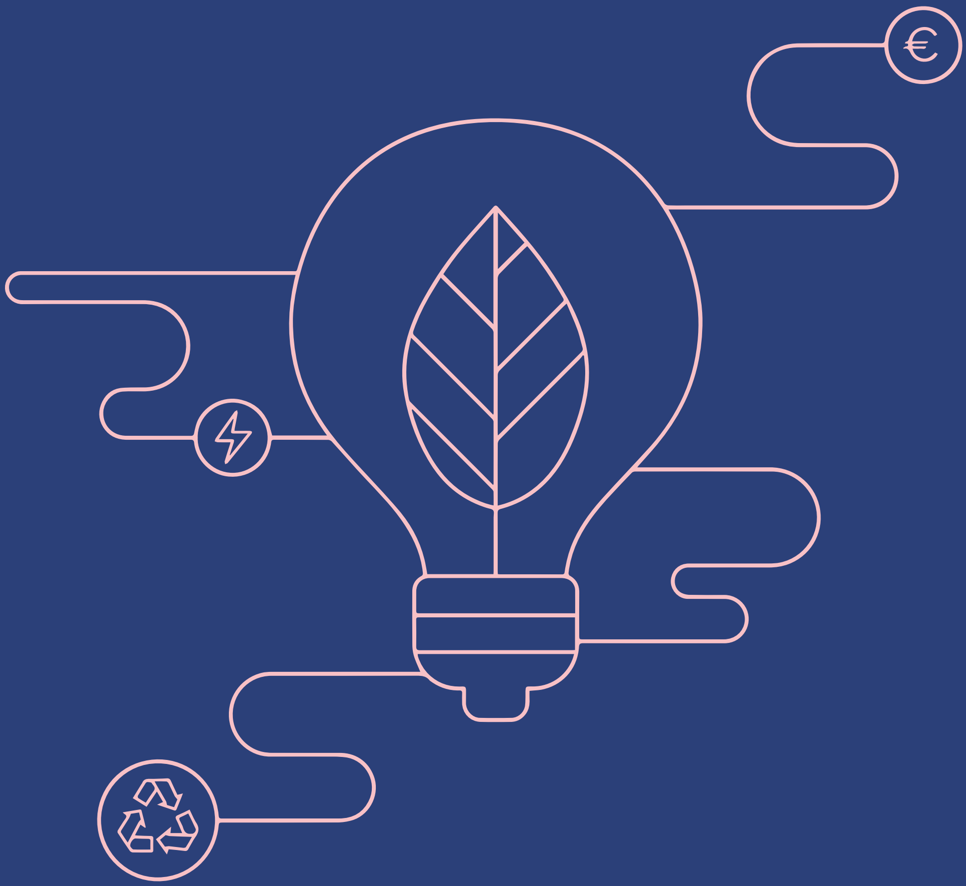
IMPULSE
PROJECT
INTERREG MED



Project co-financed by the European
Regional Development Fund

2022

INDEX

1

INTRODUCTION

The recast EPBD (2010/31/EU) and EED (2012/27/EU) pose demanding requirements for Member States for the energy renovation of public buildings (ERB) e.g.: targets in national plans for stimulating buildings' refurbishment towards Nearly Zero Energy Buildings. annual 3% renovation rate for central government buildings (or lower administrative levels). long-term strategy for mobilising investment in cost-effective deep renovation.

Also, the Covenant of Mayors sets common guidelines for local authorities to develop their Sustainable Energy Action Plans (SEAPs) including specific energy/cost indicators for Municipal buildings.

The main common territorial challenge tackled by IMPULSE is insufficient capacities of local public administrations to manage integrated, reliable and cost-effective ERB action plans for their buildings' stock, responding to the above EU Directives and ensuring reliable completion of SEAPs.

Other key challenges identified among partners territories are the insufficient level of expertise to apply advanced methodologies, difficulty in data collection for public buildings. lack of specific methodology to categorise public buildings in typologies, to complete SEAPs indicators and lack of specific decision-support system for ERB.

Objectives-Results

IMPULSE aims to address all above challenges through introducing an integrated management support system for public authorities to facilitate them in planning, financing and implementing public buildings' ERB projects. Input fields of the proposed system include buildings' characteristics and energy goals, under cost/legislative constraints. Output fields provide packaged retrofit solutions of cost-prioritised interventions accompanied by energy & cost indicators, gradual renovation and financial plan, IT results' integration on GIS maps.

The system has been tested in 6 participating MED public authorities (Municipality of Heraklion, City of Elche, City of Cannes, Municipality of Ravenna, City of Osijek, City of Mostar) and transferred to further ones at local/regional/national level in the involved MED territories. The typology approach followed and the wide territories' testing sample ensure the transnational applicability of the project outcomes, allowing other MED public authorities at local, regional and national level to apply this approach.

Project Partners

The Consortium includes public authority partners (Municipality of Heraklion-Greece, City of Elche - Spain, City of Cannes - France, Municipality of Ravenna - Italy, City of Osijek - Croatia, City of Mostar - Bosnia and Herzegovina), who are the project's principal target group, and technical partners in the respective territories, with expertise in energy-efficiency (EE) and energy renovation of buildings (ERB).

LEAD PARTNER

Centre for Renewable Energy Sources and Saving
– CRES (Greece)

ACTIVE PARTNERS

Valencia Institute of Building – IVE (Spain)
Municipality of Heraklion (Greece)
Elche City (Spain)
EnvirobatBDM (France)
Equipment and development regional agency from
Provence-Alpes-Cote d' Azur – Area Region Sud (France)
Municipality of Ravenna (Italy)
Energy Institute Hrvoje Požar – EIHP (Croatia)
City of Osijek (Croatia)
City of Mostar (Bosnia & Herzegovina)

ASSOCIATED PARTNERS

Generalitat Valenciana: Vicepresidencia segunda y Consellería
de Vivienda y Arquitectura Bioclimática (Spain)
Provincial Energy Agency of Alicante, Diputación
de Alicante (Spain)
Regional Development Fund of Crete (Greece)
City of Cannes (France)
Society for Sustainable Development Design – DOOR (Croatia)
Regional Development Agency of Slavonia and Baranja (Croatia)

What is to come after that?
IMPULSE PLUS project

IMPULSE PLUS will effectively transfer to new regions and cities the main outputs developed during the previous MED project IMPULSE. This includes the provision of support tools for the development of gradual renovation plans and financial planning for cost-optimal solutions for public building stocks.

The Financial Scheme Evaluation tool, including the decision-making support tool PLUG-IN KPIs-processor for automated hierarchy of public buildings, will be revised and adapted under a transnational and cooperative way to help territories to meet the new targets set by the EU in the Green Deal and Renovation Wave Strategy, which aim to double annual energy renovation rates in the next ten years and report on the need to renovate buildings deeply on a massive scale.

The transferring process will allow, on the one hand, to scale the scope of application in some of the countries previously involved in IMPULSE project (Spain, Greece and Italy) from small/medium municipalities to bigger cities (such as Valencia in Spain), but also, from the local to the regional scale (Emilia Romagna Region in Italy and Western Greece). On the other hand, results will be transferred to a country that was not involved previously in IMPULSE (Slovenia). It will enable other municipalities/regions in Slovenia to make use of the tools taking the Municipality of Koper as a reference. Finally, reIMPULSE will permit to improve and adapt the tools to the requirements established in the new EU program period.

LEAD PARTNER

Valencia Institute of Building – IVE (Spain)

ACTIVE PARTNERS

ART-ER – S. CONS P.A (Italy)
Region of Western Greece (Greece)
València Clima i Energia / Valencia Climate and Energy Foundation (Spain)
Regional Development Centre Koper (Slovenia)
Elche City Council (Spain)

ASSOCIATED PARTNERS

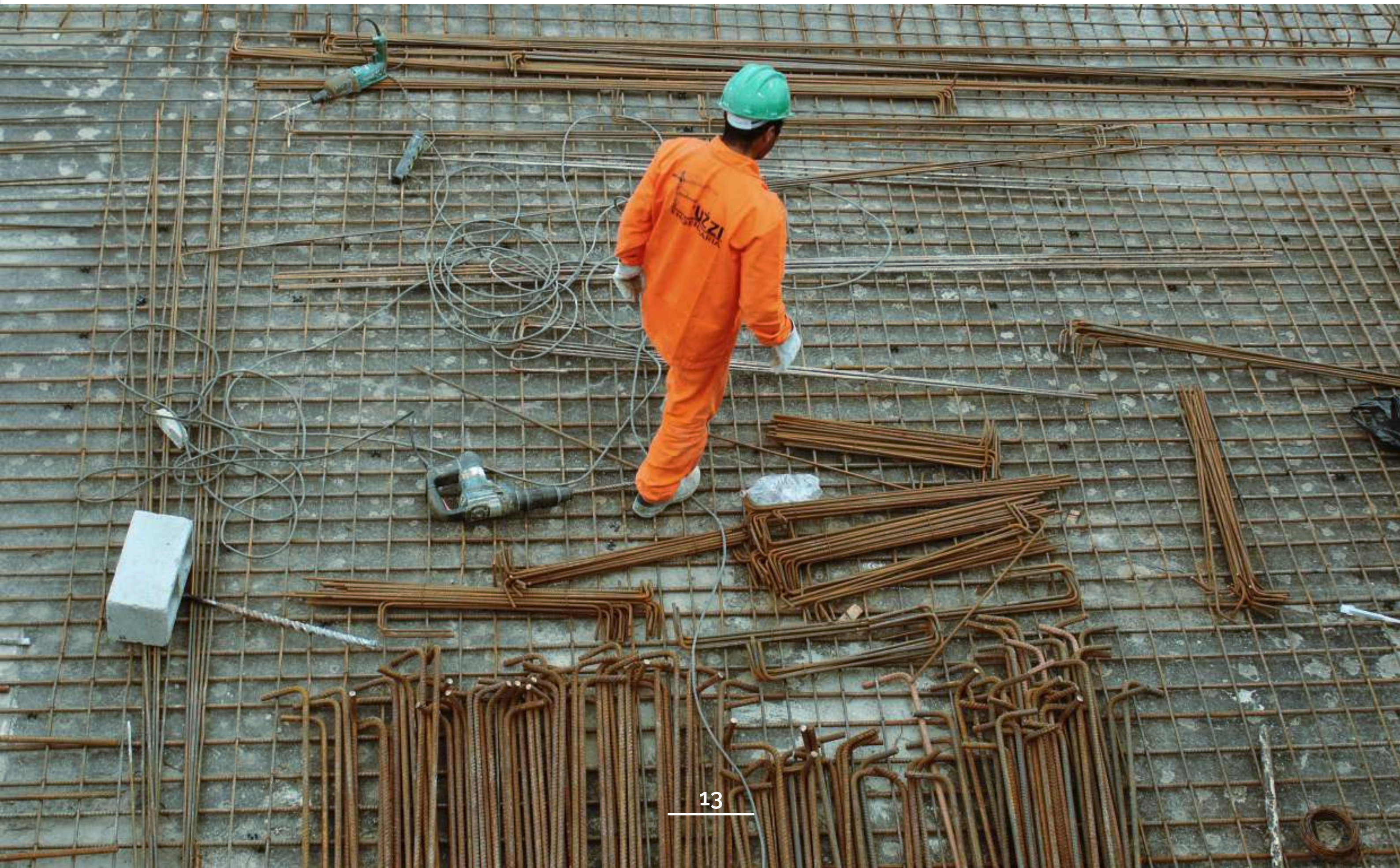
Valencia City Council (Spain)
Energy Cities
Vicepresidencia Segunda y Conselleria de Vivienda y Arquitectura Bioclimática (Spain)
CLUST-ER BUILD (Italy)
Emilia-Romagna Region (Italy)
Municipality of Patras (Greece)
Municipality of Koper (Slovenia)
Conference of Peripheral Maritime Regions (France)

2

IMPULSE METHODOLOGY DEVELOPED

The implementation of this methodology will allow public administrations to obtain an energy analysis of their public building stock, the associated energy savings potential and a prioritization of the buildings to be renovated under affordability criteria (total investment cost per total annual energy saved), based on energy, environmental and cost indicators specifically calculated to its own public building stock.

The use of the templates and tools specifically developed in IMPULSE project will allow, these public administrations implementing the methodology, to later link them to the excel tools developed to obtain a gradual yearly renovation plan and assess the potential financial schemes, for the renovation plan obtained. Last two mentioned tools have been upgraded and improved in the frame of IMPULSE PLUS project and are the ones explained later.



The methodology is consisted of the following steps and tools:

Classification of building stock

A practical guide has been developed for clustering the initial building stock into representative Typologies, based on classification criteria affecting energy performance such as construction year, building use, construction type, systems, etc. From each Typology a representative building can be selected as the "Ambassador" building with available technical information for further energy analysis.

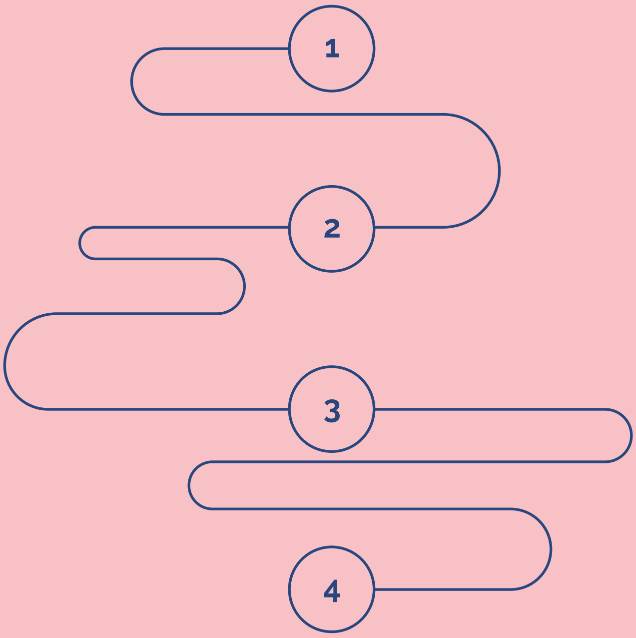
Energy analysis

Based on the assumption that similar buildings present the same energy-related Key Performance Indicators (KPIs) per sq.m., an excel-based platform has been developed which automatically extrapolates KPIs for various retrofitting scenarios from the "Ambassador" buildings to all buildings of each Typology. The approach presumes the availability of KPIs for the "Ambassadors" e.g. obtained by energy simulations. The approach is very cost-effective, at least for planning purposes, as it skips time-consuming calculations for each building separately. The platform estimates also economic indicators (such as payback period, weighted investment cost), thus facilitating bankability assessment of projects for entire groups of buildings.

Gradual renovation & financial planning

Finally, an excel-based decision-making tool is developed which allows the user to select and bias decision criteria by means of which KPIs to optimize as well as to impose the % of floor area of the building stock to be renovated each year. The tool processes the KPIs' database from the previous step and returns which buildings and what projects to take place each year, accompanied with the duration of the plan (in years), the expected energy saved, the avoided CO2 emissions and energy-related cost savings. A second excel tool developed allows analysing the possible financing scenarios associated with the renovation plan settled. The tool simulates possible financial schemes, estimating energy discount and interest rates, inflation, etc. The results are compared to energy bill baseline (if no works are done) and permit to assess the benefit of the renovation plan in a public body budget.

The resources for the implementation of the methodology are available in the Deliverable database of IMPULSE/IMPULSE PLUS project website (https://impulse.interreg-med.eu/what-we-achieve/deliverable-database/).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2.1

CLASSIFICATION INTO PUBLIC-BUILDING TYPOLOGIES

2.1.1 Description of activity and expected outcome

The aim is to produce a Library of municipal buildings' typologies. The data will be gathered from different sources: statistical info, available drawings and technical studies, previous projects, energy certificates where available, but also on-site energy inspections if needed. In the end, a library of classified municipal building stock will emerge accompanied with energy-related information.

The procedure to be followed is comprised by the following methodological steps:

Step 1:
Determination of the sample of public buildings to be "scanned/recorded".

Step 2:
Collection of data (e.g. year of construction, size, systems, etc.) (corresponding to classification criteria).

Step 3:
Determination of buildings' classification criteria.

Step 4:
Classification of the public-building sample into typologies based on the adopted criteria.

2.1.2 Implementation methodological steps

Determination of the initial testing sample of buildings

The first step is to define the sample of specific public buildings (selected out of the overall public building stock in each Municipality, meaning public buildings that the Municipality owns and/or occupies), which will be categorized/grouped into typologies.

For determining the initial testing sample of buildings, it is needed to adopt the following specifications:

- A minimum of 70 municipal buildings should constitute the initial sample.

- The initially selected buildings should have available and fully accessible technical information (e.g. drawings, systems' details, etc.) as well as being fully accessible, for external experts to collect the necessary data for classification.

- The initial sample should include building types/uses of top priority for energy renovation.

- Building types representing a limited number of buildings, e.g. 1 or 2 buildings, or those buildings, which due to their particular characteristics, are hardly susceptible to constitute a typology, e.g. Great/Royal Theater, etc... should be avoided.

- Ensure adequate diversity among the buildings of the initial sample regarding important characteristics such as number of floors, gross floor area, age, construction type, systems, etc.

Determination of buildings' classification criteria

Based on existing knowledge gained by previous projects as well as on relevant databases the following classification criteria are most frequently adopted for buildings' grouping into representative typologies:

- *Building type/use.*

- *Year of construction.*

- *Number of floors.*

- *Gross floor area (m2), i.e. the total floor area contained within the building, measured to the external face of the external walls.*

- *Construction type.*

- *Heating system.*

- *Cooling system.*

Classification procedure

The classification procedure is based on the grouping of the specific buildings of the initial testing sample into groups of buildings with similar "values" of the criteria adopted. In order to achieve the grouping, the counting of buildings with common (or "similar") criteria should be based on adopting specific ranges/intervals/options for each criterion. For adopting the most suitable ranges/intervals/options for each classification criterion, the following guidelines are provided:

- Building type/use

Educational buildings

Buildings used for pre-primary, primary and secondary education, e.g. kindergartens, nurseries, primary schools, secondary schools, high schools etc. Buildings used for higher education and research, or other type of educational activities e.g. higher education establishments, research centres, Municipal teaching centres etc.

Office buildings

Buildings used as places of business, for clerical and administrative purposes, e.g. post offices, Municipal offices, offices of local administration institutions/departments e.g. social services, citizens' advice bureau etc.

Sports halls

Buildings used for indoor sports providing facilities for spectators and for participants, e.g. basketball courts, swimming pools, gymnastic halls, ice-skating rinks etc.

Healthcare buildings

Buildings where medical/nursing care is provided for ill or injured people, e.g. hospitals, medical centres, day centres, treatment centres, maternal and child welfare centres etc.

Public entertainment buildings

E.g. cinemas, concert halls, theatres, dance halls etc.

Museums and libraries

E.g. museums, art galleries, exhibition centres, libraries, archive centres, other resource centres

Community/public assembly buildings

E.g. multi-purpose Municipal community/cultural centres, conference and congress centres, activity centres for the elderly, youth centres, courts etc.

Industrial buildings and warehouses

E.g. workshops, warehouses, buildings used for other industrial activities.

Residential buildings for communities

Public residential buildings for communities/social groups e.g. care homes for the elderly, student residences, social housing, orphanages etc.

Retail buildings

E.g. shops, indoor markets (e.g. food markets), grocery shop for low-income population etc.

Buildings used as places of workship and/or religious activities

E.g. chapels, churches, synagogues, religious institutions, buildings within cemeteries etc.

Public security buildings

E.g. police station, fire services, prison etc.

Other

Other types of public (Municipal) buildings not elsewhere classified.

Year of construction

It is needed to adopt specific intervals for the construction year that may relate to significant milestones in energy or construction national regulations, which imply different characteristics of building construction. In the case of Spain, the most significant intervals in terms of energy or construction regulations are: Until 1900/ 1901-1936/1937-1959/1960-1979/1980-2006/2007-onwards.

Number of floors

The intervals for floor number are strongly dependent on the initial sample of municipal buildings. For example, if all buildings of the initial sample are above 3 floors (including the ground floor) then there is no meaning to include the interval “up to 2 floors”. Based on some research, the following floor-number intervals can be adopted:

- Up to 2 floors (including the ground-floor).
- 3-5 floors (including the ground-floor).
- Equal or Above (≥) 6 floors (including the ground-floor).

Gross floor area

The intervals for floor area are strongly dependent on the initial sample of municipal buildings. For example, if no buildings of the initial sample have gross floor area above 10,000 m2 there is no meaning to include the interval “above 10,000m2”.

Construction type

This criterion is related to a significant difference regarding the construction among the buildings initially included in the testing sample. For example, if the main difference among buildings is whether they have flat roof or inclined roof, then the “construction-type” criterion could be represented by the criterion “Roof geometry”. Indicative criteria that stand for the “construction type” and respective options are the following:

- Criterion: Roof geometry. Options: Flat roof/ Inclined roof.
- Criterion: Roof material. Options: Concrete roof/ Pitched timber roof with concrete tiles.
- Criterion: Frame/Envelope construction. Options: Concrete frame-Common brick external walls/ Steel frame-Lightweight construction external walls etc.
- Criterion: Envelope insulation. Options: Insulation/ No-insulation.
- Criterion: Type of windows frame/glazing. Options: Timber-frame, Single-glazed windows / Aluminium-frame, Double-glazed windows.
- Etc.

Heating system

This criterion refers to the heating system of the building (the type of system used for heat generation and/or distribution and/or terminal units). Again, the classification options are dependent on the initial testing sample. For example, if no building has a natural-gas boiler, there is no meaning to include “natural-gas boiler” in the available options for this criterion.

The following indicative options are provided:

- Conventional oil boiler with radiators.
- Natural gas boiler with radiators.
- Renewable energy source, e.g. solar-thermal for space heating or GHP combined with underfloor heating.
- Etc.

Cooling system

This criterion refers to the cooling system of the building (the type of system used for cooling generation and/or distribution and/or terminal units). Again, the classification options are dependent on the initial testing sample. The following indicative options are provided:

- Local A/C units (split units):

- Central heat pump unit, with fan-coil units.
- Central air or water chiller, with fan-coil units.
- Renewable energy source e.g. GHP with fan-coil units.
- Etc.

2.1.3 Final product of building classification

As regards the municipal-building typologies (groups of buildings) expected from the classification process: At least 10 and not more than 15 Public-Building Typologies (PBT) are expected. To achieve that goal, it is allowed to go back in the classification procedure/system and modify accordingly the restrictions for criteria and/or for the intervals/options for each criterion.

From each Public-Building Typology (PBT) emerged above, ONE specific building with the maximum available technical information (e.g. drawings, construction properties/materials, heating and cooling systems' properties, etc.), will be selected as the "Ambassador" of all buildings belonging to the same Typology. For example, if one out of the 10-15 typologies includes let's say 10 specific buildings, only one (with the maximum technical information) can be selected as the "Ambassador" building of the Typology.

The final product of the classification process is the "Library of municipal buildings' typologies" which is comprised of the following files:

A. Building classification report: Document file which describes the methodology/protocol followed to identify the initial testing sample of municipal buildings and to classify it into representative building typologies.

B. Typologies database: The completed excel template entitled "D3.3.1_Municipal buildings' typologies_PILOT CITY".

Considering that the Ambassador buildings will be simulated afterwards, cities are advised to keep additional technical information (e.g. building drawings in .dwg, .dxf, etc.) in a separate folder for each Ambassador building (in the absence of available building drawings, information for the building geometry should be collected and simple building drawings with key information be made available) in accordance to the requirements in input conditions of the simulation method/tool to be used.

2.1.4 Information and data collection

Regarding the information and data of public buildings that should be collected, we can distinguish the basic information that will be necessary to compile for the list of all the public buildings that we will be classified in different typologies, according to the criteria established in each pilot city, from the detailed information that will be needed for the Ambassador buildings, which will be later energy simulated.

Basic information:

Information to be gathered for a minimum of 70 municipal buildings.

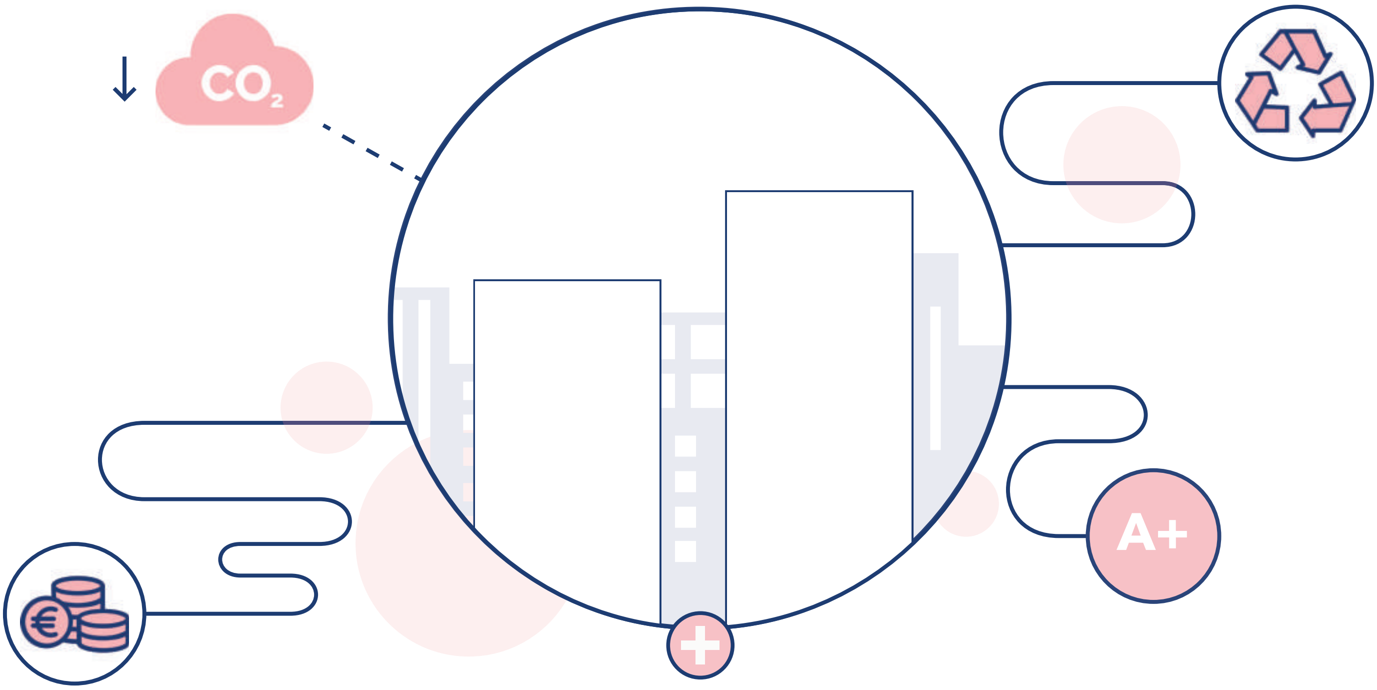
- Building name.
- Building gross floor area (m2).
- Full address (street name, street number, postcode, city, area province/region, country).
- GPS coordinates (latitude, longitude in decimal degrees).
- Building type/use (See section 3.1.2.3 Classification procedure).
- Construction year.
- N° of floors.
- Brief description of construction type: roof, envelope and windows characteristic (See section 3.1.2.3 Classification procedure).
- Type of heating system.
- Type of cooling system.
- Type of HDW system.
- Type of ventilation system.
- Inventory on other available information of the building (check list):
    - *Energy performance certification.*
    - *Energy audit.*
    - *Digital building drawings (dwg and/or dxf formats).*
    - *Project information on the construction elements and building systems (e.g. project memory).*

- Annual final energy consumption from solid fuels per square meter.
- Annual final energy consumption in electricity per square meter.
- It will be also defined if Annual final energy consumption data is real or estimated, and the source (energy modelling, bills, energy meters, energy management system) of the data.

Detailed information:

Information to be gathered for the representative buildings of each Building Type (PBT1, PBT2 ...PBTi), also called Ambassador Buildings. The information to be collected is detailed in the excel file "D3.3.1_Municipal buildings typologies_NAME OF THE CITY", in "Details for Ambassador of PBTi" sheet. Below a simplified table with the information to be collected is shown.

Table 2:
Detailed information to be collected for Ambassador Buildings.



GENERAL INFORMATION

Building Name

Owner

Tenant

Building address

Building use

Construction year

Refurbishment year/scope (if applicable)

N° of floors

Average floor height (m)

Gross floor area (m2)

Area breakdown (m2) per floor

Area breakdown (m2) per building system

Number of occupants

Schedule of occupation

Photographs

EXTERNAL WALLS

Short description of building element (key material layers / thicknesses)

Area of the building where it is met

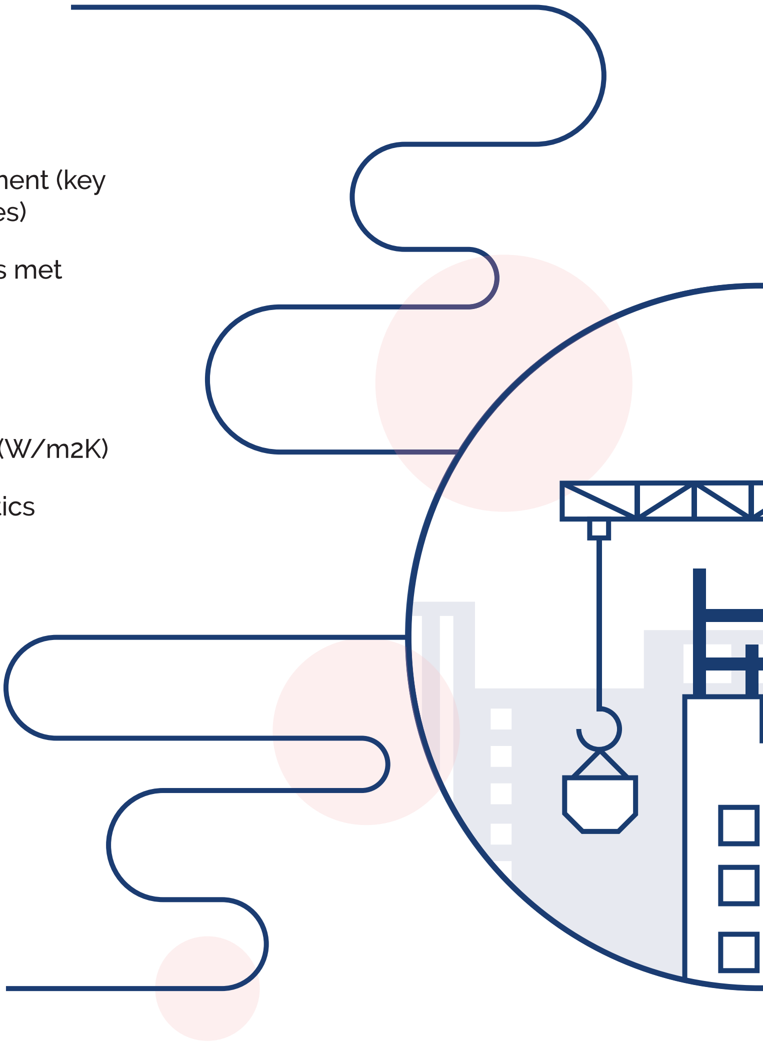
Orientation (o) / Tilt (o)

Area (m2)

Thermal transmittance - U-value (W/m2K)

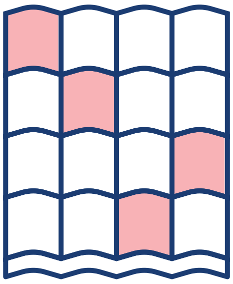
Other technical characteristics

Photograph



BUILDING ENVELO

Main construc



ROOF

Short description of building element (key material layers / thicknesses)

Area of the building where it is met

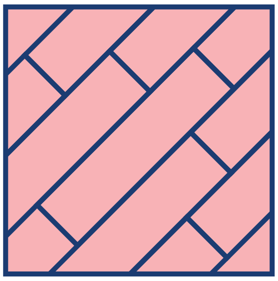
Orientation (o) / Tilt (o)

Area (m2)

Thermal transmittance - U-value (W/m2K)

Other technical characteristics

Photograph



EXPOSED FLOORS

Short description of building element
(key material layers /thicknesses)

Area of the building where it is met

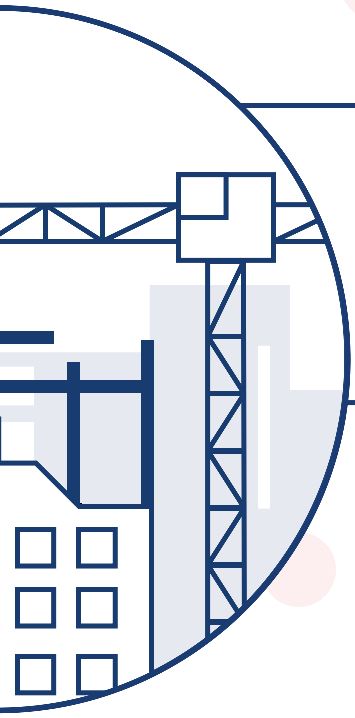
Orientation (o) / Tilt (o)

Area (m2)

Thermal transmittance - U-value (W/m2K)

Other technical characteristics

Photograph



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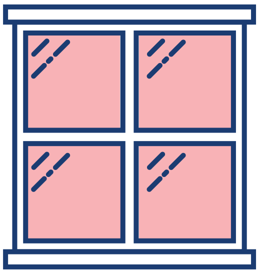


WINDOWS (GLAZING/FRAME)

Short description of building element
(key material layers /thicknesses)

Area of the building where it is met

Orientation (o) / Tilt (o)

Area (m2)

Thermal transmittance - U-value (W/m2K)

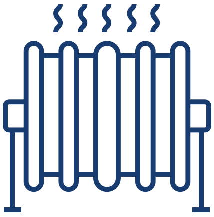
Windows solar transmission (gw)

Windows % openable area

Level of shading (from surrounding buildings/obstructions
and from shading systems (internal/external)

Other technical characteristics

Photograph



HEATING SYSTEM

Short description of system (fuel used, type of generation system, distribution system, terminal units)

Area of the building served

Year of installation

Heating power (kW)

Efficiency (%) / Coefficient of Performance (COP)

Level of insulation of heat generation system

Level of insulation of heat distribution system (pipework/ductwork)

Schedule of operation

Type of control

Other technical characteristics

Photograph

LIGHTING

Type of luminarie/lamp

Area of the building served

Year of installation

Number of luminaries

Number of lamps per luminarie

Electrical power per lamp (W)

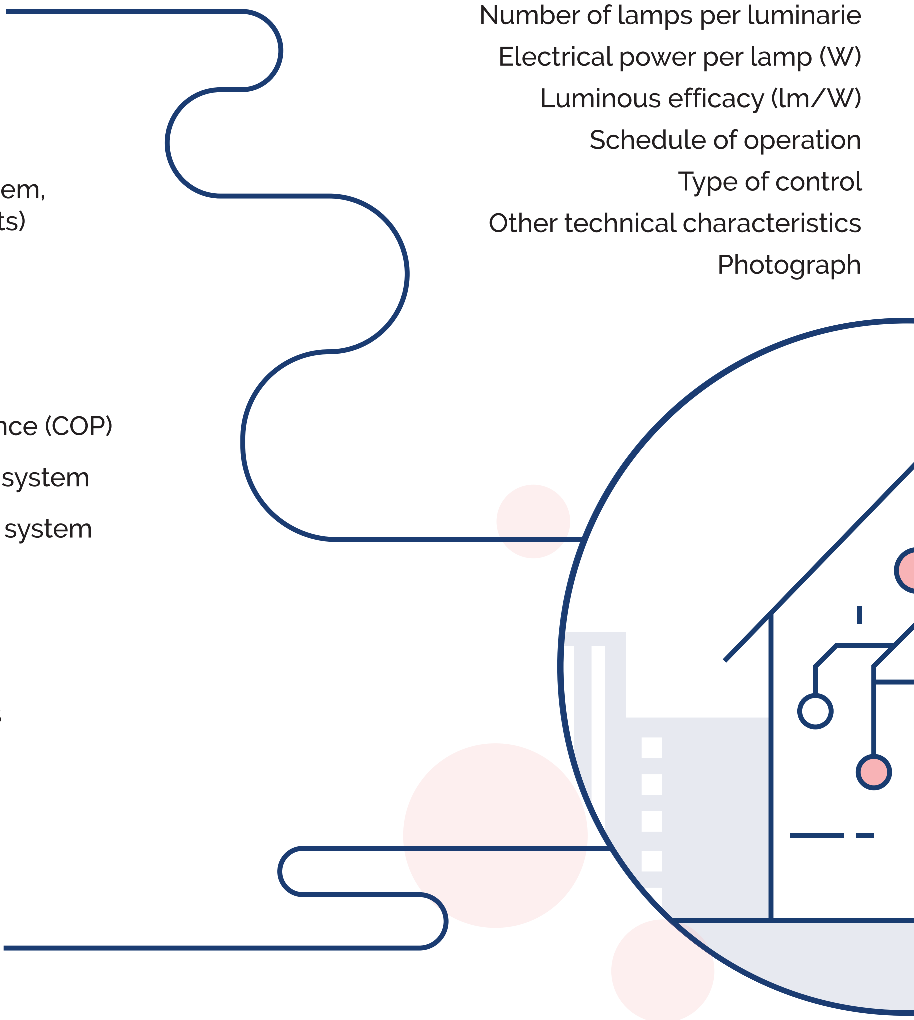
Luminous efficacy (lm/W)

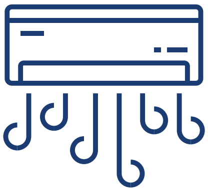
Schedule of operation

Type of control

Other technical characteristics

Photograph





COOLING SYSTEM

Short description of system (fuel used, type of generation system, distribution system, terminal units)

Area of the building served

Year of installation

Cooling power (kW)

Efficiency (%) / Energy Efficiency Ratio (EER)

Level of insulation of cooling distribution system (pipework/ductwork)

Schedule of operation

Type of control

Other technical characteristics

Photograph

BUILDING SYSTE

Main building s

RENEWABLE ENERGY TECHNOLOGIES

Short description of the Renewable Energy Technology (type/location)

Area/Load of the building served

Orientation (o) / Tilt (o)

Area (m2)

Year of installation

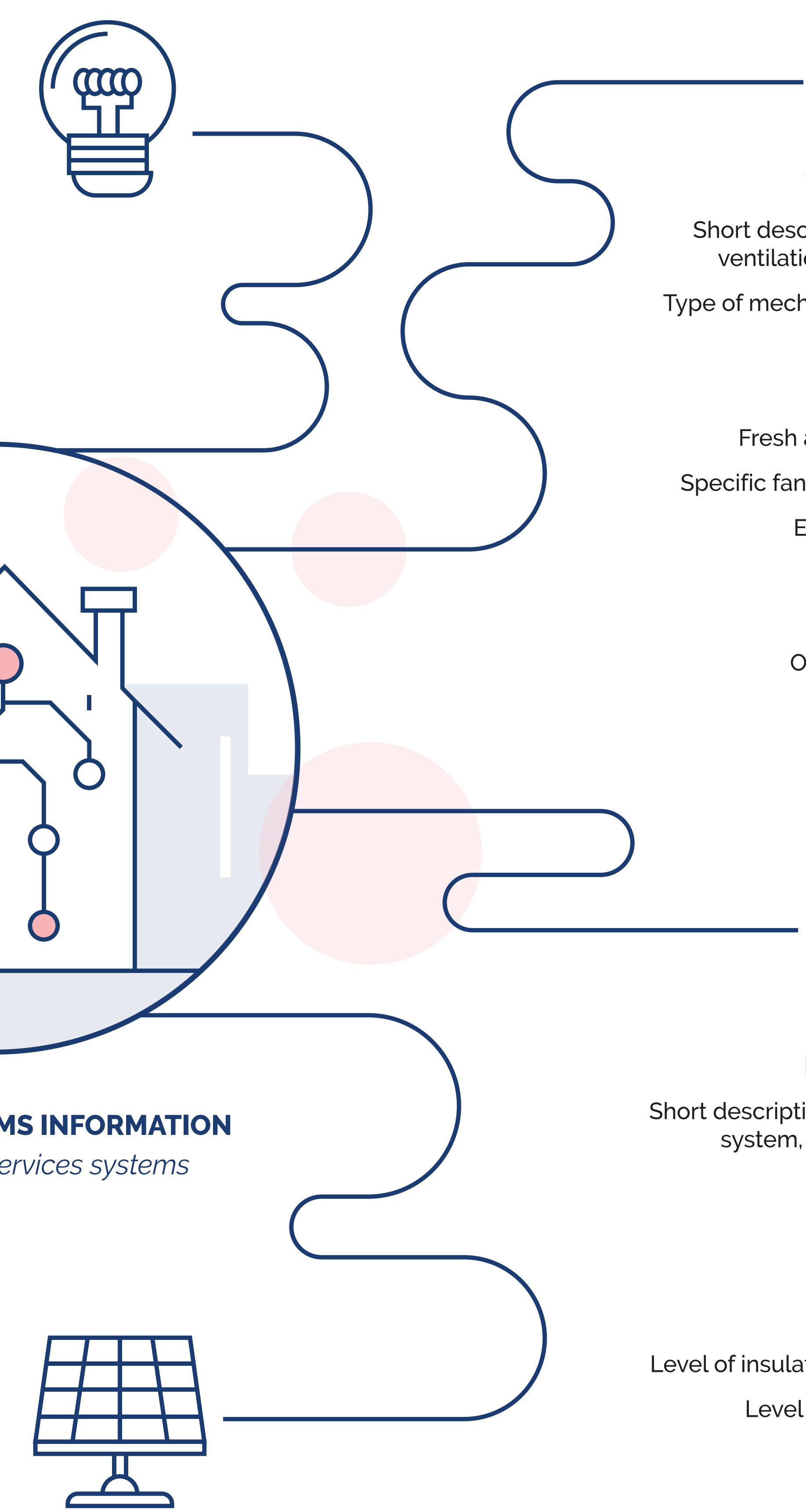
Total installed power (kW)

Annual energy generated (kWh)

Type of control

Other technical characteristics

Photograph



VENTILATION SYSTEM

Short description of system (natural/mechanical ventilation, heat recovery/no heat recovery)

Type of mechanical ventilation (supply and/or extract)

Area of the building served

Year of installation

Fresh air supply/extract rate (m3/s/m2)

Specific fan power of supply/extract fan (W/m3/s)

Efficiency (%) of heat recovery

Schedule of operation

Type of control

Other technical characteristics

Photograph

MS INFORMATION

ervices systems

DOMESTIC HOT WATER

Short description of system (fuel used, type of generation system, distribution system, type of storage)

Area of the building served

Year of installation

Installed power (kW)

Efficiency (%) / COP / EER

Level of insulation of DHW distribution system (pipework)

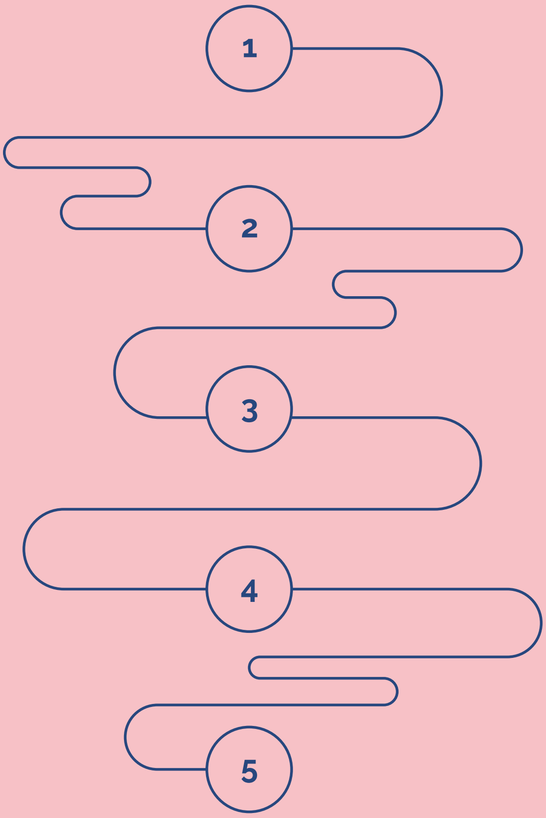
Level of insulation of DHW storage tank

Schedule of operation

Type of control

Other technical characteristics

Photograph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2.2

BUILDING ENERGY SIMULATION SURVEYS

2.2.1 Introduction

This section provides guidelines for the harmonized implementation of the activity Typologies' energy-simulation surveys.
The technical aspects expected are covered providing details on the following issues:

- Suitable Key Performance Indicators (KPIs) that reflect the energy performance of buildings in the base-case (existing situation) as well as in any alternative energy-upgrading scenario[1]. The group of KPIs includes also cost indicators so as to assess the cost-effectiveness of any suggested retrofitting scenario.
- Methods and indicative simulation tools that can be used to compute the required KPIs for the base-case and for various retrofitting scenarios in the framework of parametric analyses.
- Method for prioritizing alternative retrofitting scenarios from low - to high - cost interventions.

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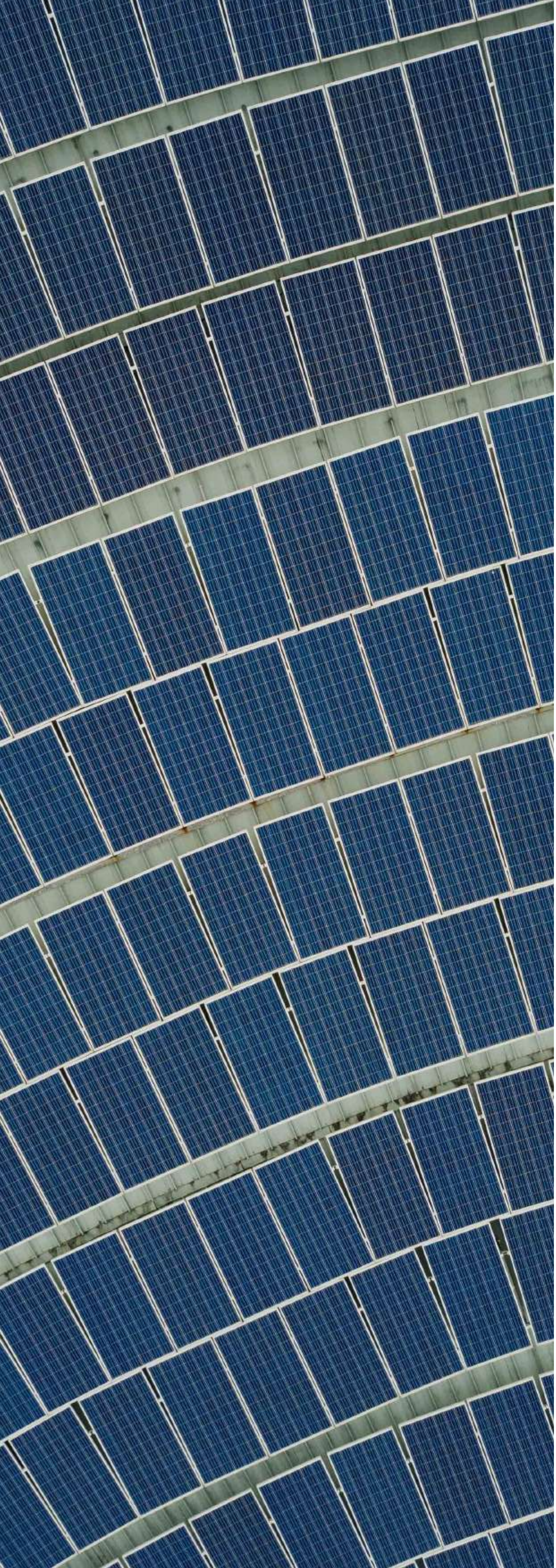
[1] *In this report the term "Energy-upgrading scenario" means the combination of energy efficiency and/or renewable energy (EE/RES) technologies/measures.*



2.2.2
Key Performance Indicators

The suggested mandatory minimum set of KPIs to be computed for each public-building typology for each City, is categorised as follows:

Building energy performance indicators (for the base-case and for each renovation scenario):

- Total annual primary energy consumption (in kWh/m2/yr and in kWh/yr).
- Annual final energy consumption for space heating (in kWh/m2/yr and in kWh/yr).
- Annual final energy consumption for space cooling (in kWh/m2/yr and in kWh/yr).
- Annual final energy consumption for domestic hot water (in kWh/m2/yr and in kWh/yr).
- Annual final energy consumption for lighting (in kWh/m2/yr and in kWh/yr) (in kWh/m^2/yr and in kWh/yr).
- Annual electricity consumption (in kWh/m2/

yr and in kWh/yr).
- Annual consumption of fossil fuel, e.g. oil, natural gas, etc. (in kWh/m2/yr and in kWh/yr).
- Annual generation of Renewable Energy (in kWh/m2/yr and in kWh/yr).

• Environmental indicators (for the base-case and for each renovation scenario):
- Total annual CO2 emissions (in kg/m2/yr and in kg/yr).
- Annual CO2 emissions from electricity consumption (in kg/m2/yr and in kg/yr).
- Annual CO2 emissions from fossil fuels consumption (in kg/m2/yr and in kg/yr).

• Cost indicators:
- Annual total energy-related operational cost (for the base-case scenario and for each renovation scenario) (in Euros or in national currency) (e.g. in €/m2/yr and in €/yr).
- Annual electricity cost (for the base-case scenario and for each renovation scenario) (in Euros or in national currency) (e.g. in €/m2/yr and in €/yr).
- Annual fossil fuel cost (for the base-case scenario and for each renovation scenario) (in Euros or in national currency) (e.g. in €/m²/yr and in €/yr).
- Total investment cost for each renovation scenario (in Euros or in national currency).
- Simple Payback period for each renovation scenario (in years).
- Total investment cost per total annual energy saved for each renovation scenario, i.e. "(Investment cost -in Euros or in national currency)/(kWh of energy saved)".

The above set is proposed as the minimum mandatory set of KPIs to be adopted while conducting the energy simulation analyses. It is up to the city to decide whether they wish to extend the computations including additional KPIs that may be useful for their cases.

As a suggestion, the following optional additional KPIs are provided:

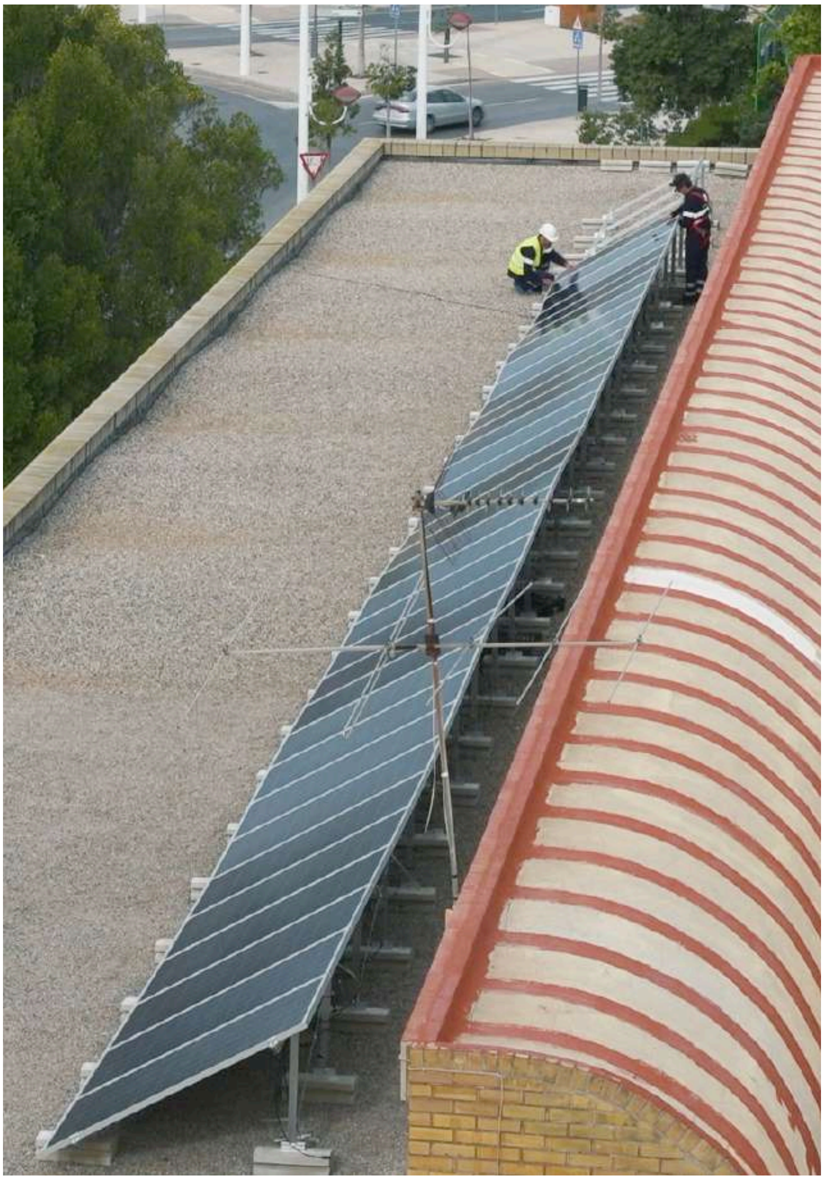
• Building energy performance indicators (for the base-case and for each renovation scenario):
- The indicators mentioned in the mandatory energy KPIs above, in monthly and/or daily and/or hourly basis.
- Energy class (in line with national calculation methodology in each pilot territory).

• Environmental indicators (for the base-case and for each renovation scenario):
- The indicators mentioned in the mandatory environmental KPIs above, in monthly and/or daily and/or hourly basis.
- GHG emissions in annual and/or monthly and/or daily and/or hourly basis.
- Indoor thermal comfort conditions indicator such as i) the Predicted Mean Vote (PMV) e.g. in terms of the number of building operation hours within which the PMV is retained in comfort range (-0.7 to 0.7)[2] and/or of its hourly distribution and mean value on a typical winter and a hot summer day or ii) the frequency (number of hours) of overheating during the occupied period in the year or iii) the peak winter/summer temperatures etc..
- Indoor air quality indicator such as the concentration of an indicative pollutant in the breathing zone.
- Indoor lighting comfort indicators such as the level of illumination e.g. in terms of the number of building operation hours within which the minimum level of illumination to perform certain tasks is achieved. The minimum level of illumination in each space needs to be adapted to the characteristics of the activity that takes places in it and is established in the current legislation. For example, for the case of work spaces in Spain, it is established by the Royal Decree 486/1997.

• Cost indicators (for each renovation scenario):
Special economic indicators could be used such as the NPV and/or IRR, or others more advanced indicators, Life Cycle Cost Indicators, etc.

• Other optional KPIs considered crucial by the involved partners according to the specificities of the pilot Cities in their Countries.

[2] *G.M. Stavrakakis, A.V. Androutsopoulos, J. Vyörykkä, Experimental and numerical assessment of cool- roof impact on thermal and energy performance of a school building in Greece, Energy and Buildings 2016 (130) 64-84.*



2.2.3

Simulation approach

What is to be simulated in IMPULSE? Which buildings to simulate

Municipal buildings' typologies energy simulations are envisaged to assess building energy performance in the base-case (the existing building) as well as for various intervention scenarios.

These selected typologies should be the most representative ones, e.g. the typologies which contain the highest number of buildings (ensuring also to cover more than just one building use).

Energy simulations will be conducted only for the Ambassador building of each of the emerging typologies of the public-buildings classification (for example, if 12 are the selected typologies for simulations the Ambassador building of each typology will be simulated. hence, 12 Ambassador buildings will be simulated), towards the calculation of KPIs for the base-case and for each renovation scenario in the framework of a parametric analysis. Given the similar characteristics of the "Ambassador" with the rest of the buildings of the same typology, it is fairly assumed that the indicators per m2 of building floor area (refer to section "Key Performance Indicators") computed for the "Ambassador" building will be the same to those of the other buildings of the typology.

Simulation and parametric analysis conditions

Each *Ambassador* building will be subjected to simulations towards the calculation of the recommended KPIs (listed in *"Key Performance Indicators*" section) in the following conditions:
- Base-case scenario (it refers to the existing building as it is today).
- Various energy-upgrading scenarios in the framework of a parametric analysis.

The first condition above is clear.

As regards the second condition, there are infinite scenarios by means of combinations of energy-upgrading measures and corresponding impacts. Hence, it needs to be decided how many and which scenarios should be tested in the framework of parametric analyses as well as what are the energy-upgrading goals to be achieved. Of course, this should be also in line with the objectives of the IMPULSE project. To that direction, cities are advised to conduct simulation parametric analysis (testing various renovation scenarios) for each one of the following objectives (opaque bullets) towards the simultaneous achievement of targets (transparent bullets):

Minor retrofit:

- Investment cost below 35,000 €.
- Easy to implement (e.g. no or minimal licensing procedures, technically easy to implement solutions, etc.).
- Reduction of at least one energy performance indicator (related to conventional energy consumption) of the ones mentioned in section “Key Performance Indicators”, by at least 15%, with minimum possible increase (in case of trade-offs) of any other indicator.
- Reduction of the annual total primary energy consumption by as much as technically and financially feasible.
- Reduction of the annual CO2 emissions by as much as technically and financially feasible.

Medium retrofit:

- Relatively easy to implement (e.g. easy to get licenses, technical solutions relatively easy to implement).
- Reduction of the total annual primary energy consumption by at least 25%.
- Reduction of the annual CO2 emissions by as much as technically and financially feasible.
- Reasonable small-scale investment, e.g. below 100,000 €.
- Reasonable payback period.

Major retrofit :

- Reduction of the annual total primary energy consumption towards levels that correspond to the minimum energy performance requirements for major retrofits according to national regulation.
- Realistic to implement (realistic licensing procedures, limited hard technical challenges).
- Achieve the above target with the least investment.
- Achieve the above with the shorter payback period.
- Reduction of the annual CO2 emissions by as much as technically and financially feasible.

Deep retrofit towards Nearly-Zero Energy Building (NZEB):

- Reduction of the annual total primary energy consumption towards levels that correspond to NZEB. For Countries that have not yet defined their NZEB levels, they could adopt the following approximate NZEB options: Reduction of the total annual primary energy consumption corresponding either to the current “A” energy class (in line with their national building energy regulations) or to a novel “A” class for the specific building that can be calculated following the procedure indicated to the regulation 244/2012/EC. Further information regarding the NZEB definitions can be found on the website of the EU Building Stock Observatory[3], within the related factsheet “Nearly zero-energy buildings and their energy performance”, as well as in the BPIE Factsheet “NZEB definitions across Europe”[4].
- Realistic to implement even under complex licensing and/or technical challenges.
- Achieve the above target with the least investment.
- Achieve the above with the shorter payback period.
- Minimum total annual CO2 emissions that correspond to the NZEB levels.

At least one intervention scenario is expected to emerge by the simulation parametric analysis, for each one of the above objectives. More than just one scenario for each one of the objectives above could be included in the suggested solutions.

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[3] *EU Building Stock Observatory, EU Buildings Factsheets, ‘Nearly zero-energy buildings and their energy performance’: https://ec.europa.eu/energy/en/eu-buildings-factsheets*

[4] *BPIE Factsheet ‘NZEB definitions across Europe’: http://bpie.eu/wp-content/uploads/2015/09/BPIE_factsheet_nZEB_definitions_across_Europe.pdf en/eu-buildings-factsheets*

Simulation methods and tools

The purpose is to select a suitable tool/ method that will be used for the simulation of the base-case scenario and of the renovation scenarios during the parametric analysis. The tool/method should be capable to calculate all the mandatory KPIs reported in section "Key Performance Indicators". Cities could use:

- A simple simulation tool (e.g. monthly-time steps) that can carry out energy calculations in line with the national calculation methodology of each Country, as long as it can calculate the mandatory indicators. For example, for Spain the national tool CALENER.

- A multi-zonal simulation tool which can carry out dynamic (hourly basis) energy analysis. For example, one of the following could be considered[5]:

- EnergyPlus
- DesignBuilder
- TRNSYS
- TAS (EDSL)
- IES-ApacheSIM
- Simergy
- eQUEST

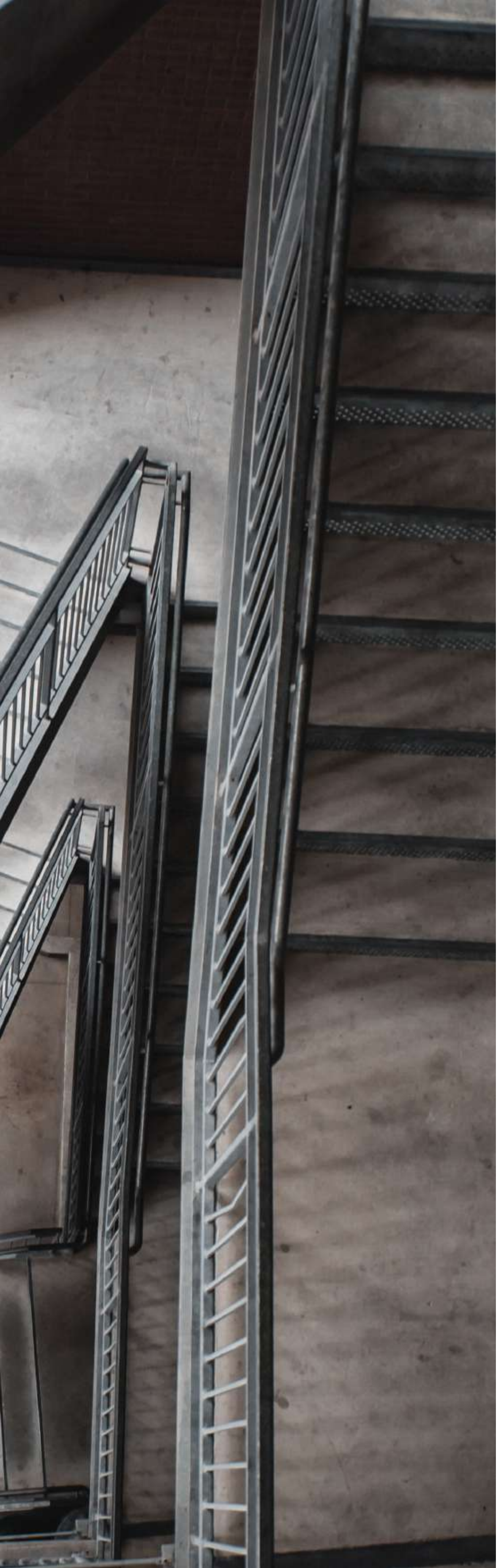
Tip: Cities should keep in mind that the impacts of small-scale interventions, e.g. the addition of heating/lighting controls or a reflective coating applied on the building envelope, are not adequately captured by "rough" simulation tools such as those of monthly-basis calculations (normally adopted in the national energy calculation tools). To demonstrate reliable impacts of small-scale energy investments more detailed simulation tools (dynamic simulation) are preferred as they are capable to capture the dynamic interaction between the external weather conditions, the thermal performance of the building envelope and the internal operating conditions (e.g. number of occupants, installed heating/cooling/lighting systems and control systems e.g. automations, BEMS etc.) far more accurately.

[5] *Review of innovative methods for retrofitting purposes, Deliverable D3.3 (2014), REPUBLIC-MED project (1C-MED12-73).*

2.2.4 Final product of energy simulation surveys

The final product of the energy simulation surveys process is the “Simulated results and hierarchy of retrofitting measures” which is comprised of the following files:

- Energy simulation report: document file with the following content is recommendable: Description of the “Ambassador” buildings including a photo view of the building, representative drawings, building use, building age, technical details about main building envelope elements (walls, roof, floor, windows), technical details about systems (heating, cooling, ventilation, domestic hot water, lighting, with photo documentation if possible), etc. Description of the simulation procedure for each “Ambassador” building including: Description of the simulation method and tool applied, description of input conditions e.g. climatic conditions, thermo-physical and optical properties of materials (e.g. U-values etc.), systems’ properties (e.g. EER, COP, etc.), description of major assumptions adopted. Presentation of KPIs’ results. Description of the current situation of each building based on the simulated results. Description of renovation scenarios tested. Simulation parametric analysis and presentation of simulated KPIs’ results for each renovation scenario with comparisons with KPIs of the base-case to assess impacts.



- An excel-based file being the KPIs' database: For ensuring harmonized results among Cities, and assure that the tool for the design of a Gradual Renovation planning can be used later, it is advisable to provide simulation results in the excel template "D3.4.1_KPIs_NAME OF THE CITY". The latter automatically calculates: prioritization of renovation scenarios and of Ambassador buildings in terms of the reference cost-indicator "(total investment cost)/(kWh of energy saved)". projections of Ambassadors' results to the initial sample of buildings for each renovation objective.

2.2.5 Prioritization of energy scenarios and projections of Ambassadors' results

Interpretation of the results obtained through the KPIs' database:

Prioritization of renovation scenarios

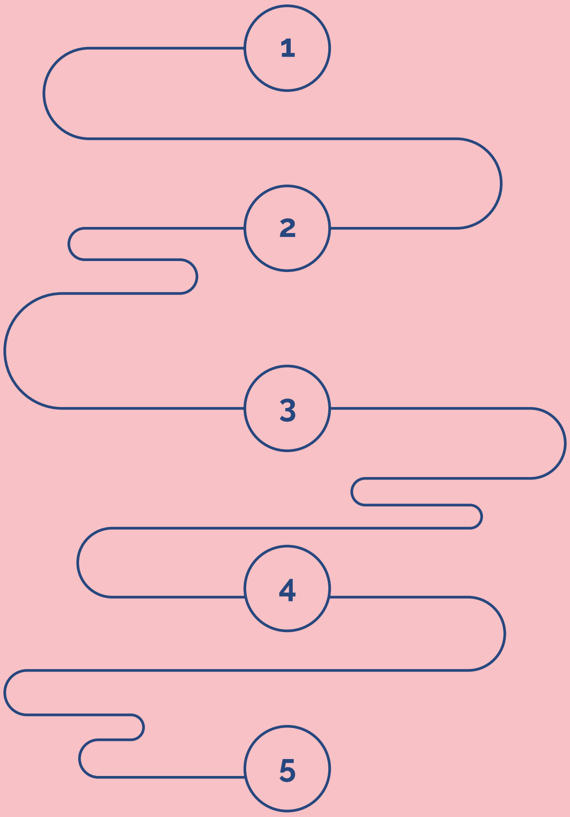
The indicator "(Investment cost) / (kWh of saved energy)" obtained for each small-scale retrofit scenario for each "Ambassador" building may be used to prioritize the Ambassador buildings by means of affordability, i.e. detect the buildings for which the highest energy saving is achieved under least cost. Prioritization can be obtained through comparing the indicator among all the "Ambassador" buildings. This comparison will reveal the "Ambassador" building with the lowest "(Investment cost) / (kWh of saved energy)" indicator, which, eventually, represents the building with the highest energy-saving potential under least cost (which according to the AF, activity A3.6, this is the criterion to select the pilot building for small-scale renovation). This means that all buildings belonging to the typology represented by the "Ambassador" building with the lowest indicator "(Investment cost) / (kWh of saved energy)" revealed previously, are good candidates to implement the energy-upgrading scenario.

For each "Ambassador" building, the energy-renovation scenarios tested could be prioritized by means of the reference cost-indicator "(Investment cost-in Euros or in national currency) / (kWh of saved energy)" (refer to section "Key Performance Indicators"), i.e. from the lowest to the highest value. Obviously, the scenario with the lowest indicator is the most affordable one and could be considered as the best retrofit.

Projections of Ambassadors' results

The projection of base case scenario for all building stock will be developed automatically (sheet Projection Base-case). The results of projected base case scenario will be presented for each building, aggregated for each public building typologies. Aggregated result for all PBT is very useful information for future renovation plans. This information will give overall view of public building typologies and their state regarding energy consumption what can be starting point in yearly renovation plans.

After the development of base case scenario for buildings is finished, next step will be development of retrofit scenarios projection for all buildings and typologies. The result will be presented in 4 excel sheets (Projection Minor retrofit, Projection Medium retrofit, Projection Major retrofit, Projection Deep retrofit). In the case of more than one renovation scenario per energy-upgrading objective (minimum, medium, major and/or deep renovation) has been calculated, the scenario to be applied in the projection must be selected manually. Each projection sheet (Projection_Minor retrofit, Projection_Medium retrofit, Projection_Major retrofit, Projection_Deep retrofit) provides valuable information regarding the energy saving potential of the public building stock depending on the energy-upgrading intervention considered.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2.3

TYPOLOGIES’ RENOVATION PLANNING AND POTENTIAL FINANCING

This section provides guidelines for the provision of optimal paths for renovation of the public building stock cities implementing IMPULSE approach. That means the optimal roadmaps, considering also potential financing, for gradual renovation, of at least 3% floor-area annual, for the sample of buildings recorded in the “Classification of public-building typologies” and “Typologies’ energy simulation surveys”.

2.3.1 Yearly renovation planning tool's functioning

(This is an improved version of the tool previously developed in the framework of the IMPULSE project.).

The objective of KPIs-processor's PLUG-IN tool is to recognize the most affordable pathways for renovating, at least, 3% of building-stock area annually, based on each territory recognized typologies and their respective renovation scenarios associated with energy and cost indicators.

The excel-based tool automatically calculates yearly renovation plan for a public administration's building-stock according to specified input data and excel KPIs database previously calculated based on the public-building stock typification and their associated energy performance upgrading scenarios.

It is important to highlight that this tool can be used only if minor to deep renovation scenarios planned in KPIs-processor is gradual. E.g. Deep retrofit scenario is consist of the major retrofit scenario and additional energy efficiency measures, Major retrofit scenario is consist of the medium retrofit scenario and additional ee measures.

2.3.2 Plug-in operating instructions

The PLUG-IN tool excel file consists of 6 sheets:

1. Cover: basic information about deliverable and developers of tool.

2. Instructions: how to use the KPIs-processor's PLUG IN tool.

3. MCA INPUT: the sheet were the user choses input data.

4. PLAN: output data: yearly renovation plan.

5. Ranking: ranking of buildings and associated renovation scenarios to be implemented according to the input data preferences.

6. MCA-CHART: graphical presentation of results.

The instructions for PLUG IN tool are specified below.

In the sheet MCA – INPUT, yellow cells are enabled input data, green cells are enabled to choose from drop down lists, and orange cells are output data automatically calculated.

Step 1.
The first step is to insert the name of the KPIs excel file you are going to work with to calculate the Energy Renovation Plan. This KPIs excel file must be necessarily open during the use of the planning tool.

Table 1 – Name of Excel City/Region file

Name of Excel CITY/REGION File	D3.4.1_KPIs_ELCHE_en_rev2.xlsx

Step 2.
Chose up to 5 the most important KPIs (use drop-down list of KPIs) and they weight factors to define gradual renovation plan.

Table 2 - Input data for weight factors and drop down list for up to five indicators

Key Performance Indicators - Units	Weight factor
2. Total annual primary energy consumption - kWh/yr	20
7. Annual generation of Renewable Energy - KWh/m^2	20
9. Total annual CO2 emissions - kg/m^2/yr	20
23. Total annual primary energy savings - kWh/m^2/yr	20
54. Total investment cost per total annual energy saved - National	20

For correct calculation the sum of weight factors must be 100.

Step 3.
In the table 3 below, plug in tool enables user to change final score according to other 3 ponderable categories, which are Public Building Typologies, Retrofit scenarios or Renewable Energy Sources, up to +/- 30%.

Table 3 – Other ponderable categories

Other ponderable categories	Option	Weight factor
Building Typology	PBT1	0%
Type if Retrofit	Deep retrofit	0%
RES	RES	30%

Using weighting (+/-30%) for building typology and type of retrofit, overall score will be increased or decreased for entered value. Using penalization (+/-30%) for RES, score from KPI related to RES (7, 8, 32, 33 and/or 34 KPIs.) will be increased or decreased for entered value.

Step 4.
In table 4 the user must enter the baseline year, so that the renovation plan proposed by the tool will start in the following year (e.g., for 2021 baseline year, the tool will start renovation plan in 2022). User can also refer to the baseline year as 0, and the tool shows the Renovation Plan for the 1, 2, 3...year.

The second data to input is the planed percentage floor area to be retrofitted annually. Tool calculates optimal option of retrofitting to fulfill annual retrofit demand.

After input relative planed retrofit area (eg 3%, 5%,...), it is possible to do combination of retrofit.

Tool shows below (orange cells) the total floor area of public building stock to be potentially renovated and the total floor area to be renovated annually.

Table 4 – Baseline year and relative annual retrofitting area

Baseline year	2021
Relative annual retrofitting area	8%
Total floor area (m^2)	166.011
Annual floor area (m^2)	13.281

Step 5.
In Cell C21 of this sheet there is dropdown list with total of 5 possibilities. If you select minor, medium, major or deep, the tool calculates only retrofit options as selected, and not considering other retrofit type (in this case you do not need to input yellow cells). By selecting "Combination" it is possible to interact with multiple retrofit types.

If chosen option is “Combination” as shown in table below it is necessary to input yellow cells. Yellow cells in this tables present the factor that decrees floor area of building by the type of retrofit. Depending on retrofit scenario, user can choose the area factor considering boundaries presumed by the developer of this tool.

Table 5 – Combination of different retrofit types

Renovation scenarios	Weight factor
Minor	15%
Medium	30%
Major	90%
Deep	100%

It means that if you have in calculations “Minor” retrofit of some building, for calculations of total retrofit floor area, it will consider only 15% of that floor area (or percentage you entered). But if you have in next option the same building with deep retrofit, in that step it will take the rest of 85% of floor area.

Step 6.
Select PBT and retrofit scenario you want to consider for the calculation and presentation.

Table 6 –Select building typology and retrofit level for calculation

	Minor retrofit	Medium retrofit	Major retrofit	Deep retrofit
PBT1	✗	✓	✓	✓
PBT2	✓	✗	✓	✓
PBT3	✓	✓	✓	✓
PBT4	✓	✓	✓	✓
PBT5	✓	✗	✓	✓
PBT6	✓	✓	✗	✓
PBT7	✓	✓	✓	✓
PBT8	✓	✓	✓	✓
PBT9	✓	✓	✗	✓
PBT10	✗	✓	✓	✓
PBT11	✓	✓	✓	✗
PBT12	✓	✓	✓	✓
PBT13	✓	✓	✓	✓
PBT14	✓	✓	✓	✓
PBT15	✓	✓	✓	✓

In table above, it is possible to select or unselect each building type or level of retrofit. With input “1” in each cell you select that indicator, and with input “0” you deselect.

Step 7.
In table 7 the user can select up to 10 combinations of building with associated retrofit scenario to be excluded from the calculation and presentation.

Table 7 - Select building together with associated scenario you want to exclude for calculation

Building and associated scenario to be excluded from the initial sample
PBT3 - Preschool and primary school Ausias March - Minor Retrofit
PBT4 - Nursery School Don Crispín - Medium Retrofit
PBT1 - Adult training Center Mercé Rodoreda - Deep Retrofit

Step 8.
In table 8 the user enters the targets to be achieved for CO2 emission reduction (%), Primary Energy Consumption reduction (%), and the share of public-building stock Primary Energy consumption covered by Renewable Energies (%).

Table 8 - Checking of objectives to be achieved with the gradual renovation plan

Targets check	
CO2 reduction (%)	55%
kWh reduction (%)	30%
RES share	9%

These data make it possible to later check at what stage of the renovation plan these targets are or are not achieved.

Step 9.
In table 9, the user enters the yearly public budget allocated for investment in energy renovation for public buildings.

Table 9 – Checking budget constrains

Limits check	
Annual Investment	1.000.000 €

This data makes it possible to later check if the yearly investment required is higher/lower than public budget availability.

2.3.3 Results from PLUG IN tool

SHEET: PLAN

Columns from E to X present yearly plan of renovation according to total result gained from user preferences explained in steps above.

The information in row 4-8 in same columns present yearly floor area presumed for retrofit, investments costs and savings (CO2, kWh and National Currency).

The information in row 9-13 in same columns present accumulated data for floor area presumed for retrofit, and investments costs and savings (CO2, kWh and National Currency).

The information in row 14, in same columns, presents the share (%) of primary energy consumption covered by renewable energies, for the entire stock of public buildings, each year, considering the energy efficiency measures implemented so far.

The information from row 15 up to 175, in each column (E to X), shows the name of the buildings and associated retrofit scenarios to be implemented in this year.

When operating the tool with the combination of several possible levels of retrofitting scenarios, when a “lower/lesser” retrofitting scenario appears after than a “higher/upper” scenario, the tool automatically removes it from the ranking.

ANUAL RETROFIT PLAN

		A–o	1	2	3	4
Annual	Floor area retrofit	m²	5.203,97	5.547,85	7.972,15	5.526,00
	Annual investment	NC	519.055	524.532	821.237	522.052
	Savings - currenc.	NC/yr	35.710	39.696	40.804	23.097
	Savings - CO2	tCO2/yr	58	55	93	57
	Savings - kWh	kWh/yr	407.957	329.064	612.570	370.273
Accumulate	Floor area retrofit	m²	5.204	10.752	18.724	24.250
	Investment	NC	519.055	1.043.587	1.864.824	2.386.876
	Savings - currenc.	NC/yr	35.710	75.406	116.210	139.307
	Savings - CO2	tCO2/yr	58	113	206	263
	Savings - kWh	kWh/yr	407.957	737.021	1.349.591	1.719.864
	Share of PEC from	%	0,97%	1,73%	3,32%	4,18%
		1	PBT12-Preschool and primaryschool. El Palmeral - n’4 - Deep retrofit	PBT12-Preschool and primaryschool. El Palmeral - n’8 - Deep retrofit	PBT6-Sociocultural centro Valverde - Deep retrofit	PBT3-Preschool and primaryschool. Miquel de Unamuna - Deep retrofit
		2	PBT4-Nursery School Don Crispín - Deep retrofit	PBT12-Preschool and primaryschool. El Palmeral - n’7 - Deep retrofit	PBT4-Adult Training Center Ramón Gil Bananza- Deep retrofit	PBT4-Cultural Center L’ercorxador and Municipal Training Center - Deep retrofit
		3	PBT4-Nursery School San Antonio - Deep retrofit	PBT12-Preschool and primaryschool. El Palmeral - n’6 - Deep retrofit	PBT10-Municipal office bulding 1 - Deep retrofit	
		4	PBT4-Nursery School Don Honorio - Deep retrofit	PBT12-Preschool and primaryschool. El Palmeral - n’5 - Deep retrofit	PBT10-Municipal office bulding 2 - Deep retrofit	
		5	PBT4-Nursery School Don Julio - Deep retrofit	PBT12-Preschool and primaryschool. El Palmeral - n’3 - Deep retrofit	PBT4-Especial Education Public Center Virgen de la Luz - Deep retrofit	
		6	PBT4-Nursery School Els Xiquets - Deep retrofit	PBT12-Preschool and primaryschool. El Palmeral - n’2 - Deep retrofit		
		7		PBT12-Preschool and primaryschool. El Palmeral - n’1 - Deep retrofit		
		8		PBT6- Social Centro Palmeras - Deep retrofit		
		9		PBT4-Nursery School Rara Fernández - Deep retrofit		
		10		PBT6-Sociocultural Centro Poeta M. Hernández - Deep retrofit		

Example of the first 4 years of the renovation plan

The cells in row 5, referring to the annual investment required, are shaded in red when the budget limit set in the MCA-INPUT sheet, cell F22, is exceeded.

Otherwise, when the investment is below the established limit, it is shaded in green. Similarly, rows 12, 13 and 14 are shaded red when CO2 reduction, energy reduction, and RES share targets defined in respective cells F17, F18 and F19 of the MCA-INPUT sheet are not achieved and are shaded green when the defined targets are met.

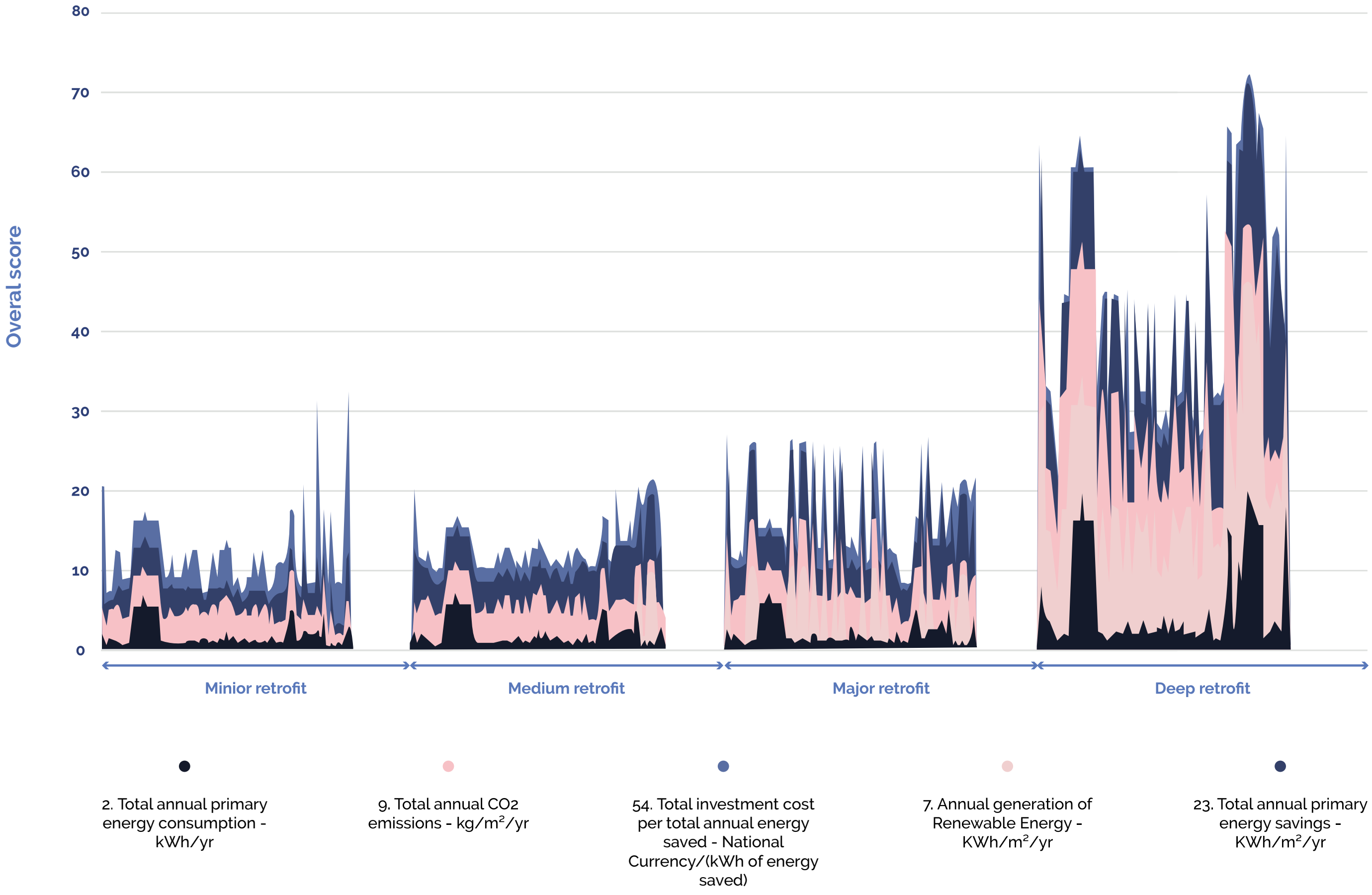
SHEET: Ranking

The table presents the intervention ranking of all building considering the input data from tables 2,3,5,6 and 7 in MCA-INPUT worksheet: chosen indicators, weighting factors of those indicators, other ponderable categories considered, selected building type and level of retrofit, and building and associated retrofit scenarios excluded.

Ranking - buildings		Building floor area (m^2)	Final Score
1	PBT4 - Nursery School Don Crispín - Deep retrofit	968,84	71,46
2	PBT4 - Nursery School Don Honorio - Deep retrofit	1.024,00	70,39
3	PBT4 - Nursery School Don Julio - Deep retrofit	1.024,00	70,39
4	PBT4 - Nursery School Rosa Fernández - Deep retrofit	1.260,00	66,85
5	PBT6 - Social Centre Palmerales - Deep retrofit	602,00	65,06
6	PBT6 - Sociocultural Centre Poeta M. Hernández - Deep retrofit	605,85	64,96
7	PBT11 - Nursery School San Antonio - Deep retrofit	851,00	64,73
8	PBT6 - Sociocultural Centre Valverde - Deep retrofit	648,00	63,97
9	PBT12 - Preschool and primary school - El Palmeral, nº 4 - Deep retrofit	351,34	63,88
10	PBT10 - Municipal office building 1 - Deep retrofit	997,15	63,27
11	PBT10 - Municipal office building 2 - Deep retrofit	1.003,00	63,22
12	PBT4 - Adult Training Center Ramón Gil Bonanza - Deep retrofit	1.670,00	63,08
13	PBT11 - Nursery School Els Xiquets - Deep retrofit	984,79	62,09
14	PBT12 - Preschool and primary school El Palmeral, nº 8 - Deep retrofit	440,00	59,85
15	PBT12 - Preschool and primary school El Palmeral, nº 7 - Deep retrofit	440,00	59,85
16	PBT12 - Preschool and primary school El Palmeral, nº 6 - Deep retrofit	440,00	59,85
17	PBT12 - Preschool and primary school El Palmeral, nº 5 - Deep retrofit	440,00	59,85
18	PBT12 - Preschool and primary school El Palmeral, nº 3 - Deep retrofit	440,00	59,85
19	PBT12 - Preschool and primary school El Palmeral, nº 2 - Deep retrofit	440,00	59,85
20	PBT12 - Preschool and primary school El Palmeral, nº 1 - Deep retrofit	440,00	59,85
21	PBT4 - Special Education Public Center Virgen de la Luz - Deep retrofit	3.654,00	56,79

SHEET: MCA-CHART

Graphic presentation of all results
is presented in sheet MCA-CHART.



Example of MCA - CHART

2.3.4 Financial schemes tool's functioning

(This is an improved version of the tool previously developed in the framework of the IMPULSE project.).

In order to make self-sustainable the renovation plan established by each city. it is needed to analyse which are the potential funding sources that can be used.

The objective of this financial schemes tool is to simulate possible financing of renovation plan calculated with PLUG-IN TOOL.

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.

The results are compared to energy bill baseline (if no works are done).

It can be used for a multiple simulation covering the possible evolution input data hypotheses, comparing up to 3 different combinations of data.

2.3.5 Financial plans tool’s operating instructions

The financial plans are produced from the excel tool “Financial schemes”. It works consecutively to the PLUG-IN excel tool used to generate the renovations plans.

The instructions for Financial schemes tool are specified below.

INSTRUCTIONS FOR EACH WORKSHEET

SHEET: Hypotheses
On the first sheet, different colored cells need to be completed according to your renovation plan:

- Yellow cells are results from previous deliverables (D3.4.1 and Plug-in tool) that need to be copy/pasted.

- Blue cells are general hypotheses about interest rate, inflation.

- Orange cells are financial information about your pilot city that needs to be completed for each year of SEAP duration.

Yellow cells - Results from previous deliverables
Total Energy Bill is a result from the sheet “Projection_Base-case” of D3.4.1 KPI : total for the whole initial sample of the Cost indicator “Annual total energy-related operational cost” in NC/yr (Cell V114).

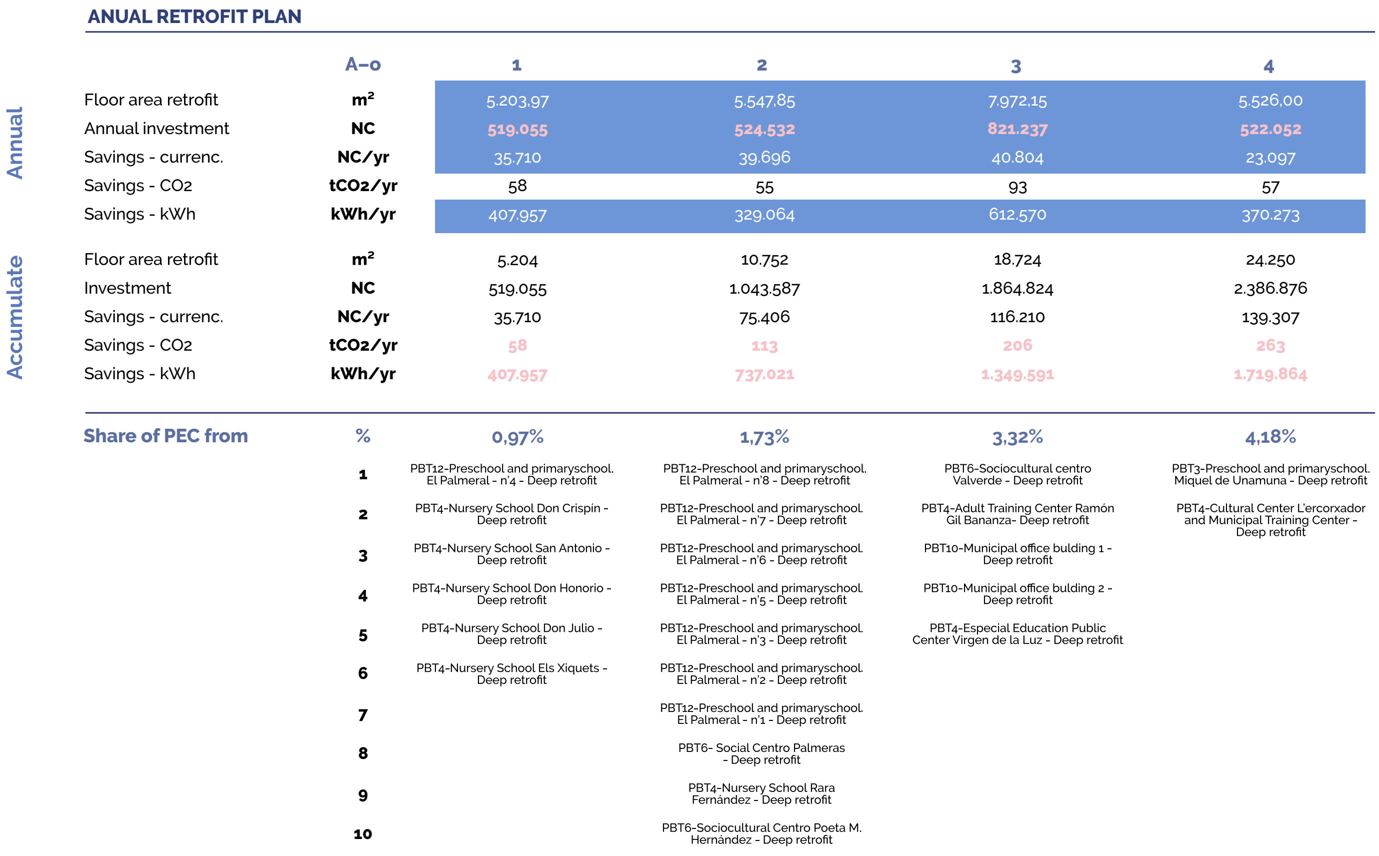
Projection of results from Ambassador to the initial testing sample of building

Base-case									
						Cost indicators			
						Annual total energy-related operational cost		Annual electricity cost	
Building No.	Building name	Building floor area (m2)	Public Building Typology	Retrofit scenario	Type of retrofit	National Currency/m^2/yr	National Currency/yr	National Currency/m^2/yr	National Currency/yr
			PBT10				15277,55		15277,5457
			PBT11				19679,67		9068,8026
			PBT12				36231,61		32960,3197
			PBT13				0		0
			PBT14				0		0
			PBT15				0		0
			TOTAL FOR THE WHOLE INITIAL SAMPLE				847957,7		680168,176

Location of field in D3.4.1

- Renovation plan results can be found in the sheet "PLAN" of the PLUG-IN tool: for every year of SEAP duration, floor area retrofitted, annual investment, savings – currency and savings – kWh need to be entered in the financial tool.

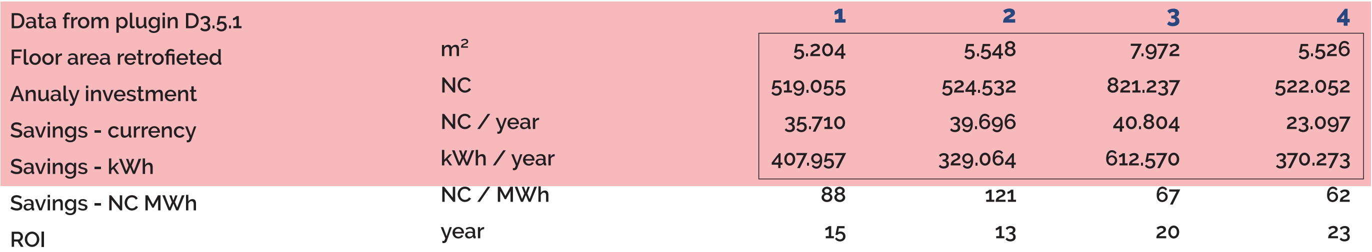
- Fields:
• Floor area retrofitted, annual investment, savings – currency = E4:X6 in field Hypotheses!D94:W96.
• Savings – kWh= E8:X8 in field Hypotheses!D97:W97".



ANUAL RETROFIT PLAN

		A–o	1	2	3	4
Annual	Floor area retrofit	m²	5.203,97	5.547,85	7.972,15	5.526,00
	Annual investment	NC	519.055	524.532	821.237	522.052
	Savings - currenc.	NC/yr	35.710	39.696	40.804	23.097
	Savings - CO2	tCO2/yr	58	55	93	57
	Savings - kWh	kWh/yr	407.957	329.064	612.570	370.273
Accumulate	Floor area retrofit	m²	5.204	10.752	18.724	24.250
	Investment	NC	519.055	1.043.587	1.864.824	2.386.876
	Savings - currenc.	NC/yr	35.710	75.406	116.210	139.307
	Savings - CO2	tCO2/yr	58	113	206	263
	Savings - kWh	kWh/yr	407.957	737.021	1.349.591	1.719.864
	Share of PEC from	%	0,97%	1,73%	3,32%	4,18%
		1	PBT12-Preschool and primaryschool. El Palmeral - n'4 - Deep retrofit	PBT12-Preschool and primaryschool. El Palmeral - n'8 - Deep retrofit	PBT6-Sociocultural centro Valverde - Deep retrofit	PBT3-Preschool and primaryschool. Miquel de Unamuna - Deep retrofit
		2	PBT4-Nursery School Don Crispín - Deep retrofit	PBT12-Preschool and primaryschool. El Palmeral - n'7 - Deep retrofit	PBT4-Adult Training Center Ramón Gil Bananza- Deep retrofit	PBT4-Cultural Center L'ercorxador and Municipal Training Center - Deep retrofit
		3	PBT4-Nursery School San Antonio - Deep retrofit	PBT12-Preschool and primaryschool. El Palmeral - n'6 - Deep retrofit	PBT10-Municipal office bulding 1 - Deep retrofit	
		4	PBT4-Nursery School Don Honorio - Deep retrofit	PBT12-Preschool and primaryschool. El Palmeral - n'5 - Deep retrofit	PBT10-Municipal office bulding 2 - Deep retrofit	
		5	PBT4-Nursery School Don Julio - Deep retrofit	PBT12-Preschool and primaryschool. El Palmeral - n'3 - Deep retrofit	PBT4-Especial Education Public Center Virgen de la Luz - Deep retrofit	
		6	PBT4-Nursery School Els Xiquets - Deep retrofit	PBT12-Preschool and primaryschool. El Palmeral - n'2 - Deep retrofit		
		7		PBT12-Preschool and primaryschool. El Palmeral - n'1 - Deep retrofit		
		8		PBT6- Social Centro Palmeras - Deep retrofit		
		9		PBT4-Nursery School Rara Fernández - Deep retrofit		
		10		PBT6-Sociocultural Centro Poeta M. Hernández - Deep retrofit		

Location of fields in PLUG-IN tool



Data from plugin D3.5.1		1	2	3	4
Floor area retrofieted	m^2	5.204	5.548	7.972	5.526
Anualy investment	NC	519.055	524.532	821.237	522.052
Savings - currency	NC / year	35.710	39.696	40.804	23.097
Savings - kWh	kWh / year	407.957	329.064	612.570	370.273
Savings - NC MWh	NC / MWh	88	121	67	62
ROI	year	15	13	20	23

Location of fields in financial schemes tool

Blue cells – General hypothesis

For your simulation, you need to estimate financial data during SEAP duration:

- Interest rate of the loan.

- Energy discount rate.

- Inflation /year (NC).

- Annual increase of public body budget (%).

- Loan duration / years in public body planning – The duration cannot exceed 20 years.

- Annual increase of loan rate (for multi-loan simulation you can either enter a different loan rate each year or increase every year your loan rate with this indicator).

Up to 3 combinations of data can be entered to compare different hypotheses simultaneously.

Hypotheses	**Comb 1**	**Comb 2**	**Comb 3**
Interest rate of the loan	1,50%	1,50%	1,50%
Energy discount rate	3,00%	6,00%	10,00%
inflation / year (NC)	2,00%	2,00%	2,00%
Annual increase of public body budget (%)	1,00%	1,00%	1,00%
Loan duration / years in public body planning	14	14	14
Seap duration (calculated)	14	14	14
Annual increase of loan rate	2,00%	2,00%	2,00%

Max 20 years for information

Example of general hypotheses

Orange cells - Your city financial information

The last entries regard your pilot city budget for building renovation and possible subsidies you need to estimate for each year investment.

- Budget of public body over SEAP Duration = equity capital.

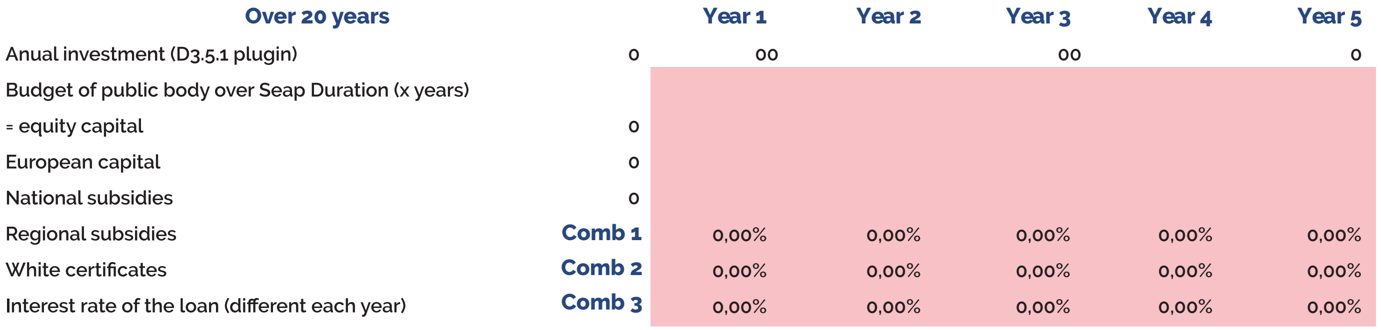
- European subsidies.

- National subsidies.

- Regional subsidies.

- White certificates.

- Interest rate of the loan (different each year) - you can use a different known value each year or use the formula with % annual increase of loan rate.



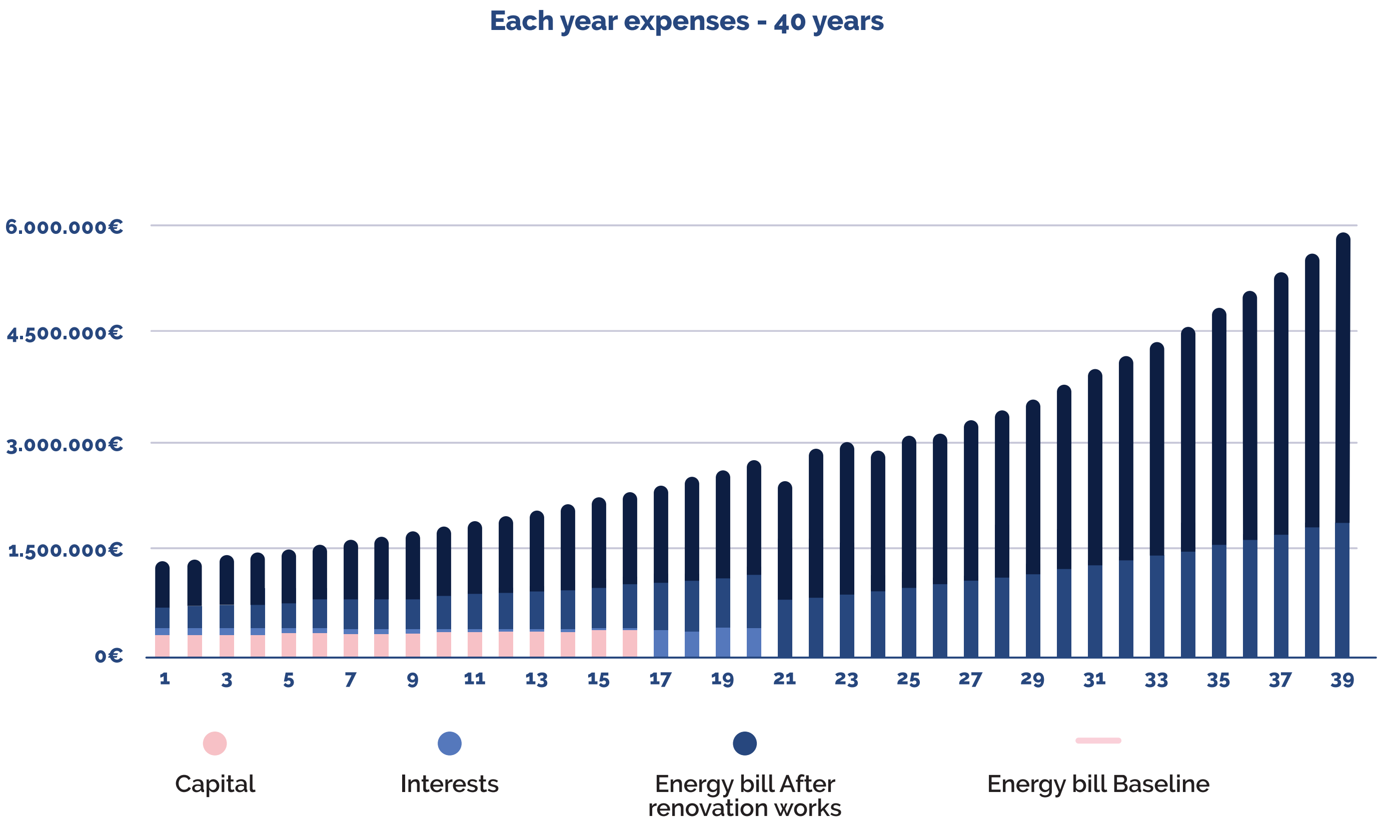
Over 20 years		Year 1	Year 2	Year 3	Year 4	Year 5
Anual investment (D3.5.1 plugin)	0	00		00		0
Budget of public body over Seap Duration (x years)						
= equity capital	0					
European capital	0					
National subsidies	0					
Regional subsidies	**Comb 1**	0,00%	0,00%	0,00%	0,00%	0,00%
White certificates	**Comb 2**	0,00%	0,00%	0,00%	0,00%	0,00%
Interest rate of the loan (different each year)	**Comb 3**	0,00%	0,00%	0,00%	0,00%	0,00%

Location of fields in financial schemes tool

SHEETS: Comb 1 or 2 or 3 + "All in one loan + Works"
Each worksheet (Comb 1/2/3 All in one loan + Works) shows expense each year of SEAP through financing all renovation plan with one loan, depending on the hypothesis introduced in blue cells for each combination.

The tool calculates loan capital and interests every year and the energy bill after renovation works.

It can be compared graphically and with the results table to energy bill baseline (no renovation works, only updated with inflation each year).

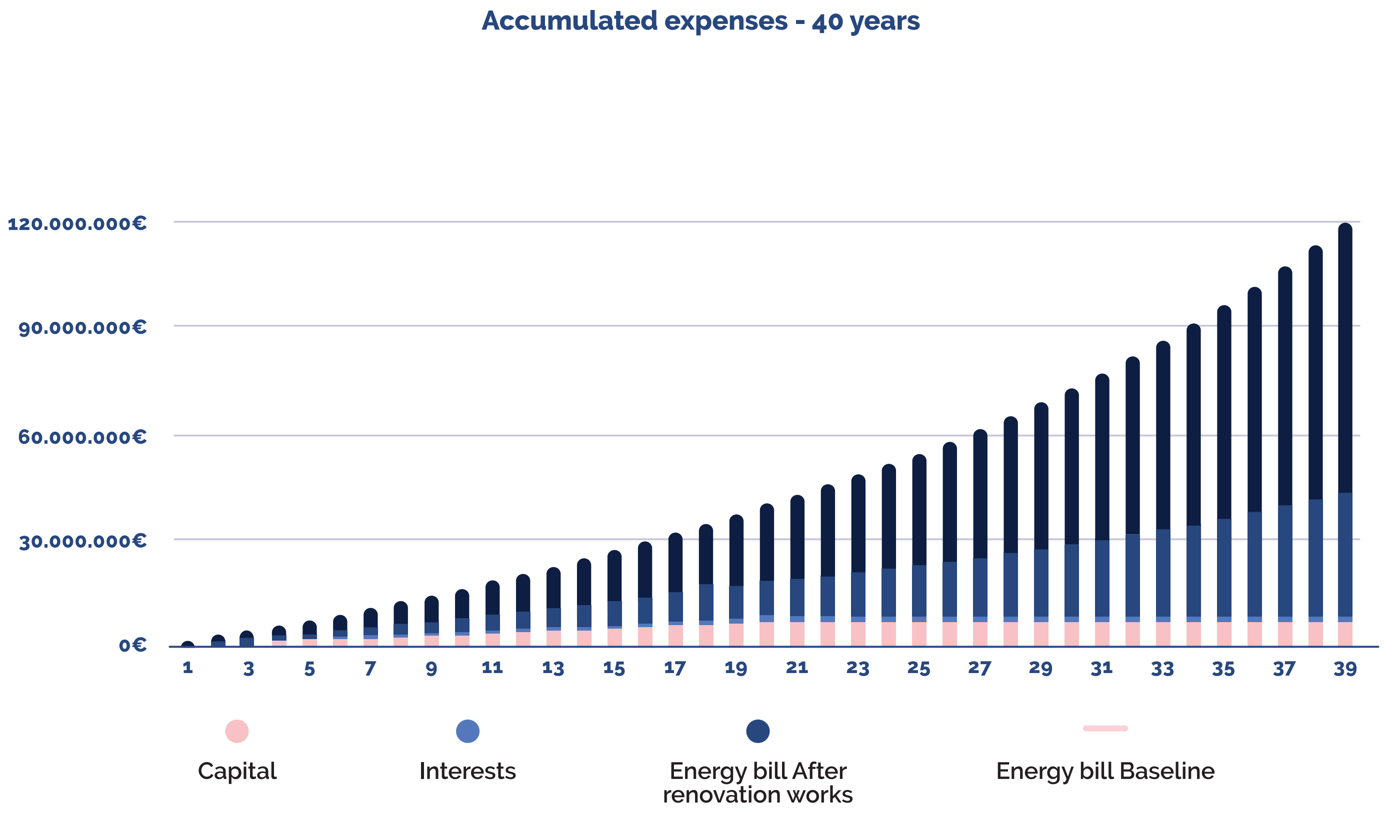


Each year expenses - 40 years

Example of each year expenses - All in one loan + Works

The "each year expenses" chart shows generally that the renovation plan (with works + loan capital and interests + energy bill after works) presents fewer annual expenses than energy bill baseline (energy bill updated with inflation each year) within a few years.

In the example above, in year 4 there are fewer expenses with renovation plan.



Example of accumulated expenses - All in one loan + Works

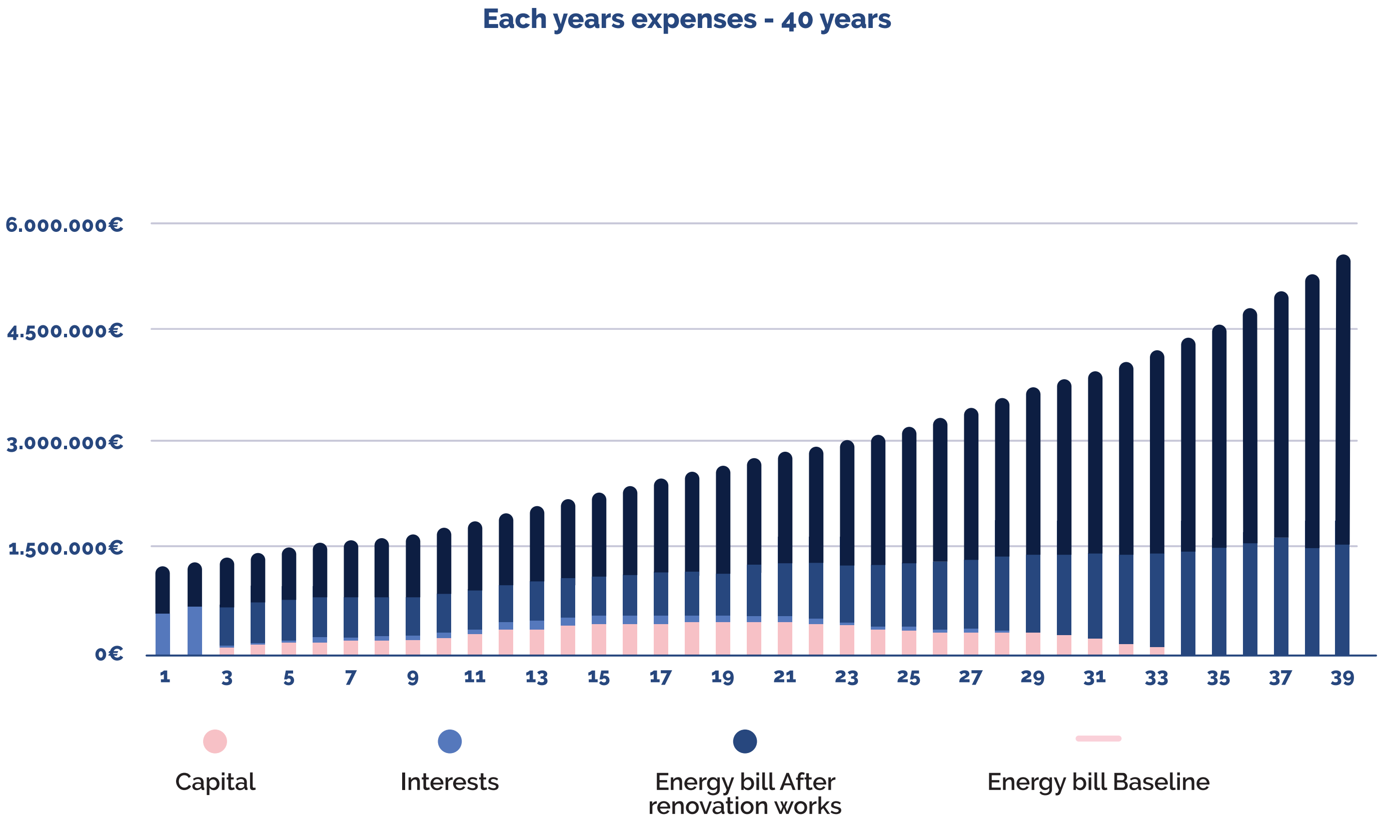
The “accumulated expenses” chart shows the accumulated expenses of the renovation work project and the energy bill baseline, and the gap between the two situations at the end of the borrowing. Generally, the balance-sheet is balanced before the end of the loan.

In the example above, the balance-sheet is balanced in 7 years and the total benefit is 30 501 k€ (-43%) over 40 years.

SHEETS: Comb 1 or 2 or 3 + "One loan + Works per year"
Each worksheet (Comb 1/2/3 One loan + Works per year) shows expense each year of SEAP through financing renovation plan gradually with multiple loans and doing parts of renovation plan every year depending on the hypothesis introduced in blue cells for each combination.

The tool calculates each loans capital and interests every year and the energy bill after renovation works.

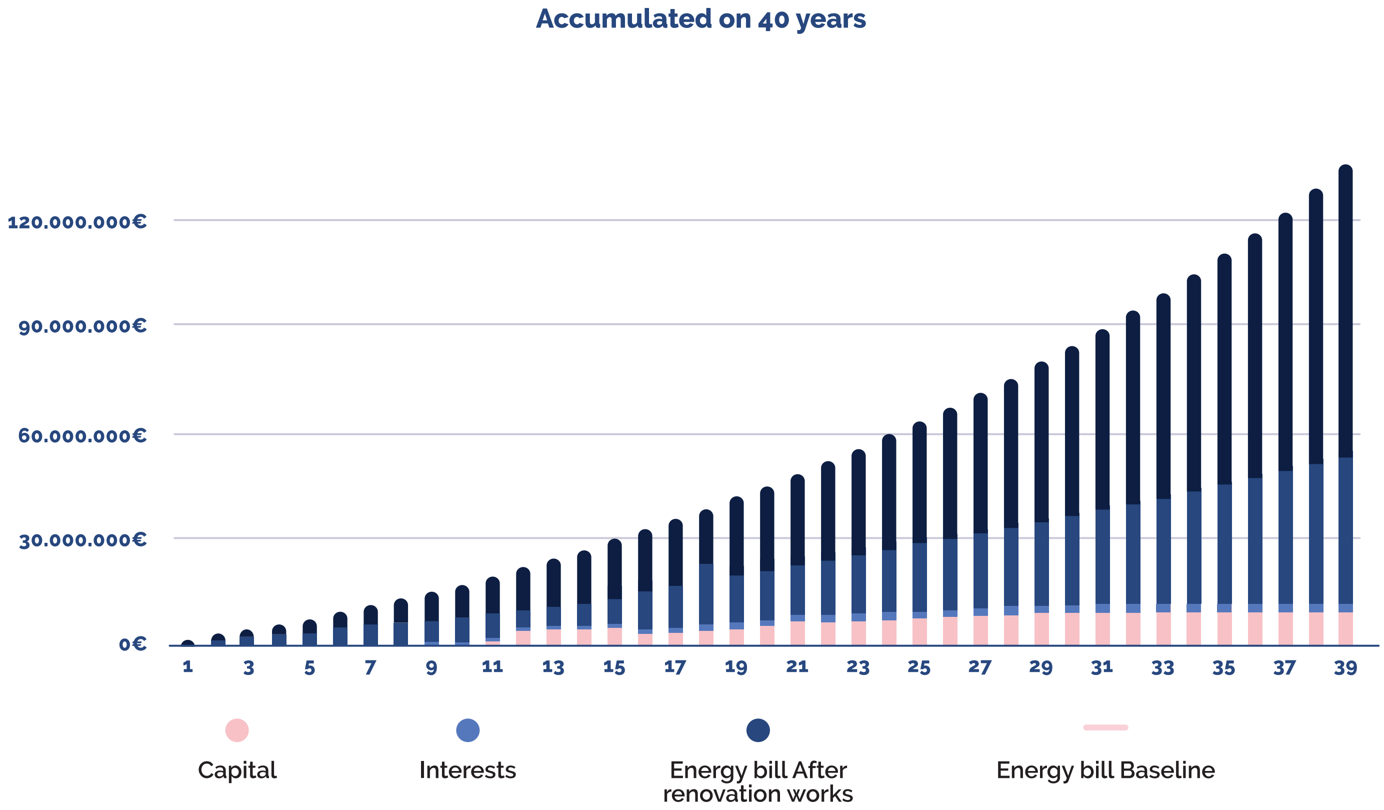
It can be compared graphically and with the results table to energy bill baseline (no renovation works, only updated with inflation each year).



Example of each year expenses - One loan + W per year

The "each year expenses" chart shows generally that the renovation plan (with works + multiple loans capital and interests + energy bill after works) presents fewer annual expenses than energy bill baseline (energy bill updated with inflation each year) within a few years.

In the example above, in year 7 there are fewer expenses with renovation plan. In year 21, first loan repayment ends. In year 34, all loans are completed.



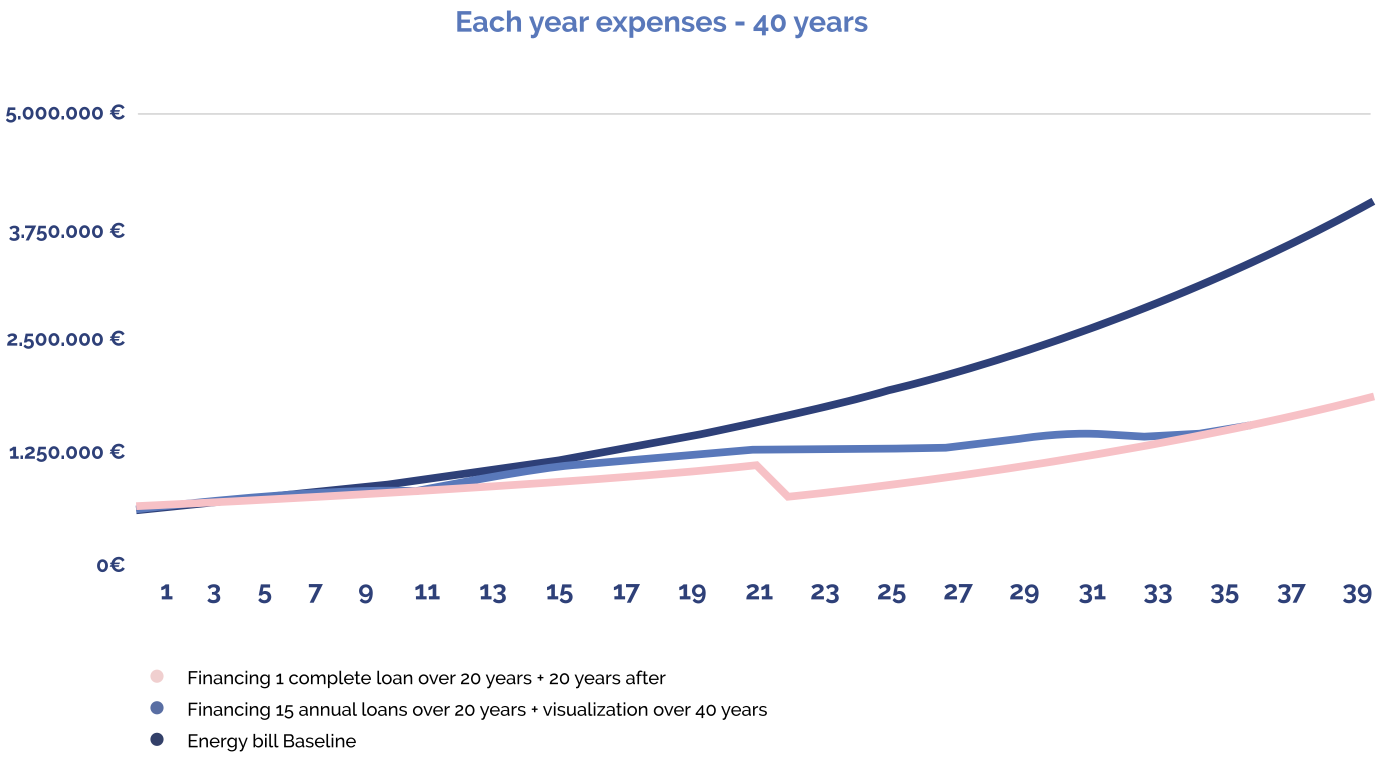
Example of accumulated expenses - One loan + W per year

The “accumulated expenses” chart shows the accumulated expenses of the renovation work project and the energy bill baseline, and the gap between the two situations at the end of the borrowing. Generally, the balance-sheet is balanced before the end of the loan.

In the example above, the balance-sheet is balanced in 8 years and the total benefit is 24 796 k€ (-35%) over 40 years.

SHEETS: Comb 1 or 2 or 3 + Comparison
Each worksheet (Comb 1/2/3 Comparison) aims at comparing each financing through SEAP duration depending on the hypothesis introduced in blue cells for each combination.

It presents calculated total expenditures (capital + interest + energy bill after renovation works) every year and accumulated with both financing and also energy bill baseline.



Example of each year expenses - Comparison

The “each year expenses” chart shows generally that the renovation plan with “all in one loan”-financing presents fewer annual expenses after the loan is repaid in year 20. The “One loan + renovation works per year” -financing curve overlap the “all in one loan” at the end of the last loan (in the case above, in year 35).

Example of accumulated expenses – Comparison

The “accumulated expenses” chart shows the accumulated expenses of the renovation work project with both financing and the energy bill baseline, and the gap between each situation at the end of the borrowing. Generally, the balance-sheet is balanced before the end of the loan and the multi-loans.

In the example above, after 5 years, financing with one loan total expenditures is inferior to 15 annual loans expenses. On year 7, balance-sheet between 1 loan and Energy bill Baseline is balanced and renovation plan means less expenditures every year. After 8 years, Financing 15 annual loans over 20 years presents inferior expenses than energy bill baseline increased with inflation.

The following tables sums up total expenditures for 3 situations:

- *Financing with 1 complete loan.*
- *Financing with X (depends on SEAP duration) annual loans.*
- *Energy bill Baseline if no renovation works are done.*

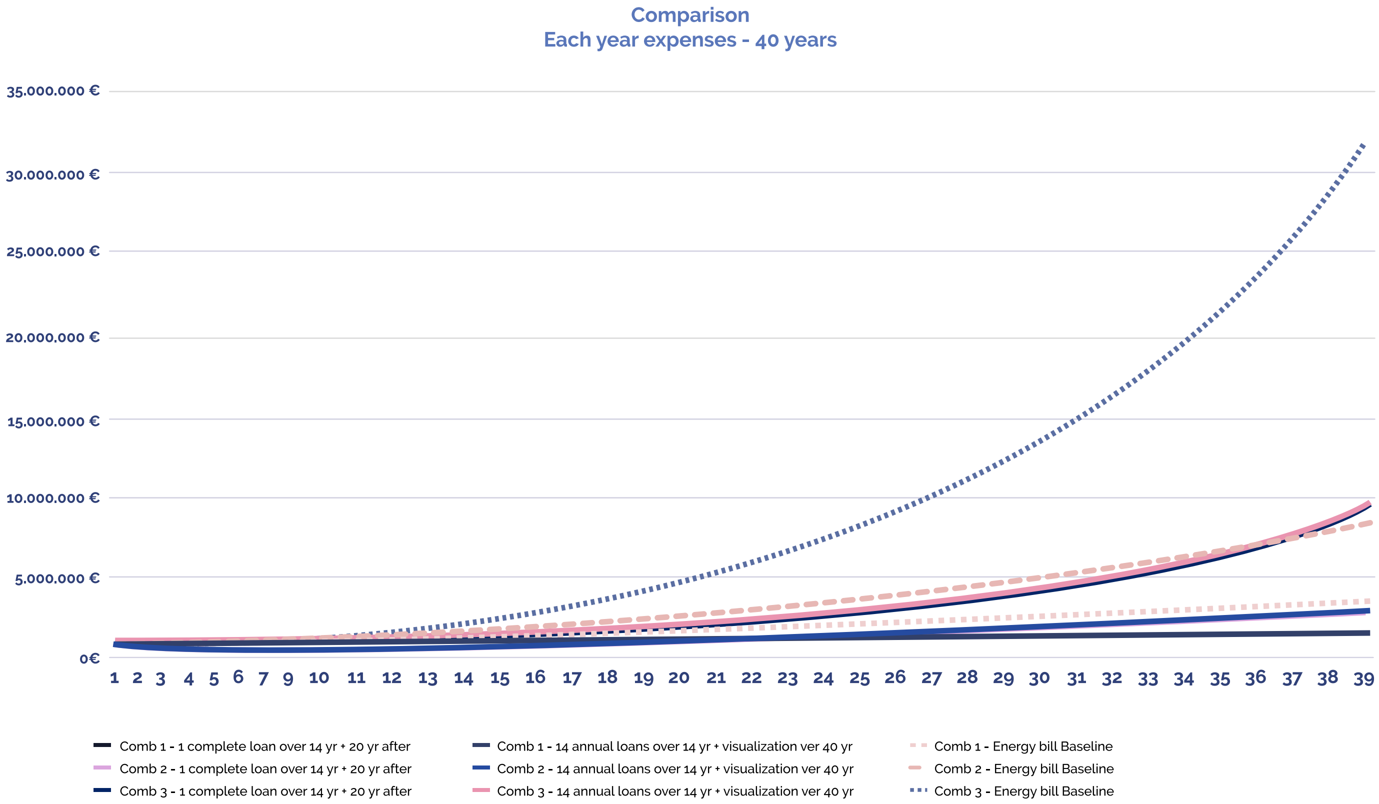
Comparison / Baseline		**Financing 1 complete loan**	**Financing 15 annual loans**	**Energy bill Baseline**
Complete expense over 40 years	k€	41.047€	46.752€	71.548€
Benefit/Baseline	k€	-30.501€	-24.796€	0€
	%	-43%	-35%	0%
Total interests	k€	1.086	2.021€	0€
Total capital	k€	6.583€	8.852€	0€
Total energy bills	k€	33.379€	35.879€	71.548€

Comparison 2 types financing		**Financing 1 complete loan**	**Financing 15 annual loans**	**Gap**
Complete expense over 40 years	k€	41.047€	46.752€	5.705€
Annual medium expense	k€ / year	1.052€	1199€	146€
Total interests	k€	1.086	2.021€	935€
Total capital	k€	6.583€	8.852€	2.269€
Total energy bills	k€	33.379€	35.879€	2.501€

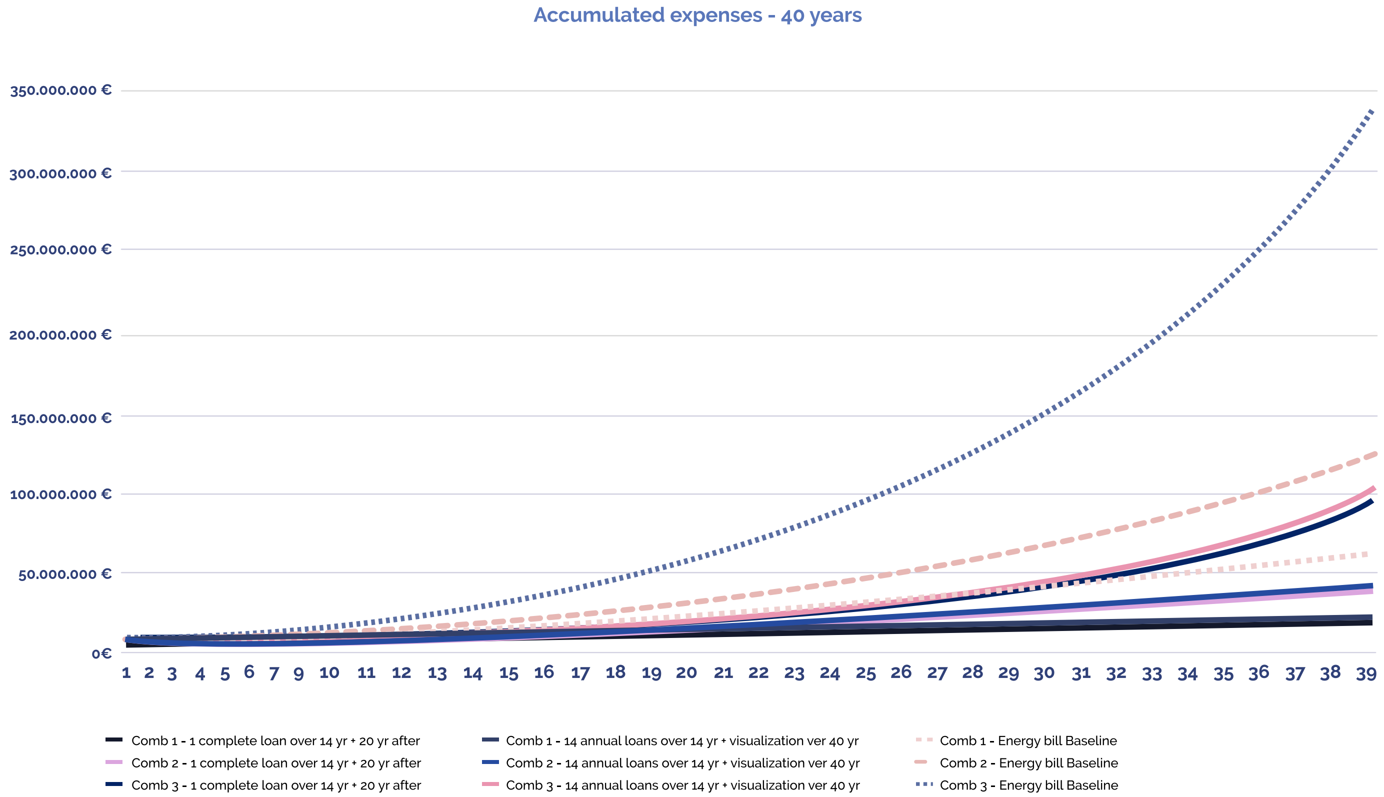
Example of tables of comparison

SHEET: Comb 1,2, 3 Comparison
This sheet aims to compare the financing, over the duration of the SEAP, for the hypotheses, up to 3 possible combinations, set out in the hypotheses tab.

It presents calculated total expenditures (capital + interest + energy bill after renovation works) every year and accumulated with both financing and also energy bill baseline, for the up to three input data combinations introduced in hypothesis tab.



Example of each year expenses – Overlapping of the 3 calculated combinations



Example of accumulated expenses – Overlapping of the 3 calculated combinations

3

VALIDATION OF THE METHODOLOGY AND TRANSFER ACTIVITIES

The above methodology has been satisfactory applied in 6 participating MED public authorities (Municipality of Heraklion, City of Elche, City of Cannes, Municipality of Ravenna, City of Osijek, City of Mostar) within the framework of IMPULSE project.

The results have been digitized on a web platform (impulseonline.eu), based on a GIS system, with the objective that other local/ regional/national administrations can make use of the indicators, based on the extrapolation of results by typological similarity of their public buildings.

The IT system provides organized packaged solutions for public-buildings retrofitting, what makes it a user-friendly decision-making tool for the design of affordable SEAPs with high impact.

The tool was verified through small-scale renovation projects in each pilot City. The interventions carried out were selected among those of high energy-saving potential under least cost as indicated by energy simulations surveys. The renovations, one building per each authority partner, and the monitoring plans undertaken, provided an assessment of system's accuracy in the ex-ante and ex-post conditions.

Besides, transfer activities of the knowledge generated by IMPULSE have been developed:

- Focus groups meetings to present the main findings of the project with particular focus on the technical, financial and policy problems that are tackled by IMPULSE.

- Training seminars, involving technicians mainly from public administrations and from private energy sector, in which they have been taught how to use pilots' outputs e.g. typologies' libraries, monitoring plans, the information system, etc.

- Portability campaigns aiming to extend the experience of public administrations interacting with project's outputs and engaging them beyond the partnership to use IMPULSE outputs. thus, being supported for future energy efficiency strategies in local level.

After that, in the framework of the IMPULSE PLUS project, the methodology is being adopted by four new territories in the MED area, two cities (Valencia in Spain and Koper in Slovenia) and two regions (Emilia Romagna and Western Greece Region). The 4 new territories will use the new improved tools to get an energy renovation plan for their public-building stock as well as the most appropriate scheme for financing the plan, providing an important insight on lessons learned during the process which will be useful for the later smooth take-up by other new territories.