracy is verified. Based on the long-term monitoring data (at least 1 year of data collection) of the existing building, the building simulation model is calibrated to improve its accuracy. The accurate simulation model (digital twin) is used for the detailed design of the renovation ECMs. After the ECMs are implemented the monitoring system may need adjustments (e.g.: to measure the newly implemented PV production).

During the operation phase the monitoring data supports the continuous commissioning of the building systems and the optimization of the operations. When low performing areas are detected the next iteration of the renovation process can be initiated, starting again the StepUP process at the Feasibility phase.

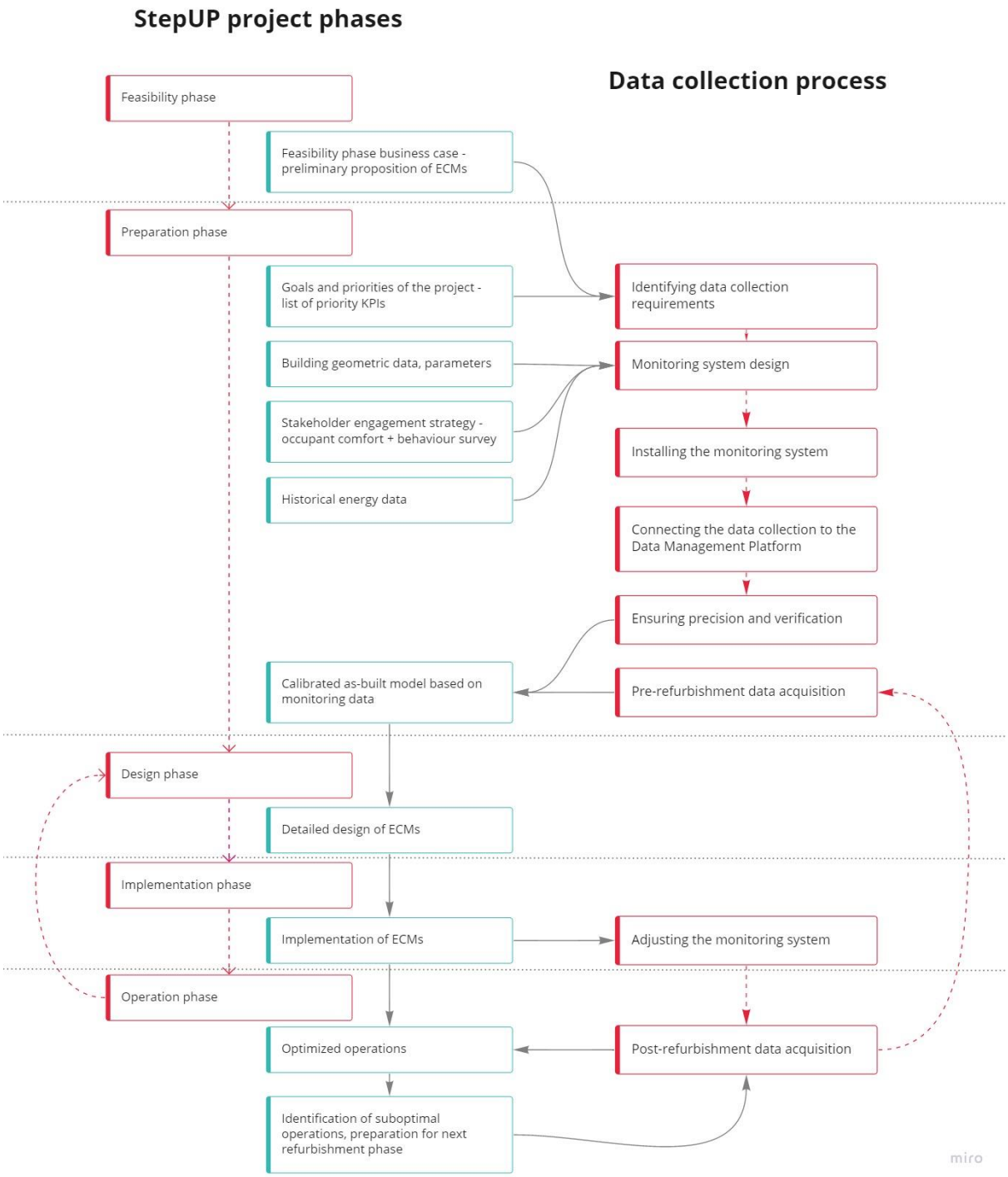

Figure 9: Data collection process and its relation to the StepUP methodological steps

6.1.7 SmartEPC

	SMARTEPC
Function	Provides the guidance to integrate the StepUP method (deep renovation process, plug and play principles…) into the existing enhanced smartEPC methodology for Maintenance and Energy Performance Contracting and provide smartEPC capabilities to organisations wanting to use StepUP principles in combination with smartEPC. This will allow to develop new or enhance existing smartEPC tools.

Target audience	ESCOs, EPC and smartEPC Project facilitators, Technology providers, Building Owners and Project Developers
Relevant phase	All phases
Link	Deliverable D2.7 (public report)

Table 12: Summary information about the smartEPC tool

The smartEPC integration guidelines are developed for 2 reasons:

- To allow ESCOs, SmartEPC project facilitators and building owners that are already using the existing smartEPC methodology to enhance it with the deep renovation capabilities that the StepUP approach is offering
- To allow technology and services providers and ESCOs that want to implement StepUP-based renovation projects to benefit from a fully performance-driven model that integrates energy, maintenance and comfort performance and that has proven its robustness in many public sector building renovation projects.
- The work in this task is aimed at combining the value of both complementary delivery models to create even more value to the target audience.

SmartEPC development started in 2011 to deal with shortcomings in existing Energy Performance Contracting (EPC) methods and contracts. It was designed as a **highly performance-driven model**, based on pilot projects with Belgian public federal buildings. It integrates many innovative features to deal with the renovation and operation of a large variety of sometimes complex building stocks in what are often complex multi-stakeholder environments. The methodology has proven its capacity to be tailored in a flexible way for a variety of building types, topologies or sizes and deals with changes in occupation or usage throughout the contract. It has been used in buildings that are occupied by building owners or rented to tenants. It has also been used with various financing mechanisms (own funding, bank funding, ESCO financing...). A comprehensive tool set is being used by smartEPC facilitators, ESCOs and end-customers in the feasibility, preparatory, tendering, design, implementation and operation phases.

The integration guidelines will allow users, who are relatively new to smartEPC, to understand the rationale between the model and all the key features and how they are being used in building renovation projects.

It will provide practical guidance, based on a thorough analysis of the StepUP approach, of how to adapt smartEPC functionality and how to adapt smartEPC tools like tendering documents. This will include features such as **performance-based maintenance mechanisms, building value concepts or tendering practices**. The impact on financing schemes will also be analysed and summarised in the guidance.

Inputs to this deliverable will be the StepUP methodology, process and technology features. Outputs will be clear guidance on smartEPC & StepUP integration and how to adapt existing tools. The adaptation of the tools itself is outside of the scope of the relevant deliverable.

As smartEPC is today mainly used for shallow renovations (typically up to 40% energy savings) the innovation lays on one hand in the capacity to **enhance smartEPC with a powerful deep renovation delivery mechanism**. On the other hand, there is innovation in the sense that it allows to use what is basically a classical input-driven approach of renovating buildings with an output-driven and performance-based business model, which can potentially offer new business opportunities for deep renovations and expand the StepUP approach to the ESCO industry which is moving towards higher ambitions in terms of renovation depth and rates.

6.2 Guidelines for different phases

6.2.1 Feasibility phase business case tool

	FEASIBILITY PHASE BUSINESS CASE TOOL
Function	Preliminary and basic financial evaluation of the renovation project showing a rough estimate of the energy savings potential of a building or project and the related financial requirements.
Target audience	Building owners, project owners
Relevant phase	Feasibility phase
Link	Deliverable D1.4. (confidential report)

Table 13: Summary information about the Feasibility Phase Business Case tool

The Feasibility Level Business Case Tool (FLBCT) is to be used during the feasibility phase and provides a **preliminary and basic financial evaluation of the renovation project's expected or required investment** in Energy Conservation Measures and the resulting benefits based on rough potential energy savings estimates and on collection and analysis of data obtained from energy bills of previous years, building or site walk-throughs and/or surveys with the project owner.

FLBCT is focused on the input of ECMs with their investment value and potential energy savings (all to be calculated and provided outside this tool). It also integrates the possibility of taking into account so-called Non-Energy Savings related Measures (NESM) such as comfort, indoor quality, safety…, that obviously do not have an impact on energy savings (on the contrary, sometimes these measures increase the energy consumption) but that are important or required from a multiple benefits perspective.

FLBCT provides the **relevant financial Key Performance Indicators** (KPI) showing a rough estimate of the energy savings potential of a building or project and the related financial requirements. As such the KPI provide information on the total required investment amount, grouped into investment value required for ECMs and investment value required for NESMs, information on the energy consumption baseline and the resulting energy savings related to the ECMs and the NESMs. The tool further allows to calculate the CO_2 savings resulting from the implementation of the project and provides the Payback Time (the investment amortisation period from energy savings) for the whole project as well as for the ECM investment part. The Payback period is also shown in a graph.

As FLBCT is a high-level estimation tool it does not include the possible effect of maintenance on the energy assets (the implemented renovation measures) or any other relevant operating costs or savings as a result of the implementation of the project. As a result, it does not integrate the concept of lifecycle costing of the project and does consequently not deal with the time value of money (cash flows). Typical KPI calculated from Lifecycle Costing and time value of money, such as Net Present Value and Internal Rate of Return will be calculated in the detailed Business Case Tool, further described under **Chapter 6.2.5 Business case tool**.

6.2.2 Technology applicability checking tool

TECHNOLOGY APPICABILITY CHECKING TOOL	
Function	This tool provides a checklist to assess whether the technologies developed in the StepUP project can be applied to a building
Target audience	Project initiator: Owner, Project management
Relevant phase	Feasibility phase
Link	Deliverable D1.2, D1.3 (public report)

Table 14: Summary information about the Technology Applicability Checking tool

The industrialized technologies developed in the StepUP project have many benefits including enhancing energy efficiency meanwhile potentially reducing construction time and costs. However, these technologies have some limitations in their applications due to the uniformization of the technology elements during the prefabrication process (to reduce production costs) and the limitations of installing them on existing buildings.

The Technology applicability checking tool provides a **checklist that can be assessed at the start of a renovation process** to see if the P&P envelope and the PV integrated heating system can be implemented to the selected building. To complete the assessment some basic information is necessary about the geometry of the building, the space availabilities on site and the existing heat distribution system.

The details of the tool are included in **Appendix 2: Technology applicability checking tool** at the end of the present document.

6.2.3 IES model setup guidelines

IES MODEL SETUP GUIDELINES	
Function	Once the renovation feasibility is confirmed, an accurate physics-based model of the building must be developed ahead of the design stage
Target audience	Design team
Relevant phase	Preparation phase
Link	To be published as an appendix of the StepUP renovation methodology (public Deliverable D1.3)

Table 15: Summary information about the IES model setup guidelines

To create a physics-based model of the building, the design team needs to collect a variety of information. The brief guidelines that are provided in D1.3 include **a list of key data needed to develop the model**, from the geometry information to the performance of the constructions, to setpoints and system schedules. An accurate starting model is fundamental to represent the building operations as close as possible, before starting the model calibration process to address outstanding uncertainties. As design teams are usually familiar with modelling for energy compliance purposes (i.e. produce an Energy Performance Certification according to local standards), the aim of this short document will be to focus on the different work to be carried out when preparing a model for calibration.

6.2.4 IES model calibration guideline

	IES MODEL CALIBRATION GUIDELINE
Function	Move from a physics-based model of the building to a digital twin, used to evaluate the potential performance of various ECMs
Target audience	Design team
Relevant phase	Preparation phase
Link	To be published as an appendix of the StepUP renovation methodology (public Deliverable D1.3)

Table 16: Summary information about the IES model calibration guideline

Model calibration, i.e. using real data from the building to finetune the model **and close the gap between simulated and measured actual performance**, is widely acknowledged as a complex task, with a heavy reliance on expert knowledge and ad-hoc solutions. The aim of this guideline will be to outline a reproducible best practice that design teams and energy modellers can follow to achieve model calibration. The guideline will be based on years of experience and outline key strategies and pitfalls of the process. Where relevant, it will refer to software tools used or developed as part of the StepUP LifeCycle and Data Management Platforms, and advise on their use in practical steps.

6.2.5 Business case tool

	BUSINESS CASE TOOL
Function	Provides the business case, focused on the financial evaluation, of the design option selected during this design phase.
Target audience	Building owners, project owners
Relevant phase	Design phase
Link	Deliverable D1.4. (confidential report)

Table 17: Summary information about the Business case tool

The Business Case Tool (BCT) is to be used during the design phase of the StepUP process and **provides the business case, focused on the financial evaluation**, of the design option selected during this design phase. It aims to support the building owners or project owners in assessing whether an investment in the selected StepUP refurbishment scenario, which might include **Energy Conservation Measures** (e.g. HVAC retrofit using SmartHeat, relighting, building envelope based on P&P protocol, shading, on-site renewable energy production, ...) and **Non-Energy Savings related Measures** (NESM) (thermal, visual and acoustic comfort, Indoor Air Quality, safety, building access,...), makes sense from a financial performance point of view. The BCT provides a number of Key Performance Indicators (KPI) which can be used by the owners in their final decision-making process.

The BCT takes into consideration all the cash flows generated by the investment in the ECM and NESM over the lifecycle of the project. It integrates both cash flows from benefits and cost reductions such as energy cost savings, increased rent income (when applicable), increased residual building value and possible maintenance savings as well as cash flows from relevant expenses such as initial and phased capital expenditures, capital replacements and, if applicable, additional repair, maintenance or operating expenses. In order to reflect time value

of money all cash flows are discounted to the present day using the Discounted Cash Flow (DCF) method.

The BCT is made available as an Excel Workbook consisting of different worksheets grouped into 4 building blocks: one or more Input worksheets, one or more Auxiliary Calculation worksheets, a Cash Flow worksheet and a KPI worksheet.

The core of the BCT is the Cash Flow worksheet which is showing the relevant project cash flows, on a year-on-year basis, after implementation of the selected StepUP refurbishment. These cash flows are being grouped as follows:

- Operating Income
- Operating Expenses
- Capital Expenditures and,
- One-off Income (grants, subsidies and sales/residual value of the building)

When relevant, the Cash Flow worksheet will also show separate financing cash flows, thus providing information on the impact on the cash flows in case third-party financing is envisaged.

The Cash Flow worksheet is being fed by the Input worksheet(s) and the Auxiliary worksheet(s).

The Auxiliary worksheet builds the financing cash flows (reimbursement schedule of the investment) related to the financing provided by the financier. It breaks out the yearly reimbursement amount of the financing into yearly principal amounts, interest amounts and remaining balance.

The Input worksheet includes all required input data to perform the calculations in the Auxiliary worksheet, the Cash Flow worksheet and the KPI worksheet. It is the only worksheet where data can be recorded either by the user of the BCT or by other StepUP tools.

The KPI worksheet groups all financial KPI calculated by the BCT. It will show Net Present Value (NPV) of the cash flows, Internal Rate of Return (IRR) and Payback period (Simple payback and discounted payback) and other project KPI such as required Investment amounts, baseline energy consumption, yearly energy cost savings and CO_2 savings. More KPI might be added during the progress of the StepUP project if they are relevant to the project and can be calculated.

6.2.6 P&P Protocol

	P&P PROTOCOL
Function	Defines specifications for integration of StepUP technologies with third party solutions and product characteristics
Target audience	Plug and Play (P&P) technologies (Manni and Suntherm), Third Party Cluster (TPC), Designer, Renovation Manager
Relevant phase	Design Phase
Link	D2.5 (public report)

Table 18: Summary information about the P&P protocol

The StepUP Protocol for Plug&Play technologies defines specifications to connect the most relevant deep renovation technologies, starting from the envelope and heating production and storage and further including passive and active solutions delivered by third parties involved in TPC. The StepUP methodology implementation **requires intercompatible and interoperable deep renovation solutions**. The methodology should allow a flexible selection of ECMs that answer the needs of the specific building and the possibility to have subsequent installation and

verification loops while always delivering a functional renovation solution after each iteration. While a variety of advanced technologies for deep renovation are now available on the market, there is always a need for compromise on the design side to minimise the downsides of their interactions. The StepUP project instead offers a paradigm shift to transform the market of deep renovation technologies, by defining and demonstrating a production process that maximises the efficacy of solutions' interaction, while minimising environmental impact, life cycle cost and installation time. The Plug and Play Protocol aims to be the tool to achieve this renovation plan.

The protocol provides principles for the development of the systems and components that will be integrated in StepUP renovation processes. The principles describe a set of requirements that should help the technologies fulfil the goals of the StepUP renovation process. There are six main principles that range from qualitative to technical aspects and are the following: industrialization, customization, compatible and interoperable, circularity, open information exchange, certification and regulation. The implementation of the tool is meant to work as a guideline for the companies to ensure successful interventions. Therefore, the rules defined are co-developed with the involved parties. This ensures that the requirements described are realistic and can be met while challenging and redesigning the existing renovation processes.

The protocol is developed in four stages. First, it describes the characteristics and solutions of the P&P Envelope, the SmartHeat and the potential TPC components that can be integrated in the StepUP renovation process. Second, it introduces the protocol explaining its functions and how it should be implemented. Third, it defines the principles and the component requirements that arise from them. Finally, the specifications for the integration of StepUP solutions with third party components are stablished and validated with TCP solution examples.

The inputs to build the tool come from: the StepUP methodology, the companies that provide the active and passive solutions, and the organization of the project. The StepUP methodology defines a new methodology and guides the definition of the P&P Protocol Principles. The companies provide the solutions that can be implemented and help in the validation of the tool functionality. The organization supports the development of the tool and bring information on the necessary parameters and characteristics that components need to provide. The collected data will inform the building analysis, the StepUP integrated technologies and the renovation process.

To sum up, the P&P Protocol guarantees the fulfilment of the StepUP deep energy renovation process. It establishes a baseline for the technologies involved in the project and helps bring innovative solutions to the market.

6.2.7 P&P envelope installation guidelines

	P&P ENVELOPE INSTALLATION GUIDELINES
Function	Installation Guideline of the P&P modules
Target audience	Construction companies and installers
Relevant phase	Implementation phase
Link	Deliverable D4.1 (included in confidential report, but the guidelines will be published)

Table 19: Summary information about the P&P envelope installation guidelines

The installation guideline is a **manual for installers and construction companies** where the information for the installation of the P&P modules are provided.

The document includes detailed step-by-step instructions, together with images, possibly a video tutorial, which will allow the installers to know how to carry out the activities, both during the handling and the installation of the P&P modules.

The manual includes information about all the phases of the installation, listed below:

- installation of the brackets to the wall
- installation of the closing flashings needed for the ventilation to the ground
- adjust horizontally the brackets
- bring all the necessary material to a height and install the module
- fix the module to the existing wall and place them
- install the elements required in order to close the thermal bridge between two modules
- install the L-profiles or T-profiles required to house the decorative all-rounder elements
- measure the space between the modules and creation of the decorative all-rounder elements
- installation of the decorative all-rounder elements
- installation of the flashing for the upper ventilation
- installation of the final flashing

Before staring the installation on site, the following activities are required:

- survey of the building / façade
- final design of the P&P modules - Even though the P&P modules are industrially produced, they required a specific designing phase and customization depending on the actual renovation project
- disassembly of possible existing plants, which are going to be installed again at the end of the activities
- securing the area
- final design and technical detail

The materials required to carry out the installation are: platforms, mobile cranes, hammer drills, drills and screwdrivers.

Reading carefully the whole document before starting the activities on site is highly recommended in order to guarantee a correct installation of the P&P modules on the façade.

6.2.8 SmartHeat installation guideline

	P&P HEATING SYSTEM INSTALLATION GUIDELINE
Function	Installation guideline of the P&P SmartHeat system
Target audience	Heating system installers.
Relevant phase	Implementation phase
Link	Deliverable D4.2 (included in confidential report, but the guidelines will be published)

Table 20: Summary information about the SmartHeat installation guideline

The installation guideline is a **manual for installers where the information for the installation of the P&P SmartHeat system** is provided.

The document includes detailed step-by-step instructions, together with images, possibly a video tutorial, which will allow the installers to know how to carry out the installation of the P&P SmartHeat system.

The manual includes information about all the phases of the installation, listed below:

- Guidelines for dimensioning the heating system and storage module.
- Preparation of electrical installation

- Preparation of foundation and drainage.
- Preparation of pipe to P&P SmartHeat system
- Physical placement of SmartHeat System.
- Connecting the SmartHeat system to the heating system of the building
- Installing indoor climate sensors to optimize the regulation

Before staring the installation on site, the following activities are required:

- Description of the existing heating system.
- Calculation of yearly heat demand, and peak demand on the coldest day.
- Decision on placement methodology. (inside, inside/outside or outside)
- Final design of P&P SmartHeat system.
- disassembly of possible existing plants, which are going to be installed again at the end of the activities
- securing the area
- final design and technical detail

Reading carefully the whole document before starting the activities on site is highly recommended in order to guarantee a correct installation of the P&P SmartHeat system with the building.

6.2.9 M&V guideline

	M&V GUIDELINE
Function	Guide the team to prepare for Measurement & Verification starting from the design phase, until its implementation after the renovation of the building
Target audience	Design team, Facility management
Relevant phase	Design and Operation phase
Link	To be published as an appendix of the StepUP renovation methodology (public Deliverable D1.3)

Table 21: Summary information about the M&V guideline

A variety of well-established Measurement & Verification (M&V) approaches exist, which focus on estimating whether the performance improvement expected from an ECM was indeed achieved. In general, these methods do not concern themselves on how the performance improvement target is defined ahead of implementation. Furthermore, M&V as a process allows to find discrepancies between target and actual performance but does not include ways to investigate what caused the issue, which could be caused by both unrealistic targets, and operational changes or malfunctions.

As such, the aim of this guideline will be **to expand on how to use a calibrated building model to define the expected savings from ECMs and potential issues ahead of deployment in the building**. This will allow to improve the accuracy of the target performance in design phase, ahead of the beginning of the M&V process, and will facilitate the investigation and correction of issues during operations.

Furthermore, M&V approaches are most often used in buildings with complex systems (retail, healthcare, industry etc). As the StepUP methodology is aimed at design teams working on buildings that typically have simpler systems (multi-apartment residential, schools, medium-sized offices etc), this guideline will aim to fill in knowledge gaps on M&V basics and enable these teams to effectively deploy M&V protocols.

7 Plan for broad scale feedback collection and update of draft methodology

This report is intended to be **distributed publicly**, aiming to collect feedback on the described process, the tools under development from its potential future users. Based on the feedback to be collected, the StepUP methodology and supporting tools will be updated and finalized at the end of the project. To collect the most useful and relevant feedbacks it is necessary to determine who the feedback should be collected from, the methods for data collection and the main communication channels.

Regarding who can be interested in a StepUP project and who can provide useful feedback, we've identified the following groups who are the main focus for feedback:

- renovation project stakeholders
- academic / expert community
- policy making bodies

These different parties have different interest in the project, which are listed in Table 22.

	TARGET AUDIENCE	MAIN INTEREST IN THE STEPUP METHODOLOGY
Stakeholders in renovations	Owners: municipalities, real estate developers, residential communities	Overall process, especially: Financial aspects Main benefits of renovations Decision making process
	Project management	Overall process Project management support tools: Stakeholder engagement strategy Life Cycle platform
	Building users	User related project benefits Stakeholder engagement strategy Optimisation of operations
	Facility management	Optimisation of operations
	Community & civic society	Benefits / negative effects of renovation on the community Stakeholder engagement strategy
	Design team	Design support tools
	Construction team	Construction support tools
	Material, solution and infrastructure providers	ECM design support tools Technology integration support tools Construction support tools
	Public / statutory bodies	Large scale benefits of renovations
	Financing bodies	Financial aspects
Policy making bodies	National policy makers	Large scale benefits of renovations
	EU policy makers	Large scale benefits of renovations Replicability of processes
Academic / expert community		Overall process Potential innovations

Table 22: Main interests of different audience groups in the StepUP methodology

The above table shows that some of the **interests of the different audience groups** are overlapping so it is possible to collect information on them on the same forums, and there are different collection methods that are capable of covering most aspects to get feedback. The following **potential forums for collecting feedback** were identified:

- during pilot activities
- dedicated workshops
- interviews
- conferences

- feedback survey

The main characteristics of these methods are described in the following Table 23.

	CHARACTERISTICS OF FEEDBACK COLLECTION METHODS
During pilot activities	During pilot activities the implementation of the methodology automatically brings feedback on the efficiency of the implemented methods. Therefore the experiences will be noted and collected continuously.
Dedicated workshops	Workshops are a good method to collect detailed information from a group of people with a similar level of interest or understanding of a topic. For example, technology providers feedback are collected through workshops from TPCs.
Interviews	Semi-structured interviews allow to collect detailed information from the participants. For this to be effective, the participant has to get familiar with the StepUP processes so this method will be used with pilot project stakeholders who are critical for the success of the project.
Conferences, relevant events	Conferences are the main forum to collect feedback from the scientific community, and policy makers who are interested in this field. So it is important that the StepUP methodology needs to be presented in these forums
Feedback survey	Along with the publishing of this report, a short 1 page flyer / fact sheet will be also produced summarizing the main information on the methodology. Attached to this a survey will be also available where interested parties can provide their feedback. The survey will contain a few questions, and should take maximum 5-10 minutes to fill it. The type of feedback questions to be included in the survey: ▪ what part of the process would be the most / least beneficial for the responder ▪ does the proposed renovation timeline makes sense ▪ is there any aspect of an energy renovation project that is missing from the proposed methodology ▪ do the supporting tools seem useful This survey can be distributed through social media channels to any interested parties, and also to targeted audience groups for a quick, high level feedback.

Table 23: Main characteristics of feedback collection methods

The main priority of the feedback collection process is to **collect relevant and quality information from the identified audience groups** and not to involve a large number of respondents. To further streamline the process, the priority groups are also identified (who can be the future main beneficiaries of StepUP projects, or can provide deep analysis and clear feedback on the methodology) who will be asked through the more detailed data collection methods, while the general feedback methods will be used for the other audience types. The proposed feedback collection strategy is included in the following Table 24:

TARGET AUDIENCE		FEEDBACK COLLECTION METHOD
Stakeholders in renovations	Owners Project management Building users Facility management Design team	During pilot activities – continuously during pilot development Dedicated workshops – dedicated workshops for the critical renovation stakeholders in pilots, Interviews – dedicated semi structured interviews with stakeholders from pilot activities
	Owners	dedicated workshops for potential developers who are interested in the StepUP methods
	Community & civic society	Feedback survey
	Construction team	During pilot activities Feedback survey
	Material, solution and infrastructure providers	Dedicated workshops – TPCs Feedback survey
	Public / statutory bodies	Feedback survey
	Financing bodies	Feedback survey
Policy making bodies	National policy makers	Interviews Feedback survey
	EU policy makers	Conferences
Academic / expert community		Conferences Feedback survey

Table 24: Feedback collection strategy for different audience groups

The feedback from the above listed channels will be collected during the next phases of the StepUP project. The comment will be then analysed and critical ones (that can affect positively the methodology, where gaps in the methodology are discovered etc.) will be selected for further investigation. The critical comments will be analysed and the partners participating in the StepUP methodology development will decide how to adapt the methodology to reflect the comments.

7.1 Plan for update of the methodology

The **updated version of the StepUP methodology** will be published at the end of the project. This will include the above detailed feedback from experts, pilots and other identified stakeholders. It will also be updated with the results of the next project development activities, especially the findings during technology development and the Life Cycle Platform and Data Management Platform development. Based on this information the steps included in the methodology phases and the description of the supporting tools will be refined.

Also, the final version of the methodology will include the following fully developed guidelines:

- Stakeholder engagement strategy
- Technology applicability checking tool
- IES model setup guidelines
- IES model calibration guidelines
- M&V guidelines

8 Appendices

8.1 Appendix 1: Stakeholder Engagement Strategy

Taking the most used and broadest definition, "stakeholder in an organization is (by definition) any group or individual who can affect or is affected by the achievement of the organization's objective" (Freeman, 2010, 46).

While this definition generally viewed in the stakeholder theory literature as a good starting point, it is usually considered as too broad for practical purposes (Achterkamp & Vos, 2007; Mitchell et al., 1997; Olander, 2007). A need for narrower definitions emerged with the recognition that all the actual, potential and sometimes conflicting claims cannot be attended due to objective constrains like time and energy (Mitchell et al., 1997).

According to Achterkamp and Vos (2007), narrowing the definition is a normative act of boundary drawing, distinguishing the stakeholders to be involved and to be excluded. The narrower definitions usually set up categorizations other than the broad 'can affect/being affected' distinction, like primary/secondary, voluntary/involuntary, fiduciary/non-fiduciary (*ibid*.).

Morris and Baddache (2012) simply defines stakeholders as a person or a group of people, who has stake in the successful execution of the project and in the environment, where the project takes place.

> *"… Without attention to needs and expectations of a diverse range of stakeholders, a project will probably not be regarded as successful, even if the project manager was able to stay within the original time, budget and scope (Bourne, Walker, 2005)*

In this sense a dialogue between various partners should not only channel the preferences or opinions of stakeholders, but nurture a context-specific interpretation of sustainability, which potentially results changes in the institutional mechanisms related to decision making (Ratner, 2004) and contributes to a common understanding of the various dimensions related to sustainability. In line with StepUP's long-term engagement goals, another approach by Dijkema (2006) of stakeholder involvement is also taken into consideration, in which systems should be set within the context of learning societies are key when it comes to sustainability-oriented innovation.

Regarding to stakeholder engagement, three conceptual pathways emerge based on the interest, role and contribution throughout the project lifecycle. The first approach puts stakeholder engagement in a strategic management perspective, identifying which claims or persons, or groups or organizations are significant for a company/project and whose usefulness or performance is decisive in a management point of view. This concept is highly relevant in the StepUP project, since it operates deep energy renovations with different building types and stakeholder settings, therefore it welcomes special settings of partners and interests. The second approach empowers stakeholders as "citizens" in the project, whose participation – based on general democratic reasons - is able to influence the outcomes of the project, such as e.g. the owners and users connected directly to the buildings under renovation in the case of StepUP.

Similarly to Ratner's definition (2004), the third approach puts dialogue in the centre of stakeholder engagement as inherits "elements of reflection and mutual learning" (Innes and Booher, 2004). This perspective highlights the less tangible yet useful inputs of a dialogue in a constructive manner, which requires a constant attention for both strongly structured and soft activities of involvement in the course of the future renovations.

Narrowing down our scope to the construction industry, the above-mentioned benefits of active stakeholder engagement becomes more distinct. El-Gohary (2006) argues, that one of the lessons learned of the failed public-private partnership infrastructure projects is capturing stakeholder inputs. While it enables the system to discover the needs of its users at increasing market competitiveness, it mainly echoes a consumerist approach instead of a democratic understanding of cooperation, which can be crucial in public building investments.

8.1.1 Objectives of stakeholder engagement

For working out the Stakeholder Engagement Strategy it is vital to understand what the objectives of stakeholder engagement are in the StepUP project. According to the theory of Integrative Project Delivery (IPD), the stakeholder engagement serves managerial purposes, being associated with increased quality, innovation, and more effective processes. As opposed to this one dimensional approach, Mathur, Price and Austin (2008) differentiate three potential conceptualization of stakeholder engagement in construction projects: managerial perspective, ethical perspective, and social learning perspective. The considerations behind the three perspectives can be the following:

- Managerial perspective: The benefits of stakeholder engagement include capturing knowledge, increasing ownership of the project by users, reducing conflict, encouraging innovation, and facilitating spin-off partnerships.
- Ethical perspective: Stakeholder engagement can enhance inclusive decision making, promote equity, support local decision making and build social capital.
- Social learning perspective: The benefits of stakeholder engagement is in the creation of a common forum, where stakeholders could reflect upon their own values while learning about each other. It is also a forum for increasing awareness, changing attitudes, and affecting behaviours.

The StepUP Stakeholder Engagement Strategy aims to give importance to all the three perspectives by capturing knowledge of the various stakeholders, emphasizing inclusive decision-making and organizing awareness-raising programs about energy-saving behaviour and climate change mitigation.

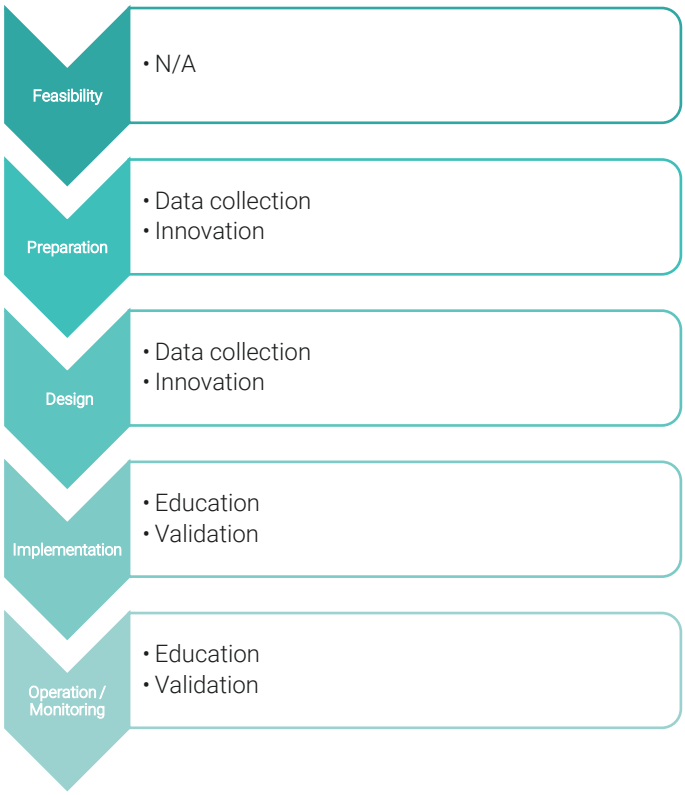

Figure 10: Stakeholder engagement in different project phases

Considering the aims of the StepUP project, the objectives of the stakeholder engagement are:

- Data collection (Capturing knowledge)
- Innovation (Encouraging innovation, Facilitating spin-off partnerships)
- Education (Raising awareness, Changing attitudes, Affecting behaviours).

The different objectives of stakeholder engagement can be connected to different phases of the project.

8.1.2 Identification of potential stakeholders

After defining the objectives of stakeholder engagement in the StepUP project, the next step is the identification of the potential stakeholders of the project. The aim of the identification process is to outline a general list of stakeholders (or groups of stakeholders) and define a potential method of engaging them. It has to be noted that each renovation project is different. The general list of stakeholders aims to serve as a basis for the StepUP renovation methodology and should be reviewed in case of any projects applying it.

A practical way of identifying the stakeholders is to review similar projects and their stakeholders, as it was implemented in D1.1. The identified stakeholders in D1.1 were:

- Facility management
- Public/statutory bodies
- Owners
- Building users
- Community&civic society
- Project management
- Design and construction team
- Material, solution and infrastructure providers
- Financing bodies.

- StepUP Deep renovation manager

In D1.1 this initial list of stakeholders was useful for outlining a plan of the methodology. However, in the followings a more thorough analysis of stakeholders will be implemented, to avoid leaving out important actors, and to justify the list of stakeholders to be involved.

Table 2: Final list of stakeholders

Stakeholders identified in D1.1	Final list of stakeholders (Identified in D1.2)
Facility management	Facility Manager
Public / Statutory bodies	Public & Statutory Bodies
Owners	Building Owners
Building users	Building Users
Community & civic society	Community
Project management	Deep Renovation Manager
Design and construction team	Design Team
	Construction Team
Material, solution and infrastructure providers	Technology Providers
Financing bodies	Financing bodies
	Commissioning Team
	Third Party, P&P

Since the aim was the creation of a general stakeholder list based on theoretical projects, the most feasible way of stakeholder identification was implemented with focus group method Reed *et al.* (2009). Due to the COVID-19 lockdown, an online brainstorming session was organized, where a small group of experts with different background brainstormed on stakeholders. Both the number and the different professional background of the participants in the brainstorming session served to reduce the effect of personal and professional bias and to exclude certain stakeholder groups a priori and arbitrarily (Achterkamp & Vos, 2007). Furthermore, this method helped to create an open-ended list of stakeholders that can be extended during the project that apply the StepUP methodology.

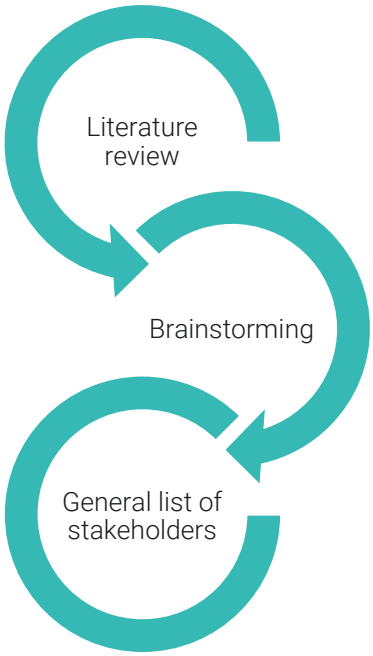

Figure 11: Process of stakeholder identification

The StepUP is a complex project with multiple goals, fields and location of action. Therefore, for the identification of stakeholders, the project has to be divided in well-defined sub-project to understand what the stakeholders would be involved in (Reed et al., 2009). In line with Section 4.1, in the brainstorming session the organizers differentiated between the development of the StepUP renovation methodology and the adapted renovation projects. The renovation methodology is understood here as a management solution and does not include the StepUP technology solution. Furthermore, since the StepUP project targets different functions and ownership structures, the brainstorming session focused on three building types that can be seen below. Given that public building is a large category, within public function three categories were differentiated according to the patterns of use. The discussed building types were:

- Privately owned residential building
- Private rental office building
- Public building
    - Well-defined users, significant change in the set of users is slow (yearly or less frequent), e.g. academic buildings, offices
    - Quasi well-defined users, significant change in the set of users is moderate (weekly or less often), e. g. healthcare
    - Non-defined users, significant change in the set of users is fast (3 hourly or more often), e. g. cultural buildings

After the brainstorming session, the list of stakeholders was reviewed, and the duplicates were removed. The general list of stakeholders, according to function, are presented in the following tables, divided by building ownership type.

Table 25: Stakeholders of a privately owned residential building, methodology development

	1. Privately owned residential building	
	Category	Example
1	Policy-makers on local, regional, national and supranational level	Municipality, National government, EU, green NGOs
2	Executive powers on local, regional and national level	Energy infrastructure authorities, building authorities
3	Facility management	General facility management, maintenance, utilities
4	Primary users	Households, property owners
5	Secondary users	Visitors
6	Networks	Energy communities, neighbourhood communities, housing associations
7	Financing bodies	Bank, local, national, supranational governmental funding, ESCO, energy community
8	Third parties	neighbourhood members, adjacent tenants, locally interested RE developers, local flora/fauna
9	Design and Construction team	Design and construction companies, contractors and subcontractors, installers, construction workers
10	Consultants	Green certifiers, sustainable consultants
11	Material, solution and infrastructure providers	Building material manufacturers, energy service providers
12	StepUP Deep renovation manager	

Table 26: Stakeholders of a privately owned residential building, adapted phase

	1. Privately owned residential building	
	Category	Example
1	Policy-makers on local, regional, national and supranational level	Municipality, National government, EU, green NGOs
2	Executive powers on local, regional and national level	Energy infrastructure authorities, building authorities
3	Facility management	General facility management, maintenance, utilities
4	Primary users	Property owners, households
5	Secondary users	Visitors
6	Networks	Energy communities, neighbourhood communities, housing associations
7	Financing bodies	Bank, local, national, supranational governmental funding, ESCO, energy community
8	Third parties	neighbourhood members, adjacent tenants, locally interested RE developers, local flora/fauna
9	Design and Construction team	Design and construction companies, contractors and subcontractors, installers, construction workers
10	Consultants	Green certifiers, sustainable consultants
11	Material, solution and infrastructure providers	Building material manufacturers, energy service providers
12	StepUP Deep renovation manager	

Table 27: Stakeholders of a privately rented office building

	2. Private rental office building	
	Category	**Example**
1	Policy-makers on local, regional, national and supranational level	Municipality, National government, EU, green NGOs
2	Executive powers on local, regional and national level	Energy infrastructure authorities, building authorities
3	Facility management	Facility management companies, operators, cleaning companies
4	Primary users	Tenant companies, employees
5	Secondary users	Visitors, potential future tenants
6	Networks	Broader society, Flora/fauna/Climate, Neighbours, Green NGOs, Rental office market
7	Financing bodies	Bank, local, national, supranational governmental funding, ESCO, energy community
8	Third parties	
9	Design and Construction Teams	Design and Construction companies, Contractors, Sub-contractors, Installers, Construction workers
10	Property owners	Landlords
11	Consultants	Green certifiers, Sustainable consultants
12	Material, solution and infrastructure providers	Building material manufacturers, energy service providers
13	StepUP Deep renovation manager	

Table 28: Stakeholders of a publicly owned non-residential building

	3. Public building	
	Category	**Example**
	3.1 Academic building	
1	Policy-makers on local, regional, national and supranational level	European Commission, National government, Municipality, Politicians
2	Maintainer	Ministry of Education, Culture, Municipality
3	Executive powers on local, regional, national and supranational level	Energy infrastructure authorities, building authorities
4	Financing bodies	Banks, National Government
5	Decision-makers	Boards, committees
6	Primary users	Administrative staff, researchers, students, children
7	Secondary users	Citizens, visitors
8	Asset management	Managers, public workers
9	Network	Cultural organizations
10	Design&Construction teams	Engineers, designers, modelling teams
11	Consultants	
12	Researchers	
	Healthcare building (hospitals)	
1	Ministry of health	Government officials, decision-makers, lawmakers, politicians
2	EU	Policy makers, advocates
3	Municipality	Staff of Building, Planning, Public Works department

4	Facility management	Cleaning, maintenance
5	Hospital staff	Director, administrative staff, medical staff
6	Research institute	Researchers, consultants
7	Individual users	Patients, family members, visitors
	Cultural building (museum)	
1	Bank	Investors, financial experts, account managers
2	EU	Policy makers, advocates
3	Public procurement authority	Public Procurement Council members, tenderers, procurement experts, secretary
4	Designer, construction team	Engineers, designers, contractors
5	Project management	Project managers,
6	Municipality asset management department	Finance and budget department staff, commissioning staff, experts
7	Government asset management department	Government officials, decision-makers
8	Cultural ministry	Government officials, decision-makers, lawmakers, politicians
9	Museum staff	Board, committees, director, workers, researchers, exhibition organisers, curators, facility management (cleaning, maintenance)
10	Media	Reporters, photographers
11	Individuals	Visitors, locals, members of international communities, cultural organisations, NGO's, volunteers
12	International community	Visitors

8.1.3 Stakeholder engagement activities

The StepUp Stakeholder Engagement Strategy focuses on various engagement activities throughout the project phases identified by the methodology. The strategy outlines the main attributes of the activities based on their goals, involved stakeholder groups and expected outcomes, which may be implemented in different scenarios by the proceeding of the project with a recurring and iterative nature. After identifying the main stakeholders and partners relevant to the renovation project, an overarching series of engagement activities should take place in order to build up and strengthen the collaboration of future participants.

The following chapters introduce different stakeholder engagement activity types and give practical recommendations and expected outcomes for the project.

The identified engagement activities detailed here:

- Networking dinner
- Sandpit for innovation
- Design thinking workshop
- Participative learning workshop
- Training
- Open day
- Presentation
- Focus group interview
- Individual interview
- Surveys

8.1.3.1 Networking dinner

Engagement type: Data collection

Networking dinner offers a meeting platform for the various stakeholders of the project as a defining possibility to create a cooperative community, seek and recognise main partners and create constructive group dynamics. The semi-formal nature of the networking dinner provides a safe environment for the stakeholders to share information, build partnerships and discuss further steps, common interests.

Relevant phase	Supported methodology step	Involved Stakeholders	Expected outcomes
Preparation	Initiate contact with stakeholders	Owners, Building management, Building users, (Public / statutory bodies, Community & civic society)	Stakeholder agreement in participation activities
Design	Find solution providers based on P&P protocol	Owners, Project management, P&P providers	Contact with potential supplier groups

8.1.3.2 Sandpit for innovation

Engagement type: Innovation

Sandpits are interactive, multiple day workshops involving individual participants, experts and selected stakeholders. Sandpits represent a unique approach to address research challenges. Having a highly multidisciplinary mix of participants is a key, active researchers and other potential users to create parallel thinking.

Sandpit workshops require intensive, open discussions over problems and challenges to find atypical, innovative solutions. Each event should be led by a trainer, who defines the topic and facilitates discussions at the event.

Relevant phase	Supported methodology step	Involved Stakeholders	Expected outcomes
Design	Define refurbishment scenarios	Deep Renovation Manager, Owners, design & construction team, MSI providers	List of refurbishment scenarios beneficial to every stakeholder

8.1.3.3 Design thinking workshop

Engagement type: Innovation

The human-centered core of design thinking encourages organizations to focus on the people they're creating for, which leads to better products, services, and internal processes. A Design Thinking workshop is a hands-on, activity-based session built around the Design Thinking process. Design Thinking workshops are all about collaboration and problem-solving, which is highly beneficials with regard to the renovation processes and the expected user experiences of the future demo buildings.

Relevant phase	Supported methodology step	Involved Stakeholders	Expected outcomes
Preparation	Develop initial project schedule	Deep Renovation Manager, Owners, Users	An agreement on the project schedule
Design	Define refurbishment scenarios	Deep Renovation Manager, Owners, Users, design & construction team, Solution providers	List of refurbishment scenarios beneficial to every stakeholder
Design	Decision-making between the options	Deep Renovation Manager, Owners, Users, design & construction team	Final of refurbishment scenario beneficial to every stakeholder

8.1.3.4 Participative learning workshop

Engagement type: Education

Participative learning workshops are a range of community learning techniques to afford contextualized learning environments (static, mobile and scenario) to engage with the collaborative processes of the project. The workshops provide opportunities to community participants engage with in a collaborative and dialogic environment for the purpose of building renovations.

Relevant phase	Supported methodology step	Involved Stakeholders	Expected outcomes
Preparation	Define project scope, and goals	Owner, Design and construction team, Users,	A consensus on the goal of the StepUP project
Implementation	Involve the stakeholders on the scheduling of the implementation	Owner, Design and construction team, Users, Solution providers	Agreed timeline for implementation
Operation	Optimize operations	Facility management, Users, Owners, Deep Renovation Manager	An understanding of operations, ideal user behaviour

8.1.3.5 Training

Engagement type: Education

Trainings will offer a platform for exchange of knowledge and information both about technological details and overall project proceedings. Early in the Design phase, Deep Renovation Manager (DRM) will hold a training for all relevant stakeholder groups on the agenda and methodology, while the Implementation (and Operation) phase will require a thorough technical guidance training from the DRM and/or the operator towards future tenants/users of the refurbished building.

Relevant phase	Supported methodology step	Involved Stakeholders	Expected outcomes
Preparation	StepUP Methodology	Facility management, Users, Owners, Design and construction team, Deep Renovation Manager	An understanding of the StepUP methodology process
Operation	Optimize operations	Facility management, Users, Owners, Deep Renovation Manager	An understanding of operations, ideal user behaviour

8.1.3.6 Open day

Engagement type: Education

Open days will serve as events in which the developments can be presented by inviting the public to visit the buildings.

Relevant phase	Supported methodology step	Involved Stakeholders	Expected outcomes
Operation	Tracking building performance	Facility management, Users, Owners, Community, Public & Statutory Bodies, Financing Bodies	Presentation of the StepUP methodology and the renovation outcomes to the public

8.1.3.7 Presentation

Engagement type: Education

Presentations are recommended to take place only later in the Operation / Monitoring phase to communicate and distribute overall project results the monitored performance of the refurbished building.

Relevant phase	Supported methodology step	Involved Stakeholders	Expected outcomes
Operation	Tracking building performance	Facility management, Users, Owners, Community, Public & Statutory Bodies, Financing Bodies	Presentation of the StepUP methodology and the renovation outcomes to the public

8.1.3.8 Focus group interview

Engagement type: Data collection

A focus group is a group interview involves a small number of participants in order to gain their specific insights and knowledge to the researcher-posed questions. As this method is mainly used in market research and studies of people's views on public matter the discussions can be guided or open. The crucial point is to invite participants accurately representing all stakeholder or a given target group to efficiently reflect on their opinion. The researcher shall organize for the purpose of collecting qualitative data, through interactive and directed discussions.

Relevant phase	Supported methodology step	Involved Stakeholders	Expected outcomes
Preparation	Define project scope, and goals	Owner, Design and construction team, Users,	A list of priorities and needs of different stakeholders
Preparation	Develop initial project schedule	Deep Renovation Manager, Owners, Users	A list of priorities and needs of different stakeholders
Preparation	Collect all relevant building related information	Facility management, Users	Building user related data
Design	Decision-making between the options	Deep Renovation Manager, Owners, Users, design & construction team	A list of priorities and needs of different stakeholders
Implementation	Involve the stakeholders on the scheduling of the implementation	Owner, Design and construction team, Users, Solution providers	A list of priorities and needs of different stakeholders

8.1.3.9 Individual interview

Engagement type: Data collection

In the case of StepUp, individuals interviews will be structured conversation where individuals of various stakeholder groups will provide insights for semi-structured questions. Different results may occur based on renovations types taking into consideration their affects on the user experiences and behaviour on a daily basis, e.g. offices, parents, etc.

Relevant phase	Supported methodology step	Involved Stakeholders	Expected outcomes
Preparation	Define project scope, and goals	Owner, Design and construction team, Users,	A list of priorities and needs of different stakeholders
Preparation	Develop initial project schedule	Deep Renovation Manager, Owners, Users	A list of priorities and needs of different stakeholders
Preparation	Collect all relevant building related information	Facility management, Users	Building user related data

Design	Decision-making between the options	Deep Renovation Manager, Owners, Users, design & construction team	A list of priorities and needs of different stakeholders
Implementation	Involve the stakeholders on the scheduling of the implementation	Owner, Design and construction team, Users, Solution providers	A list of priorities and needs of different stakeholders

8.1.3.10 Set of Survey

Engagement type: Data collection

Survey as research method shall be present nearly during all the project phases as it provides well-structured data from a predefined group respondents. Thanks to its multiple purposes a survey can be easily altered to different phases and topics to deliver essentials insights. Questionnaires (online or offline) can serve well as standardized procedures to gather information as well as to compare developments by repeating at a later stage.

Relevant phase	Supported methodology step	Involved Stakeholders	Expected outcomes
Preparation	Collect all relevant building related information	Facility management, Users	User comfort and behaviour data
Preparation	Define project scope, and goals	Owner, Design and construction team, Users	A list of priorities and needs of different stakeholders
Operation	Regular occupant surveys	Facility management, Users	User comfort and behaviour data

8.1.4 Summary

The above listed stakeholder engagement activities and the supported methodology steps that are recommended in this initial version of the stakeholder engagement strategy are summarised in the table below.

Table5: Stakeholder involvement activities over different project phases

Engagement activity	Project phase				
	Feasibility	Preparation	Design	Implementation	Operation
Networking dinner					
Sandpit for innovation					
Design thinking workshop					
Participative learning workshop					
Training					
Open day					
Presentation					

Focus group interview					
Individual interview					
Surveys					

This report includes the initial version of the Stakeholder Involvement Strategy. The listed engagement options will be further refined and the described methods tested during pilot activities. For the final version the best engagement method will be selected to support the relevant methodology steps. For the selected final methods supporting templates will be provided that serves as a step-by-step guide for implementation of the selected action.

The StepUP Stakeholder Engagement Strategy strongly resonates with the iterative approach of the overall methodology as well as empowers it with continuous inputs and insight from the broad set of stakeholders. Thanks to its structured and detailed plan to involve future partners during the complete renovation process, it not only allows StepUP to put conceptual engagement tools into practice but to oversee its effect regarding to different building types and scenarios being able to diagnose and overcome bottlenecks in the system dynamics of renovation projects.

8.1.5 References

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8.2 Appendix 2: Technology applicability checking tool

The following table shows the checklist detailing the main constraints and criteria for deciding the applicability of the P&P technologies.

Topic	Criteria	Priority
P&P envelope		
Compactness of façade	flat façade is preferred to be able to implement modular façade solution	High
Window to façade area ratio	large, continuous window areas on the façade should be avoided (lower Window/total facade ratio is needed)	High
Load bearing capacity of façade	façade should be able to host connections to the P&P envelope, if façade is more than one storey, space is needed for additional foundations	High
Roof overhang	Pitched and overhanging roofs are not preferred as it would make the façade installation more difficult	Medium
Site availability	For façade installations the building façade has to be accessible with cranes	Medium
Data collection necessity	The following data should be made available for the product manufacturer to start the solution design: • history of the building (year of construction, year of renovation if any, structural or envelope problems if any) • detailed pictures in order to have an adequate overview of the state of the property (facade by facade) • detailed pictures of the windows and doors • plan and sections of the building • building façade survey, measurements of the façade • technical construction details • type of existing structure (thicknesses, morphology) • structural study • renovation permit and execution design	High
SmartHeat system		
Space for thermal storage	needs space in the building / outside in a shipping container (approx. container dimensions: 20ft container - 6,1*2,5 m; 40ft container – 12,2*2,5m)	High
Space for heat pumps	needs space outside, close to the thermal storage	High
Compatibility with existing system types	Individual, central heating system is needed. For secondary systems radiators or floor heating are both acceptable	High
Compatibility with SH output temperature	The max. SH output temperature is around 55°C, so systems should be compatible with that. (e.g.: for radiators old cast iron radiators work with higher temperature, while aluminium radiators can be applicable)	High
Load bearing capacity of roof	The roof should be able to hold PV for the Smartheat solution	High

Space for PV on southern facing roof	Should be enough space on roof (sloped - southern roof) for PV installation	High

Data collection necessity	The following data should be made available for the product manufacturer to start the solution design:
	Drawings:
	• Floorplan of building – as a minimum dimension of the boiler room. Preferably for the entire building.
	• Piping details – dimensions of pipes, radiators.
	• Electrical outlet:
	  • What is available in boiler room.
	  • What is available close to container placement.
	Pictures:
	• Boiler room
	• Radiators
	• Pipes
	• Meters
	• Outside placement of container
	Suggestions for placement of the container
	• Placement is ideally as close to boiler room as possible, and with easy access from parking lot.
	Data:
	• Historical data on district heating consumption, as detailed as possible.
	• Cost of electricity
	• Electrical connection: What is available now, what is the maximum available upgrade
	Renovation permit and execution design
		High