MEDNICE
MED programme Network for an Innovative Cooperation Energy Efficiency

D. 4.3.1 Technical paper and lessons learned report – MED Tools, Methodologies and Indicators

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Author: Ramon Pascual, Jordi Pascual, Joana Ortiz

Technical review: Jaume Salom

Catalonia Institute for Energy Research

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PP5	Region of North Aegean – RNA

Disclaimer

This report considers the Modular Project deliverables available on-line up to January 2019.

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List of Abbreviations

BEMS – Building Energy Management System
BEO – Baseline Emission Inventory
CC - Climate Change
DST – Decision Support Tool
EB Community – Efficient Building Community
ECM – Energy Conservation Measures
EE – Energy Efficiency
EED – Energy Efficiency Directive
EPBD – Energy Performance of Buildings Directive
EPC – Energy Performance Contracting
ESC - Energy Supply Contracting
ESCO – Energy Service Company
ET- Energy Team
FE – Final Energy
GHG – Greenhouse gas
HVAC – Heating Ventilation Air Conditioning
IEQ – Indoor Environmental Quality
IPMVP - International Performance Measurement and Verification Protocol
IRR – Internal Rate of Return
LCA - Life Cycle Analysis
M&V – Measurement and Verification
MP – Modular Project
NPV - Net Present Value
nZEB – nearly Zero Energy Building
O&M – Operation and Maintenance
OEF – Organization Environmental Footprint
PA – Public Administration
PB – Public Building
PE – Primary Energy
PPP - Public-Private Partnership
RE – Renewable energy
SEAP – Sustainable Energy Action Plan
SECAP - Sustainable Energy and Climate Action Plan
SET – Subsidy Evaluation Tool

Executive Summary

Public Administrations (PAs) have to be seen as example of best practices and a reference for the private sector. Concerning the issue of increasing sustainability of their building stock, PAs are facing several challenges and barriers like lack of knowledge, awareness, data, financing and supporting material. About this last issue, this report collects and analyzes methodologies, tools and indicators elaborated or analyzed by 10 Modular Projects (MPs) (Figure 1), which are financed by the MED Programme on the topic of Energy Efficiency (EE) in Public Buildings (PBs). That means, the document aims to be a sort of guidelines, by offering a complete point of view to PA and addressing them to the key aspects; from there, more detail could be found in the related MP when required.

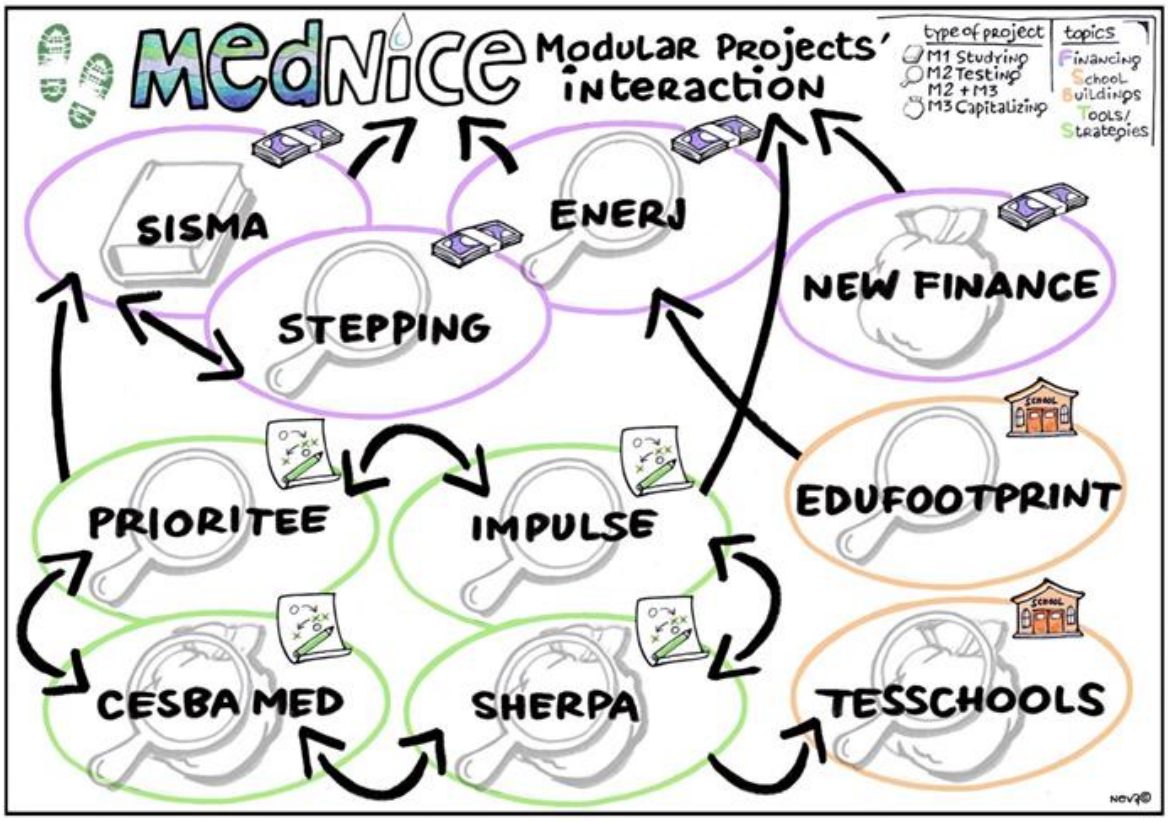


Figure 1. Modular Projects under the umbrella of MEDNICE Project (Source: MEDNICE Project)

In chapter 1. the study identifies 11 circular building stages, represented in Figure 2. Considering these 11 stages, numerous methodologies were harmonized and analyzed, and 151 indicators and 15 tools were identified and classified. This approach aims at facilitating the comprehension and usefulness of MPs results.

The 11 stages have their own importance for the whole building life in a holistic approach and are defined as follows:

1. Purpose and Target, to define the building project and the energy targets of the building project.
2. Energy audit, to stablish the current conditions and the best refurbishment options.
3. Stakeholder involvement, to detect main stakeholders and ensure participation to gather information, increase support and reduce resistance.
4. Financing, to find and adapt available sources, funds or models for financing EE measures.
5. Design tendering, to clearly define the framework conditions of the call.
6. Planning, to define the future EE project and minimize defects during the construction and usage phase.
7. Procurement, to find and agree the terms of services, goods or works under national, regional and/or local regulations.
8. Implementation, to ensure the proper construction of the sustainable requirements described in the planning.
9. Commissioning, to prepare the building or interventions for a correct operation and ensure the defined goals accomplishment.
10. Awareness, training and communication, to prepare and teach actors involved in the building life cycle, from technicians and politicians to users.
11. Monitoring and Usage, to ensure a correct user behavior and to detect malfunctioning systems reducing the efficiency of the building.

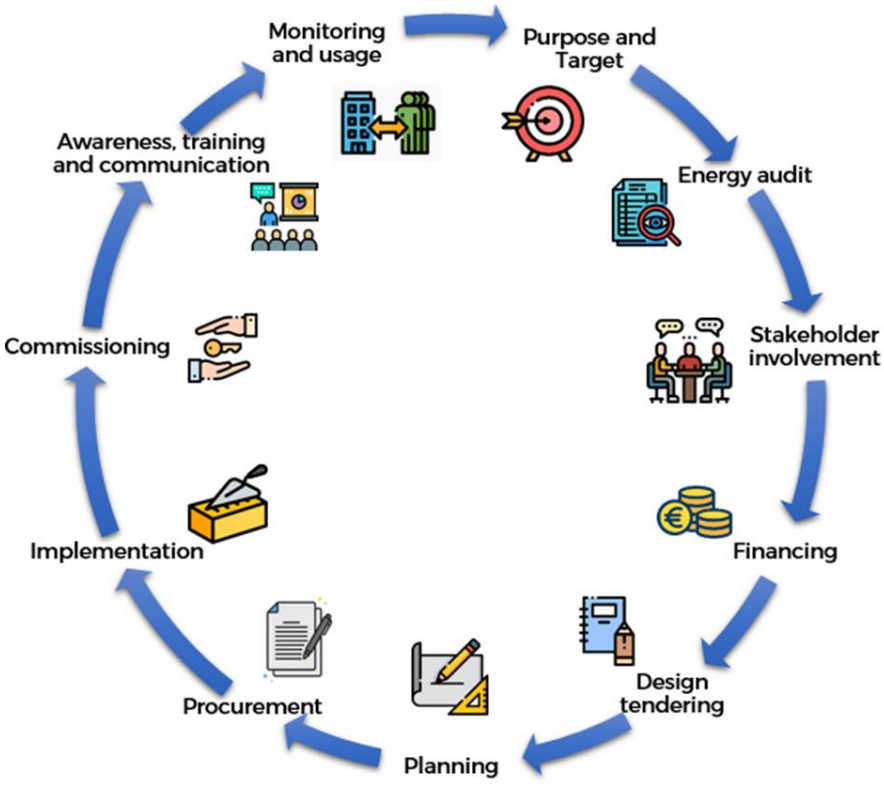


Figure 2. Stages of a building project (source: own elaboration)

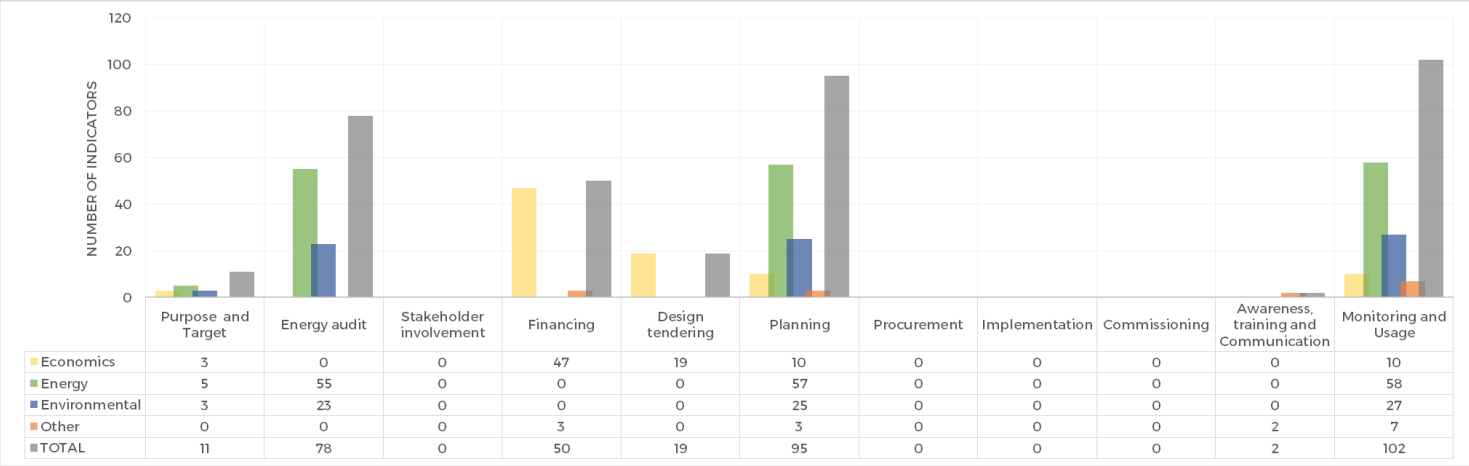
The analyzed methodologies tackle the issue of EE in PBs from different perspectives due to the variety of topics of the MPs. Some of them are already well known (e.g. definition of PBs' typologies), nonetheless they are applicated and contextualized to the Mediterranean territory, and in some cases they are adapted to overcome the barriers with a different approach (e.g. joint SEAPs). Besides, in chapter 1. all the indicators used or mentioned by the MPs results are listed.

In chapter 2. (Cross-analysis of indicators), it is done an analysis of the indicators according to the different building stages. As shown in Table 1, the report lists the 13 most recurrent indicators, which are mentioned by at least 4 MPs.

Table 1. Recurrent indicators by Modular Projects (source: own elaboration)

Category	Subcategory	Indicator	Modular Project Source
Energy	Energy per uses	Annual final energy consumption for heating	IMPULSE, PrioritEE, SHERPA, ENERJ, STEPPING, TEESCHOOL
Energy	Energy per uses	Annual final energy consumption for cooling	IMPULSE, PrioritEE, ENERJ, STEPPING
Energy	Energy source	Annual electricity consumption	IMPULSE, PrioritEE, SHERPA, EduFootprint, ENERJ, NEW FINANCE, TEESCHOOL
Energy	Energy source	Annual consumption of fossil fuel	IMPULSE, EduFootprint, NEW FINANCE, STEPPING, TEESCHOOLS, SHERPA
Energy	Renewable energy	Annual generation of Renewable Energy	IMPULSE, PrioritEE, EduFootprint, ENERJ, STEPPING
Environmental	CO_2 emissions	Total annual avoided CO2 emissions	IMPULSE, PrioritEE, NEW FINANCE, STEPPING, TEESCHOOLS
Economic	Costs savings	Annual savings of total energy-related operational cost	IMPULSE, PrioritEE, NEW FINANCE, SISMA, STEPPING, TEESCHOOLS, SHERPA
Economic	Costs savings	Annual electricity cost savings	IMPULSE, NEW FINANCE, SHERPA, TEESCHOOLS
Economic	Costs savings	Annual fossil fuel cost savings	IMPULSE, NEW FINANCE, SHERPA, TEESCHOOLS
Economic	Costs savings	Simple Payback period for each renovation scenario	IMPULSE, PrioritEE, STEPPING, SHERPA
Economic	Energy costs	Electricity Price	NEW FINANCE, SISMA, STEPPING, SHERPA
Economic	Energy costs	Natural Gas Price	NEW FINANCE, SISMA, STEPPING, SHERPA
Economic	Investment costs	Total investment cost for each renovation scenario	IMPULSE, PrioritEE, SHERPA, SISMA, STEPPING, TEESCHOOLS

Moreover, the cross-analysis also shows the lack of indicators for some stages like "Stakeholders involvement", "Procurement", "implementation" and "Commissioning", as represented in Graph 1 .



	Purpose and Target	Energy audit	Stakeholder involvement	Financing	Design tendering	Planning	Procurement	Implementation	Commissioning	Awareness, training and Communication	Monitoring and Usage
Economics	3	0	0	47	19	10	0	0	0	0	10
Energy	5	55	0	0	0	57	0	0	0	0	58
Environmental	3	23	0	0	0	25	0	0	0	0	27
Other	0	0	0	3	0	3	0	0	0	2	7
TOTAL	11	78	0	50	19	95	0	0	0	2	102

Graph 1. Indicators developed by Modular Projects by building project stages (source: own elaboration)

In the last chapter (3. . Catalog of Tools), 15 tools elaborated by the different MPs are described and analyzed. These tools are free and available online and can be very useful in some stages for the realisation of public EE projects. Besides, several indicators are integrated in the tools, thus allowing the joining of different stages in a continuous process.

As shown in Table 2, the 15 analyzed tools cover 6 out of the 11 stages of EE Projects and can support PA in specific cases, like analysing the PB stock, engaging stakeholders, assessing the needed sources to finance EE projects, or listing possible EE measures to be implemented in PBs.

Lastly, it is essential to highlight the achievements of the MPs and to ensure the use and accessibility of these results to their potential final users, i.e. PA.

Table 2. Tools developed by Modular Projects by building project stages (source: own elaboration)

IMPULSE – MyGIS https://cres.mygis.gr/index_en.html	
IMPULSE – Building typologies and performance indicators platform https://impulse.interreg-med.eu/fileadmin/user_upload/Sites/Efficient_Buildings/Projects/IMPULSE/D3.2.1_revised_annex_Sep_2018.zip	
IMPULSE – Networking Forum https://impulseforum.eu/	
IMPULSE – Financial scheme evaluation tool for gradual building energy renovation planning https://impulse.interreg-med.eu/fileadmin/user_upload/Sites/Efficient_Buildings/Projects/IMPULSE/Financial_tool_D3.5.1Annex.xlsx	
PrioritEE Analytic Database https://prioritee.interreg-med.eu/toolbox/analytic-database/	
PrioritEE – Decision Support Tool https://prioritee.interreg-med.eu/toolbox/decision-support-tool/	
EduFootprint –Calculator https://edufootprint.interreg-med.eu/news-events/news/detail/actualites/edufootprint-app/	
EduFootprint –Platform http://edufootprint.provinciatreviso.it/index.php/en/	
TEESCHOOLS – Pre-audit web tool and Best Available Techniques Database www.improveyourschool.enea.it	
NEW FINANCE –Platform http://newfinanceplatform.com/	
SISMA – SET TOOL https://sisma.interreg-med.eu/sisma-set-tool/	
STEPPING –EPC Simulation Tool https://stepping.interreg-med.eu/news-events/news/detail/actualites/epc-simulation-tool-1/	
SHERPA - Funding tool https://sherpa.interreg-med.eu/what-we-achieve/what-has-been-done-so-far/	
SHERPA – Information System Tool http://eem.sherpa.cimne.com/es/login/	
ENERJ – Web platform http://www.enerj-platform.eu/enerj/	

INTRODUCTION

Nearly 40% of Final Energy (FE) consumption in Europe is in houses, offices, shops and other buildings, therefore buildings are a priority for Energy Efficiency (EE) policy. Moreover, there are also important co-benefits from making buildings more efficient, including job creation, fuel poverty alleviation, health improvements, improved energy security and better industrial competitiveness.

While the Energy Performance of Buildings Directive (EPBD) [1] sets minimum energy performance requirements for all buildings that undergo major renovation, Article 5 of the Energy Efficiency Directive (EED) [2] sets a binding renovation target for public buildings (PBs) and imposes related obligations. It also stresses that governments shall undertake an exemplary role in the energy retrofit of their countries' building stock.

In this context, the MED Efficient Buildings Community [3] (EB Community), established by MEDNICE Project within the Interreg MED programme framework [4], was created precisely to support this transformation in PBs, specifically in the Mediterranean region. The community brings together local, regional and national stakeholders to exchanges methodologies, experiences and tools.

The Activity 4.3 *"Convergence of EEB MED outputs through technical papers and lessons learned reports"* (Analysis and harmonization) of MEDNICE Project aims to systematize knowledge from the ten Modular Projects (MPs) (Figure 3) and to help find technical answers to common identified cross-cutting priority issues.

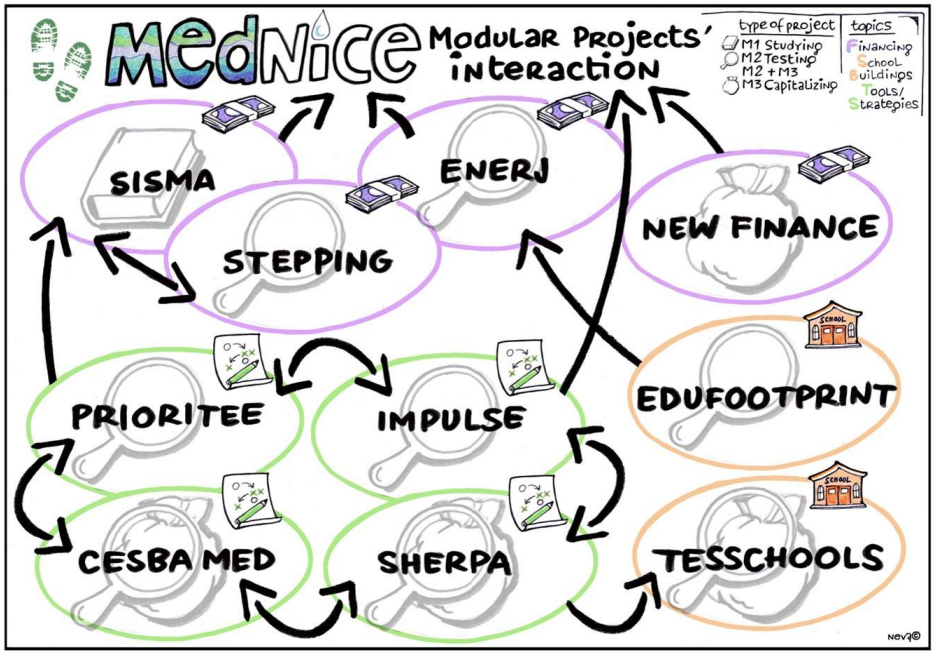


Figure 3. Modular Projects under the umbrella of MEDNICE Project (Source: MEDNICE Project)

In order to achieve the objectives of the Activity 4.3, it is foreseen the elaboration of several reports which will collect EE challenges and obstacles in the Mediterranean PBs and will provide solutions and identified gaps.

The present report (D4.3.1. Technical paper – MED Tools, Methodologies and Indicators) is focused on available tools, methodologies and indicators elaborated within the MED Programme and aiming at supporting Public Administration (PA) to increase EE in Mediterranean PBs.

1. Stages for Energy Efficiency

The Article 5 of the EED asks for PA to play an exemplary role when it comes to EE. For this reason, it is expected the realisation of projects, interventions and plans aiming at improving the energy performance of PBs and Public Infrastructure. Nevertheless, the implementation of these actions is not an easy task, since every decision making requires to set clear and assessable objectives, to have the required knowledge, to use appropriate tools, to obtain funding, to address the appropriate target groups and to properly implement and follow the designed plan, also after its implementation. That is why PAs, in particular those with fewer resources, need effective methodologies, quantifiable indicators, benchmarking systems, decision support tools, addressed training and tailor-made guidelines.

In order to support PAs in every stage of EE projects in PBs, several EU initiatives are working on the identification, elaboration, definition and development of methodologies, indicators, and support tools. Nonetheless, in some cases such amount of results requires to be collected, analyzed and systemized to be easily found, understood and used by the key stakeholders in their day to day work.

Under the umbrella of MEDNICE, 10 MPs have elaborated diverse results approaching the matter from different perspective. The results can address a particular kind of intervention (new construction or refurbishment), a specific project stage (from planning to commissioning), a different kind of building according to its use (from schools to administrative uses), or even a part of larger actions such as urban planning of neighborhoods or joint Sustainable Energy/Climate Action Plans (SEAP/SECAP) for a group of municipalities.

Within this report, the results will be showed and classified according to the different stages of EE projects in order to facilitate their comprehension and its usefulness. From the introduced structure of some of the MPs and other initiatives, it has been decided to establish the following 11 stages:

1. Purpose and Target, to define the building project and the energy targets of the building project.
2. Energy audit, to stablish the current conditions and the best refurbishment options.
3. Stakeholder involvement, to detect the main stakeholders and to ensure participation of interested parties in order to gather information, increase support and minimize resistance.
4. Financing, to find and adapt available sources, funds or models for financing EE measures.
5. Design tendering, to clearly define the framework conditions of the call.
6. Planning, to define the future EE project and minimize defects during the construction and usage phase.
7. Procurement, to find and agree the terms of services, goods or works under national, regional and/or local regulations.

8. Implementation, to ensure the proper construction of the sustainable requirements described in the planning.
9. Commissioning, to prepare the building or interventions for a correct operation and ensure the defined goals accomplishment.
10. Awareness, training and communication, to prepare and teach the actors involved in the whole building life cycle, from technicians and politicians to building users.
11. Monitoring and Usage, to ensure a correct user behavior and to detect malfunctioning systems reducing the efficiency of the building.

Based in the CESBA Building Life Cycle approach [5], the proposed classification considers every stage as a part of a cycle, as shown in Figure 4. The CESBA scheme is in line with the Life Cycle Assessment approach and slightly differs from existing standards like the EN 15643-1 [6], which also includes "Deconstruction" and "Disposal" stages, but not the "Purpose and Target" and "Design Tendering" stages.

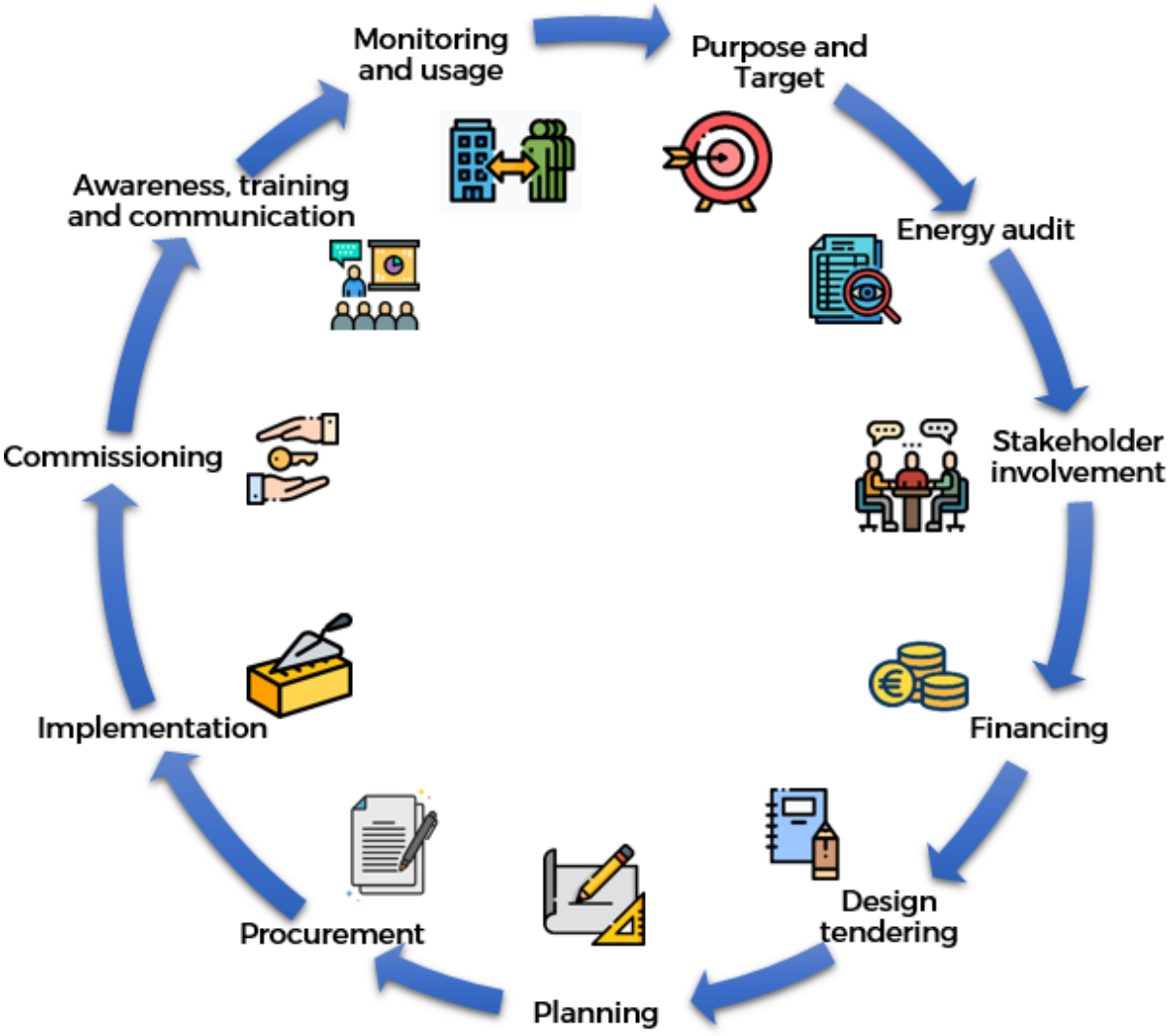


Figure 4. Stages of a building project (source: own elaboration)

The circular stage approach is also pertinent in the case of existing buildings, since within the "Monitoring and Usage" stage may appear needs that require improvement interventions, i.e. returning again to the "Purpose and Target" stage.

On the other hand, this report lists several indicators that could be relevant for the decision making. These indicators are mentioned and used in the different results of the MPs. Moreover, MEDNICE have categorized these indicators according the established EE project stages, following the approach used within this report.

1.1. Purpose and Target

The "Purpose and Target" stage would be described [5] as a stage to define the targets of the building EE project, where is important to include aspects of sustainability from the very beginning.

1.1.1. Methodologies for Purpose and Target

In this first stage, MPs have exposed different methodologies or approaches for setting EE targets and coming up with new sustainable initiatives for PBs.

Most MPs' results generally mark purely energetic objectives for PBs, while just a few projects' results set more holistic targets considering other aspects of sustainability beyond energy.

In addition to the different approaches for improving the sustainability or efficiency of PBs, among the results we can also find differences in spatial boundaries, whether at the level of buildings such as schools or at the neighborhood level.

For the decision making process, 6 key steps could be adviced [7]:

- Get the right people around the table,
- Adapt the tools to your specific context,
- Evaluate the level of sustainability of your building or your urban area,
- Identify constraints and set targets,
- Build and rank scenarios, and
- Transform the selected scenarios into a concrete project.

On the other hand, and in a transnational scale, it is proposed a holistic and peer-to-peer approach for developing strategies for EE of PBs based in the coordination of 4 key areas [8]:

- Governance,
- Information System,
- Training, and
- Financing assessment.

From there, some basic topics could be considered depending on the scope of the project.

Sustainable Energy Action Plan

At local level, several municipalities in the MED area joined the Covenant of Mayors and decided to implement a Sustainable Energy (and Climate) Action Plan (SEAP/SECAP), which is an important first step to reduce Greenhouse gas (GHG) emissions by improving EE and increasing Renewable Energy (RE).

Within this context, several methodologies have been elaborated [9] [10] [11] aiming at supporting local PA in identifying and implementing actions to be included in their SEAPs.

Basic information on the Covenant of Mayors [12], as well as a clear and concise definition of a SEAP, its contents, the Baseline Emission Inventory (BEI) and the Climate Risk and Vulnerability Assessments could be found in the references [9]. Besides, it is provided too information on how to design and implement a SECAP, including description for each phase (Initiation, Planning&Implementation and Monitoring&Reporting).

At building level, specifically for schools [13] they are shown the steps to follow in order to integrate building actions in the municipal SEAPs:

- Step 1: Make a list of the real issues, for each component of the footprint.
- Step 2: Make a list of the most realistic and effective changes.
- Step 3: Develop an Action Plan for each component of the footprint, matching a list of key objectives with actions.
- Step 4: Agree the Action Plans and the priorities with everyone across the whole school community and stakeholders.
- Step 5: Draw up an overall improvement Program and help the involved people to think about monitoring, evaluating and promoting its progress.
- Step 6: Communicate the improvement Program.

In the case of schools, the energy action plan consists of:

- Implementation of management actions;
- Implementation of behavioral actions;
- Implementation of direct actions.

On the other hand, as acknowledged by the EU Commission and highlighted in ENERJ project [10], joint SEAPs can allow achieving more effective results than an isolated one, especially for small local authorities. For that reason, it is important to define and implement a joint coordination and governance structure, outlining its composition and defining the functions of the structure.

To do so, they are established [10] 4 preliminary analysis activities for a joint SEAP, providing possible models to perform this analysis:

- Survey of building stock,
- Energy audits,
- Preliminary evaluation of technical and economic feasibility of actions,
- Creation of a joint database of buildings.

In short, a SEAP is a very useful plan that includes actions improving EE at municipal level and allows multiple and flexible ways of implementation, like joint actions between small municipalities or actions at different levels. At present, thousands of municipalities all over Europe already joined the Covenant of Mayors and implemented their own SEAP; MEDNICE results could help to those ones aiming to be part of this cluster, but also to the Municipalities that wishes to improve their current SEAP.

Building typology definition

The decision making by the PA requires a good knowledge of the existing PB stock and unfortunately, the lack of tailored and reliable data for building typologies, specifically related to commercial and tertiary uses, is a recurrent barrier for the PA. Therefore, several MPs have elaborated methodologies for the definition of building typologies, which have a common structure, with slightly differences one to each other.

In Table 3, the different building typologies identified by the MPs:

Table 3. Identified building typologies by Modular Projects (source: PrioritEE, ENERJ and IMPULSE)

Building typology	**PrioritEE** [14]	**ENERJ** [15]	**IMPULSE** [16]
Cultural building / Museums / Libraries	■	■	■
Educational building			■
School building	■	■	
Kindergarten		■	
Office / Administrative building	■	■	
Sport facility	■	■	■
Social Center	■	■	
Swimming pool	■		
Healthcare building		■	■
Public entertainment			■
Community / Public assembly building			■
Industrial building and warehouse			■
Residential building for communities			■
Retail building			■
Building for workshop and/or religious activities			■
Public security buildings			■
Other		■	

To define this classification, several activities could be implemented [14] with local and technical partners. As an example, they are proposed 4 methodological steps [16]:

- Step 1: Determination of the sample of PBs to be "scanned/recorded"
- Step 2: Collection of data (e.g. year of construction, size, system, etc.)
- Step 3: Determination of buildings' classification criteria
- Step 4: Classification of the PBs sample into typologies based on the adopted criteria.

Besides, a survey in the pilot territories could be implemented to detect the main building typologies to be considered; for example, and for a particular case [17] it was noticed that school building was the most common type of building considered as priority, as shown in Table 4.

Table 4. Most common type of building considered a priority (source: IMPULSE)

Building typology considered a priority for energy renovation	Heraklion	Elche	Cannes	Ravenna	Osijek	Mostar
Municipal offices						
Schools						
Sport centres						

From the different MPs, it is noticed that the size of the municipality is relevant when defining the building typologies or, more in detail, the buildings to be selected for the EE action plans. In this regards, Municipalities according to their needs have to reach compromise between reduced efforts with reduced number of building typologies and a large number of building typologies with accurate detail of their PB stock. In this sense, it is recommended to define as much detailed as possible the different building typologies and, from there, select the one's to be affected by the EE actions, considering local factors as: prioritization on large-scale actions or singular projects, current energy consumption per buildings, available budget, etc.

Renovation scenarios and criteria

The definition of an EE project, the selection of the buildings to be renovated and the ambition of the actions to be implemented depend on various factors. Sometimes these kinds of projects require a great investment by the PA and it is important to make sure to select an adequate option.

On this regards, it is possible to propose 4 kind of retrofit scenarios [16] based on the investment cost, easiness of the implementation, reduction of energy consumption, reduction of CO_2 emissions and payback period:

- Minor retrofit,
- Medium retrofit,

- Major retrofit,
- Deep retrofit (nearly Zero Energy Buildings (nZEB)).

For the prioritization of energy scenarios and the selection of building, it is proposed the reference cost-indicator "(Investment cost-in Euros or in national currency) / (kWh of saved energy)", i.e. detect the buildings for which the highest energy saving is achieved under least cost. Nevertheless, for the final selection other factors should be taken into account, i.e. priorities of the PA, citizens' wishes, socio-economic factors, high visibility and use of the building, etc.

On the other hand, and when considering specific scopes as the adoption of Energy Performance Contracting (EPC), it is possible to propose a more detailed criteria to select candidates' buildings for this kind of financing scheme [18]. For example;

- Excessive or higher than market annual utility costs with savings opportunities;
- Equipment/systems are outdated or near the end of their useful life;
- Relatively consistent energy-use patterns over several years – relatively consistent facility use and stabilized occupancy;
- Access to several years of utility records;
- Assets identified for strategic repositioning or reported in the SEAP or other policy plans to undergo a major renovation;
- Assets that are already planned to undergo a major capital improvement;
- Larger facilities with complex building systems;
- Larger facilities with high energy consumption to hot water.

At the end, for any single case PA should firstly clarify the main scope of the intervention and, from there, it would be easiness to select the renovation scenarios with their specific set of criteria.

Beyond the Energy Issue

From the very beginning the PA has to decide how ambitious their interventions in the public infrastructure are going to be. In this regard, the European Directives EPBD and EED fixed the Energy issue as a clear priority for EU2020, nonetheless many administrations at different level introduce other kind of sustainable requirements in their projects.

The requirements on sustainability can be classified in three major issues:

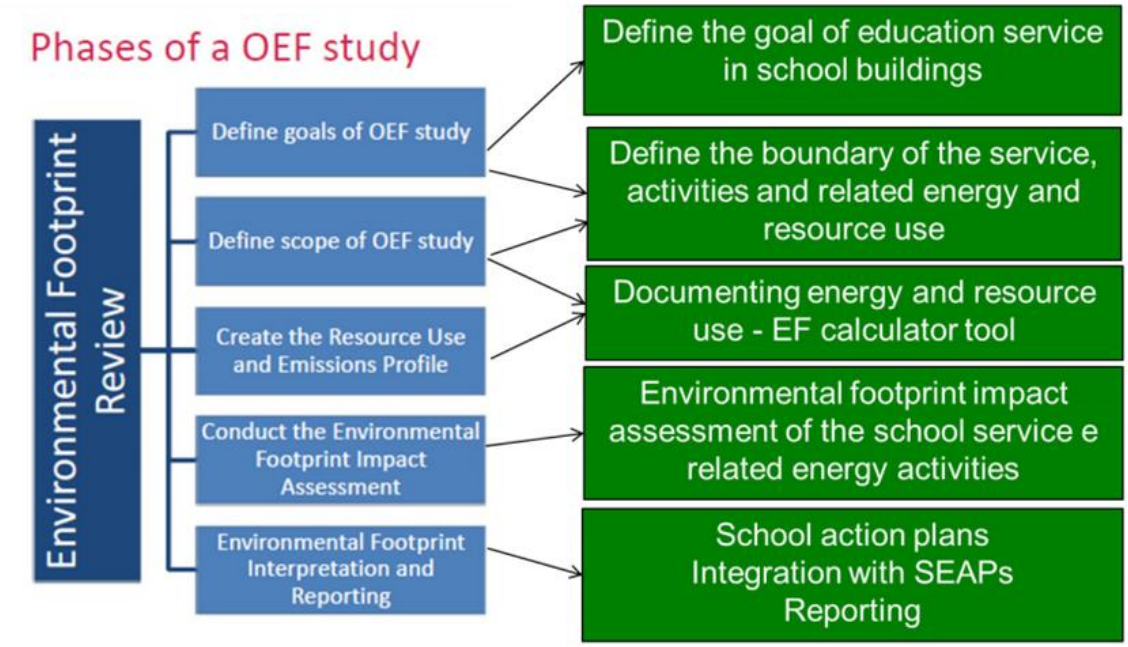
- Economic,
- Environmental, which includes the Energy issue, and
- Social.

In this regard, they could be selected a long list of indicators and methodologies to assess the sustainability of neighborhoods and PBs [19]. These indicators take into account the three major issues, therefore they can be very relevant to fix sustainable objectives at a city or neighborhood level, considering PBs and other infrastructure.

Assessing different areas or buildings can, on one hand, be used as benchmarking criteria for the selection of intervention areas, and on the other hand, assess the effectiveness of the interventions after its realization.

When it comes to implement sustainable actions in a specific building, we can find the Life Cycle Analysis (LCA) and the Organisation Environmental Footprint (OEF). These are decision support tools to improve energy and environmental impact of education service and to increase resource efficiency, as shown on the next phases in Table 5 [13].

Table 5. Phases of a Organisation Environmental Footprint (source: EduFootprint)



Not many PAs use the multicriteria analysis that considers other aspects beyond the energy issue. This a complex approach that may require decision support tools adapted for the context of each administration level and territory, and may also require specific knowledge and capacities of the public decision makers and public technicians.

1.1.2. Indicators for Purpose and Target

In order to support the Purpose and Target stage, specific indicators could be needed. These indicators can be used to assess the PA needs and to prioritize their actions.

The analyzed MPs have mentioned a long list Indicators, which can be a relevant for this stage and can be classified by Energy and Environmental indicators, as shown in Table 6:

Table 6. Indicators for Purpose and Target stage (source: own elaboration)

Category	Subcategory	Indicator	Modular project Source
Energy	Energy source	Annual electricity savings	IMPULSE, SHERPA
Energy	Energy source	Annual savings of fossil fuel consumption	IMPULSE, SHERPA
Energy	Global energy consumption	Energy consumption Baseline	SISMA
Energy	Global energy consumption	Annual energy savings	PrioritEE, STEPPING
Energy	Renewable energy	Annual increase of Renewable Energy generation	IMPULSE, PrioritEE
Environmental	CO_2 emissions	Total annual avoided CO_2 emissions	IMPULSE, PrioritEE, NEW FINANCE, STEPPING, TEESCHOOLS
Environmental	CO_2 emissions	Climate Change	EduFootprint
Environmental	Other emissions	Annual GHG emissions avoided	IMPULSE
Economic	Costs savings	Annual savings of total energy-related operational cost	IMPULSE, PrioritEE, NEW FINANCE, SISMA, STEPPING, TEESCHOOLS, SHERPA
Economic	Costs savings	Annual electricity cost savings	IMPULSE, NEW FINANCE, SHERPA, TEESCHOOLS,
Economic	Costs savings	Annual fossil fuel cost savings	IMPULSE, NEW FINANCE, SHERPA, TEESCHOOLS

At this stage, the used indicators have to be general since their have to be used to fix an initial objective and in this stage the current status of the existing PB stock is still unkonwn.

1.2. Energy audit

There are several official definitions but, in general an energy audit could be defined [18] as an examination of a building for EE improvement purposes. Through analysis of energy usage, building characteristics, weather data and the typical usage of the building, an energy audit uncovers energy conservation opportunities. These measures are then assessed to identify savings, improve the quality of life within the building and provide environmental benefits.

The objectives of the energy audit are:

- Streamlining the flow of energy;
- The recovery of lost energy;
- The identification of technologies for energy savings;
- The optimization of energy supply contracts;

- The management of the technical and economic risks;
- The improvement in the method of Operation and Maintenance (O&M).

1.2.1. Methodologies for Energy audit

When a PA implements an energy audit in order to know better the performance of their buildings and to improve their efficiency, there are several aspects to take into account [18]:

- Credibility: the actual data should be acquired in number and quality necessary for the development of the energy inventory of the Energy System;
- Completeness: the energy system described should cover significant energy aspects;
- Traceability: there must be an energy inventory with the identification of the origin of the data, how to process the data and the procedures employed;
- Utility: measures to improve EE must be identified and assessed in terms of cost/benefit;
- Verifiability: the elements that allow the client to verify the attainment of EE improvements resulting from the application of the proposed actions must be identified.

According to the available resources and needs of a PA, different levels of analysis for the energy audits can be done [18]:

- Level 0 - Energy benchmarking: Analysis of historic utility data of the building and comparison with similar buildings. This is used to identify inefficiencies of the building.
- Level 1 – Walk-through audit: Brief assessment to identify low cost energy improvements and potential areas for future audits.
- Level 2 – General audit: Comprehensive evaluation of the building and potential energy conservation measures.
- Level 3 – Investment-grade audit: Comprehensive analysis of potentially pricey EE improvements with a focus on financial concerns and return on investment.

Moreover, for any kind of energy audit, real data acquisition and analysis on possible interventions becomes crucial factors to be considered.

Data collection

The first step for the elaboration of an energy audit is the collection of data of the PBs, which uses to be a big challenge and it is time consuming for PA.

The data collection can be mainly divided in different chapters depending on the level of analysis that is going to be implemented [10]:

- Building Characterization: Dimensions, constructive type, climate data of the place, indoor climate data and thermophysical specifications of the building envelope.
- Performance indicators: Consumption and production of energy.
- Technological systems: Heating and DHW thermal, Air Conditioning plants and air treatment plants, electric plants.

There exist some other EU projects (i.e. ENTRANZE [20]) and bibliography references and regulations focused on most of these concepts.

Nonetheless, other data can be collected and used for a more detailed energy audit, like "usage profile of the installations", or even "usage profile of different spaces" when the building have particular uses like schools.

When the aim is to improve not only the EE of the PB, but also other sustainable aspects, other data can be collected, as for example mobility or waste production indicators [13].

Interventions

In an energy audit, a first list of possible EE interventions can be listed by a qualified technician, who can also estimate achievable savings, costs, contributions and funding available, and time to return investment.

Summarizing, the list of EE interventions can be applied to the building components, but also to the behavior of their occupants. In the case of building envelope and installations. As a reference, the most recurrent ones could be listed as [11]:

- Insulation of perimeter walls,
- Insulation of the cover,
- Insulation of the floors,
- Efficiency of window frames:
  - Adhesive film applications,
  - Insulation of the bins,
  - Installing a double glazing,
  - Replacement of glass,
  - Replacement of the entire window frame,
- Install sunscreens,
- Ordinary maintenance of the installations,
- Installation of room temperature control systems,
- Replacement of fluid circulation pumps with inverter pumps,
- Condensation heat generator replacement,
- Heat pump installation,
- Implementation of controlled mechanical ventilation,
- Use for timed circuit lighting,
- Provide automatic shutdown of all the lamps,
- Replacing old lamps,
- Installation of photovoltaic plants,
- Installation of solar thermal systems.

From where, the qualified technician should validate and valuate them in order to sort the interventions according to the agreed criteria (maximum energy savings, cost-optimal measures, etc.).

Several projects, initiatives and standards at national and European level have already defined energy audits (European Standard EN 16247-2 [21]) and developed methodologies to implement them. Therefore, many bibliography is already existing on this issue, nonetheless the use of one methodology rather than another has to be evaluated by the corresponding PA according to their objectives, sources and possibilities. In this sense, MPs have given it a more oriented approach to the typology of the Mediterranean PBs.

1.2.2. Indicator for Energy audit

The Energy audit stage requires the use of many indicators. These indicators can be used to assess in detail the Energy performance the PBs and the results will be used to identify specific needs that could not be identified in the previous stage.

The analyzed MPs have mentioned a long list Indicators, which can be a relevant for this stage and can be classified by Energy and Environmental indicators, as shown in Table 7:

Table 7. Indicators for Energy audit stage (source: own elaboration)

Category	Subcategory	Indicator	Modular project Source
Energy	Energy per uses	Monthly Primary Energy consumption for heating	TEESCHOOLS
Energy	Energy per uses	Total annual primary energy consumption for Heating and DHW	PrioritEE
Energy	Energy per uses	Ratio Primary Energy consumption and total heating volumes	STEPPING
Energy	Energy per uses	Annual final energy consumption for heating	IMPULSE, PrioritEE, SHERPA, ENERJ, STEPPING, TEESCHOOL
Energy	Energy per uses	Annual final energy consumption for cooling	IMPULSE, PrioritEE, ENERJ, STEPPING
Energy	Energy per uses	Annual final energy consumption for DHW	IMPULSE, STEPPING
Energy	Energy per uses	Annual final energy consumption for lighting	IMPULSE, PrioritEE, STEPPING
Energy	Energy per uses	Total cooling demand	PrioritEE
Energy	Energy per uses	Annual Final Energy Savings for space heating	IMPULSE, PrioritEE
Energy	Energy per uses	Annual Final Energy Savings for space cooling	IMPULSE, PrioritEE
Energy	Energy per uses	Annual Final Energy Savings for DHW	IMPULSE, PrioritEE
Energy	Energy per uses	Annual Final Energy Savings for lighting	IMPULSE, PrioritEE
Energy	Energy source	Monthly electricity consumption	TEESCHOOLS
Energy	Energy source	Monthly Primary Energy for electricity consumption	TEESCHOOLS
Energy	Energy source	Total heat Consumption	PrioritEE, STEPPING
Energy	Energy source	Annual electricity consumption	IMPULSE, PrioritEE, SHERPA, EduFootprint, ENERJ, NEW FINANCE, TEESCHOOL
Energy	Energy source	Annual consumption of fossil fuel	IMPULSE, EduFootprint, NEW FINANCE, STEPPING, TEESCHOOLS, SHERPA
Energy	Global energy consumption	Total annual primary energy consumption	IMPULSE, STEPPING

Category	Subcategory	Indicator	Modular project Source
Energy	Global energy consumption	Daily energy consumption	SHERPA
Energy	Global energy consumption	Monthly energy consumption	SHERPA
Energy	Global energy consumption	Annual Final Energy consumption	TEESCHOOLS
Energy	Other indicators	Thermal transmittance	PrioritEE, TEESCHOOLS, SHERPA
Energy	Other indicators	Efficiency of a technology	PrioritEE
Energy	Other indicators	Power of installations	PrioritEE
Energy	Other indicators	Weekly type hours of occupation	PrioritEE, STEPPING
Energy	Other indicators	Monthly occupation	NEW FINANCE
Energy	Other indicators	Indoor Winter Heating Temperature	ENERJ, NEW FINANCE, STEPPING
Energy	Other indicators	Indoor Temperature Cooling	ENERJ, NEW FINANCE, STEPPING
Energy	Other indicators	Average number of people per square meter	ENERJ
Energy	Other indicators	Heated Volume	STEPPING
Energy	Other indicators	Contribution of internal heat	ENERJ
Energy	Other indicators	Renewal fresh air	ENERJ
Energy	Other indicators	Total Hot Water Consumption	PrioritEE
Energy	Other indicators	Total Water consumption	NEW FINANCE
Energy	Other indicators	Total Heat Losses	PrioriTEE
Energy	Other indicators	Heat Losses for the Outside (Ht)	PrioriTEE
Energy	Other indicators	Heat Losses in the distribution network	PrioriTEE
Energy	Other indicators	Ventilation Losses	PrioriTEE
Energy	Other indicators	Total power of existing heating system	PrioriTEE
Energy	Renewable energy	Electricity consumption from certified clean energy	EduFootprint

Category	Subcategory	Indicator	Modular project Source
Energy	Renewable energy	Electricity consumption from self-produced renewable energy	EduFootprint
Energy	Renewable energy	Annual generation of Renewable Energy	IMPULSE, PrioritEE, EduFootprint, ENERJ, STEPPING
Energy	Renewable energy	Annual generation of Solar thermal Energy	ENERJ, SHERPA
Energy	Renewable energy	Annual generation of Photovoltaic systems	ENERJ, STEPPING, SHERPA
Energy	Renewable energy	Annual generation of Biomass systems	ENERJ
Energy	Renewable energy	Annual generation of gethermal systems	ENERJ
Energy	Renewable energy	Self-produced energy	EduFootprint
Energy	Renewable energy	Solar Hot Water Energy needs	PrioriTEE
Energy	Renewable energy	Energy generation of PV panels	PrioritEE
Energy	Thermal comfort	Annual occupancy hours in which PMV is retained in the range (-0.7 to 0.7)	IMPULSE
Energy	Thermal comfort	Hourly-averaged PMV value on a hot summer day of the year	IMPULSE
Energy	Thermal comfort	Hourly-averaged PMV value on a typical winter day of the year	IMPULSE
Energy	Thermal comfort	Number of hours of overheating in the year	IMPULSE
Energy	Thermal comfort	Minimum winter indoor temperature (°C)	IMPULSE
Energy	Thermal comfort	Maximum summer indoor temperature (°C)	IMPULSE
Environmental	CO_2 emissions	Total annual CO2 emissions	IMPULSE, PrioritEE, SHERPA
Environmental	CO_2 emissions	Total monthly CO2 emissions	TEESCHOOLS
Environmental	CO_2 emissions	Total monthly CO2 emissions for electricity consumption	TEESCHOOLS
Environmental	CO_2 emissions	Total monthly CO2 emissions from fossil fuels consumption	TEESCHOOLS
Environmental	CO_2 emissions	Annual CO2 emissions from electricity consumption	IMPULSE, TEESCHOOLS
Environmental	CO_2 emissions	Annual CO2 emissions from fossil fuels consumption	IMPULSE, TEESCHOOLS

Category	Subcategory	Indicator	Modular project Source
Environmental	CO_2 emissions	Total annual avoided CO2 emissions	IMPULSE, PrioritEE, NEW FINANCE, STEPPING, TEESCHOOLS
Environmental	CO_2 emissions	Climate Change	EduFootprint
Environmental	Indoor Environmental quality	Ecotoxicity for aquatic fresh water	EduFootprint
Environmental	Indoor Environmental quality	Human toxicity- cancer effect	EduFootprint
Environmental	Indoor Environmental quality	Human toxicity- non cancer effect	EduFootprint
Environmental	Indoor Environmental quality	Particulate matter / respiratory inorganics	EduFootprint
Environmental	Indoor Environmental quality	Ionising radiations – human health effects	EduFootprint
Environmental	Indoor Environmental quality	Acidification	EduFootprint
Environmental	Indoor Environmental quality	Eutrophication – terrestrial	EduFootprint
Environmental	Indoor Environmental quality	Eutrophication – aquatic freshwater	EduFootprint
Environmental	Indoor Environmental quality	Eutrophication – marine	EduFootprint
Environmental	Indoor Environmental quality	Resource depletion – water use	EduFootprint
Environmental	Indoor Environmental quality	Resource depletion – mineral, fossil & renewable	EduFootprint
Environmental	Indoor Environmental quality	Occupancy hours in which breathingzone pollutants is below maximum allowed	IMPULSE
Environmental	Other environmental effects	Ozone depletion	EduFootprint
Environmental	Other environmental effects	Photochemical ozone formation	EduFootprint
Environmental	Other environmental effects	Land transformation	EduFootprint

Among the list of indicators, it can be noticed the high degree of detail of the indicators, which not only consider energy consumptions and emissions, but also the impact on health and environment of other components and materials which are present in PBs.

This degree of detail allows also to identify specific interventions in building components which may require an urgent intervention due to particular high consumptions or high impact on the environment or health of the building occupants.

In spite of the high number of indicators, economic indicators are not allocated in this stage but in others, thus it is necessary to link this stage with indicators in other stages in order to make the Energy Audit a useful tool supporting decision making.

1.3. Stakeholders involvement

The engagement of stakeholders is the practice of interacting with and influencing project stakeholders for the overall benefit of the project and its supporters [22]. The different MPs outline the relevance of the stakeholders' involvement for the success of a project, since it is highly dependent on the people interested in its subject or affected by the results of the proposed changes.

1.3.1. Methodologies for Stakeholders involvement

The involvement and management of stakeholders is crucial to implement EE projects, mainly because of the required transversality for those kind of interventions, from the different personnel of several PA departments, to private actors (i.e. the execution works companies). For that, first is needed to identify all stakeholders and their needs, and then to find the way to involve them in our project, not only to inform about the convenience of the project, but also to receive their specific contribution for a better final result.

Some concepts and process steps could be pointed to properly focus the main actors and key roles, in order to avoid neglecting crucial contributions.

Map of stakeholders

It is crucial to know well all the stakeholders and their objectives (shown in Table 8). For this purpose three phases to map them could be introduced [10]:

- Identify: listing relevant groups, organizations and people.
- Analyzing: understanding stakeholders' perspective and interests.
- Mapping and Prioritizing: visualizing stakeholders" relationships with the project objectives and other stakeholders & ranking stakeholders' relevance for identified issues.

Table 8. Category, stakeholders and objectives of stakeholders (source: ENERJ and Fasudir Projects)

Category	Stakeholder	Objectives			
		Economic	Environmental	Social	Political
Energy Policy makers and authorities	-Local/Regional/National authorities -Covenant of Mayors Coordinators -Local/Regional/National Energy Agencies	-Stimulate and promote economy. -Optimize consumption and maximize economic benefit.	-Sustainability, CO_2 reduction, energy security, safeguard of environmental components.	-Increase social welfare, social cohesion and service to citizens.	-Transposition of EU, and national policies and regulations -Formulation of national/local programs and strategic action plans.
Suppliers of energy-related services	-ESCO -Energy management authorities -Trade associations	-Access to coverage of financing. -Minimize amortization. -Innovative energy business models. -Quality of data -Management of big data open standard technology.	-Effcient use of resources.	-Improve quality of life. -Increase awareness of final user and citizen.	-Hgher level of transparency. -Data exchange. -Smart data infrastructure.
Energy users	-Large energy users -Associations of condominium managers -Small and Medium Enterprises	-Reduce energy costs.	-Improve environmental conditions. -Sustainable energy.	-Increase welfare and social cohesion. -New services to citizens. -Answers to expectations.	-Coverage of services to the territory.
Experts	-Professional associations and grouping professionals -Universities and Research Centers -Single experts	-Stimulate and promote economy. -Energy simulations. -Economic analysis.	-Experimentation and scientific support.	-Increase welfare and social cohesion. -Third mission. -Promotion of Urban Living Labs.	-Coverage of services to the territory. -Redaction of strategic action plans for the environment and sustainable energy.
Civil society organizations:	-Environmental associations -Local interest groups -NGOs -Citizens associations.	-Reduce energy costs.	-Improve environmental conditions. -Sustainable energy.	-Increase welfare and social cohesion. -New services to citizens. -Answers to expectations.	-Coverage of services to the territory.
Citizens	-Owners -Tenants -Condominiums -Buildings users.	-Reduce energy costs.	-Improve environmental conditions. -Sustainable energy.	-Increase welfare and social cohesion. -New services to citizens. -Answers to expectations.	-Coverage of services to the territory.

The “identification” and “analysis” phases can be done through a survey related to the level of affectation by the project, and the relevance and perspective that the stakeholders can offer. While for “mapping and prioritization”, a matrix could be proposed, as shown in the example of Figure 5.

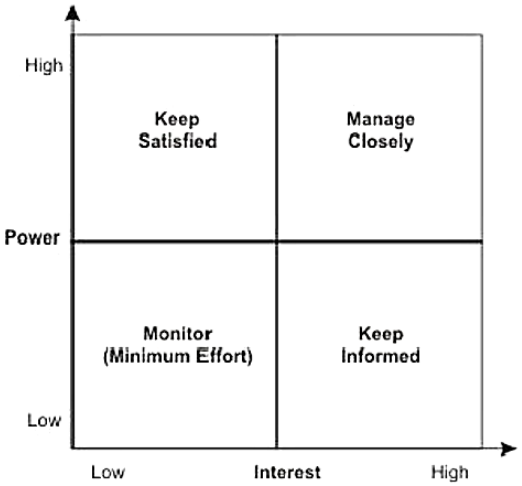


Figure 5. Prioritization matrix of stakeholders (source: ENERJ)

In the first instance, these could be long processes but, most of the work done could be reused for further interventions.

Engagement methods

Once the mapping is completed, it is possible to define a strategy to increase stakeholders’ consent and support and reduce risks. Understanding stakeholders and communicating frequently with them is important,

The success of a project and the engagement of the stakeholders can be achieved following several steps [22]:

- Define objectives: Define the purpose you want to achieve and adapt to specific needs of your Municipality;
- Set targets: Define measurable targets you want to achieve;
- Involve stakeholders: Identify, analyze and prioritize the key stakeholders and target groups, and define an engagement strategy;
- Define resources: Quantify human, technological and economic resources necessary for the involvement process;
- Select the topics, messages and deliverables: Check the information you would like to transfer, and the topics you want to put in consultation, and define the tasks in which stakeholders should be involved;
- Use creative strategies and effective tools: Use the appropriate tools based on the message and target group;
- Track communication: Share minutes, use surveys and evaluation forms;
- Evaluate: Measure and analyze the results;
- Repeat: Correct if necessary and repeat the actions.

The stakeholders' engagement it is not only about the starting of the EE projects. When implementing a public tender, it is also very important to have the engagement of the actors in order to obtain a good competition result. As an example, and for launching an EPC tender [18] it could be proposed a participative approach from the very beginning in order to:

- Get significant suggestions from the market (Local companies and Energy Service Companies (ESCOs)) and from the financial institutions on how to build up proposals also in line with their expectations.
- Avoid not receiving any answer from the market to the call for tenders for the EPC contract.

Technics of engagement methods

There are different means of engagement, but as mentioned above, it is important first to know well the target group we want to communicate, to analyze their expectations and to find the most effective way to communicate with them. As a first classification, the following technics could be introduced [22]:

- Information and education,
- Information and feedback,
- Advisory Boards,
- Workshops,
- Competitions,
- Living Labs,
- World CAFÉ,
- Energy Days,
- Web technologies,
- Social media,
- Social Networks,
- WEB/Mobile applications,
- Track communication to monitor engagement actions,
- Evaluate: Measure and analyze the results.

Depending on the EE intervention degree (from building to town) and local characteristics and references, the PA should decide which of these techniques fits better in their case.

1.3.2. Indicators for Stakeholders involvement

Mainly due the nature of this topic, no specific indicators has been mentioned by the MPs in the "Stakeholders involvement" stage. Nonetheless, in order to assess the effectiveness of the actions implemented in this stage, some relevant indicators could be considered in this stage like "Number of engagement activities for an EE project" or "Number of contacts established with stakeholders", among others.

1.4. Financing

Based on the results of the energy audits, a financial and economic simulation uses to be done to verify the feasibility of the investment plan [23]. This means to estimate the potential of savings and the investment volume.

The limitation of public debt, in particular for municipalities, makes necessary to find the most appropriate way of financing the project.

1.4.1. Methodologies for Financing

At have been widely uncovered in most studies and analysis (i.e. BPIE reports [24]), lack of financial sources is probably the greatest barrier that a PA can find when implementing an EE project. On this regard, several MPs have described existing financing schemes and have identified the most common financial barriers. These results can be found in the first technical paper (D4.3.1 [25]) of MEDNICE. Besides, the technical paper provides a description of the different stakeholders and some best practices for financing EE projects.

At EU level it is possible to find the following funding programs and financial schemes:

- European Structural and Investment Funds: ERDF [26], Cohesion Fund [27].
- European Funding Programmes: LIFE [28], Horizon2020 [29], etc.
- European Project Development Assistance: ELENA [30], JASPERS [31], etc.
- Financial Institutions Instruments: EFSI [32], EEEF [33], etc.
- Energy Service Contracting: EPC, Energy Supply Contracting (ESC), etc.
- Alternative Financing Schemes: Crowd-funding, On Bill Financing, Green Municipal Bonds, etc.

Besides, the financial process can be summarized in four main assessment steps [34]:

- Project Assessment: analyses whether the project is mature and complete to check the real potential in terms of savings and investment return.
- Promoter Assessment: an in-depth analysis of the promoter of the project in order to understand if the promoter itself has the enough experience to face the project.
- Credit Assessment: If the promoter or a third part creditor is able to pay its financial obligations. This section aims to understand who the payer of last resort is and what its financial capabilities are.
- Return Assessment: assessment of the project from a pure economic return, using the IRR method.

From the above-mentioned technical paper, as well as the own programs' information, it is possible to properly select the best options case by case. Nevertheless, the consideration of some key aspects will eases the financial vision.

Conditions for the economic sustainability

In some cases, in particular in some EPCs, an EE project can be not attractive for the current market. Therefore, the choice of the optimal financial scheme is decisive. Considering this issue, three possible situations could be described [10]:

- The EE project is fully sustainable under market conditions. Thus, the priority should be given to Public-Private Partnership (PPP) procedures, where private actors can assume the responsibility and most of the risks.
- The EE project is partially sustainable under market conditions. In this circumstance, the PA should assess the availability of specific financial source to support the EE project sustainability.
- The project is not sustainable under market conditions. In this situation, there are alternatives solutions:
    - PA uses internal resources to cover sufficiently the whole investment.
    - Internal resources of PA can cover only a part of the whole investment.

In all the cases, and for sure under self-financing interventions, PA must consider factors like the priority assigned to the project, the cost-effectiveness and its urgency.

Moreover, the following conditions have to be met when using an EPC [10]:

- Existence of a high energy saving potential;
- Need for qualified implementation and operation of energy saving technologies and measures;
- Payback time of the energy saving measures lower than expected contract duration;
- The owner of the target building(s) is lacking expertise in energy saving technologies and in their financing and operation;
- For the customer: total cost savings achieved through the contract are larger than the payments to ESCO together with the transaction costs incurred (which include labour/staff costs, legal costs, consulting costs, and all costs associated with tendering and contracting procedures, monitoring contract performance, resolving disputes, etc.);
- For the ESCO: contract revenues are larger than the total costs incurred.

Detailed establishment of these background conditions is a key factor in order to ensure the overall process success.

Sources to finance EPC in EE projects

According to the conclusions of the first technical paper of MEDNICE on financing schemes and barriers [25], the most recurrent financial scheme used by PA is the EPC. This is mainly because of the debt limitation of PA, in particular for Municipalities.

In this scheme modality, the ESCO have to finance the interventions and there are sources that can be used to fund an ESCO for an EPC project [18]:

- Direct financing provided from the balance sheet of the ESCO (unusual);
- Third party financing: leverage by the ESCO, equipment suppliers, or leasing firms;
- Direct financing by the Customer using traditional sources of project funds.

The source of fund depends on a various factors like the type of EPC, available terms for the different sources, tax implications or availability of funding from the source.

At the other hand, when the internal rate of return (IRR) of an EPC project is low or inexistent, but the EE intervention is relevant and needed for the PA, a subsidy contribution is needed. In this context, it is possible to provide a method to assess what should be the subsidy contribution to make the project attractive for the market and participating ESCOs [35].

If a subsidy is needed, then it should be optimized and not based on general flat rate, fixed percentage or defined as certain amount of the energy measure investment. This optimization requires to know in advance the costs of EE measures with reference to local standard costs, as well as baselines and savings from EE measures, and specially the IRR that must reach the market threshold.

The subsidy is a total amount in Euro that may be provided through a single funding measure or a combination of several financial instruments from the following possibilities:

- Grant from local and national authorities,
- European funds,
- Incentives: local and national,
- Technical assistance.

In Figure 6, it can be observed the logical framework of the subsidy process.

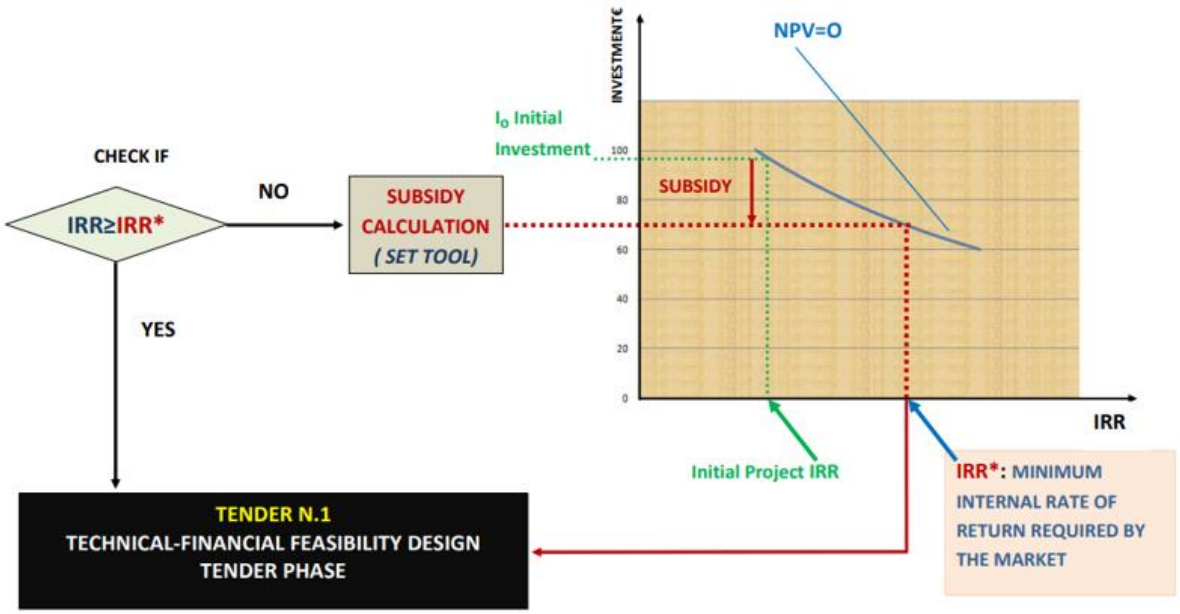


Figure 6. Logical framework of the subsidy process (source: SISMA)

There exist specific tools to calculate the project's IRR (Subsidy Evaluation Tool (SET) [36] elaborated by SISMA Project and described in chapter 3.

Considerations to finance EE Projects

Some MPs provide a list of considerations to be taken into account when financing an EE project.

At first, some general considerations and tips could be introduced [37]:

- Accelerating investment in EE is key to meet the objectives of the Energy Union and support the transition to a clean energy system.
- Many EE investments have short payback periods.
- Find the most cost-effective way to make your building more energy efficient.
- EU has developed several support schemes and funding programmes aiming to help successfully implement EE projects.
- The main available EU financing channels subsidize energy retrofit, building works, design, technical assistance and communication.
- Successful EE policy cannot be achieved without unlocking and mobilizing private investment. A good option is to establish a PPP in the form of EPC.

When we look at more concrete considerations, specifically regarding to EPC projects, they could be outlined [18];

- Viable: The savings generally have to be sufficient to recover the original capital cost and investment return over a number of years (3 to 20 years). If the savings are insufficient, then the customer may have to fund a portion of

the works. Besides, the project must be of sufficient scale to justify the transaction cost and attract finance.

- Capital: This can be supplied out of the customer's own funds, by an ESCO or a third party. The overall capital can be financed from a number or sources. The cost of this capital is critical and depends on the risks.
- Risk: There is the risk that equipment will not perform as was expected and projected savings were wrongly calculated due to assumptions. This risk is normally borne by the ESCO. There is also a credit risk, in which the customer cannot pay at some point. Lastly, there is the energy price risk, if energy prices change and therefore the value of the savings.
- Savings: These are allocated among the different parties. Normally if the savings are high and allocated to the ESCO, the contract term is shorter.
- Energy Baseline: An accurate energy consumption baseline is needed to know how to act if there are future significant changes in the client's process during the contract, and to link the savings with the risks.

Lastly, there are three aspects that could make the EPC not the best choice:

- The public body needs to be comfortable with a long-term relationship. One possible issue is the loss of flexibility when signing a contract with a single contractor for a lengthy time period.
- Besides to the capital investment costs, EPC are turnkey arrangements that involve also engineering audits, the implementation and corresponding project management time, ongoing monitoring and maintenance.
- For the public body is important to know if they can try something innovative. Customers should check their internal procedures before a performance contract can be signed.

The analysis and valuation of these generic and specific considerations could result in the basis of the EE interventions success.

1.4.2. Indicators for Financing

In this stage, the indicators are needed to identify if the EE project is economically sustainable and feasible, according to the available resources and interests of the PA. Some decisions can be based in economic parameters rather than environmental criteria.

The analyzed MPs have cited several indicators that can be appropriate for this stage, as shown in Table 9. These are mainly included in the Economic category:

Table 9. Indicators for Financing stage (source: own elaboration)

Category	Subcategory	Indicator	Modular project Source
Economic	Costs savings	Value of EPC contract	STEPPING
Economic	Costs savings	Sharing savings	STEPPING
Economic	Costs savings	Simple Payback period for each renovation scenario	IMPULSE, PrioritEE, STEPPING, SHERPA
Economic	Costs savings	Return period on Investment	PrioritEE, STEPPING
Economic	Costs savings	Internal Rate of Return	SISMA, STEPPING, SHERPA
Economic	Costs savings	Net Present Value	SISMA, STEPPING
Economic	Costs savings	Net Profit ratio	STEPPING
Economic	Costs savings	Cash Flow	SISMA
Economic	Costs savings	Annual savings of total energy-related operational cost	IMPULSE, PrioritEE, NEW FINANCE, SISMA, STEPPING, TEESCHOOLS, SHERPA
Economic	Costs savings	Annual electricity cost savings	IMPULSE, NEW FINANCE, SHERPA, TEESCHOOLS
Economic	Costs savings	Annual fossil fuel cost savings	IMPULSE, NEW FINANCE, SHERPA, TEESCHOOLS
Economic	Costs savings	Water Savings	NEW FINANCE
Economic	Energy costs	Annual total energy-related operational cost	IMPULSE, STEPPING
Economic	Energy costs	Monthly electricity cost	TEESCHOOLS
Economic	Energy costs	Annual electricity cost	IMPULSE
Economic	Energy costs	Total Electricity cost for space cooling	PrioritEE
Economic	Energy costs	Annual fossil fuel cost	IMPULSE
Economic	Energy costs	Monthly fossil fuel cost	TEESCHOOLS

Category	Subcategory	Indicator	Modular project Source
Economic	Energy costs	Energy supply fee	STEPPING
Economic	Energy costs	Initial Energy Costs (baseline)	STEPPING, SHERPA
Economic	Energy costs	Electricity Price	NEW FINANCE, SISMA, STEPPING, SHERPA
Economic	Energy costs	Natural Gas Price	NEW FINANCE, SISMA, STEPPING, SHERPA
Economic	Financial costs	Financial fee	STEPPING
Economic	Financial costs	Incoming Fee	STEPPING
Economic	Financial costs	Incoming equity	STEPPING
Economic	Financial costs	Value-Added Tax	STEPPING
Economic	Financial costs	Rate of co-financing	ENERJ
Economic	Financial costs	Debt Service Cover Ratio	SISMA
Economic	Financial costs	Interest rate	STEPPING
Economic	Financial costs	Annual financial savings	PrioritEE
Economic	Investment costs	Total investment cost for each renovation scenario	IMPULSE, PrioritEE, SHERPA, SISMA, STEPPING, TEESCHOOLS
Economic	Investment costs	Total investment cost per total annual energy saved for each renovation scenario	IMPULSE
Economic	Investment costs	Cost of materials	PrioritEE
Economic	Other	Number of Buildings (bundled EPC)	STEPPING
Economic	Other	Number of EEM registered	SHERPA
Economic	Other	ESC Contract duration	STEPPING
Economic	Other	Water Price	NEW FINANCE, SISMA, STEPPING

Category	Subcategory	Indicator	Modular project Source
Economic	Other costs	Administrative and management fee	STEPPING
Economic	Other costs	Works costs	STEPPING
Economic	Other costs	Operation and Maintenance fee	STEPPING
Economic	Other costs	Professional fee	STEPPING
Economic	Subsidies, loans and incentives	Incoming incentives schemes	STEPPING
Economic	Subsidies, loans and incentives	Incoming Loans	STEPPING
Economic	Subsidies, loans and incentives	Loan by the Public Body	STEPPING
Economic	Subsidies, loans and incentives	Available public funding/incentives	STEPPING
Economic	Subsidies, loans and incentives	Subsidy	SISMA
Economic	Subsidies, loans and incentives	Loan Life Cover Ratio	SISMA
Other	Characterization	Surface of External Wall for renovation	PrioritEE, SHERPA
Other	Characterization	Surface of External Windows for renovations	PrioritEE, SHERPA
Other	Characterization	Number of lightbulbs	PrioritEE

In this case, the selected indicators consider economic aspects like the savings related to the energy (or source) consumption of the public infrastructure, the costs of the possible interventions and other structural and administrative costs.

Concrete ratios like "Total investment cost per total annual energy saved for each renovation scenario" are especially interesting to identify the most convenient scenarios or interventions.

1.5. Design tendering

Design tendering is an important phase to clearly define the goals of sustainability for the participants within the call for a public tender. Only with a detailed predefinition of the framework conditions, all submitted concepts will be sustainable. The criteria should not constrain the innovation. The main goal of the competition is to find the best solution for a special project, while following national and regional standards [5].

1.5.1. Methodologies for Design tendering

Tendering is a crucial step for the succeed of a project. For this stage, and in particular for EPC projects as an increasingly emerging mechanisms, MPs provide valuable information on the criteria to be included in a tender, detailed information on the type of tenders and technical requirements to be included.

Evaluation criteria and process awarding

In the case of EPC, the tendering documents should define clear and transparent evaluation criteria (both quantitative and qualitative), as well as their weights and calculation methods.

On this regard it is recommended [10]:

- Financial evaluation criteria should aggregate the present value of all monetary benefits and all costs incurred by the client. Net Present Value (NPV) can be a suitable criterion.
- Additional non-financial quantitative criteria can be defined to reflect the preferences of the client or the environmental benefits of the project.
- Qualitative evaluation criteria can include energy management level, compatibility of the proposed measures with the existing system, maintenance level, activities proposed for motivating, involve and train the users, quality of technology equipment, project organization, company expertise/qualification, etc.

Another aspect to take into account is the attractiveness of the call for tender and the related EPC contract to the companies. For this it is possible to propose some thresholds to be considered [18]. The threshold can vary from country to country and can be related to different indicators like the minimum amount of energy saving, payback of each project or a minimum number of buildings to be refurbished. Projects should be feasible, bankable and profitable for every party involved thanks to the proposed contractual models and their tailor-made financing mechanisms.
In the case of EPC, the energy costs baseline should be above a certain economic threshold (about €200,000 in most EU countries). Pooling of several buildings into a single EPC contract could be an option to reach a plausible amount for the baseline.

Concerning the awarding of an EPC contract there could be considered two phases:

- Selection criteria: Selection of candidates with the required capacities by means of selection criteria. Selection criteria are used in a pre-selection procedure to restrict the number of participants that will be invited to submit a tender. There could be requirements on sustainability, financial and economic, technical and professional competence and certification.
- Selection of a tender on the basis of award criteria: Most of European legislations prescribe that a public contract must in principle be awarded on the basis of the criterion 'economically most advantageous tender'. If the department inviting tenders opts for awarding the contract on the basis of the lowers price in derogation of the previous criterion, the department must justify the application of that criterion in the tender documents. The lowest price criterion is difficult to apply in many EPC and needs the application of a combination of criteria.

Clearly introducing, both internally and externally, the evaluation criteria and process awarding it is not only mandatory but will benefit the success of the overall procedure.

Tender procedures

When implementing an EPC in EE projects for PBs there could be two tenders, as described in Figure 7 [35]:

- Tender N.1 Technical-financial feasibility documentation: Includes technical designs, an EPC model and an IREE Certification that assesses the initial compliance with the ICP with all the documentation part of the Annexes.
- Tender N.2 Energy Conservation Measures (ECM) realization: Intervention on the building with all the ECMs on the basis of the technical-financial documentation from Tender N.1.

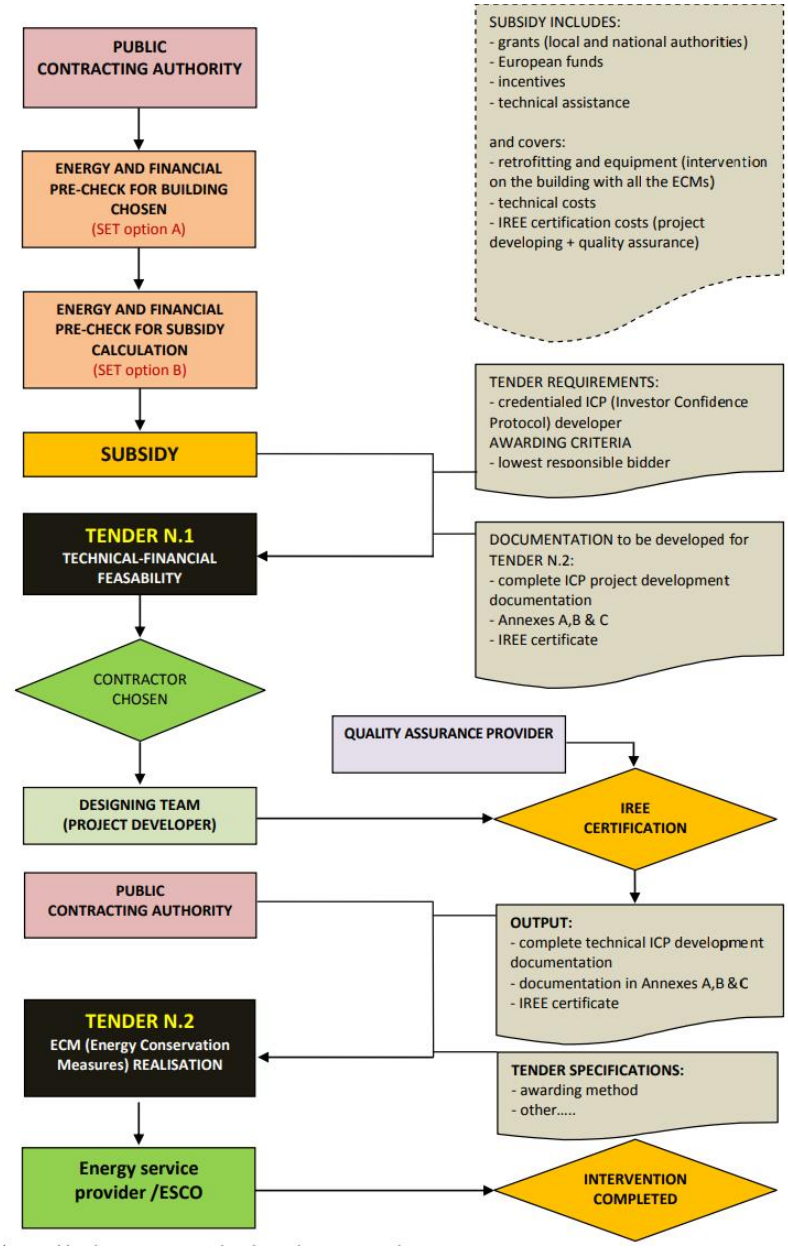


Figure 7. Tender N.1 and N.2 of an EPC project (source: SISMA)

It should be highlighted [18], the fact that for the application of the European rules governing tenders, a differentiation between public works contracts, public supply contracts and public service contract has to be done:

- Public works contract refers to the execution of structural or civil-engineering works.
- Public supply contract refers to the purchase, leasing, rent or hire-purchase of products potentially including the additional affixing and/or installation of that supply.
- Public service contract refers to the performance of services, in which any potential product to be delivered are lower in value than those services and in which potential work to be performed is secondary in nature.

Moreover, there are two kind of standard procedures:

- Open procedure: It is a standard procedure that can always be used. It consists in a single round, in which all interested ESCOs submit a tender. The obstacle of this procedure is that everyone can submit a tender. Thus, it increases the cost of the procedure and time consumption of PA. It can be suitable for less complex EPCs, like ESCOs implementing only energy management/monitoring or a single specific measure.
- Private procedure: It is a standard procedure in which candidates and tenders are assessed in two different rounds. The first round is a pre-qualification phase, which is used to select those ESCOs that will be invited to submit a tender in a second round. In the second round the tenders of the selected candidates are assessed. Usually, this procedure is more suitable for EPCs, since often these are complex contracts with extensive tenders.

These standard procedures are probably not the most appropriate ones when multiple energy-saving solutions are possible and some measures have not been selected. Other exempted procedures are competitive dialogue and negotiation procedure.

Tender requirements

In order to make ECM project feasible, 5 requirements could be introduced [35]:

- Requirement n.1 – meet market thresholds: A project is really bankable only if it is yielding an interest rate equal to the minimum interest rate required for projects with similar risk reward profiles.
- Requirement n.2 – optimize public funding: Subsidies are minimized when their amount enables the project to yield an IRR equal to the market threshold.
- Requirement n.3 – define a sound technical framework covering its entire project lifecycle for a complete control of the project.
- Requirement n.4 – foster tender participation: ESCOs/Providers can easily participate to the tender because all the technical documentation is predefined.
- Requirement. N5 – facilitate the awarding process: A standard process for the financial assessment of tender participants and for the awarding system is assumed.

A contract must include technical and functional specifications. On this regard, there exists some templates (as for EPC "Tender specification", from STEPPING [38]) which uses to contain the following categories:

- Introduction;
- Tender object;
- Tender documents;
- General information;
- Avail;
- Guarantees and insurance;
- Subcontracting;
- Exclusion Causes;

- Subjects admitted;
- Requirements for participation;
- Awarding criteria;
- Energy supply;
- Determination of the Annual Fee;
- Contract duration
- Terms and modalities to present the application form;
- Offer contents;
- Temporary groups;
- Procedure for offers evaluation and performance of the tender;
- Ranking list validity;
- Financial flows traceability;
- Treatment of personal data;
- Exclusion of refunds and expenses;
- Communications; and
- Jurisdiction in case of disputes.

Most of these ones are sorted by local, national and European regulations that should be taken into account.

1.5.2. Indicators for Design tendering

In this stage, the indicators are basically part of the same indicators already identified in other stages, but they need to be described in the tendering documents.

As exposed in Table 10, the analyzed MPs have named several indicators that can be appropriate for this stage, in particular for EPC tenders:

Table 10. Indicators for Design tendering stage (source: own elaboration)

Category	Subcategory	Indicator	Modular project Source
Economic	Costs savings	Value of EPC contract	STEPPING
Economic	Costs savings	Sharing savings	STEPPING
Economic	Energy costs	Energy supply fee	STEPPING
Economic	Financial costs	Financial fee	STEPPING
Economic	Financial costs	Incoming Fee	STEPPING
Economic	Financial costs	Incoming equity	STEPPING
Economic	Financial costs	Value-Added Tax	STEPPING
Economic	Financial costs	Rate of co-financing	ENERJ
Economic	Investment costs	Cost of materials	PrioritEE
Economic	Other	Number of Buildings (bundled EPC)	STEPPING
Economic	Other	Number of EEM registered	SHERPA
Economic	Other	ESC Contract duration	STEPPING
Economic	Other costs	Administrative and management fee	STEPPING
Economic	Other costs	Works costs	STEPPING

Category	Subcategory	Indicator	Modular project Source
Economic	Other costs	Operation and Maintenance fee	STEPPING
Economic	Other costs	Professional fee	STEPPING
Economic	Subsidies, loans and incentives	Incoming incentives schemes	STEPPING
Economic	Subsidies, loans and incentives	Incoming Loans	STEPPING
Economic	Subsidies, loans and incentives	Loan by the Public Body	STEPPING

The selected indicators, which are also considered in the Financing stage, consider economic aspects like the savings, incentives or subsidies, duration of the legal relation, and fees.

1.6. Planning

Planning a building or set of buildings project in detail with the appropriate measures is a crucial factor for the sustainability in the subsequent life Cycle stages. Many parties are involved in this stage: public decision makers, administrative staff, building engineers, architects, technical planners, energy experts and others. These parties should meet regularly during the planning stage to minimize defects during construction and find the most adequate architectural solutions. For refurbishment projects, measures that increase the sustainability of the building should be taken into account, to be carried out during the refurbishment process. The better and more detailed the planning of a project, the less can go wrong in the end [5].

1.6.1. Methodologies for Planning

The determination of the ambition of an EE project is determinant for the selection of the EE measures to be applied and its correspondent planning. On this regard, it is possible to list several measures to be applied according to the following 4 retrofit scenarios [16].

- Minor retrofit scenario,
- Medium retrofit scenario,
- Major retrofit scenario, and
- Deep retrofit scenario.

These lists can be expanded or shorten depending on applicability for the building.

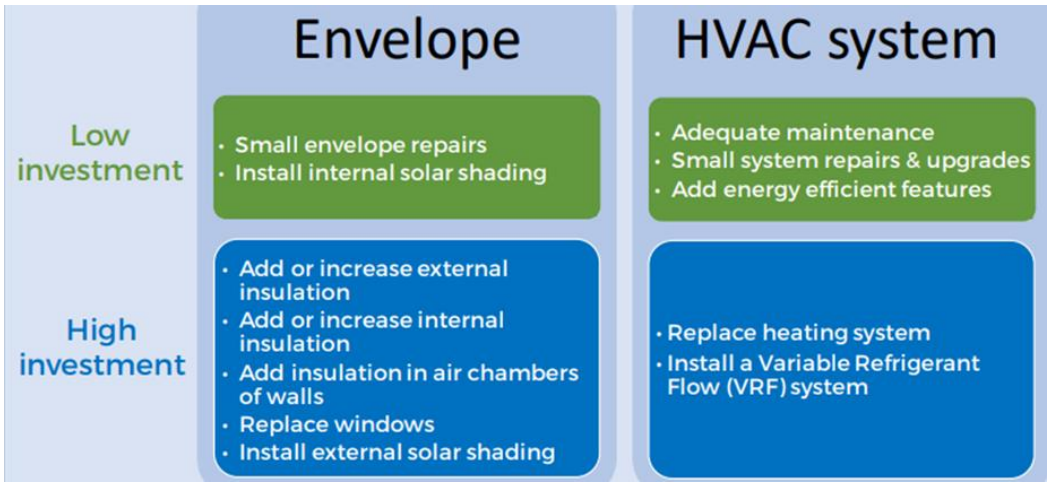
For the selection of an appropiate measure, it could be quite useful the consideration of technologic analytical databe (as the PrioritEE one [39], described in chapter 3.). The database could incorporate:

- Detailed measures for five end uses (HVAC; Water Heating, Lighting, Cooking and Other Electric Equipment).
- Passive measures and improvements on the building structure, as through windows replacement, external and internal insulation of walls, thermal improvement of floors and roofs.
- Decentralized, small scale renewable energy sources technologies that could be used at a building level.

Some more specific tools could be introduced as brochures with technical and practical information on how to improve the efficiency of buildings by improving the building envelope and systems, including costs and benefits [40]. From there, some recommendations would be introduced, also in Table 11:

- Common problems in the building envelope include leaky windows, glare from inappropriately oriented or unshaded windows, and excessive heat gain from east- or west-facing windows.
- Leaky and uninsulated walls and roofs lead to high energy bills and uncomfortable conditions when Heating Ventilation Air Conditioning (HVAC) equipment is unable to maintain desired temperatures.
- Choosing the correct insulation material, and having it installed correctly are key to achieve energy savings.
- You can reduce energy costs by installing energy-efficient windows. If your budget is limited, EE improvements to existing windows can also help.
- Shading windows can block up to 90% of heat generated by direct sun radiation and can reduce heat losses through the windows by approximately 10%-20%.
- An adequate maintenance and smalls repairs of the heating and cooling systems can result in important energy savings at no or very little cost.
- Installing small EE devices (such as radiator boosters or thermostatic valves) can reduce by 10-15% the energy consumption for space heating.
- Replacing traditional heating systems with more efficient ones can result in up to 50% energy savings.

Table 11. Envelope and HVAC systems interventions by degree of investment (source: PrioritEE)



Lastly, in EPC projects, technical and definitive choices can be made by the ESCO or the PA can impose a definitive project to be implemented by the ESCO [18].

1.6.2. Indicators for Planning

The planning stage is particularly complex. In this stage, it is needed to know well the current status and estimate the future scenario of the EE project.

Depending on the ambition of the project, the planning stage will define the future performance of the building, will measure more in detail the intervention costs and will assess the building impact from different points of view (e.g. use and indoor conditions).

Numerous indicators were mentioned by the analyzed MPs, which can be considered for this stage, as shown in Table 12:

Table 12. Indicators for Planning stage (source: own elaboration)

Category	Subcategory	Indicator	Modular project Source
Energy	Energy per uses	Monthly Primary Energy consumption for heating	TEESCHOOLS
Energy	Energy per uses	Total annual primary energy consumption for Heating and DHW	PrioritEE
Energy	Energy per uses	Ratio Primary Energy consumption and total heating volumes	STEPPING
Energy	Energy per uses	Annual final energy consumption for heating	IMPULSE, PrioritEE, SHERPA, ENERJ, STEPPING, TEESCHOOL
Energy	Energy per uses	Annual final energy consumption for cooling	IMPULSE, PrioritEE, ENERJ, STEPPING
Energy	Energy per uses	Annual final energy consumption for DHW	IMPULSE, STEPPING
Energy	Energy per uses	Annual final energy consumption for lighting	IMPULSE, PrioritEE, STEPPING
Energy	Energy per uses	Total cooling demand	PrioritEE
Energy	Energy per uses	Annual Final Energy Savings for space heating	IMPULSE
Energy	Energy per uses	Annual Final Energy Savings for space cooling	IMPULSE
Energy	Energy per uses	Annual Final Energy Savings for DHW	IMPULSE
Energy	Energy per uses	Annual Final Energy Savings for lighting	IMPULSE
Energy	Energy source	Monthly electricity consumption	TEESCHOOLS
Energy	Energy source	Monthly Primary Energy for electricity consumption	TEESCHOOLS
Energy	Energy source	Total heat Consumption	PrioritEE, STEPPING
Energy	Energy source	Annual electricity consumption	IMPULSE, PrioritEE, SHERPA, EduFootprint, ENERJ, NEW FINANCE, TEESCHOOL
Energy	Energy source	Annual consumption of fossil fuel	IMPULSE, EduFootprint, NEW FINANCE, STEPPING, TEESCHOOLS, SHERPA
Energy	Energy source	Annual electricity savings	IMPULSE, SHERPA

Category	Subcategory	Indicator	Modular project Source
Energy	Energy source	Annual savings of fossil fuel consumption	IMPULSE, SHERPA
Energy	Global energy consumption	Total annual primary energy consumption	IMPULSE, STEPPING
Energy	Global energy consumption	Daily energy consumption	SHERPA
Energy	Global energy consumption	Monthly energy consumption	SHERPA
Energy	Global energy consumption	Annual Final Energy consumption	TEESCHOOLS
Energy	Global energy consumption	Energy consumption Baseline	SISMA
Energy	Global energy consumption	Total annual primary energy savings	IMPULSE, PrioritEE
Energy	Global energy consumption	Annual energy savings	PrioritEE, STEPPING
Energy	Other indicators	Thermal transmittance	PrioritEE, TEESCHOOLS, SHERPA
Energy	Other indicators	Efficiency of a technology	PrioritEE
Energy	Other indicators	Power of installations	PrioritEE
Energy	Other indicators	Weekly type hours of occupation	PrioritEE, STEPPING
Energy	Other indicators	Monthly occupation	NEW FINANCE
Energy	Other indicators	Indoor Winter Heating Temperature	ENERJ, NEW FINANCE, STEPPING
Energy	Other indicators	Indoor Temperature Cooling	ENERJ, NEW FINANCE, STEPPING
Energy	Other indicators	Average number of people per square meter	ENERJ
Energy	Other indicators	Heated Volume	STEPPING
Energy	Other indicators	Contribution of internal heat	ENERJ
Energy	Other indicators	Renewal fresh air	ENERJ
Energy	Other indicators	Total Hot Water Consumption	PrioritEE
Energy	Other indicators	Total Water consumption	NEW FINANCE
Energy	Other indicators	Total Heat Losses	PrioriTEE

Category	Subcategory	Indicator	Modular project Source
Energy	Other indicators	Heat Losses for the Outside (Ht)	PrioriTEE
Energy	Other indicators	Heat Losses in the distribution network	PrioriTEE
Energy	Other indicators	Ventilation Losses	PrioriTEE
Energy	Renewable energy	Electricity consumption from certified clean energy	EduFootprint
Energy	Renewable energy	Electricity consumption from self-produced renewable energy	EduFootprint
Energy	Renewable energy	Annual generation of Renewable Energy	IMPULSE, PrioritEE, EduFootprint, ENERJ, STEPPING
Energy	Renewable energy	Annual generation of Solar thermal Energy	ENERJ, SHERPA
Energy	Renewable energy	Annual generation of Photovoltaic systems	ENERJ, STEPPING, SHERPA
Energy	Renewable energy	Annual generation of Biomass systems	ENERJ
Energy	Renewable energy	Annual generation of gethermal systems	ENERJ
Energy	Renewable energy	Self-produced energy	EduFootprint
Energy	Renewable energy	Annual increase of Renewable Energy generation	IMPULSE, PrioritEE
Energy	Renewable energy	Solar Hot Water Energy needs	PrioriTEE
Energy	Renewable energy	Energy generation of PV panels	PrioritEE
Energy	Thermal comfort	Number of hours of overheating in the year	IMPULSE
Energy	Thermal comfort	Minimum winter indoor temperature (°C)	IMPULSE
Energy	Thermal comfort	Maximum summer indoor temperature (°C)	IMPULSE
Environmental	CO_2 emissions	Total annual CO2 emissions	IMPULSE, PrioritEE, SHERPA
Environmental	CO_2 emissions	Total monthly CO2 emissions	TEESCHOOLS
Environmental	CO_2 emissions	Total monthly CO2 emissions for electricity consumption	TEESCHOOLS
Environmental	CO_2 emissions	Total monthly CO2 emissions from fossil fuels consumption	TEESCHOOLS

Category	Subcategory	Indicator	Modular project Source
Environmental	CO_2 emissions	Annual CO2 emissions from electricity consumption	IMPULSE, TEESCHOOLS
Environmental	CO_2 emissions	Annual CO2 emissions from fossil fuels consumption	IMPULSE, TEESCHOOLS
Environmental	CO_2 emissions	Total annual avoided CO2 emissions	IMPULSE, PrioritEE, NEW FINANCE, STEPPING, TEESCHOOLS
Environmental	CO_2 emissions	Annual CO2 emissions avoided from electricity consumption	IMPULSE
Environmental	CO_2 emissions	Annual CO2 emissions avoided from fossils fuels consumption	IMPULSE
Environmental	CO_2 emissions	Climate Change	EduFootprint
Environmental	Indoor Environmental quality	Ecotoxicity for aquatic fresh water	EduFootprint
Environmental	Indoor Environmental quality	Human toxicity- cancer effect	EduFootprint
Environmental	Indoor Environmental quality	Human toxicity- non cancer effect	EduFootprint
Environmental	Indoor Environmental quality	Particulate matter / respiratory inorganics	EduFootprint
Environmental	Indoor Environmental quality	Ionising radiations – human health effects	EduFootprint
Environmental	Indoor Environmental quality	Acidification	EduFootprint
Environmental	Indoor Environmental quality	Eutrophication – terrestrial	EduFootprint
Environmental	Indoor Environmental quality	Eutrophication – aquatic freshwater	EduFootprint
Environmental	Indoor Environmental quality	Eutrophication – marine	EduFootprint
Environmental	Indoor Environmental quality	Resource depletion – water use	EduFootprint
Environmental	Indoor Environmental quality	Resource depletion – mineral, fossil & renewable	EduFootprint
Environmental	Other emissions	Annual GHG emissions avoided	IMPULSE
Environmental	Other environmental effects	Ozone depletion	EduFootprint
Environmental	Other environmental effects	Photochemical ozone formation	EduFootprint
Environmental	Other environmental effects	Land transformation	EduFootprint

Category	Subcategory	Indicator	Modular project Source
Economic	Energy costs	Annual total energy-related operational cost	IMPULSE, STEPPING
Economic	Energy costs	Monthly electricity cost	TEESCHOOLS
Economic	Energy costs	Annual electricity cost	IMPULSE
Economic	Energy costs	Total Electricity cost for space cooling	PrioritEE
Economic	Energy costs	Annual fossil fuel cost	IMPULSE
Economic	Energy costs	Monthly fossil fuel cost	TEESCHOOLS
Economic	Energy costs	Electricity Price	NEW FINANCE, SISMA, STEPPING, SHERPA
Economic	Energy costs	Natural Gas Price	NEW FINANCE, SISMA, STEPPING, SHERPA
Economic	Investment costs	Cost of materials	PrioritEE
Economic	Other	Water Price	NEW FINANCE, SISMA, STEPPING
Other	Characterization	Surface of External Wall for renovation	PrioritEE, SHERPA
Other	Characterization	Surface of External Windows for renovations	PrioritEE, SHERPA
Other	Characterization	Number of lightbulbs	PrioritEE

In particular in this stage, it can be noticed the high variety of indicators which can measure or assess the same issue. This is the case of energy parameters, since we can find indicators like FE or Primary Energy (PE), measured in different units and timeframe.

For the PA and planners, it is especially relevant to be aware of the meaning of each type of Energy, but also the current legislation affecting the different territories in the MED area, which may use different requirements.

1.7. Procurement

Public procurement refers to the process by which PAs, such as government departments or local authorities, purchase work, goods or services from companies [41]. On this regard, EU law sets out minimum harmonized public procurement rules, which organize the way PAs can purchase goods, works and services.

The legal relation between PAs and other third parties has to be well defined to avoid possible future disputes, as it has been well documented in several MEDNICE MPs.

1.7.1. Methodologies for Procurement

There could be different possibilities for approaching the procurement process of EE projects. MPs focusses and provide information on the different approaches for EPC contracts, as well as the contents and clauses that an EPC contract should contain, and a list of recommendations for its implementation.

Approaches for an EPC contract

As a reference, three possible procurement options when contracting an ESCO are proposed [10]:

- Indefinite contracting: direct negotiation with one or more ESCOs pre-selected on the basis of general qualifications;
- Project bundling: a pool of buildings is grouped together to award a single contract to a large ESCO;
- Quality and cost-based selection (two-steps procedure): bidders present short proposals, which are evaluated in accordance with a set of project-specific pre-qualification criteria. Bidders matching the criteria are the requested to submit detailed proposals.

The size, the typology and the number of the buildings to be renovated by a PA will be determinant for selecting the type of EPC contract.

Contents and clauses of an EPC contract

As noticed in the first technical paper of MEDNICE [25], there is a need to standardize and publicize performance contracts' models.

Currently, the Annex XIII of the EED Directive (2012/27/EU) [2] provides indications on the minimum items that should be included in an EPC with the public sector, namely:

- List of the efficiency measures to be implemented or efficiency results to be obtained;
- Guaranteed savings to be achieved by implementing the measures throughout the duration of the contract. The contract has to define what happens if guaranteed savings are not achieved;
- Duration and milestones of the contract, terms and period of notice;
- List of the obligations of each contracting party, including the obligation by the ESCO to fully implement the measures in the contract and documentation of all changes made during the project. ESCO can also be obliged to provide a yearly report on achieved savings;
- Reference dates to establish achieved savings;
- List of steps to be performed to implement a measure or package of measures and associated costs;
- Regulations specifying the inclusion of equivalent requirements in subcontracting;
- Display of financial implications of the project and distribution of the share of the monetary savings achieved between parties. Means of payment for the services and savings should also be specified;
- Provisions on the measurement and verification of the guaranteed savings achieved, quality checks and guarantees;
- Provisions clarifying the procedure to deal with changing framework conditions that affect the content and the outcome of the contract;
- Detailed information on penalties to be applied for non-compliance with the obligations set within the contract.

From there, other key elements are:

- Volume of investment needed to ensure the guaranteed savings and a commitment by the client to pay the investment after its installation;
- Clear definition of a reference scenario of future energy consumption in physical units;
- Ownership transfer of the installed energy saving technologies to the client;
- Disputes management procedures.

The contract should include administrative and technical specifications. On this regard they could be listed a set of clauses for an EPC contract, which are necessary to ensure the success of the project [18]. The clauses content mainly information related with the type, goal, length and budget of the contract, price review and energy baselines and exclusions, among others.

Besides, some useful EPC models are available ([42] and [43]), in some cases valid for any EU country. The model provides:

Administrative information:

- General Provisions;
- Provisions related to tender, award and formalization of the contract;
- Provisions relating to the execution of the contract;
- Provisions on rights and obligations of the parties;
- Provisions on the tender, award and contract prices;
- Provisions relating to rescinding the contract;
- Resources, provisional measures and special cases of contractual nullity; and
- Annexes.

Technical specifications:

- Purpose;
- Provisions in the scope of the contract: EE service and Maintenance service;
- Execution term;
- Scope;
- Description of the centre;
- Inventory of facilities subject to the contract;
- Characterization of the building;
- EE service;
- Maintenance service;
- Technical and energy management of installations,
- Contract monitoring;
- Return of services; and
- Annexes).

MEDNICE MPs have elaborated and provided EPC models and concrete lists of specifications, both administrative and technical. This standardization of the documents and processes can strongly support PA in the implementation of this kind of scheme for PB renovation.

Recommendations for an EPC contract

The procurement of an EPC is a time-consuming process. In order to facilitate this process, it is recommended to [10]:

- Create a long-term partnership between the EPC provider and the client, based on common goals (energy and cost savings);
- Involve the appropriate management level for all important aspects of the EPC project (e.g. technical development, financing…);
- Have strong political endorsement;
- Rely on legal advisors to prevent and manage other legal problems.

It could be observed that MEDNICE MPs have basically provided methodologies and support documentation to implement EPC contracts. As noticed in the conclusions of the MEDNICE first technical paper [25], most of the best practices implemented by the MPs' territories to renovate PBs used the EPC scheme.

1.7.2. Indicators for Procurement

Mainly due to the nature of this issue, no specific indicators has been mentioned by the MPs in the "Procurement" stage. Nonetheless, every phase of a building project is crucial for the overall success, therefore it is recommended to use indicators for each stage in order to assess and validate the compliance of the objectives of each step.

As example of indicator for Procurement, it could be considered "average time in EPC contracting".

1.8. Implementation

After the planning and procurement stages, the EE project has to be implemented in the target building. The details for its implementation are described in the Planning documents and drawings, and the construction company and craftsmen are responsible for its proper construction, respecting quality, safety and time-schedule.

1.8.1. Methodologies for Implementation

Even so the relevance of the implementation steps, in order to close the gap among theoretical analysis and scopes and real results, no specific results of MPs have been focused on the implementation stage, but only it is relevance. Nonetheless, for the accomplishment of a good EE project it is highly recommended to implement a holistic approach considering all stages and to enhance communication with all actors involved. In particular, in this phase, problems and delays may occur due to unforeseen aspects in the building site.

1.8.2. Indicators for Implementation

Consistently with the lack of MPs methodologies, no specific indicators has been mentioned by the MPs in the "Implementation" stage. As mentioned above in other steps, each one is crucial. Therefore, in order to ensure the accomplishment of the Implementation stage, it is recommended the utilization of indicators like "number of visits to building site" or "number of control meetings" with all involved actors.

1.9. Commissioning

When the construction process is finished, most of the involved actors (engineers, architects and construction companies) leave the building site. After that, building end users are in charge of the using phase. Therefore, a knowledge transfer and an

adequate commissioning are needed to use properly the building and its components, in order to obtain the expected performance. This process can last more than a year considering all seasons, specially heating and cooling seasons.

1.9.1. Methodologies for Commissioning

In the case of the commissioning stage for an EPC project, not only the building users but also the ESCO is also involved in the operation and maintenance (O&M) phase.

It is highlighted that most ESCOs establish a training schedule for O&M coinciding with the commissioning of the ECMs [18]. It is adviced that the ESCO involve the Public Body (end user) in the commissioning process and use this as a part of training. Moreover, third parties involved in the maintenance may also participate in the training during the commissioning.

1.9.2. Indicators for Commissioning

No specific indicators have been mentioned by the MPs in the "Commissioning" stage. Nevertheless, some specific indicators (and methodologies) have been mentioned for the Monitoring and Usage (Chapter 1.1.1), which are quite linked to the Commissioning step.

1.10. Awareness, training and communication

This stage could be considered a continuous process chronologically allocated in the whole building life cycle. Even so in this report it has been allocated before the "usage and monitoring" stage, in-line with some MPs established ranking, due to the relevance impact of the human behavior in the achievement of the expected energy savings of an EE project, this step could be placed too from the beginning of the overall process.

A successful energy management strategy requires an active participation of all people involved in operation and use of buildings and energy infrastructures. Besides, the adoption of sustainable behaviors can significantly contribute to decrease energy consumption [44].

1.10.1. Methodologies for Awareness, training and communication

Raise awareness, training and communication are crucial to ensure a good usage of the building by the end user. This is particularly relevant in non-residential buildings, where users are not the actors paying the energy bills.

Adaptation of training to the target

Regardless the subject, the training activities have to be tailored to the specific target groups in order to be more effective. In this regard, the following steps are proposed [45]:

- Mapping of knowledge & mapping of skills: to evaluate the existing experience and needs.
- Process: to select participants, to analyze specific training needs in each region, to prepare training contents, to select trainers and to develop the courses.
- Multidisciplinary approach: to balance between deepness and comprehensiveness, specific and general contents, due to multidisciplinary groups of participants.
- Scope action: to find the most important knowledge and skill gaps among the target groups.
    - Transnational training: to consider the diversity, due to the different territories and profiles of the participants.
    - Regional training: to consider the schemes "learning by doing", which are useful to develop pilot actions.
- Description of phases.

Benefits, recommendations and experiences of training activities

In the case of EPCs, it is important to involve PA in training activities already in the commissioning process.

It could be affirmed that training usually improves morale and job satisfaction because of the following reasons [18]:

- It shows interest by management in the O&M responsibilities and systems that may not have been evident before, demonstrating to staff that all areas are important for the success;
- It shows that the PA values its staff's ability to contribute;
- It enhances the PA staff's skills and experience with new equipment; and
- It demonstrates how changes can significantly impact on savings, leading to a more proactive approach to identify future operational changes.

Several recommendations on Building, Users, Raising Awareness and Designing Behavioral Change Program (shown in Figure 8) could be given [44].

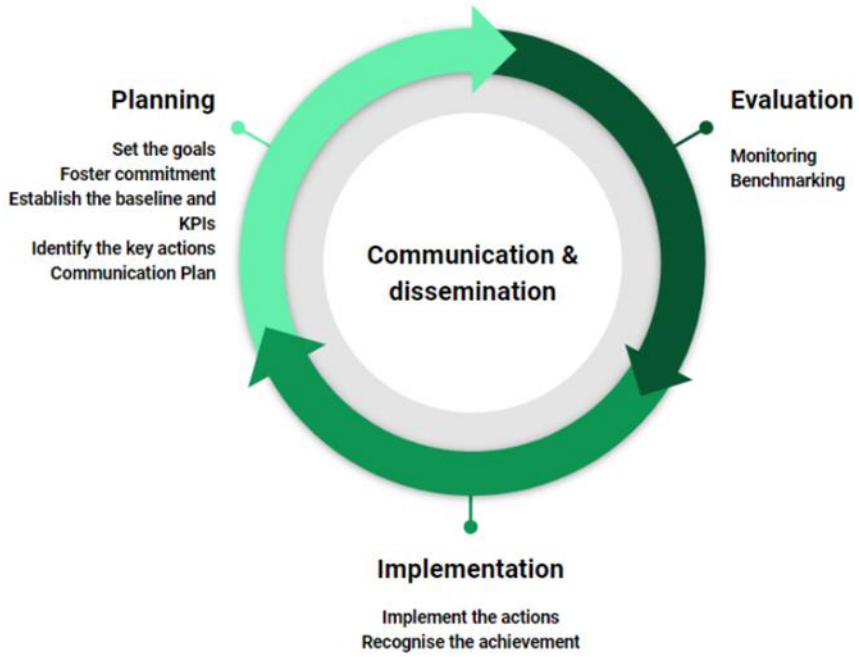


Figure 8. Main phases of an Energy Awareness Program (source: PrioritEE)

There are several municipalities in the MED area already implementing activities to raise capacity in EE. Among these activities, it could be highlighted the case of Osijek staff [17] whom are trained to enter energy consumption data for each PB into the national Information System for Energy Management, as well as to read the data of energy and water. In the other hand, in Mostar and Heraklion, personnel have been trained on EE regulations, methodologies for Energy audits and other EE issues.

Main considerations

From some references the following affirmations could be pointed [44]:

- Potential energy savings due to measures targeting behavior can vary among 5% and 20%.
- Emissions targets may be reached at lower costs if behavioral change would occur.
- An awareness program is a key tool that increases energy savings.
- A comprehensive energy management strategy should be defined to actively engage energy users.
- Competition and rewarding have proven effective in motivating energy users.
- Communication is key to achieving energy goals, supporting behavioral change and sharing success.
- Cooperation and networking are important to share goals and support capacity building.

Several studies have proven that the behavior of the building users can have a very negative impact on the energy performance of the building. On the other hand, this fact stands out that awareness, training and communication campaigns have a great potential in increasing energy savings at a low cost. Moreover, these campaigns are already being used in the private sector, in particular in buildings where the user is not in charge of the energy costs (e.g. office buildings). The campaigns have to be implemented regularly due to the staff renewal.

1.10.2. Indicators for Awareness, training and communication

In this transversal stage, it has been noticed a lack of measurable indicators mentioned by the MPs. Only the following two indicators listed in Table 13 were mentioned as indicators to be taken into account:

Table 13. Indicators for Awareness, training and communication stage (source; own elaboration)

Category	Subcategory	Indicator	Modular project Source
Other	Staff and training	Staff training plan	NEW FINANCE
Other	Staff and training	Degree of staff turnover	NEW FINANCE

1.11. Monitoring and Usage

This is the last stage of the Building Life Cycle. Here the building user and the building manager are in charge of the correct use of the building and its technologies.

In many cases there is a deviation between the expected and the real performance of a building or technology. This issue could appear because of several reasons like bad quality of design and construction, unexpected performance of a technology, but also due to an inappropriate use.

The monitoring of a building is crucial to identify the existence and reasons of the possible deviations, to calibrate technologies, to identify anomalies and to correct and improve the user behavior.

1.11.1. Methodologies for Monitoring and Usage

Monitoring and Usage is very relevant for the achievement of the initial objectives. On the one hand it is needed to verify the proper implementation of the initial planning, and on the other hand, it is needed to use properly the building and its installations. For this purpose, it is required the elaboration of a Measurement and Verification (M&V) plan.

Measurement and Verification (M&V) Plan

On this subject there is already extensive bibliography and reference protocols like the below mentioned IPMV [46].

An M&V Plan can contain the following aspects [38]:

- Introduction;
- Purpose of the Plan;
- Performance Monitoring and Verification Plan (PMVP) type chosen and boundaries of the measurement system;
- Baseline, period, energy and conditions of use;
- Monitoring period;
- Standardization of measures;
- Data Analysis;
- Energy price;
- Meter specifications;
- Other measurements and adjustments;
- Monitoring responsibility;
- Performance test and grace period;
- Expected accuracy;
- Monitoring budget;
- Activity report;
- Quality assurance; and
- Extraordinary adjustments of the PMVP.

Concerning the proof of energy savings during the usage phase when implementing an EPC, the International Performance Measurement and Verification Protocol (IPMVP) (DOE 2002), which is shown in Figure 9, provides internationally accepted concepts and options for determining energy and water savings. The IPMVP is used as reference protocol for EPC in some commercial buildings and industries, and some IPMVP rules would be applicable for PBs in Europe. Nevertheless, the IPMPV is perceived as a complex protocol.

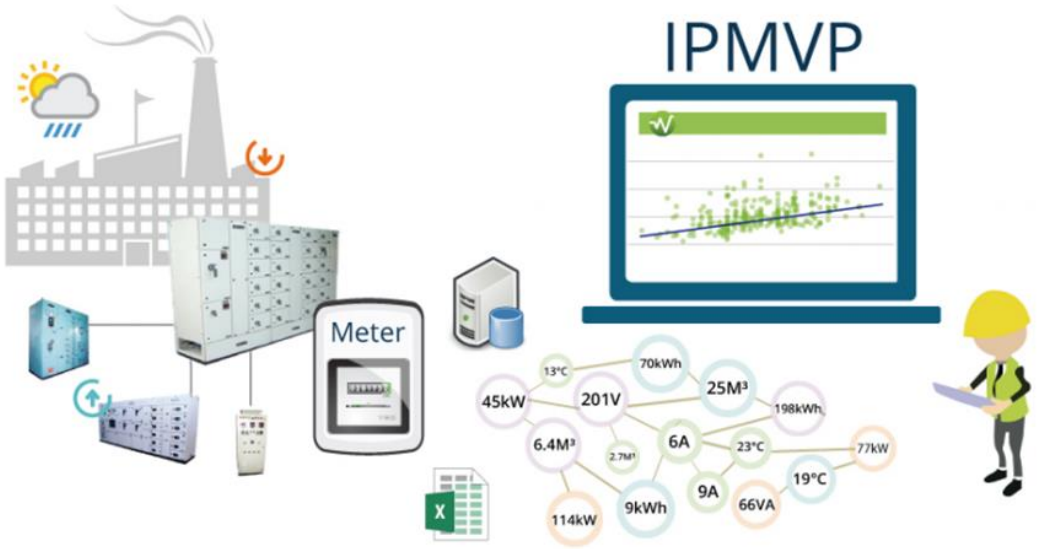


Figure 9. Internationial Performance Measurement and Verification Protocol (source; STEPPING)

There are three verification options:

- Option 1: Use measured value;
- Option 2: Measurement of individual power parameters in combination with operands;
- Option 3: Mathematical methods by using authorized M&V methods.

Specifically, for some type of uses, as the educational ones, the procedure for the management of PB can include the following points [11]:

- Establishment of an Energy Team (ET) supervising the data collection phase, as shown in Figure 10;
- Introduction of a methodology for collecting and archiving data to obtain an updated and detailed building file;
- Implementation of a consumption's monitoring plan;
- Introduction of an analytical phase of: usage profiles, users' behaviors, envelope and installations

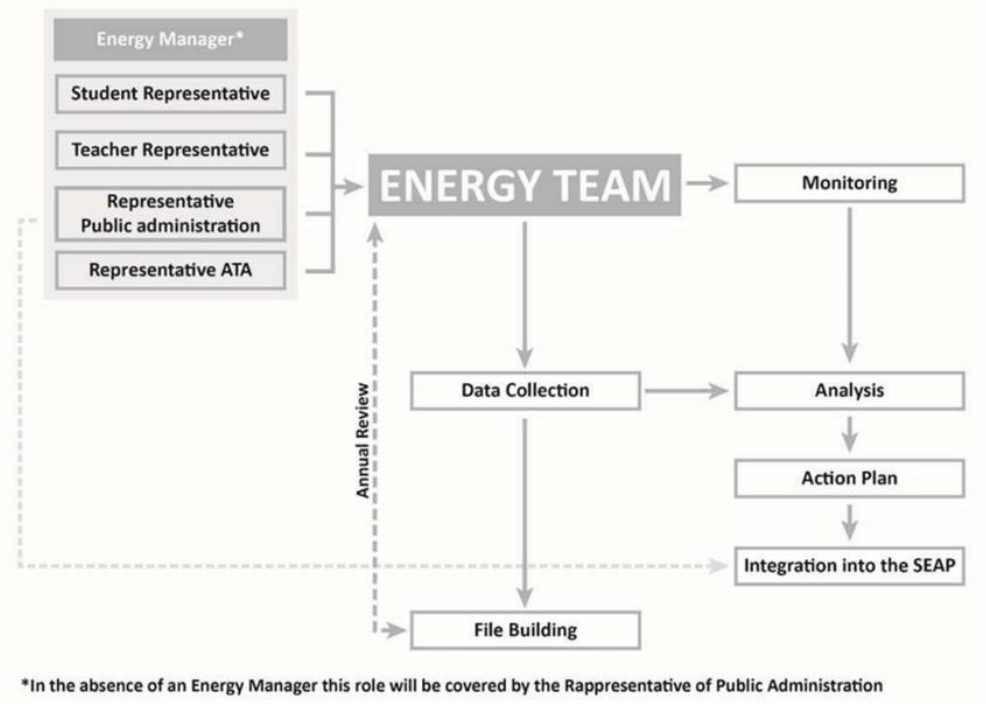


Figure 10. Energy Team composition (source: EduFootprint)

Moreover, the energy consumption of the PB stock can be implemented by [17]:

- Tracking energy bills,
- Monthly management review of the outcomes of the data analysis of invoices,
- External management service for both maintenance and calculation of energy consumption,
- Information System for Energy Management, where consumption is entered manually.

In this stage, as well as in the "Energy Audit" stage, the collection of comprehensive and reliable data is crucial and should be coherent with other related steps. An efficient, but easy to use, protocol and trained staff in form of Energy Team, able to track consumptions and anomalies, would contribute posetively to the achievement of the energy targets.

Recommendations in the monitoring and usage phase

In the maintenance and monitoring of EE interventions, there could be considered five main points to pay attention [10]:

- Identification of relevant indicators, setting of targets;
- Monitoring of implementation of EE plans and measures;
- Monitoring planning and procedures;
- Corrective measures and management of non-compliances and defaults;
- Long-term maintenance planning and management.

Besides, in the management of PBs they could be focus results on centralized energy management and ICT, concluding that [47]:

- ICT have an important role to play in reducing the energy intensity and increasing the EE of EU economy to help on the mitigation efforts to tackle climate change (CC) globally.
- Smart buildings deliver useful building services that make occupants productive at the lowest cost and environmental impact over the building's life-cycle.
- Centralized Building Energy Management System (BEMS) is computer-based control system that is connected to the building's mechanical and electrical equipment's such as heating, cooling, ventilation, lighting and even insulation and appliances, in addition to power systems, fire systems, and security systems.
- Smart meters can record and report energy use information automatically. The information can then be sent on a daily, hourly or real-time basis to all actors involved, so that they can analyze it, take appropriate measures, etc.
- Microgrids control methods are categorized into three major groups: centralized, decentralized and distributed control methods.

The large number of supporting material elaborated by MPs on the "Monitoring and Usage" stage demonstrates the relevance of this phase for the performance of PBs. PA need not only standards, protocols and trained staff, but also user awareness and utilization of new technologies and new approaches like BEMS.

Bringing innovation to the PA is a future and a present challenge.

1.1.1. Indicators for Monitoring and Usage

"Monitoring and Usage" and "Planning" stages are probably the building phases that require more measurable indicators, most of them linked too to some of the other process steps. As mentioned above, "Planning" requires to estimate the future performance of the building, but sometimes the estimated performances differ from the real ones. The identification of this deviation has to be done in the monitoring phase in order to identify and correct anomalies, or change specific behaviors of the building occupants.

The MED projects selected the following Indicators in Table 14, which can particularly be relevant for the Monitoring and Usage phase:

Table 14. Indicators for Monitoring and Usage stage (souce: own elaboration)

Category	Subcategory	Indicator	Modular project Source
Energy	Energy per uses	Monthly Primary Energy consumption for heating	TEESCHOOLS
Energy	Energy per uses	Total annual primary energy consumption for Heating and DHW	PrioritEE
Energy	Energy per uses	Ratio Primary Energy consumption and total heating volumes	STEPPING
Energy	Energy per uses	Annual final energy consumption for heating	IMPULSE, PrioritEE, SHERPA, ENERJ, STEPPING, TEESCHOOL
Energy	Energy per uses	Annual final energy consumption for cooling	IMPULSE, PrioritEE, ENERJ, STEPPING
Energy	Energy per uses	Annual final energy consumption for DHW	IMPULSE, STEPPING
Energy	Energy per uses	Annual final energy consumption for lighting	IMPULSE, PrioritEE, STEPPING
Energy	Energy per uses	Annual Final Energy Savings for space heating	IMPULSE
Energy	Energy per uses	Annual Final Energy Savings for space cooling	IMPULSE
Energy	Energy per uses	Annual Final Energy Savings for DHW	IMPULSE
Energy	Energy per uses	Annual Final Energy Savings for lighting	IMPULSE
Energy	Energy source	Monthly electricity consumption	TEESCHOOLS
Energy	Energy source	Monthly Primary Energy for electricity consumption	TEESCHOOLS
Energy	Energy source	Total heat Consumption	PrioritEE, STEPPING
Energy	Energy source	Annual electricity consumption	IMPULSE, PrioritEE, SHERPA, EduFootprint, ENERJ, NEW FINANCE, TEESCHOOL
Energy	Energy source	Annual consumption of fossil fuel	IMPULSE, EduFootprint, NEW FINANCE, STEPPING, TEESCHOOLS, SHERPA
Energy	Energy source	Annual electricity savings	IMPULSE, SHERPA
Energy	Energy source	Annual savings of fossil fuel consumption	IMPULSE, SHERPA

Category	Subcategory	Indicator	Modular project Source
Energy	Global energy consumption	Total annual primary energy consumption	IMPULSE, STEPPING
Energy	Global energy consumption	Daily energy consumption	SHERPA
Energy	Global energy consumption	Monthly energy consumption	SHERPA
Energy	Global energy consumption	Annual Final Energy consumption	TEESCHOOLS
Energy	Global energy consumption	Total annual primary energy savings	IMPULSE, PrioritEE
Energy	Global energy consumption	Annual energy savings	PrioritEE, STEPPING
Energy	Other indicators	Efficiency of a technology	PrioritEE
Energy	Other indicators	Power of installations	PrioritEE
Energy	Other indicators	Weekly type hours of occupation	PrioritEE, STEPPING
Energy	Other indicators	Monthly occupation	NEW FINANCE
Energy	Other indicators	Indoor Winter Heating Temperature	ENERJ, NEW FINANCE, STEPPING
Energy	Other indicators	Indoor Temperature Cooling	ENERJ, NEW FINANCE, STEPPING
Energy	Other indicators	Average number of people per square meter	ENERJ
Energy	Other indicators	Contribution of internal heat	ENERJ
Energy	Other indicators	Renewal fresh air	ENERJ
Energy	Other indicators	Total Hot Water Consumption	PrioritEE
Energy	Other indicators	Total Water consumption	NEW FINANCE
Energy	Other indicators	Total power of existing heating system	PrioriTEE
Energy	Renewable energy	Electricity consumption from certified clean energy	EduFootprint
Energy	Renewable energy	Electricity consumption from self-produced renewable energy	EduFootprint
Energy	Renewable energy	Annual generation of Renewable Energy	IMPULSE, PrioritEE, EduFootprint, ENERJ, STEPPING

Category	Subcategory	Indicator	Modular project Source
Energy	Renewable energy	Annual generation of Solar thermal Energy	ENERJ, SHERPA
Energy	Renewable energy	Annual generation of Photovoltaic systems	ENERJ, STEPPING, SHERPA
Energy	Renewable energy	Annual generation of Biomass systems	ENERJ
Energy	Renewable energy	Annual generation of gethermal systems	ENERJ
Energy	Renewable energy	Self-produced energy	EduFootprint
Energy	Renewable energy	Annual increase of Renewable Energy generation	IMPULSE, PrioritEE
Energy	Renewable energy	Energy generation of PV panels	PrioritEE
Energy	Thermal comfort	Annual occupancy hours in which PMV is retained in the range (-0.7 to 0.7)	IMPULSE
Energy	Thermal comfort	Increase of annual occupancy hours in which PMV is retained in the range (-0.7 to 0.7)	IMPULSE
Energy	Thermal comfort	Hourly-averaged PMV value on a hot summer day of the year	IMPULSE
Energy	Thermal comfort	Improvement of hourly-averaged PMV value on a hot summer day of the year	IMPULSE
Energy	Thermal comfort	Hourly-averaged PMV value on a typical winter day of the year	IMPULSE
Energy	Thermal comfort	Improvement of hourly-averaged PMV value on a typical winter day of the year	IMPULSE
Energy	Thermal comfort	Number of hours of overheating in the year	IMPULSE
Energy	Thermal comfort	Reduction of number of hours of overheating in the year	IMPULSE
Energy	Thermal comfort	Minimum winter indoor temperature (°C)	IMPULSE
Energy	Thermal comfort	Increase of minimum winter indoor temperature (°C)	IMPULSE
Energy	Thermal comfort	Maximum summer indoor temperature (°C)	IMPULSE
Energy	Thermal comfort	Reduction of maximum summer indoor temperature (°C)	IMPULSE

Category	Subcategory	Indicator	Modular project Source
Environmental	CO_2 emissions	Total annual CO2 emissions	IMPULSE, PrioritEE, SHERPA
Environmental	CO_2 emissions	Total monthly CO2 emissions	TEESCHOOLS
Environmental	CO_2 emissions	Total monthly CO2 emissions for electricity consumption	TEESCHOOLS
Environmental	CO_2 emissions	Total monthly CO2 emissions from fossil fuels consumption	TEESCHOOLS
Environmental	CO_2 emissions	Annual CO2 emissions from electricity consumption	IMPULSE, TEESCHOOLS
Environmental	CO_2 emissions	Annual CO2 emissions from fossil fuels consumption	IMPULSE, TEESCHOOLS
Environmental	CO_2 emissions	Total annual avoided CO2 emissions	IMPULSE, PrioritEE, NEW FINANCE, STEPPING, TEESCHOOLS
Environmental	CO_2 emissions	Annual CO2 emissions avoided from electricity consumption	IMPULSE
Environmental	CO_2 emissions	Annual CO2 emissions avoided from fossils fuels consumption	IMPULSE
Environmental	CO_2 emissions	Climate Change	EduFootprint
Environmental	Indoor Environmental quality	Ecotoxicity for aquatic fresh water	EduFootprint
Environmental	Indoor Environmental quality	Human toxicity- cancer effect	EduFootprint
Environmental	Indoor Environmental quality	Human toxicity- non cancer effect	EduFootprint
Environmental	Indoor Environmental quality	Particulate matter / respiratory inorganics	EduFootprint
Environmental	Indoor Environmental quality	Ionising radiations – human health effects	EduFootprint
Environmental	Indoor Environmental quality	Acidification	EduFootprint
Environmental	Indoor Environmental quality	Eutrophication – terrestrial	EduFootprint
Environmental	Indoor Environmental quality	Eutrophication – aquatic freshwater	EduFootprint
Environmental	Indoor Environmental quality	Eutrophication – marine	EduFootprint
Environmental	Indoor Environmental quality	Resource depletion – water use	EduFootprint
Environmental	Indoor Environmental quality	Resource depletion – mineral, fossil & renewable	EduFootprint

Category	Subcategory	Indicator	Modular project Source
Environmental	Indoor Environmental quality	Occupancy hours in which breathingzone pollutants is below maximum allowed	IMPULSE
Environmental	Indoor Environmental quality	Increase of occupancy hours in which breathingzone pollutants is below maximum allowed	IMPULSE
Environmental	Other emissions	Annual GHG emissions avoided	IMPULSE
Environmental	Other environmental effects	Ozone depletion	EduFootprint
Environmental	Other environmental effects	Photochemical ozone formation	EduFootprint
Environmental	Other environmental effects	Land transformation	EduFootprint
Economic	Costs savings	Annual savings of total energy-related operational cost	IMPULSE, PrioritEE, NEW FINANCE, SISMA, STEPPING, TEESCHOOLS, SHERPA
Economic	Costs savings	Annual electricity cost savings	IMPULSE, NEW FINANCE, SHERPA, TEESCHOOLS
Economic	Costs savings	Annual fossil fuel cost savings	IMPULSE, NEW FINANCE, SHERPA, TEESCHOOLS
Economic	Costs savings	Water Savings	NEW FINANCE
Economic	Energy costs	Annual total energy-related operational cost	IMPULSE, STEPPING
Economic	Energy costs	Monthly electricity cost	TEESCHOOLS
Economic	Energy costs	Annual electricity cost	IMPULSE
Economic	Energy costs	Total Electricity cost for space cooling	PrioritEE
Economic	Energy costs	Annual fossil fuel cost	IMPULSE
Economic	Energy costs	Monthly fossil fuel cost	TEESCHOOLS
Other	Lyfe cycle	Compliance with the preventive maintenance	NEW FINANCE
Other	Lyfe cycle	Compliance with the response time during the on-call service	NEW FINANCE

Category	Subcategory	Indicator	Modular project Source
Other	Lyfe cycle	Waste Management	NEW FINANCE
Other	Lyfe cycle	Incidents	NEW FINANCE
Other	Lyfe cycle	Quality Control Audit	NEW FINANCE
Other	Staff and training	Staff training plan	NEW FINANCE
Other	Staff and training	Degree of staff turnover	NEW FINANCE

In the “Monitoring and usage” stage is happening the same situation as in the “Planning” stage, there is a plenty number of indicators assessing the same issue. Nonetheless, in this stage it can be also assessed the internal comfort of the building occupants by indicators like “Annual occupancy hours in which PMV is retained in the range (-0.7 to 0.7)” or “Reduction of number of hours of overheating in the year”.

This stage could use also indicators for assessing energy costs, RE production or waste generation.

2. Cross-analysis of indicators

When it comes to EE projects, there are innumerable list of indicators produced by research projects and other initiatives. In this context, selecting the most appropriate ones and using them properly become a real challenge for the PAs who want develop EE projects in the most effective way and for the different process steps' (as shown in the previous chapter).

In the analysis of the 10 MPs here implemented, 151 indicators were identified as possible useful indicators. Some of they were very recurrent among the results of the projects.

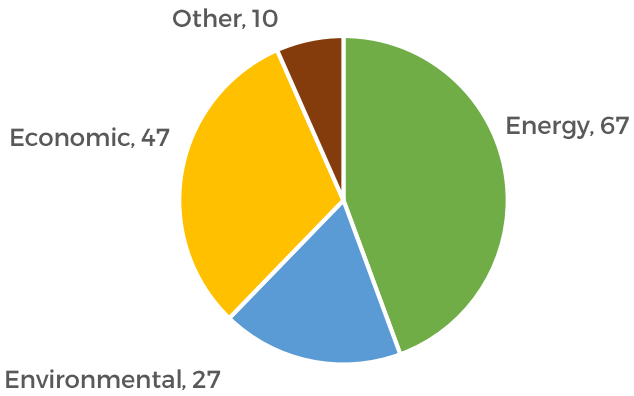
It is recommended for PAs with low resources and availability of data to select adequate Key Performance Indicators in order to find the right balance between importance and effort.

It has to be mentioned that even a MP [48] has the objective of identifying, analyzing and selecting existing indicators for transforming sustainable buildings and neighborhoods. From there, in such a case they have been identified 216 indicators, while the analyzed MPs mentioned 151, including indicators which can be unified since they assess the same issue with different unit. It is understood that this specific project [48] would analyze a wide range of existing indicators, while the MPs, which aim is not to analyze indicators, would focus only on these indicators interesting for their own purpose, being thus more pragmatic and less exhaustive.

In order to facilitate the reader's comprehension, it has been decided to introduce the key indicators related to the different process steps (see previous chapter 1.). Nevertheless, in this chapter 2. , a global and summarized vision is performed, in order to focus all this information at a glance.

2.1. Type of indicators

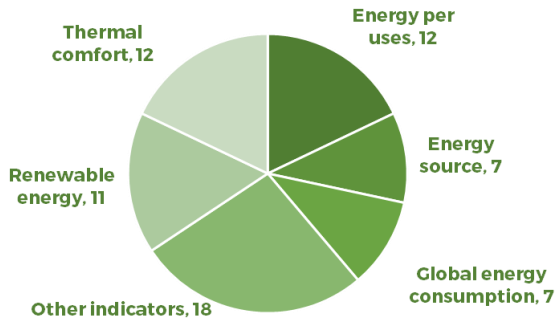
In order to classify the 151 MP final indicators in line with the main topics of the MPs, 4 categories were defined, as shown in Graph 2.



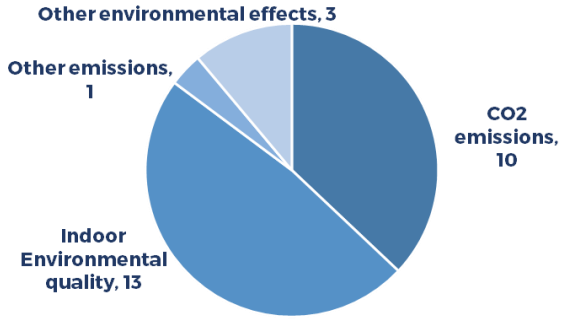
Graph 2. Number of indicators by categories (source: own elaboration)

In the case of the Energy indicators, they can be included within the category of Environmental indicators, but a separated category has been created due to its relevance within the MPs.

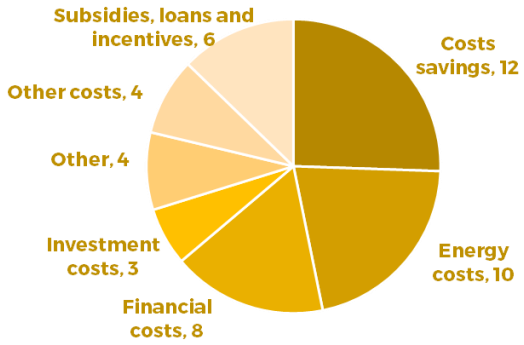
For the different categories of indicators, in order to be more precise, other subcategories are possible as shown in Graph 3, Graph 4, Graph 5 and Graph 6.



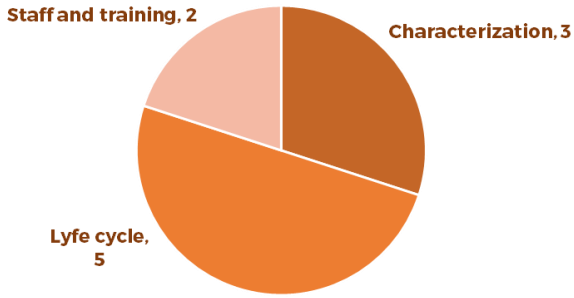
Graph 3. Subcategories of Energy Indicators (source: own elaboration)



Graph 4. Subcategories of Environmental Indicators (source: own elaboration)



Graph 5. Subcategories of Economic Indicators (source: own elaboration)



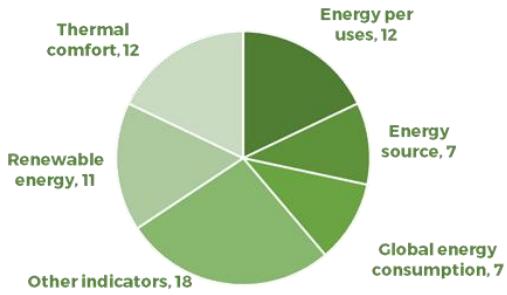
Graph 6. Subcategories of Other Indicators (source: own elaboration)

Concerning the subcategories, it can be noticed that some of them collect a relatively large number of indicators. More concretely, in the Energy issue there are numerous indicators for the different energy uses, thermal comfort and Renewable Energy production. Concerning the Environmental issue, most of the indicators are related to Indoor Environmental Quality (IEQ) and CO_2 emissions. While in the Financing issue, it is relevant the large number of indicators allocated in costs savings and energy costs.

Sometimes, especially in the main categories, the indicators are equivalents but they are given with different procedure of calculation (e.g. annual consumption versus daily consumption).

An integrated compilation of all mentioned Indicators classified by category and subcategory are shown in Graph 3, Graph 4, Graph 5, Graph 6, Table 15,

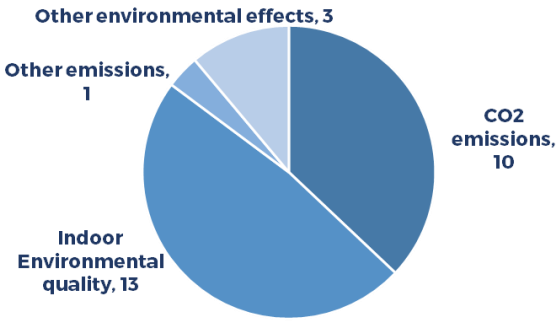
Table 16, Table 17 and Table 18.



Graph 3. Subcategories of Energy Indicators (source: own elaboration)

Table 15. Modular Projects' Indicators by Energy category (source: own elaboration)

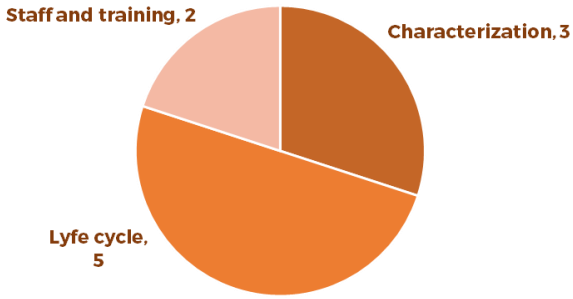
	Indicator	Modular Project
ENERGY PER USES	Monthly Primary Energy consumption for heating	TEESCHOOLS
	Total annual primary energy consumption for Heating and DHW	PrioritEE
	Ratio Primary Energy consumption and total heating volumes	STEPPING
	Annual final energy consumption for heating	IMPULSE, PrioritEE, SHERPA, ENERJ, STEPPING, TEESCHOOLS
	Annual final energy consumption for cooling	IMPULSE, PrioritEE, ENERJ, STEPPING
	Annual final energy consumption for DHW	IMPULSE, STEPPING
	Annual final energy consumption for lighting	IMPULSE, PrioritEE, STEPPING
	Total cooling demand	PrioritEE
	Annual Final Energy Savings for space heating	IMPULSE, PrioritEE
	Annual Final Energy Savings for space cooling	IMPULSE, PrioritEE
	Annual Final Energy Savings for DHW	IMPULSE, PrioritEE
	Annual Final Energy Savings for lighting	IMPULSE, PrioritEE
ENERGY SOURCE	Monthly electricity consumption	TEESCHOOLS
	Monthly Primary Energy for electricity consumption	TEESCHOOLS
	Total heat Consumption	PrioritEE, STEPPING
	Annual electricity consumption	IMPULSE, PrioritEE, SHERPA, EduFootprint, ENERJ, NEW FINANCE, TEESCHOOLS
	Annual consumption of fossil fuel	IMPULSE, EduFootprint, NEW FINANCE, STEPPING, TEESCHOOLS, SHERPA
	Annual electricity savings	IMPULSE, SHERPA
	Annual savings of fossil fuel consumption	IMPULSE, SHERPA
GLOBAL ENERGY CONSUMPTION	Total annual primary energy consumption	IMPULSE, STEPPING
	Daily energy consumption	SHERPA
	Monthly energy consumption	SHERPA
	Annual Final Energy consumption	TEESCHOOLS
	Energy consumption Baseline	SISMA
	Total annual primary energy savings	IMPULSE, PrioritEE
	Annual energy savings	PrioritEE, STEPPING
OTHER INDICATORS	Thermal transmittance	PrioritEE, TEESCHOOLS, SHERPA
	Efficiency of a technology	PrioritEE
	Power of installations	PrioritEE
	Weekly type hours of occupation	PrioritEE, STEPPING
	Monthly occupation	NEW FINANCE
	Indoor Winter Heating Temperature	ENERJ, NEW FINANCE, STEPPING
	Indoor Temperature Cooling	ENERJ, NEW FINANCE, STEPPING
	Average number of people per square meter	ENERJ
	Heated Volume	STEPPING
	Contribution of internal heat	ENERJ
	Renewal fresh air	ENERJ
	Total Hot Water Consumption	PrioritEE
	Total Water consumption	NEW FINANCE
	Total Heat Losses	PrioriTEE
	Heat Losses for the Outside (Ht)	PrioriTEE
	Heat Losses in the distribution network	PrioriTEE
	Ventilation Losses	PrioriTEE
	Total power of existing heating system	PrioriTEE
RENEWABLE ENERGY	Electricity consumption from certified clean energy	EduFootprint
	Electricity consumption from self-produced renewable energy	EduFootprint
	Annual generation of Renewable Energy	IMPULSE, PrioritEE, EduFootprint, ENERJ, STEPPING
	Annual generation of Solar thermal Energy	ENERJ, SHERPA
	Annual generation of Photovoltaic systems	ENERJ, STEPPING, SHERPA
	Annual generation of Biomass systems	ENERJ
	Annual generation of gethermal systems	ENERJ
	Self-produced energy	EduFootprint
	Annual increase of Renewable Energy generation	IMPULSE, PrioritEE
	Solar Hot Water Energy needs	PrioriTEE
	Energy generation of PV panels	PrioritEE
THERMAL COMFORT	Annual occupancy hours wtih PMV in the range (-0.7 to 0.7)	IMPULSE
	Increase of annual occupancy hours wtih PMV in the range (-0.7 to 0.7)	IMPULSE
	Hourly-averaged PMV value on a hot summer day of the year	IMPULSE
	Improvement of hourly-averaged PMV value on a hot summer day	IMPULSE
	Hourly-averaged PMV value on a typical winter day of the year	IMPULSE
	Improvement of hourly-averaged PMV value on a typical winter day	IMPULSE
	Number of hours of overheating in the year	IMPULSE
	Reduction of number of hours of overheating in the year	IMPULSE
	Minimum winter indoor temperature (°C)	IMPULSE
	Increase of minimum winter indoor temperature (°C)	IMPULSE
	Maximum summer indoor temperature (°C)	IMPULSE
	Reduction of maximum summer indoor temperature (°C)	IMPULSE



Graph 4. Subcategories of Environmental Indicators (source: own elaboration)

Table 16. Modular Projects' Indicators by Environment category (source: own elaboration)

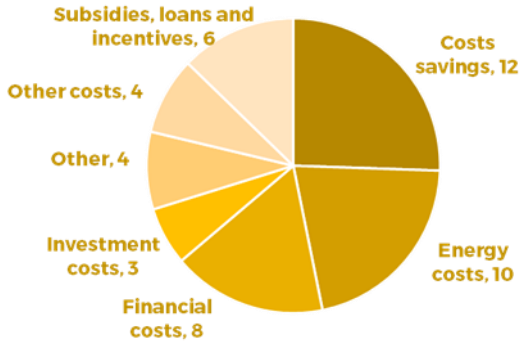
	Indicator	Modular Project
CO2 EMISSIONS	Total annual CO_2 emissions	IMPULSE, PrioritEE, SHERPA
	Total monthly CO_2 emissions	TEESCHOOLS
	Total monthly CO_2 emissions for electricity consumption	TEESCHOOLS
	Total monthly CO_2 emissions from fossil fuels consumption	TEESCHOOLS
	Annual CO_2 emissions from electricity consumption	IMPULSE, TEESCHOOLS
	Annual CO_2 emissions from fossil fuels consumption	IMPULSE, TEESCHOOLS
	Total annual avoided CO_2 emissions	IMPULSE, PrioritEE, NEW FINANCE, STEPPING, TEESCHOOLS
	Annual CO_2 emissions avoided from electricity consumption	IMPULSE
	Annual CO_2 emissions avoided from fossils fuels consumption	IMPULSE
	Climate Change	EduFootprint
INDOOR ENVIRNMENTAL QUALITY	Ecotoxicity for aquatic fresh water	EduFootprint
	Human toxicity- cancer effect	EduFootprint
	Human toxicity- non cancer effect	EduFootprint
	Particulate matter / respiratory inorganics	EduFootprint
	Ionising radiations - human health effects	EduFootprint
	Acidification	EduFootprint
	Eutrophication - terrestrial	EduFootprint
	Eutrophication - aquatic freshwater	EduFootprint
	Eutrophication - marine	EduFootprint
	Resource depletion - water use	EduFootprint
	Resource depletion - mineral, fossil & renewable	EduFootprint
	occupancy hours breathingzone pollutants retained below maximum allowed	IMPULSE
	increase of occupancy hours breathingzone pollutants retained below maximum allowed	IMPULSE
O	Annual GHGemissions avoided	IMPULSE
OEE	Ozone depletion	EduFootprint
	Photochemical ozone formation	EduFootprint
	Land transformation	EduFootprint



Graph 6. Subcategories of Other Indicators (source: own elaboration)

Table 17. Modular Projects' Indicators by Other category (source: own elaboration)

	Indicator	Modular Project
CHAR.	Surface of External Wall for renovation	PrioritEE, SHERPA
	Surface of External Windows for renovations	PrioritEE, SHERPA
	Number of lightbulbs	PrioritEE
LYFE CYCLE	Compliance with the preventive maintenance	NEW FINANCE
	Compliance with the response time during the on-call service	NEW FINANCE
	Waste Management	NEW FINANCE
	Incidents	NEW FINANCE
	Quality Control Audit	NEW FINANCE
S&T	Staff training plan	NEW FINANCE
	Degree of staff turnover	NEW FINANCE



Graph 5. Subcategories of Economic Indicators (source: own elaboration)

Table 18. Modular Projects' Indicators by Economy category (source: own elaboration)

	Indicator	Modular Project
COSTS SAVINGS	Value of EPC contract	STEPPING
	Sharing savings	STEPPING
	Simple Payback period for each renovation scenario	IMPULSE, PrioritEE, STEPPING, SHERPA
	Return period on Investment	PrioritEE, STEPPING
	Internal Rate of Return	SISMA, STEPPING, SHERPA
	Net Present Value	SISMA, STEPPING
	Net Profit ratio	STEPPING
	Cash Flow	SISMA
	Annual savings of total energy-related operational cost	IMPULSE, PrioritEE, NEW FINANCE, SISMA, STEPPING, TEESCHOOLS, SHERPA
	Annual electricity cost savings	IMPULSE, NEW FINANCE, SHERPA, TEESCHOOLS
	Annual fossil fuel cost savings	IMPULSE, NEW FINANCE, SHERPA, TEESCHOOLS
	Water Savings	NEW FINANCE
ENERGY COSTS	Annual total energy-related operational cost	IMPULSE, STEPPING
	Monthly electricity cost	TEESCHOOLS
	Annual electricity cost	IMPULSE
	Total Electricity cost for space cooling	PrioritEE
	Annual fossil fuel cost	IMPULSE
	Monthly fossil fuel cost	TEESCHOOLS
	Energy supply fee	STEPPING
	Initial Energy Costs (baseline)	STEPPING, SHERPA
	Electricity Price	NEW FINANCE, SISMA, STEPPING, SHERPA
	Natural Gas Price	NEW FINANCE, SISMA, STEPPING, SHERPA
FINANCIAL COSTS	Financial fee	STEPPING
	Incoming Fee	STEPPING
	Incoming equity	STEPPING
	Value-Added Tax	STEPPING
	Rate of co-financing	ENERJ
	Debt Service Cover Ratio	SISMA
	Interest rate	STEPPING
	Annual financial savings	PrioritEE
INVESTMENT	Total investment cost for each renovation scenario	IMPULSE, PrioritEE, SHERPA, SISMA, STEPPING, TEESCHOOLS
	Total investment cost per total annual energy saved	IMPULSE
	Cost of materials	PrioritEE
OTHER	Number of Buildings (bundled EPC)	STEPPING
	Number of EEM registered	SHERPA
	ESC Contract duration	STEPPING
	Water Price	NEW FINANCE, SISMA, STEPPING
OTHER COSTS	Administrative and management fee	STEPPING
	Works costs	STEPPING
	Operation and Maintenance fee	STEPPING
	Professional fee	STEPPING
SUBSIDIES, LOANS, INV	Incoming incentives schemes	STEPPING
	Incoming Loans	STEPPING
	Loan by the Public Body	STEPPING
	Available public funding/incentives	STEPPING
	Subsidy	SISMA
	Loan Life Cover Ratio	SISMA

2.2. Recurrent indicators

From the previously introduced, there are 13 indicators which are mentioned at least by 4 MPs and, because of that, should be specifically emphasized. These are shown in Table 19:

Table 19. Recurrent Indicators by Modular Projects (source: own elaboration)

Category	Subcategory	Indicator	Modular project Source
Energy	Energy per uses	Annual final energy consumption for heating	IMPULSE, PrioritEE, SHERPA, ENERJ, STEPPING, TEESCHOOL
Energy	Energy per uses	Annual final energy consumption for cooling	IMPULSE, PrioritEE, ENERJ, STEPPING
Energy	Energy source	Annual electricity consumption	IMPULSE, PrioritEE, SHERPA, EduFootprint, ENERJ, NEW FINANCE, TEESCHOOL
Energy	Energy source	Annual consumption of fossil fuel	IMPULSE, EduFootprint, NEW FINANCE, STEPPING, TEESCHOOLS, SHERPA
Energy	Renewable energy	Annual generation of Renewable Energy	IMPULSE, PrioritEE, EduFootprint, ENERJ, STEPPING
Environmental	CO_2 emissions	Total annual avoided CO2 emissions	IMPULSE, PrioritEE, NEW FINANCE, STEPPING, TEESCHOOLS
Economic	Costs savings	Annual savings of total energy-related operational cost	IMPULSE, PrioritEE, NEW FINANCE, SISMA, STEPPING, TEESCHOOLS, SHERPA
Economic	Costs savings	Annual electricity cost savings	IMPULSE, NEW FINANCE, SHERPA, TEESCHOOLS
Economic	Costs savings	Annual fossil fuel cost savings	IMPULSE, NEW FINANCE, SHERPA, TEESCHOOLS
Economic	Costs savings	Simple Payback period for each renovation scenario	IMPULSE, PrioritEE, STEPPING, SHERPA
Economic	Energy costs	Electricity Price	NEW FINANCE, SISMA, STEPPING, SHERPA
Economic	Energy costs	Natural Gas Price	NEW FINANCE, SISMA, STEPPING, SHERPA
Economic	Investment costs	Total investment cost for each renovation scenario	IMPULSE, PrioritEE, SHERPA, SISMA, STEPPING, TEESCHOOLS

Heating, Cooling and Electricity consumption (Energy), and their equivalent indicator on costs (Economic) are clearly particular matters taken into account by the MPs. Besides, in the Environmental category it appears the CO_2 emissions, which actually is a mandatory indicator when implementing a SEAP or SECAP and is usually the key indicator for the building certification mandatory procedures.

On the other hand, it could be strangely noticed that the indicator of PE is been mentioned but it is not among the most mentioned ones, even it is a compulsory indicator used in the national transposition of the EPBD for the definition of nZEB.

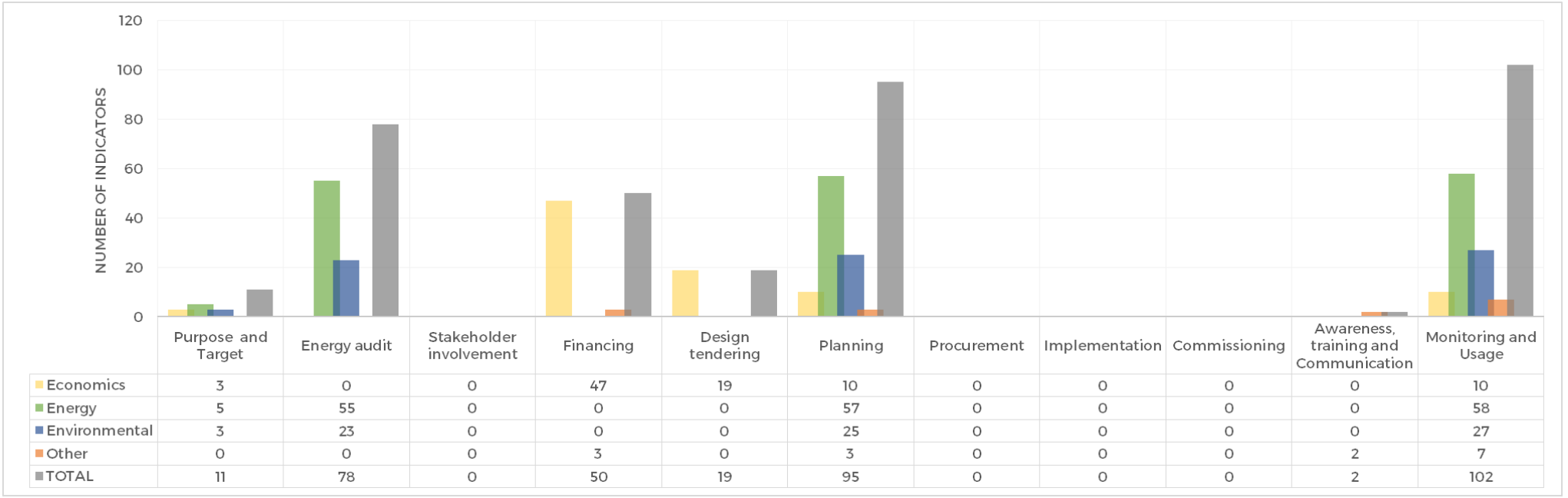
Other recurrent indicators, but not included in this list, were related to indoor comfort indicators.

It has to be emphasized that some issues are recurrent, but they are not reflected in this list due to the existence of different indictors used to approach the same aspect. This is the case of profitability, which can be assessed by indicators like NPV, IRR or Simple payback period.

2.3. Lack of indicators

Looking at the different EE project stages, it is evidenced the lack of indicators for Stakeholders involvement, Procurement, Implementation, Commissioning, and Awareness, training and communication, as shown in Graph 7.

For some cases (procurement and commissioning), these lack of specific indicators is mainly due to the MP reference on existing and well established methodologies (i.e. the IPMVP protocol), which introduce their own indicators. Nevertheless, for some other steps (Stakeholders' involvement and Awareness, training and communication), the lack of introduced indicators could become a real constrain on these steps and could result in a real delimiting of the overall process. Because of this, it is strongly recommended to define, for these steps, specific indicators which helps to establish reliable goals and monitor the success.



	Purpose and Target	Energy audit	Stakeholder involvement	Financing	Design tendering	Planning	Procurement	Implementation	Commissioning	Awareness, training and Communication	Monitoring and Usage
Economics	3	0	0	47	19	10	0	0	0	0	10
Energy	5	55	0	0	0	57	0	0	0	0	58
Environmental	3	23	0	0	0	25	0	0	0	0	27
Other	0	0	0	3	0	3	0	0	0	2	7
TOTAL	11	78	0	50	19	95	0	0	0	2	102

Graph 7. Indicators developed by Modular Projects by building project stages (source: own elaboration)

3. Catalog of Tools

The implementation of the above mentioned stages of an EE project by a PA require guidelines and detailed methodologies, staff with the right capacities and effective supporting tools. Regarding this last aspect, the MPs have elaborated several tools aiming at helping PA in implementing their EE projects.

The following 15 analyzed tools elaborated by the MPs cover 6 out of the 11 stages of EE Projects, as shown in Table 20 and Figure 11.

Table 20. Tools developed by Modular Projects by building project stages (source: own elaboration)

PROJECTS AND TOOLS BY BUILDING STAGES	Purpose & Target	Energy audit	Stakeholders' involvement	Financing	Design tendering	Planning	Procurement	Implementation	Commissioning	Awareness, training & Comm.	Monitoring & usage
IMPULSE – MyGIS	■	■		■							
IMPULSE – Building typologies and performance indicators platform	■	■		■							
IMPULSE – Networking Forum										■	
IMPULSE – Financial scheme evaluation tool for gradual building energy renovation planning				■							
PrioritEE Analytic Database		■		■		■					
PrioritEE – Decision Support Tool		■		■		■					
EduFootprint – EduFootprint Calculator						■				■	
EduFootprint – EduFootprint Platform						■				■	
TEESCHOOLS – Pre-audit web tool and Best Available Techniques Database	■	■				■					
NEW FINANCE – NEW FINANCE Platform			■	■						■	
SISMA – SISMA SET TOOL				■						■	
STEPPING – STEPPING EPC Simulation Tool				■							
SHERPA – Funding tool	■	■		■		■					
SHERPA – Information System tool	■	■				■					
ENERJ Web platform	■	■				■				■	

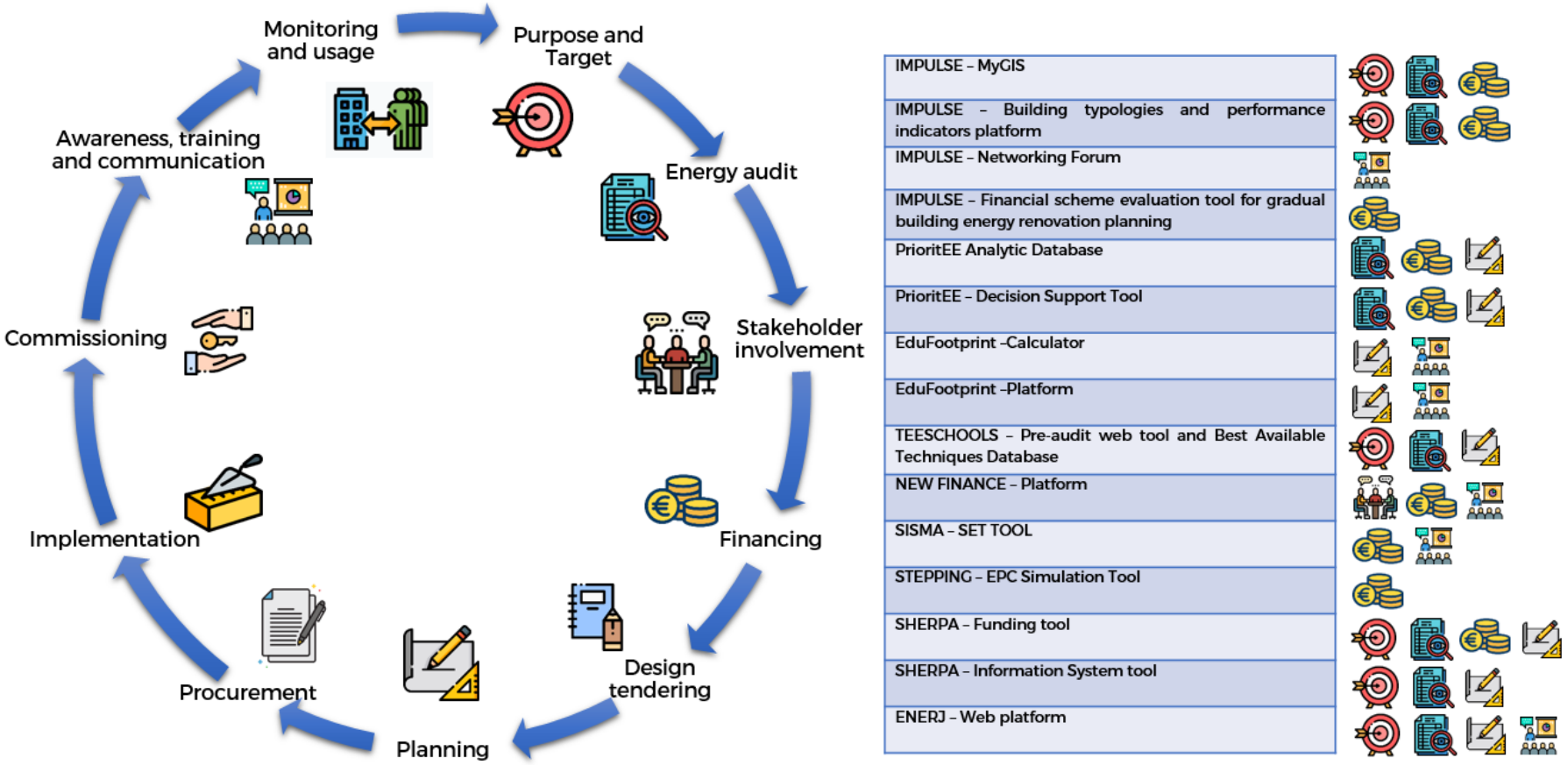
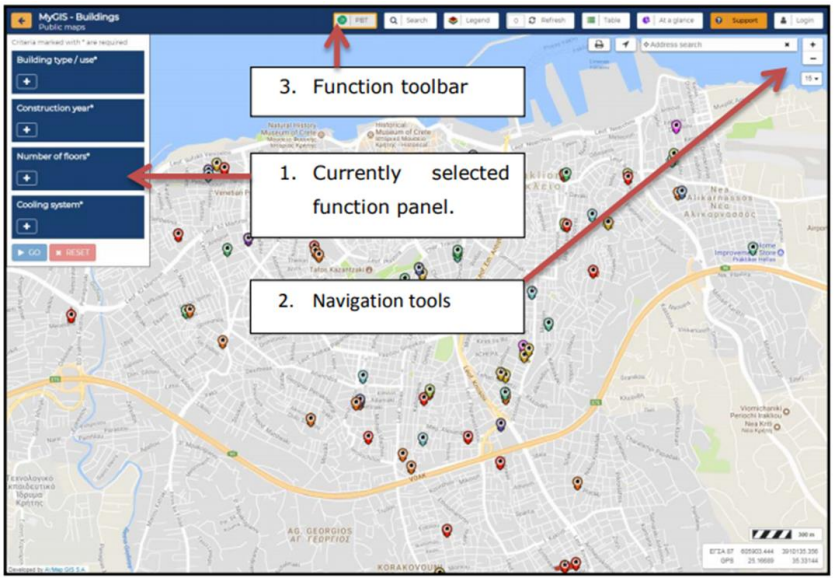


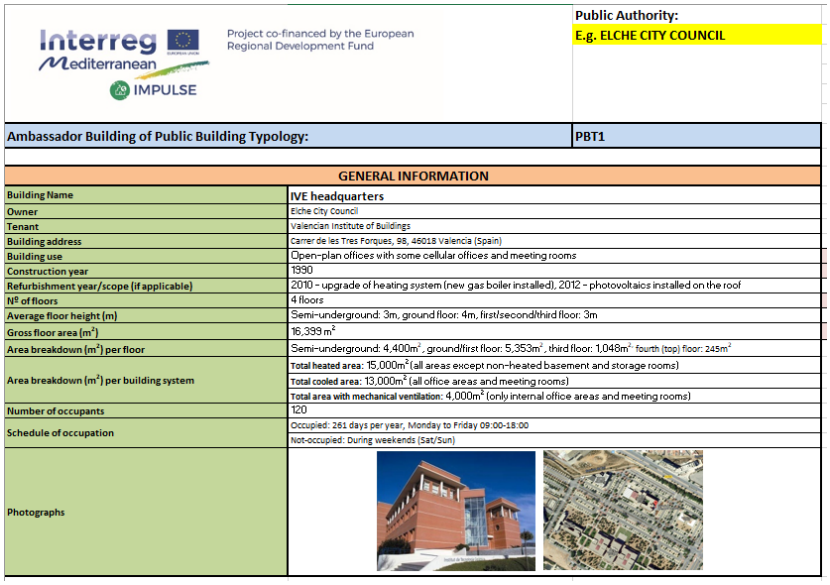
Figure 11. Tools developed by Modular Projects by building project stages (source: own elaboration)

In the case of tools developed by the MPs, the uncovered stages are Design tendering, Procurement, Implementation, Commissioning, and Monitoring and Usage.

Beyond that for some stages it would be comprehensive the inexistence of new MP developed tools (considering the scope or the market existing ones), it should be emphasized that Procurement and Commissioning are the two stages in which no indicator or tool has been mentioned or elaborated.

Here below it is provided a short description of 15 tools elaborated the MPs, which are public and free:

Name	IMPULSE - MyGIS
Stage	Purpose and Target, Energy Audit, Financing
Objective and short description	Two web applications have been developed for the IMPULSE project, in order to assist with the organization of a Management Information System, which will map the Public Building Typologies and their energy profiles. - Application 1: Public Buildings' typology mapping. - Application 2: Buildings' energy upgrade scenarios ranking. The objective of this tool is to support PA in identification of building typologies and make effective decisions according to different renovation scenarios.
Target	Decision makers and technicians of PA at all levels.
Link	https://cres.mygis.gr/index_en.html
Picture	

Name	IMPULSE – Building typologies and performance indicators platforms
Stage	Purpose and Target, Energy Audit, Financing
Objective and short description	Free-download excel platforms for buildings' classification and for the estimation of energy performance indicators. The goal of this tool is to improve management of energy in PBs by supporting the collection of building data.
Target	Decision makers and technicians of PA at all levels.
Link	https://impulse.interreg-med.eu/fileadmin/user_upload/Sites/Efficient_Buildings/Projects/IMPULSE/D3.2.1_revised_annex_Sep_2018.zip
Picture	

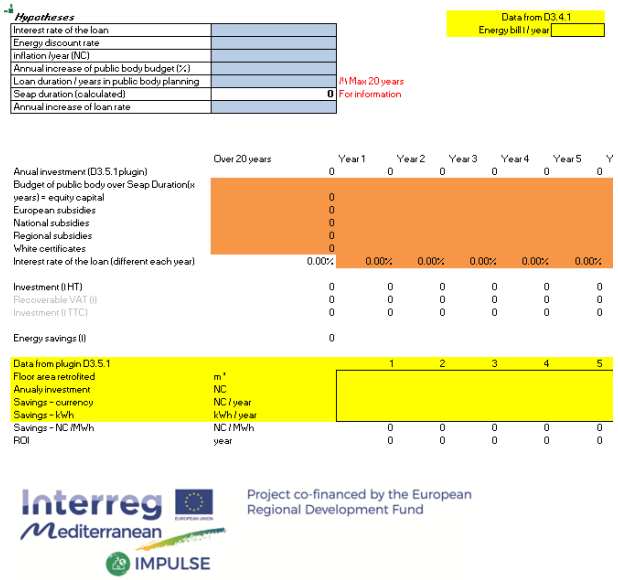
Interreg Mediterranean IMPULSE — Project co-financed by the European Regional Development Fund

Public Authority: E.g. ELCHE CITY COUNCIL

Ambassador Building of Public Building Typology:	PBT1

GENERAL INFORMATION	
Building Name	IVE headquarters
Owner	Elche City Council
Tenant	Valencian Institute of Buildings
Building address	Carrer de les Tres Forques, 98, 46018 Valencia (Spain)
Building use	Open-plan offices with some cellular offices and meeting rooms
Construction year	1990
Refurbishment year/scope (if applicable)	2010 - upgrade of heating system (new gas boiler installed), 2012 - photovoltaics installed on the roof
Nº of floors	4 floors
Average floor height (m)	Semi-underground: 3m, ground floor: 4m, first/second/third floor: 3m
Gross floor area (m^2)	16,339 m^2
Area breakdown (m^2) per floor	Semi-underground: 4,400m^2, ground/first floor: 5,353m^2, third floor: 1,048m^2, fourth (top) floor: 245m^2
Area breakdown (m^2) per building system	**Total heated area:** 15,000m^2 (all areas except non-heated basement and storage rooms) **Total cooled area:** 13,000m^2 (all office areas and meeting rooms) **Total area with mechanical ventilation:** 4,000m^2 (only internal office areas and meeting rooms)
Number of occupants	120
Schedule of occupation	Occupied: 261 days per year, Monday to Friday 09:00-18:00 Not-occupied: During weekends (Sat/Sun)
Photographs	

Name	IMPULSE – Networking Forum
Stage	Awareness, training and communication
Objective and short description	Forum aiming at supporting stakeholders, creating community and promoting IMPULSE local events.
Target	General public
Link	https://impulseforum.eu/
Picture	

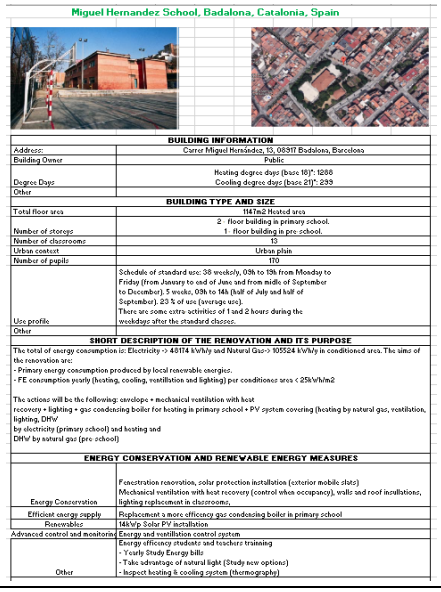
Name	IMPULSE – Financial scheme evaluation tool for gradual building energy renovation planning
Stage	Financing
Objective and short description	The objective of the tool is to simulate possible financing of renovation plan calculated with PLUG-IN TOOL. The tool considers that two ways of financing the renovation plan are foreseen for the financial plan: - The public body contracts one loan at the beginning whose amount is the total investment required for the entire renovation plan; - The public body contracts one loan per year over the duration of the renovation plan.
Target	Decision makers and technicians of PA at all levels.
Link	https://impulse.interreg-med.eu/fileadmin/user_upload/Sites/Efficient_Buildings/Projects/ IMPULSE/Financial_tool_D3.5.1Annex.xlsx
Picture	

Name	PrioritEE – Analytic Database
Stage	Energy Audit, Financing, Planning
Objective and short description	This is a compilation of technological solutions to improve EE in Municipal PBs. It is split by end-use: lighting, space heating, space cooling, water heating and cooking, as well as measures to reduce the energy needs of the buildings structure and improve renewable electricity generation. For each of these you can find information on technological characteristics, investment and operation and maintenance costs, energy savings, etc. The objective of the tool is to provide indicative and representative EE solutions for MED countries.
Target	Decision makers, planners and technicians of PA at all levels.
Link	https://prioritee.interreg-med.eu/toolbox/analytic-database/
Picture	

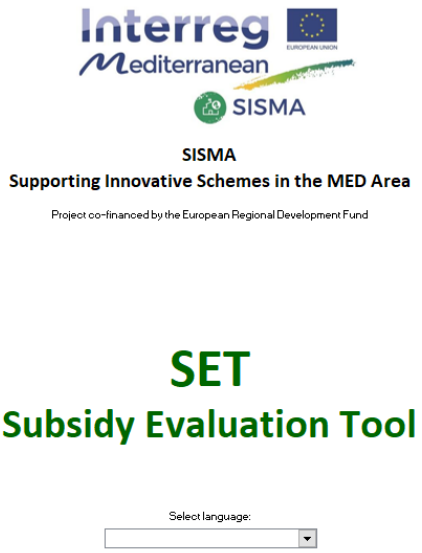
Name	PrioritEE – Decision Support Tool
Stage	Energy Audit, Financing, Planning
Objective and short description	A decision support tool (DST) has the purpose of helping local and regional authorities to quickly evaluate the possibility for energy (and financial) savings by applying EE measures in PBs. The DST is built in a flexible manner and designed both for users with and without detailed information. In the first case users can input their building specific data, whereas in the second case users can benefit from generic pre-filled in information for typical buildings in the MED region.
Target	Decision makers, planners and technicians of PA at all levels.
Link	https://prioritee.interreg-med.eu/toolbox/decision-support-tool/
Picture	

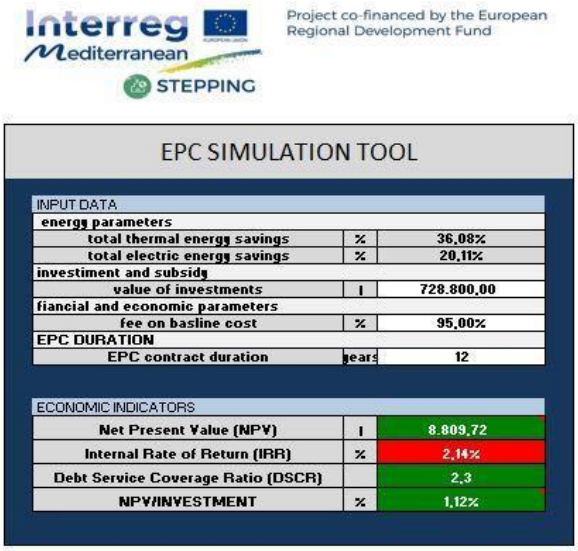
Name	EduFootpring –calculator
Stage	Planning, Awareness, Training and Communication
Objective and short description	The EduFootprint App is an interactive tool for students and teachers that can be used to experiment with the evolution of the schools' CO_2 footprint when increasing or reducing specific parameters directly related to the consumption of energy and resources. The objective of the tools is to facilitate the active environmental involvement of the school communities and other stakeholders.
Target	General Public
Link	https://edufootprint.interreg-med.eu/news-events/news/detail/actualites/edufootprint-app/
Picture	

Name	EduFootprint - Platform
Stage	Planning, Awareness, Training and Communication
Objective and short description	The platform collects the best practices in the fields of energy management and reduction of the carbon footprint developed by the EduFootprint partners and categorized into five main topics. The aim of the tool is to share best practices and increase the knowledge and awareness on general public.
Target	General Public
Link	http://edufootprint.provinciatreviso.it/index.php/en/
Picture	

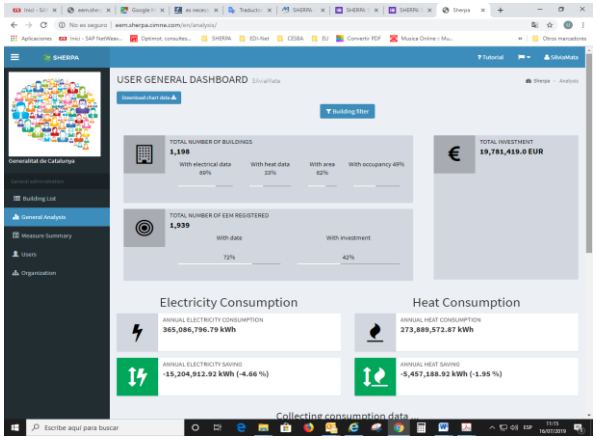
Name	TEESCHOOLS – Pre-audit web tool and Best Available Techniques Database
Stage	Purpose and Target, Energy Audit and Planning
Objective and short description	The set contains a simplified energy and environmental audit tool and best available techniques for efficient and low impact buildings in all partners' countries, which is composed of at least 5 BATs for each country. The objective of the tool is to provide best examples that can serve as a reference for future actions.
Target	Planners and technicians of PA at all levels.
Link	https://teeschools.interreg-med.eu/fileadmin/user_upload/Sites/Efficient_Buildings/Projects/ TEESCHOOLS/Library/D_3.3.7_BAT_Database_final.zip www.improveyourschool.enea.it
Picture	 Miguel Hernandez School, Badalona, Catalonia, Spain BUILDING INFORMATION Address: Carrer Miguel Hernández, 93, 08917 Badalona, Barcelona Building Owner: Public Degree Days: Heating degree days (base 18)°: 1286 Cooling degree days (base 21)°: 233 Other: BUILDING TYPE AND SIZE Total floor area: 1147m2 Heated area Number of storeys: 2 - floor building in primary school. 1 - floor building in pre school. Number of classrooms: 13 Urban context: Urban plain Number of pupils: 170 Use profile: Schedule of standard use: 38 weekly, 03h to 19h from Monday to Friday (from January to end of June and from midle of September to December), 5 weeks, 03h to 14h (half of July and half of September), 20 % of use (average use). There are some extra activities of 1 and 2 hours during the weekdays after the standard classes. Other: SHORT DESCRIPTION OF THE RENOVATION AND ITS PURPOSE The total of energy consumption is: Electricity -> 481174 kWh/y and Natural Gas-> 105524 kWh/y in conditioned area. The aims of the renovation are: - Primary energy consumption produced by local renewable energies. - FE consumption yearly (heating, cooling, ventillation and lighting) per conditioned area < 25kWh/m2 The actions will be the following: envelope + mechanical ventilation with heat recovery + lighting + gas condensing boiler for heating in primary school + PV system covering (heating by natural gas, ventilation, lighting, DHW by electricity (primary school) and heating and DHW by natural gas (pre school) ENERGY CONSERVATION AND RENEWABLE ENERGY MEASURES Energy Conservation: Fenestration renovation, solar protection installation (exterior mobile slats) Mechanical ventilation with heat recovery (control when occupancy), walls and roof insullations, lighting replacement in classrooms, Efficient energy supply: Replacement a more efficency gas condensing boiler in primary school Renewables: 14kWp Solar PV installation Advanced control and monitoring: Energy and ventillation control system Other: Energy efficiency students and teachers trainning - Yearly Study Energy bills - Take advantage of natural light (Study new options) - Inspect heating & cooling system (thermography)

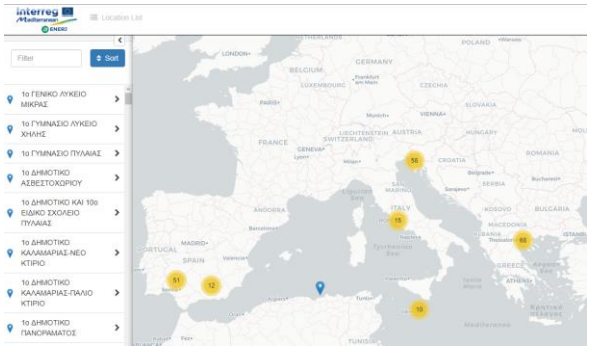
Name	NEW FINANCE – Platform
Stage	Stakeholders involvement, Financing, Awareness, Training and Communication
Objective and short description	Platform with good practices of innovative financial models for EE measures in public owned buildings and with the networking area. The goals of the tool are to give visibility to best practices and to increase awareness, knowledge and communication between stakeholders in the topic of financing.
Target	Decision Makers and technicians of PA at all levels.
Link	http://newfinanceplatform.com/
Picture	

Name	SISMA – SET TOOL
Stage	Financing, Awareness, Training and Communication
Objective and short description	The SISMA Set Model is an innovative tool to quickly perform the energy and economic-financial assessment of energy savings measures. The objective of the tool is to support PA in financing and in making attractive EE projects.
Target	Decision Makers and technicians of PA at all levels.
Link	https://sisma.interreg-med.eu/sisma-set-tool/
Picture	

Name	STEPPING – EPC Simulation Tool
Stage	Financing
Objective and short description	The main objective of this tool is to find different investment scenarios that would balance the public and private interest in making the investment.
Target	Decision Makers and technicians of PA at all levels.
Link	https://stepping.interreg-med.eu/news-events/news/detail/actualites/epc-simulation-tool-1/
Picture	

Name	SHERPA – Funding tool
Stage	Purpose and Target, Energy Audit, Planning, Financing
Objective and short description	The main goal is the financial analysis of Energy Renovated Building projects, to identify financing alternatives for these ERB projects and to innovate the financial schemes applied, according to the specific characteristics of these projects. Therefore, the main agreed goals are: • To Identify and agree on the financial process to be implemented in order to get ERB projects financed. • To Identify the best financial solution to renovate buildings
Target	Decision Makers and technicians of PA at all levels.
Link	https://sherpa.interreg-med.eu/what-we-achieve/what-has-been-done-so-far/
Picture	

Name	SHERPA – Information System tool
Stage	Purpose and Target, Energy Audit, Planning
Objective and short description	The main objective is to provide a common Information System for the collection and analysis of building data of the public administrations. The SHERPA Information System brings together energy consumption data and information about Energy Efficiency Measures (EEM) being implemented in public buildings to treat these data using Big Data Analysis techniques. This data-driven analytic approach aims to overcome the disadvantages of simulation-based approaches, which have shown a considerable gap between predicted and real building performance. Unlike simulation, SHERPA approaches the analysis of the diverse building stock from the perspective of real building performance and reveals the most cost-effective measures to apply to different building typologies, as proved in real life operation.
Target	Decision Makers and technicians of PA at all levels.
Link	http://eem.sherpa.cimne.com/es/login/ In order to get a badge you have to register like "Observer". (https://docs.google.com/forms/d/e/1FAIpQLSfB2joVNNZJNY3mBlpV2DlxSNgcwXiS3099mYz8kU-NLY4Acw/viewform?c=0&w=1)
Picture	

Name	ENERJ – Web platform
Stage	Purpose and Target, Energy Audit, Planning and Awareness, Training and Communication
Objective and short description	The main objective is to help authorities and enterprises being aware of the energy characteristics of the local PBs, and actions that the local authorities have committed to undertake , such as those included in their SEAPs. The web platform gives access to two databases: • Database of the energy characteristics of PBs. • Database of the energy retrofit actions contained in the SEAPs.
Target	Decision Makers and technicians of PA at all levels.
Link	http://www.enerj-platform.eu/enerj/
Picture	

CONCLUSIONS

The present analysis has been done to collect and analyze results of 10 MPs. The MPs are focused on the topic of EE in PBs and their results aim at finding answers and supporting other PAs when implementing EE projects. From there, this document aims to be a sort of guidelines for PA, summarizing the most relevant findings, methodologies, KPIs and tools to offer a complete point of view of the overall EE projects stages established.

To gather these results, it has been followed the Building Life Cycle approach, in which 11 building stages are proposed. The importance of each stage can vary from project to project, but the first aspect to take into consideration is the importance of the process as a whole, recognizing the particular relevant stages for each project, which can have a crucial impact in the final aim of the project. This holistic approach has to be considered by PAs from the very beginning.

Following this first consideration, the implemented analysis aims at finding the results of MPs covering these stages for either new and retrofit projects, or even plans considering broader infrastructure levels (e.g. neighborhoods).

In order to find these answers and overcome existing barriers (e.g. technical, financial, knowledge, awareness…), MPs have elaborated several results like methodologies, tools and indicators. Usually the consortium of MPs includes research centres, universities, network associations, energy agencies and PAs, which really know the problems to be faced in their daily work and know the existing lack of supporting material.

The analyzed methodologies in some cases are already well know, but the added value can be the contextualization to the Mediterranean territory, the application in the public ownership and the holistic vision. In addition, some methodologies propose new ways of solving the barriers (e.g. joint SEAPs).

The methodologies identified and analyzed within the study cover most of the building stages, but some appear to be neglected and with a lack of results. This is the case of the Implementation and Commissioning stages which for several analysis and real cases have been demonstrated their relevance. On the other hand, other stages like Energy audit, Design Tendering, Procurement or Monitoring and Usage have several methodologies, which can be overlapping or complementary, approaching the issue from different perspectives.

Other aspect to be stressed after the analysis, is the special focus on EPC projects. Many results, especially the ones of those projects treating the financing topic, provide methodologies and guidelines to implement EPC projects. In a first study within the MEDNICE project, it was noticed that most of the pilot projects and best practices of financing schemes within the MED programme were EPC projects. This financial scheme is not always easily applicable for PA, but it is frequently used in pilots of research and cooperation projects. These projects offer the possibility to learn how to apply these schemes, to elaborate tools and methodologies supporting

its dissemination, and to learn from other experiences. EPC is especially interesting for PA with a lack of cash flow because the initial investment has to be done by a third party.

The analysis has also shown the huge amount of really useful key performance indicators that mostly cover the overall stages process. Nevertheless, it is recommended for PAs with low resources and availability of data, to select adequate Key Performance Indicators in order to find the right balance between importance and effort.

Some stages have a big number of indicators and some of them are recurrent and are mentioned by several projects. These recurrent indicators like Total annual avoided CO2 emissions are compulsory for certifications or plans (e.g. SEAP). Besides, various indicators are covering many aspects and stages, thus allowing a more holistic vision. However, it is needed to deselect the appropriate ones depending on the type of project and resources.

At the other hand, the analysis on the indicators shows clearly that here there is also a lack of indicators for some stages, in particular in Stakeholders' involvement, Procurement, Implementation, Commissioning and Awareness, training and communication. The reasons behind this lack could be because of existing and well established methodologies like in the Procurement stage. Nonetheless, in other stages like Stakeholders' involvement, or Awareness, training and communication, the lack of introduced indicators could become a real constrain. It is strongly recommended that, for such cases, specific indicators could be defined and implemented in order to fulfill the overall process. In fact, the lack of indicators becomes more relevant than the lack of tools and methodologies, since indicators are crucial to ensure and assess the achievement of the objectives.

At the same time, the MPs have elaborated 15 tools, which are free and available online. These tools can be very useful in some stages for the realisation of public EE projects. Besides, several indicators are integrated in the tools, thus allowing the joining of different stages in a continuous process.

The analyzed tools cover only 6 out of the 11 building stages. Nevertheless, these can support PA in fundamental activities like analyzing the PB stock, engaging stakeholders, assessing the needed sources to finance EE projects, or listing possible EE measures to be implemented in PBs.

Concluding, it is recommended to promote the achievements of the MPs and to ensure the use and accessibility of these results to their potential final users, i.e. PA.

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