OptEEmAL

OPTIMISED ENERGY EFFICIENT DESIGN PLATFORM FOR REFURBISHMENT AT DISTRICT LEVEL

Optimised Energy Efficient Design Platform for Refurbishment at District Level
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D2.2: Report on District Sustainability Indicators to formulate and optimise scenarios

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Author(s): Gema Hernández[1], Miguel Ángel García-Fuentes[1], Víctor Iván Serna[1], Georgios Giannakis[2], Georgios Lilis[2], Dimitrios Rovas[2], Maxime Pousse[3], Patricio Moreno[4], Alejandro Martín[4], Hassan Ridouane[5], Lara Mabe[6]

([1]CAR, [2]TUC, [3]NBK, [4]ACC, [5]UTRC, [6]TEC)

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Abbreviations and Acronyms

Acronym	Description
BEMS	Building Energy Management System
BIM	Building Information Model
CM	Calculation Methodology
CS	CitySim
DDM	District Data Model
DPI	District Performance Indicator
ECM	Energy Conservation Measure
EP	Energy Plus
EPBD	Energy Performance Buildings Directive
EPC	Energy Performance Certificate
FIBP	Fraunhofer Institute for Building Physics
FU	Functional Unit
GIS	Geographic Information System
HVAC	Heating, Ventilation and Air Conditioning
IFC	Industry Foundation Classes
IPD	Integrated Project Delivery
KPI	Key Performance Indicator
LoD	Level of Detail
NS	Nest
OT	OptEEmAL Tool
OptEEmAL	Optimised Energy Efficient Design Platform for Refurbishment at District Level.

Executive Summary

This deliverable aims at compiling all the necessary information with regards to the District Performance Indicators (DPIs) that are required by the OptEEmAL platform. The use of these DPIs lies in the need to establish objective comparison values in order for the platform to be able to provide the user with the optimal scenarios according to their objectives and needs. This benchmarking of scenarios through the values obtained in the DPIs will allow formulating the multi-objective optimisation of scenarios by applying a weight to each DPI. More information on how the DPIs are used in the definition of prioritisation criteria and thus in the optimisation process is to be found in deliverables 4.1 “Requirements and design of the optimisation module” and D4.2 “Optimisation module prototype”.

The DPIs assess seven different categories, namely: energy, comfort, environment, economic, social, urban and global and will be calculated through external tools, depending on their topic. All of the DPIs deal with measurable aspects, which cannot be biased. However, there is the necessity to settle the minimum information required, which calculation methodology is going to be used and which tools are deployed to be able to ensure that the maximum accuracy is reached.

For all of these reasons, this deliverable offers information firstly about the methodology that has been followed to select the final list of District Performance Indicators to be used in OptEEmAL, that is, which criteria has been followed to consider some indicators of higher importance over others.

Secondly, the DPIs used in OptEEmAL are tackled. Their role inside the OptEEmAL platform is explained and how they are a key element in the process. Afterwards in section 3 they are precisely described, and tables are provided where information about the types of DPIs, tools used and calculation methodology are presented, as well as tables offering information about the data requirements needed to calculate each category. Furthermore, their calculation sequence is presented together with the relations existing among the DPIs.

Last but not least, the DPIs are put in relation to the case studies used in OptEEmAL, where some Indicators are being currently used and the logic behind this use

To sum up all of the information presented in this deliverable, Annex 1 provides the reader with a quick guide to all of the DPIs and basic information related to them presented in easy-to-read tables and Annex 2 provides information about the calculation sequence which complements section 3.2.

1 Introduction

1.1 Purpose and target group

This deliverable provides information regarding the District Performance Indicators (DPIs) that are to be used in OptEEmAL to evaluate the optimal retrofitting scenario. It mainly related with tasks 4.3 “Simulation model input generator module: requirements, specifications and design”, T4.2 “Optimisation module prototype development and validation”, T2.1 “District Data Model requirements definition and specification” and T1.2 “Definition of required input data to evaluate users’ objectives and current conditions”.

In this deliverable, the focus is on the definition of the final list of District Performance Indicators, their calculation methodologies, their input data requirements and their relation to the case studies, based on the methodology used in OptEEmAL to progress.

As a result from this deliverable the reader should have acquired the knowledge on the aspects related to the District Performance Indicators in OptEEmAL, namely:

1. How they have been chosen and why
2. The role of the DPIs in the OptEEmAL platform
3. Description of each DPI, scale, calculation methodology, sequence followed and information required for its calculation
4. Relation of the DPIs with the case studies in OptEEmAL

1.2 Contributions of partners

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

Table 1: Contribution of partners

Participant short name	Contributions
CAR	Task coordination. Contributions to sections 3 (Urban, Social, Global DPIs), arrangement of annex 1 and elaboration of DPI calculation sequence and annex 2.
TEC	Collaboration in economic DPIs definition and methodology to define DPIs.
NBK	Definition of environmental DPIs, case study DPIs definition and analysis.
TUC	Definition of energy DPIs and collaboration on comfort DPIs. Definition of calculation schemes to be found in annex 1.
ACC	Collaboration on the definition of Urban and Social DPIs, and analysis of the results of the case studies’ DPIs.
UTRC	Definition of the comfort DPIs and the role of the DPIs in the OptEEmAL platform.

1.3 Relation to other activities in the project

The following Table 2 depicts the main relationship of this deliverable to other activities (or deliverables) developed within the OptEEmAL Project, that should be considered along with this document for further understanding of its contents.

Table 2: Relation to other activities in the project

Deliverable Number	Contributions
D1.2	This deliverable provides the overall description of the input data from the end-user perspective, which will be used in the calculation of the DPIs.
D2.1	This deliverable contributes to the definition of the District Data Model and is intricately linked to this deliverable, since the information required for DPI calculation and the DPIs itself will be stored according to this data model.
D4.1 and D4.2	These deliverables provide information on the optimisation module, one with regards to its requirements definition and the latter with the development of the optimisation module prototype. Since DPIs are meant to be deployed in the optimisation process, these two deliverables are related to the present one.
D4.4	This deliverable is strongly linked to the present one. While D2.2 focuses on the selection and definition of relevant DPIs for diagnosis and evaluation purposes, D4.4 focuses on the tools and the methodologies that will be used/integrated in the OptEEmAL platform to support their evaluation.
D3.2	This deliverable establishes the Energy Conservation Measures Catalogue foundations, design and implementation and is related to the DPIs calculation process since each measure applied will have an effect on the DPIs results.

2 Methodology followed to select the DPIs

The retrofitting actions contribute to the development of low energy and low carbon cities reducing the energy demand and favouring the deployment of energy efficient technologies and the use of renewable energy sources.

However, not only energy and environmental aspect should be taken into account, but also urban and economic targets and boundaries must be considered when selecting the optimal retrofitting scenario. Furthermore, the quality of life of citizens identifies the well-being of the districts.

All districts cannot be refurbished in the same way but they have the commitment to contribute to their sustainable development. In this sense, Europe is working in the development and validation of indicators within international standards and committees, research and innovation projects, European initiatives, decision-making tools, strategic plans, etc.

According to the DoA, OptEEmAL must define retrofitting scenarios, considering cost, energy, environment (LCA), comfort, social and urban performance indicators as global optimization parameters. The platform should allow the calculation of DPIs for the baseline scenario, but also calculate the improvement between the baseline and the district after the refurbishment implementation.

The use of these indicators is of the utmost importance since the implementation of a measurable value enables municipalities to objectively evaluate the performance of a district and choose among possible refurbishment scenarios. In addition, these values also allow these entities willing to refurbish a district to aim at the right targets and be able to decrease specific performance values of their district, e.g. their demand, consumption, C02 emissions or other relevant measurable aspects. As a consequence, sustainability and energy efficiency objectives can be tackled and therefore, comply as well with the different existing initiatives and directives. Consequently, the selection of these indicators is of paramount importance and the methodology followed to choose them is described below, based on real-life interventions, projects and initiatives, which are considered to be the most accurate depiction of the problematic at hand and to cover all relevant aspects to be tackled.

The methodology followed to select the list of District Performance Indicators to use in OptEEmAL was a three step process, which is described in more depth below. First of all, a preliminary list was created by partners, based on several initiatives, standards and projects. Then this list was evaluated and validated by the rest of the partners and confronted with the DPIs used in the case studies. Finally, the possibility to calculate the DPIs correctly with the help of calculation tools was studied in order to guarantee the desired accuracy.

1. **Development of the preliminary list of DPIs**: the first list of DPIs was developed by OptEEmAL partners based on the following initiatives, which are considered of relevance in this field:
    a. International standard:
        - "ISO 37120:2014 Sustainable development of communities – Indicators for city services and quality of life" became the first international standard for cities to be published. Its main objective was to establish a set of indicators to evaluate and monitor city performance in terms of sustainable development and resilience.
    b. Technical committee:
        - "ISO TC 268/WG2. Sustainable Development in Communities — Inventory and review of existing frameworks on sustainable development and resilience in cities" has been used to complement the list of indicators from ISO 37120.
    c. European projects:
        - CITyfiED project ("Replicable and Innovative Future Efficient Districts and Cities. H2020 programme"). Within "D2.25: Methodology for city renovation at district

level. Systemic approach." [01] CITyFiED has defined Key Performance Indicators (KPIs) for district renovation based on the European framework.

- CITYKEYS Project www.citykeys-project.eu. The aim of CITYkeys is to develop and validate, with the aid of cities KPIs and data collection procedures for the common and transparent monitoring as well as the comparability of smart city solutions across European cities
- CONCERTO PREMIUM http://smartcities-infosystem.eu/concerto/concerto-premium. This initiative has built up a solid database where a great amount of projects and indicators are to be found, which have served as a basis for the ones defined in OptEEmAL.
- FASUDIR "Friendly and Affordable Sustainable Urban Districts Retrofitting". Has developed an Integrated Decision Support Tool (IDST) based on CityGML to help decision makers to select the best energy retrofitting strategy to increase the sustainability of the whole district.
- REMOURBAN "REgeneration MOdel for acceleration the smart URBAN transformation". In deliverable D2.2 "Report on high-value energy products" [02] and D5.1 "Integrated methodology development for energy efficient district renovation" [03] the set of indicators to be evaluated in the retrofitting projects of REMOURBAN are described.
- R2CITIES "Renovation of Residential urban spaces: towards nearly zero energy cities". In deliverable D2.2 "Evaluation protocols and indicators" [04] and D3.1 "Characterisation report of European Cities" [05] the set of indicators to be evaluated in the retrofitting projects of R2Cities are described.
- The Work Programme 2016-2017 on Competitive Low Carbon Energy focuses on cost-effective innovative renewable generation technologies.

2. **Evaluation and validation of the list:** The first list of DPIs followed an evaluation and validation process by OptEEmAL partners. Since the final purpose of the DPIs is to establish an unbiased reference framework which enables the platform to satisfy the main objectives of the project focusing on the targets of the potential end users, the indicators used in the case studies and the Covenant of Mayors initiative were analysed
    - The first part of this evaluation process has been to contrast the first list of DPIs with the list of indicators selected by the case studies and demo cases (see 4). The selected DPIs must meet the End User's needs.
    - Within the Covenant of Mayors initiative, thousands of local and regional authorities voluntarily committed to implement EU climate and energy objectives on their territory [06]. A Sustainable Energy Action Plan (SEAP) is the key document in which the Covenant signatory outlines how it intends to reach its CO_2 reduction target by 2020. Through the development of SEAPs, local and regional authorities have defined emission reduction targets and specific budget for each initiative.

3. **Validation of calculation tools**: the OptEEmAL platform must be able to calculate all DPIs. In this sense, the functionalities of the external tools have been assessed. Their alignment with the pre-selected DPIs has been evaluated.
    - Some of the notable features and capabilities of EnergyPlus include calculation of thermal and visual comfort, condensations, energy demand, HVAC systems and control simulation.
    - The software CitySim aims to provide a decision support allowing the calculation of energy demand at urban scale, energy consumption due to HVAC systems and energy supplies of these buildings issued from renewable sources.
    - NEST tool allows the evaluation of environmental impacts of urban retrofitting projects based on Life Cycle Assessment (LCA) methodology. The software

calculates Global Warming Potential (in kg CO2 eq/user/year) and Primary Energy Consumption (in MJ eq/user/year) of retrofitting strategies (including their whole life cycle) and use phase (related to energy consumption).

Not all DPIs can be calculated with the external tools listed above. However, their outputs will be needed as inputs to evaluate the whole list of DPIs requiring extra calculations. These intermediate calculations will be implemented into the OptEEmAL platform (OT).

3 District Performance Indicators (DPIs)

This section presents all the relevant information of the District Performance Indicators with regards to the OptEEmAL platform. Section 3.1 offers information about the role of the DPIs inside the platform, and why their use is of utmost importance for its performance.

The following section (3.2 District Performance Indicators calculated in OptEEmAL) provides insight about the District Performance Indicators which will be evaluated for the ranking of different retrofitting scenarios, which can be classified into seven categories (energy, comfort, economic, environmental, social, urban and global). In the next pages, several tables present the basic information related to each DPI, the inputs needed for its calculation and the tool deployed to calculate them.

From each category, three aspects of the DPIs are considered, namely:

1. Description of the DPIs: brief description of what each DPI means
2. DPI tables: information about the calculation of the DPI and in which stage it is calculated. Further description about the sections included inside this tables can be found below:
    a. **DPI Identification**
        i. **Code and name:** identification of the DPI
        ii. **Unit:** units used to measure the quantifiable value
        iii. **Scale**: scale in which the DPIs are calculated
    b. **DPI type:** DPIs are sorted into two types, depending on if they evaluate only the baseline scenario (diagnosis DPIs) or the generated scenarios (evaluation DPIs)
        i. **D**: stands for diagnosis
        ii. **E:** stands for evaluation
    c. **Starts calc. in step (1, 2, 3):** this section has to do with the DPI calculation sequence (explained in section 3.2) and it presents when the calculation of each DPI starts.
    d. **Ends calc. in step (1, 2, 3):** this section has to do with the DPI calculation sequence (explained in section 3.2) and it presents when the calculation of each DPI ends.
    e. **Required to calculate:** this column lists the DPIs which need information from the DPI considered to be calculated.
    f. **Needs info from:** this column lists the required DPIs to calculate the one considered.
    g. **Calc. tools:** calculation tools required to obtain the results of the considered DPI.
        i. **EP:** Energy Plus
        ii. **CS:** CitySim
        iii. **NS:** Nest
        iv. **OT:** OptEEmAL tool
3. DPI information requirements: the information needed for the calculation of the DPIs is presented in this section.
    a. **Type of information:** type of information grouped by categories
    b. **Available information / datasets:** available data according to the input information asked to the user.
    c. **Required accuracy:** level of accuracy requested from the information to be able to provide adequate results.
    d. **Required information:** from the information described in b, the necessary information to calculate the DPIs.
    e. **Calculation tools:** tools which require the information described in each row.

3.1 Role of the DPIs inside the OptEEmAL platform

Owners and operators of buildings and districts are interested and willing to engage in discussions about retrofit initiatives, but the costs and benefits need to be clear. While sustainability was an essential and non-negotiable criterion for government and larger corporate tenants, sustainability was not yet a core business value for smaller organisations. This is now emerging and stakeholders are requesting detailed cost-benefit analyses, pay-back calculations of proposed technologies, and most importantly a standard set of key performance metrics to provide a systematic way to evaluate the performance of their buildings. Most owners have relatively minimal knowledge of specific measures, designs or products and in order to build trust in energy retrofits measures, it will be necessary to clearly identify their performance requirements, and to assure that these requirements are met.

One of the OptEEmAL objectives is to provide building and district decision-makers with the information and tools needed to cost effectively assure the desired performance. A key element required in achieving this goal is the establishment of performance metrics for explicit evaluation of the building performance objectives that are of importance to stakeholders. Such a metrics should clearly define each objective (energy, comfort, environment, economic, social, urban and global) and its desired level of performance. This information is intended to be used for comparative performance analysis useful in evaluating alternative design solutions.

OptEEmAL refers to these performance metrics as District Performance Indicators (DPIs), and they are a principal element of information that captures the ranking of a retrofit strategy or a design as a whole. The OptEEmAL platform will be used by different stakeholders involved in a retrofitting project following the IPD approach detailed in D1.2 “Requirements and specification of input data process to evaluate users’ objectives and current conditions” [08]. OptEEmAL understands that different stakeholders, depending on their role, may have different objectives and expectations. To meet these diverse expectations, OptEEmAL considers a complete list of DPIs covering seven categories: energy, comfort, environment, economics, social, urban, and global.

DPIs are meant to be maintained and used by the OptEEmAL platform and also shared with the platform user across the complete design stages. The platform will make use of DPIs, which will be stored within the District Data Model, to make decisions relevant to the design stage that is currently being executed by the platform. The relevant design stages are:

- **Input data insertion stage**. The platform user will be asked to specify the main objectives of the design in the input data insertion stage. In this process, targets, barriers and boundaries are defined among others. From these three types of information, some boundaries are related to DPIs and the user is enabled to fix a determined value as a limit that cannot be surpassed. This does not mean that only certain DPIs will be calculated, but that the platform will use these boundaries to set limits to the user designated DPIs throughout the design process.
- **Diagnosis stage**. Current conditions of the district before refurbishment (baseline) will be evaluated and ranked using DPIs. Establishing the baseline of the district is very important to understand the district performance before and after the implementation of OptEEmAL design for refurbishment. Baseline DPIs will be stored and used at later stages of the design to quantify post retrofit improvements of district performance. In addition, baseline DPIs are key to the identification of underperforming components of the district. Such information will be used to select applicable ECMs necessary to formulate retrofit scenarios.
- **Evaluation of retrofit scenarios**. Once the refurbishment scenarios are formulated based on the ECMs catalogue and satisfying barriers and boundaries, the next step is the evaluation. During this phase, each scenario will be evaluated and ranked by calculating the set of DPIs for that scenario. The scenario DPIs along with baseline DPIs from the diagnosis stage will represent the core of the evaluation/optimization module. They are key information for performance evaluation of each scenario.

An overview of the DPIs used in the OptEEmAL platform can be found below, classified according to the seven categories:

Table 3: List of District Performance Indicators

DPI IDENTIFICATION			
CODE AND NAME		UNIT	SCALE
ENERGY INDEX			
ENE01	Energy demand	kWh/m^2	District
ENE02	Final energy consumption	kWh/m^2	District
ENE03	Peak load and profile of electricity demand	kW	District
ENE04	Peak load and profile of thermal energy demand	kW	District
ENE05	Degree of energetic self-supply	kWh/kWh	District
ENE06	Net fossil energy consumed	kWh/m^2	District
ENE07	Total energy use per capita	kWh/hab · year	District
ENE08	Total residential electrical energy use per capita	kWh/hab· year	District
ENE09	Energy demand covered by renewable sources	%	District
ENE10	Total residential natural gas energy use per capita	kWh/hab· year	District
ENE11	Total residential butane gas energy use per capita	kWh/hab· year	District
ENE12	Energy consumption of public buildings per year	kWh/year·m^2	District
ENE13	Energy use from District Heating	kWh/year·m^2	District
ENE14	Energy use from Biomass	kWh/year·m^2	District
ENE15	Energy use from PV	kWh/year·m^2	District
ENE16	Energy use from Solar Thermal	kWh/year·m^2	District
ENE17	Energy use from Hydraulic	kWh/year·m^2	District
ENE18	Energy use from Mini-Eolica	kWh/year·m^2	District
ENE19	Energy use from Geothermal	kWh/year·m^2	District
COMFORT INDEX			
COM01	Local thermal comfort	Level	District

COM02	Local temperature deviation from setpoint	Δ °C	District
COM03	Percentage outside range	%, Δ (COMOI)xtime	District
COM04	Indoor air quality	n.a.	District
COM05	Visual comfort	lux	District
ENVIRONMENTAL INDEX			
ENV01	Global Warming Potential - GWP (kg CO2)	kg CO_2 eq/m^2/year	District
ENV02	GWP investment	kg CO2 eq/m^2	District
ENV03	GWP reduction	kg CO2 eq/m^2	District
ENV04	Primary energy consumption	MJ/a·m^2	District
ENV05	Embodied energy of refurbishment scenarios	MJ/ m^2	District
ENV06	Energy payback time	years	District
ECONOMIC INDEX			
ECO01	Operational energy cost	€/year	District
ECO02	Investments	€, €/m2 of refurbished surface	District
ECO03	Life cycle cost	€, €/m2 of refurbished surface	District
ECO04	Return on investment	%	District
ECO06	Payback Period	years	District
SOCIAL INDEX			
SOC01	Energy poverty measured as % of inhabitants that use more than 10% of their incomes to pay energy bills	%	District
URBAN INDEX			
URB01	Percentage of buildings compliant with EPBD standard	%	District
URB02	Percentage of buildings compliant with Passivhaus standards	%	District
URB03	Percentage of buildings compliant with EnerPhit standards	%	District
URB04	Percentage of buildings compliant with nZEB standards	%	District
GLOBAL INDEX			

GLO01	kwh energy saved / euro invested	kWh/y / €	District
GLO02	CO2 saved / euro invested	Kg CO2/y / €	District

In the next sections explanations with regards to each category of DPIs can be found.

3.1.1 Energy DPIs

3.1.1.1 Energy DPI description

ENE01: Energy Demand

The total energy required in order to maintain predefined conditions to all of the conditioned building spaces in the district is captured by the Energy Demand DPI. The boundaries of conditioned building spaces extend beyond the physical building room boundaries including multiple rooms or room parts. In order to maintain the predefined conditions (temperature, humidity…), ideal energy systems of infinite capacity and 100 % efficiency are considered in every conditioned building space in the district. The Energy Demand DPI is calculated by adding all the individual energy demands of these ideal systems divided by the heated surface in the district.

ENE02: Final Energy Consumption

In contrast to the Energy Demand DPI, the Final Energy Consumption DPI is evaluated by adding all the individual energy consumptions of the real systems installed in the building spaces of the district taking into account their efficiencies and all the associated energy losses. The specifications of the installed building systems are derived either from system templates or are based on the manufacturer's detailed description. This DPI is calculated per sqm.

ENE03: Peak load and profile of electricity demand

This DPI contains peak electricity power load in Watts for every building space in the district as well as, the electricity power profile of the overall district for a considered period of time. The peak electricity load of the overall district is the maximum of the peak electricity power loads of all the conditioned building spaces in the district.

ENE04: Peak load and profile of thermal energy demand

Similar to DPI ENE03, this DPI contains peak thermal power load in Watts for every building space in the district as well as, the thermal power profile of the overall district for a considered period of time. The peak thermal load of the overall district is the maximum of the peak thermal power loads of all the conditioned building spaces in the district.

ENE05: Degree of energetic self-supply

The degree of energetic self-supply is defined as ratio of locally produced energy and the local consumption over a period of time. If the district relies on its own energy production, then is considered energy independent and achieves the highest degree of energetic self-supply. On the contrary if the district relies on only external energy sources is totally energy dependent and has the lowest degree of energetic self-supply.

ENE06: Net fossil energy consumed

This DPI includes the energy consumed by the district which comes directly from fossil fuel. Fossil fuels are materials which contain high concentration of carbon such as coal, petroleum and natural gas.

ENE07: Total energy use per capita

Energy use refers to the use of primary energy before transformation to other end-use fuels. This amount equals to indigenous production from renewable energy sources, plus energy imports, minus energy exports and the energy storage. This amount is divided by the number of inhabitants in the district.

ENE08: Total residential electrical energy use per capita

The total residential electrical energy use per capita, is the part of the total energy use, which refers to electric energy which is used for residential buildings in the district. This amount is divided by the total number of residents of the district.

ENE09: Energy demand covered by renewable sources

This DPI refers to the part of the total energy demand of the district which is covered by renewable sources of energy such as solar, wind and geothermal sources of energy.

ENE10: Total residential natural gas energy use per capita

The total residential natural gas energy use per capita, is the part of the total energy use, which refers to energy originating from natural gas use and is used for the residential part of the district. This amount is divided by the total number of residents of the district.

ENE11: Total residential butane gas energy use per capita

The total residential butane gas energy use per capita, is the part of the total energy use, which refers to energy originating from butane gas use and is used for the residential part of the district. This amount is divided by the total number of residents of the district.

ENE12: Energy consumption of public buildings per year

The energy consumption of public buildings per year is the part of the total energy consumption (DPI ENE02) which refers to public buildings in the district, for a single year period. This DPI is calculated per sqm.

ENE13: Energy Use from District Heating

This is the amount of total district energy use which is originated from District Heating. This DPI is calculated per sqm.

ENE14: Energy Use from Biomass

This DPI refers to the part of the total district energy use, where the energy is obtained directly from biomass materials. This DPI is calculated per sqm.

ENE15: Energy Use from PV

This DPI refers to the part of the total district energy use, where the energy is obtained directly from solar photovoltaic panels, installed in the buildings. This DPI is calculated per sqm.

ENE16: Energy Use from Solar Thermal

This DPI refers to the component of the total district energy use, the energy of which is obtained directly from solar thermal panels, installed in the buildings. This DPI is calculated per sqm.

ENE17: Energy Use from Hydraulic

This DPI refers to the part of the total district energy use, the energy of which is originated from hydraulic generators. This DPI is calculated per sqm.

ENE18: Energy Use from Mini-Eolica

This DPI refers to the part of the total district energy use, the energy of which is originated from wind turbine generators. This DPI is calculated per sqm.

ENE19: Energy Use from Geothermal

This DPI refers to the part of the total district energy use, the energy of which is originated from geothermal installations. This DPI is calculated per sqm.

3.1.1.2 Energy DPIs table

Table 4: Energy DPIs table with basic information

ENERGY DPIs DPI IDENTIFICATION				DPI TYPE		STARTS CALC. IN STEP	ENDS CALC. IN STEP	REQUIRED TO CALCULATE	NEEDS INFO FROM	CALC. TOOLS
CODE AND NAME		UNIT	SCALE	D	E	(1 to 5)	(1 to 5)	-	-	
ENE01	Energy demand	kWh/m²	District	x	x	1	1 or 2	URB01 URB02 URB03	-----	EP + OT or CS
ENE02	Final energy consumption	kWh/m²	District	x	x	1	1 or 2	ENV01 ENV04 ECO01 ENE13 ENE14 ENE15 ENE16 ENE17 ENE18 ENE19	-----	EP + OT or CS
ENE03	Peak load and profile of electricity demand	kW	District	x	x	1	1 or 2	URB02 URB03 ECO01	-----	EP + OT or CS
ENE04	Peak load and profile of thermal energy demand	kW	District	x	x	1	1 or 2	URB02 URB03 ECO01	-----	EP + OT or CS
ENE05	Degree of energetic self-supply	kWh/kWh	District	x	x	1	2	-----	-----	EP CS OT
ENE06	Net fossil energy consumed	kWh/m²	District	x	x	1	1 or 2	-----	-----	EP + OT or CS
ENE07	Total energy use per capita	kWh/hab·year	District	x	x	1	2	SOC01	-----	EP + OT or CS + OT

ENE08	Total residential electrical energy use per capita	kWh/ha b·year	District	x	x	1	2	-----	-----	EP + OT or CS + OT
ENE09	Energy demand covered by renewable sources	%	District	x	x	3 or 4	3 or 4	URB04	ENE13 ENE14 ENE15 ENE16 ENE17 ENE18 ENE19	OT
ENE10	Total residential natural gas energy use per capita	kWh/ha b·year	District	x	x	1	2	-----	-----	EP + OT or CS + OT
ENE11	Total residential butane gas energy use per capita	kWh/ha b·year	District	x	x	1	2	-----	-----	EP + OT or CS + OT
ENE12	Energy consumption of public buildings per year	kWh/yea r·m^2	District	x	x	1	1 or 2	-----	-----	EP + OT or CS
ENE13	Energy use from District Heating	kWh/yea r·m2	District	x	x	1	2 or 3	ENE09	ENE02	CS + OT or EP + OT
ENE14	Energy use from Biomass	kWh/yea r·m2	District	x	x	1	2 or 3	ENE09	ENE02	CS + OT or EP + OT Or OT + OT
ENE15	Energy use from PV	kWh/yea r·m2	District	x	x	1	2 or 3	ENE09	ENE02	CS + OT or EP + OT Or OT + OT

ENE16	Energy use from Solar Thermal	kWh/year·m2	District	x	x	1	2 or 3	ENE09	ENE02	CS + OT or EP + OT Or OT + OT
ENE17	Energy use from Hydraulic	kWh/year·m2	District	x	x	1	2 or 3	ENE09	ENE02	CS + OT or EP + OT
ENE18	Energy use from Mini-Eolica	kWh/year·m2	District	x	x	1	2 or 3	ENE09	ENE02	CS + OT or EP + OT
ENE19	Energy use from Geothermal	kWh/year·m2	District	x	x	1	2 or 3	ENE09	ENE02	CS + OT or EP + OT

3.1.1.3 Energy DPIs information requirements

Table 5: Energy DPI information requirements

Type of Information	Available Information / Datasets	Req. Accuracy	Required Information	Calc. Tools
Simulation Parameters	Initial Parameters, Selected Algorithms	High	All datasets	EP CS
Building Geometry	CityGML Lod1, CityGML Lod2, CityGML Lod3, CityGML Lod4, IFC	Variable (low to high)	One of the available datasets	EP CS
Building Materials	Equivalent Single-Layer Opaque, Multi-Layer Opaque, Multi-Layer Transparent	Variable (low to high)	One or more than one, of the available datasets	EP CS
Weather Data	Measurements	High	All datasets	EP, CS
Schedules	Reference Data,	Variable	One of the available datasets	EP, CS, NS

	Measurements	(low, high)		
Internal Gains	Reference Data, Measurements	Variable (low, high)	One of the available datasets	EP, CS
Energy Systems	Ideal Load System, Systems' Templates, Detailed Description	Medium	One of the available datasets	EP, CS, NS
Exterior Equipment	Exterior Lights, Exterior Fuel Equipment, Exterior Water Equipment	Medium	None, one or more than one, of the available datasets	EP, CS
Renewable Energy Systems	Photovoltaic, Wind Turbine, Geothermal Heat Pump	Medium	None, one or more than one, of the available datasets	EP, CS
Source Energy Factors	Factors	High	One of the available datasets	EP, CS
Conversion Factors	GWP/type of fuel	High	One of the available datasets	EP, CS
Other DPIs	ENE01 ENE02	High	One of the available datasets	EP, CS
ECMs Catalogue	GWP/FU	High	One of the available datasets	NS

3.1.2 Comfort DPIs

3.1.2.1 Comfort DPI description

COM01: Local Thermal Comfort

Thermal comfort is difficult to measure because it is highly subjective. It depends on the air temperature, humidity, radiant temperature, air velocity, metabolic rates, and clothing levels, and each individual experiences these sensations differently because of his or her physiology and state. According to the ANSI/ASHRAE Standard 55-2010, thermal comfort is defined as “that condition of mind which expresses satisfaction with the thermal environment and is assessed by subjective evaluation”.

A method for describing thermal comfort is referred to as Predicted Mean Vote (PMV) and Predicted Percentage of Dissatisfied (PPD). Using this DPI, the thermal comfort level of occupants can be evaluated using PMV and PPD. This thermal comfort level is estimated from air temperature, air velocity, metabolic rate, clothing and humidity.

COM02: Local Temperature Deviation from Set-Point

As mentioned in COM01, thermal comfort is difficult to evaluate because it is a subjective indicator. One of the parameters influencing thermal comfort is air temperature. With this DPI we consider more specifically the deviation of building and zone temperatures from desired values in terms of percentage of time outside a predefined comfort band. This DPI is needed for the assessment of control ECMs which aim at supplying the building thermal consumption such that the building/zone temperatures are maintained as close as possible to the corresponding set-points.

COM03: Percentage Outside Range

This DPI refers to the percentage of time outside the comfort zone. Standard comfort zones are established and comfort DPIs such as COM01 will be used to calculate COM02. The percentage of time outside the comfort zone needs to be normalized by the magnitude of the deviation to obtain meaningful values for COM02.

COM04: Indoor Air Quality

This DPI is evaluated by estimating the clearness of the air inside all the conditioned building spaces. This air clearness is affected by the presence of various air pollutants, such as CO_2, the concentration of which is estimated and added in order to evaluate the total air quality.

COM05: Visual Comfort

Using this DPI, the visual comfort level of the users of the conditioned building spaces of the district can be evaluated. This comfort level can be estimated based on the amount of light measured in lumens entering the building space which is originated from natural sources such as the sun or artificial sources such as building lights.

3.1.2.2 Comfort DPIs table

Table 6: Comfort DPIs table with basic information

COMFORT DPIs DPI IDENTIFICATION				DPI TYPE		STARTS CALC. IN STEP	ENDS CALC. IN STEP	REQUIRED TO CALCULATE	NEEDS INFO FROM	CALC. TOOLS
CODE AND NAME		UNIT	SCALE	D	E	(1 to 5)	(1 to 5)	-	-	
COM01	Local thermal comfort	Level	District	x	x	1	1	-----	-----	EP
COM02	Local Temperature Deviation from Set-Point	Δ °C	District	x	x	2	2	COM03	-----	EP
COM03	Percentage outside range	%, Δ(COM0i) ×time	District	x	x	1	1	-----	COM02	OT
COM04	Indoor air quality	n.a.	District	x	x	1	12	URB02 URB03	-----	EP
COM05	Visual comfort	lux	District	x	x	1	1	-----	-----	EP

3.1.2.3 Comfort DPIs information requirements

Table 7: Comfort DPIs information requirements

Type of Information	Available Information / Datasets	Required Accuracy	Required Information	Calc. Tools
Simulation Parameters	Initial Parameters, Selected Algorithms	High	All datasets	EP
Building Geometry	CityGML Lod1, CityGML Lod2, CityGML Lod3, CityGML Lod4, IFC	Variable (low to high)	One of the available datasets	EP
Building Materials	Equivalent Single-Layer Opaque, Multi-Layer Opaque, Multi-Layer Transparent	Variable (low to high)	None, one or more than one, of the available datasets	EP
Weather Data	Measurements	High	All datasets	EP
Schedules	Reference Data, Measurements	Variable (low, high)	One of the available datasets	EP
Internal Gains	Reference Data, Measurements	Variable (low, high)	None, one or more than one, of the available datasets	EP
Energy Systems	Ideal Load System, Systems' Templates, Detailed Description	Medium	None, one or more than one, of the available datasets	EP
Building Management Systems	Measurements	High	All datasets	OT
Clothing Value	Seasonal Dynamic	Medium	One of the available datasets	EP
Metabolic Rate	Constant Schedule	Medium	One of the available datasets	EP
Air Velocity	Reference Data, Measurements	Medium	One of the available datasets	EP
Acceptable Range	Constant	High	All datasets	EP

3.1.3 Environmental DPIs

3.1.3.1 Environmental DPI description

ENV01: Global Warming Potential (GWP)

This DPI is used to estimate the total CO_2 equivalent emissions (in kg CO_2 eq) due to the energy consumption and the use of construction materials in the district. For energy consumption, the final energy consumption values of different energy types are multiplied by appropriate conversion factors to estimate the CO_2 equivalent emissions. For construction materials, Greenhouse Gas emissions are accounted all along their lifecycle and then multiplied by the relevant conversion factors. Greenhouse Gases are all gases which have an influence on Global Warming namely carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), etc.

Conversion factors are called Global Warming Potentials. The Global Warming Potential of a substance represents its potential contribution to the global warming effect. It is expressed as the GWP value in relation to the global warming potential of carbon dioxide (CO_2). For evaluation, GWP100 is used, meaning the effect of each greenhouse gas is calculated over a 100 years period and then the effects of the different gases are summed. GWP values are developed by the UN's Intergovernmental Panel on Climate Change (IPCC) [1].

In OptEEmAL, this indicator will be expressed in kg CO_2 equivalent per square meter of building and per year (kg CO_2 eq/m^2/year). It will be calculated for the diagnosis step as well as for all retrofitting scenarios.

ENV02: Global Warming Potential Investment

The GWP Investment is the GWP related to the retrofitting materials of a given scenario. It only accounts for building materials (ECMs in the case of OptEEmAL) used in a given retrofitting scenario.

In OptEEmAL, this indicator will be expressed in kg CO_2 equivalent per square meter of building (kg CO_2 eq/m^2). It will be calculated only for retrofitting scenarios as it is equal to zero in the diagnosis step (no retrofitting materials used).

ENV03: Global Warming Potential Reduction

The GWP Reduction is the difference between the GWP of the baseline and the GWP of a given retrofitting scenarios. It accounts both for energy consumption and construction materials.

In OptEEmAL, this indicator will be expressed in kg CO_2 equivalent per year (kg CO_2 eq/year). It will be calculated only for retrofitting scenarios.

ENV04: Primary energy consumption

Life cycle energy consumption is usually expressed in Primary Energy rather than delivered energy (or final energy) units. The primary energy is defined as the intrinsic energy in a primary product or resource. The primary energy contained in a block of coal used to fire a power station will be many times greater than the delivered electrical energy at a premise due to heat losses at the power plant and transmission losses in the electricity grid.

In the building sector, the total life cycle energy is composed of two components:

- Operational Energy: the energy consumed by a building during its life from commissioning to demolition.
- Embodied Energy: the energy requirement to construct and maintain the building (see below for more details).

In OptEEmAL, this indicator will be expressed in MJ of primary energy per square meter of building and per year (MJ/m^2/year). It will be calculated for the diagnosis step as well as for all retrofitting scenarios.

ENV05: Embodied energy of refurbishment scenarios

As mentioned above, the Embodied Energy is the energy requirement to construct and maintain the building. For instance, for a brick wall, it is the energy required to make the bricks, transport them to site, lay them, plaster them and if necessary paint and re-plaster over the wall's life cycle.

The Embodied Energy of refurbishment scenarios is the equivalent of ENV02 (related to CO2 emissions) but for energy.

In OptEEmAL, this indicator will be expressed in MJ of primary energy per square meter of building (MJ/m^2). It will be calculated only for retrofitting scenarios as it is equal to zero in the diagnosis step (no retrofitting materials used).

ENV06: Energy payback time

The Energy Payback Time is the time needed to save the amount of primary energy "invested" in the life cycle of retrofitting materials (production, transport, end-of-life, etc.) with the energy consumption reduction due to the retrofitting process. The Energy Payback Time is the ratio of the energy "invested" over the energy "saved".

In OptEEmAL, this indicator will be expressed in years. It will be calculated only for retrofitting scenarios.

3.1.3.2 Environmental DPIs table

Table 8: Environmental DPIs table with basic information

ENVIRONMENTAL DPIs DPI IDENTIFICATION				DPI TYPE		STARTS CALC. IN STEP	ENDS CALC. IN STEP	REQUIRED TO CALCULATE	NEEDS INFO FROM	CALC. TOOLS
CODE AND NAME		UNIT	SCALE	D	E	(1 to 5)	(1 to 5)	-	-	
ENV01	Global Warming Potential - GWP	kg CO_2 eq/m²/year	District	x	x	2 or 3	2 or 3	ENV03	ENE02	NS
ENV02	GWP investment	kg CO_2 eq/m²	District	-	x	1	1	-----	-----	NS
ENV03	GWP reduction	kg CO_2 eq/m²/year	District	-	x	3 or 4	3 or 4	GLO02	ENV01 (d) ENV01 (e)	OT
ENV04	Primary energy consumption	MJ/m²/year	District	x	x	2 or 3	2 or 3	GLO01 ENV06 URB 04	ENE02	NS
ENV05	Embodied energy of refurbishment scenarios	MJ/m²	District	-	x	1	1	ENV06	-----	NS
ENV06	Energy payback time	years		-	x	3 or 4	3 or 4	-----	ENV04 ENV05	OT

3.1.3.3 Environmental DPIs information requirements

Table 9: Environmental DPIs information requirements

Type of Information	Available Information / Datasets	Required Accuracy	Required Information	Calc. Tools
Quantity of ECM	Scenario generator	High	One of the available datasets	OT
GWP impact per ECM	Reference data / ECM catalogue	High	One or more than one, of the available datasets	NS
PEC impact per ECM	Reference data / ECM catalogue	High	One or more than one, of the available datasets	NS
Other DPIs	ENE02 (ENV01) (ENV04) (ENV05)	High	One of the available datasets	EP
GWP impact per energy source	Reference data / NEST database	High	One or more than one, of the available datasets	NS
PEC impact per energy source	Reference data / NEST database	High	One or more than one, of the available datasets	NS
Total surface of buildings	Simulation model input generator	High	One of the available datasets	OT
District lifetime	District Data Model	High	One of the available datasets	OT

3.1.4 Economic DPIs

3.1.4.1 Economic DPI description

ECO01: Operational energy cost

The operational energy cost is the amount of monetary units required during the operation of a particular district refurbishment solution.

It is calculated as the energy consumption per type of fuel multiplied to the energy cost per type of fuel. This DPI is needed to calculate the Life Cycle Cost, the Payback period and the ROI.

ECO02: Investments:

Investments are the total monetary assets related to each refurbishment scenario. This DPI is an evaluation DPI and it will be calculated multiplying COST/FU of ECM and quantity of this ECM within the refurbishment scenario. Alternatively, this value will be expressed in relation to the total square meters refurbishment surface

ECO03: Life cycle cost

The life cycle cost measured by this DPI, is the amount of monetary units required for the initial installation, operational energy cost and maintenance of a particular refurbishment scenario.

ECO04: Return on investment

The return on investment is the clear gain in monetary units associated with a particular refurbishment scenario (gain minus the total cost), relative to the total cost of this refurbishment scenario.

In OptEEmAL the return on investment is the ratio of the difference of the gain minus the life cycle cost divided by the total life cycle cost of the refurbishment scenario.

ECO05: Payback Period

The payback period is the time it takes to cover the investment costs. It can be calculated from the number of years elapsed between the initial investment, its subsequent operating costs and the point in time when cumulative savings offset the investment.

3.1.4.2 Economic DPIs table

Table 10: Economic DPIs table with basic information

ECONOMIC DPIs DPI IDENTIFICATION				DPI TYPE		STARTS CALC. IN STEP	ENDS CALC. IN STEP	REQUIRED TO CALCULATE	NEEDS INFO FROM	CALC. TOOLS
CODE AND NAME		UNIT	SCALE	D	E	(1 to 5)	(1 to 5)	-	-	
ECO01	Operational energy cost	€/year/m²	District	x	x	2 or 3	2 or 3	SOC01 ECO03 ECO05	ENE02 ENE03 ENE04	OT
ECO02	Investments	€, €/m²	District	-	x	1	1	GLO01 GLO02 ECO03 ECO04 ECO05	-----	OT
ECO03	Life cycle cost	€, €/m²	District	-	x	3 or 4	3 or 4	ECO04	ECO01	OT
ECO04	Return of investment	%	District	-	x	4 or 5	4 or 5	-----	ECO02 ECO03	OT
ECO05	Payback Period	Nº of years	District	-	x	3 or 4	3 or 4	-----	ECO01 ECO02	OT

3.1.4.3 Economic DPIs information requirements

Table 11: Economic DPIs information requirements

Type of Information	Available Information / Datasets	Required Accuracy	Required Information	Calc. Tools
Building Geometry	CityGML Lod1, CityGML Lod2, CityGML Lod3, CityGML Lod4, IFC	Variable (low to high)	One of the available datasets	OT
Energy Systems	Detailed Description	Medium	None, or the available dataset	OT
Conversion Factors	Constant	High	All datasets	OT
Other DPIs	ENE02 ECO01 for the baseline ECO02 ECO03	High	One of the available datasets	OT
Refurbishment scenario	Type of ECM and quantity	High	All of the available datasets (of applied ECMs)	OT
ECM catalogue	Investment cost, performance, fuel type, maintenance cost	High	All of the available datasets	OT

3.1.5 Social DPIs

3.1.5.1 Social DPI description

SOC01: <u>Energy poverty measured as % of inhabitants that use more than 10% of their incomes to pay energy bills.</u>

This DPI is used to estimate the ability of the district inhabitants to pay energy bills. It is expressed as the percentage of people that are in energy poverty using the definition of energy poverty as "Situation in which a household has to spend more than one tenth of its income to pay bills to heat its dwelling to an acceptable standard based on levels recommended by the World Health Organization.

3.1.5.2 Social DPIs table

Table 12: Social DPIs table with basic information

SOCIAL DPIS DPI IDENTIFICATION				DPI TYPE		STARTS CALC. IN STEP	ENDS CALC. IN STEP	REQUIRED TO CALCULATE	NEEDS INFO FROM	CALC. TOOLS
CODE AND NAME		UNIT	SCALE	D	E	(1 to 5)	(1 to 5)	-	-	
SOC01	Energy poverty measured as % of inhabitants that use more than 10% of their incomes to pay energy bills.	%	District	x	x	3 or 4	3 or 4	-----	ENE07 ECO01	OT

3.1.5.3 Social DPIs information requirements

Table 13: Social DPIs information requirements

Type of Information	Available Information / Datasets	Required Accuracy	Required Information	Calc. Tools
Average Incomes	External Sources Real Data	High	One, or more than one, of the available datasets	OT
Other DPIs	ENE07 ECO01	High	One, or more than one, of the available datasets	OT

3.1.6 Urban DPIs

3.1.6.1 Urban DPI description

URB01: Percentage of buildings with an 'A' rating in the Energy Performance Certificate (EPC)

This indicator is devoted to the calculation of the percentage of buildings that can reach an A rating in the Energy Performance Certificate (EPC).

Nowadays, and since the implementation of the obligation to certify the performance of dwellings and premises at European level, each country has established certain reference values some dependent on the demand, C02 emissions or consumption to be accomplished in order to rate a dwelling or premise in a scale normally from A to G (most to least efficient, respectively).

To obtain these values in real life, it is necessary to deploy a specifically validated tool to be able to certify a determined rating.

In OptEEmAL, since these reference values are to be calculated by more precise tools than the ones proposed by the different countries in Europe, the value obtained from the indicator ENE01 "Energy demand" will be deployed for comparison purposes, since this parameter is the most widely used in the different countries' ratings.

Another issue to be dealt with in the platform is the comparison value upon which to contrast the results. To this regard and after having analysed the different values established by the countries a figure has been fixed in the platform of 25kWh/m^{2}y demand. It is a restrictive value, but it ensures to comply with the conditions of the strictest countries,

The calculation of this DPI is based on an approximation on the two abovementioned issues and as such the user will be informed appropriately when viewing the results of this DPI.

URB02: Percentage of buildings compliant with PassivHaus standards

This indicator will calculate the percentage of buildings compliant with adapted PassivHaus standards. It will be based on the comparison of other indicators calculated within OptEEmAL (listed below) to satisfy the requirements established by the PassivHaus Institute for a determined dwelling or premise to be certified as PassivHaus.

The requirements established by the PassivHaus Institute for PassivHaus certification are listed below. They are compared with the reference values to be considered in OptEEmAL (since an adaptation needs to be done).

The calculation of this DPI is based on an approximation and as such the user will be informed appropriately when viewing the results of this DPI.

Table 14: Parameters for PassivHaus definition in OptEEmAL

Parameter	PassivHaus standard	Comments	Reference value in OptEEmAL	Related DPI in OptEEmAL
Space heating energy demand (kWh/m2y)	< 15 kWh per square meter of treated floor area per year	Or 10 W per square meter peak demand	<15 kWh/ m^{2}y	ENE01
Space cooling energy demand	< 15 kWh per square meter of	Or 10 W per square meter peak demand	<15 kWh/ m^{2}y	ENE01

(kWh/m2y)	treated floor area			
Primary energy demand (kWh/m^2)	<120 kWh per square meter of treated floor area per year	Total energy to be used for all domestic applications (heating, hot water and domestic electricity) must not exceed 120 kWh per square meter of treated floor area per year.	ENE03 + ENE04 < 120kWh /m^{2}y	ENE03 ENE04
Airtightness	Maximum of 0.6 air changes per hour at 50 Pascals pressure (ACH50)	Verified with an onsite pressure test (in both pressurized and depressurized states).	Not to be considered in OptEEmAL, since it cannot be calculated and tested onsite.	
Thermal comfort	<10 % of the hours in a given year over 25 °C	For all living areas during winter as well as in summer.	<10 %	COM03

URB03: Percentage of buildings compliant with EnerPhit standards

This indicator will calculate the percentage of buildings compliant with adapted EnerPhit standards, which are comparable to the ones established for PassivHaus, but applied to refurbished buildings. This indicator will be based on the comparison of other indicators calculated within OptEEmAL (listed below) to satisfy the requirements established by the PassivHaus Institute for a determined dwelling or premise to be certified as EnerPhit according to the energy demand method.

The requirements established by the PassivHaus Institute for EnerPhit certification are listed below. They are compared with the reference values to be considered in OptEEmAL (since an adaptation needs to be done).

The calculation of this DPI is based on an approximation and as such the user will be informed appropriately when viewing the results of this DPI.

Table 15: Parameters for EnerPhit definition in OptEEmAL

Parameter	PassivHaus standard	Comments	Reference value in OptEEmAL	Related DPI in OptEEmAL
Space heating energy demand (kWh/m2y)	< 25 kWh per square meter of treated floor area per year	-	<25 kWh/ m^{2}y	ENE01

Space cooling energy demand (kWh/m2y)	< 15 kWh per square meter of treated floor area	Or 10 W per square meter peak demand	<15 kWh/ m^2y	ENE01
Primary energy demand (kWh/m^2)	<120 kWh per square meter of treated floor area per year + (space heating demand - 15) x1,2	Total energy to be used for all domestic applications (heating, hot water and domestic electricity) must not exceed 120 kWh per square meter of treated floor area per year.	ENE03 + ENE04 < 120kWh /m^2y + (space heating demand -15) x1,2	ENE01 ENE03 ENE04
Airtightness	Maximum of 1 air changes per hour at 50 Pascals pressure (ACH50)	Verified with an onsite pressure test (in both pressurized and depressurized states).	Not to be considered in OptEEmAL, since it cannot be calculated and tested onsite.	
Thermal comfort	<10 % of the hours in a given year over 25 °C	For all living areas during winter as well as in summer.	<10 %	COM03

URB04: <u>Percentage of buildings compliant with nZEB standards</u>

This indicator will calculate the percentage of the district buildings that are compliant with nearly Zero Energy Building's standards. However, even though the concept of nZEB is explained in the EPBD it neither prescribes a common approach to implement nearly Zero-Energy Buildings, nor it describes the assessment categories in detail. However, it establishes that by 31st December 2020, all new buildings shall be nZEB and after 31st December 2018 new buildings occupied and owned by public authorities are nZEBs.

According to the definition established in the EPBD [a nearly zero energy building is a] "building that has a very high energy performance"50. The nearly zero or very low amount of energy required should to a very significant extent be covered by energy from renewable sources, including renewable energy produced on-site or nearby

In view of these circumstances and according to the cross-country overview table offered in the document [07] about the different definitions established across the countries in Europe, the necessary values to define an existing building as an nZEB within OptEEmAL are detailed below, taking the most restrictive values. The list of parameters has been established according to the most often regarded parameters by the countries to consider a building a nZEB.

Table 16: Parameters for nZEB definition in OptEEmAL

Parameter	Building typology	Value	Related DPI in OptEEmAL
Very high energy performance	All	A rating according to URB01	URB01
Maximum primary energy (kWh/m2y)	Residential	<20	ENV04 *
	Non-residential	<25	ENV04 *
Share of renewable energy (%)	District	20	ENE05 *

The values reflected in the table are an average logical value based on the ones established in the countries.

*The results of the DPIs will have to be processed to separate residential typologies from non-residential ones.

3.1.6.2 Urban DPIs table

Table 17: Urban DPIs table with basic information

URBAN DPIS DPI IDENTIFICATION				DPI TYPE		STARTS CALC. IN STEP	ENDS CALC. IN STEP	REQUIRED TO CALCULATE	NEEDS INFO FROM	CALC. TOOLS
CODE AND NAME		UNIT	SCALE	D	E	(1 to 5)	(1 to 5)	-	-	
URB01	Percentage of buildings with an A rating in the Energy Performance Certificate (EPC)	%	District	x	x	2 or 3	2 or 3	URB 04	ENE01	OT
URB02	Percentage of buildings compliant with Passiv House standards	%	District	x	x	2 or 3	2 or 3	-----	ENE01 ENE03 ENE04 COM03	OT
URB03	Percentage of buildings compliant with EnerPhit standards	%	District	x	x	2 or 3	2 or 3	-----	ENE01 ENE03 ENE04 COM03	OT

URB04	Percentage of buildings compliant with nZEB standards	%	District	x	x	4 or 5	4 or 5	-----	ENV04 ENE09 URB01	OT

3.1.6.3 Urban DPIs information requirements

Table 18: Urban DPIs information requirements

Type of Information	Available Information / Datasets	Required Accuracy	Required Information	Calc. Tools
Building Geometry	CityGML Lod1, CityGML Lod2, CityGML Lod3, CityGML Lod4, IFC	Variable (low to high)	One of the available datasets	OT
Building typologies	District data model	High	All datasets	OT
Other DPIs	ENE01 ENE03 ENE04 ENE09 ENV04 COM03 (URB01)	High	One, or more than one, of the available datasets	OT

3.1.7 Global DPIs

3.1.7.1 Global DPI description

GLO01: kWh energy saved / euro invested

This DPI measures the ratio of the estimated energy savings of a particular refurbishment scenario divided by the total monetary amount in euros invested to this scenario. It brings into relation two previously calculated DPIs, namely: ENE02 (evaluation and diagnosis) “Final energy consumption” and ECO02 “Investments”.

GLO02: C02 saved / euro invested

This DPI measures the ratio of the estimated C02 savings of a particular refurbishment scenario divided by the total monetary amount in euros invested to this scenario. It brings into relation two previously calculated DPIs, namely: ENV03 “GWP reduction” and ECO02 “Investments”.

3.1.7.2 Global DPIs table

Table 19: Global DPIs table with basic information

GLOBAL DPIS DPI IDENTIFICATION				DPI TYPE		STARTS CALC. IN STEP	ENDS CALC. IN STEP	REQUIRED TO CALCULATE	NEEDS INFO FROM	CALC. TOOLS
CODE AND NAME		UNIT	SCALE	D	E	(1 to 5)	(1 to 5)	-	-	
GLO01	kwh energy saved / euro invested	kwh.a / €	District	-	x	3 or 4	3 or 4	-----	ENV04* ECO02	OT
GLO02	C02 saved / euro invested	Kg C02 / €	District	-	x	4 or 5	4 or 5	-----	ENV03 ECO02	OT

3.1.7.3 Global DPIs information requirements

Table 20: Global DPIs information requirements

Type of Information	Available Information / Datasets	Required Accuracy	Required Information	Calc. Tools
Other DPIs	ECO02 ENV03 ENV04* *diagnosis and evaluation	High	One of the available datasets	OT

4 Relation to the case studies

The main objective of this section is to highlight the relationships between the indicators used for decision making purposes in the different case studies and the DPIs envisaged in OptEEmAL. It has to be noted that in these projects (except for Case study 2, see dedicated section), each indicator is assessed using a specific tool. For instance, energy demand is assessed using energy simulation tools while total investment is calculated using a specifically created tool. The opportunity to calculate them using a single platform as OptEEmAL thus represents a very interesting feature in order to ensure consistency among the different analyses.

4.1 DPIs in the case studies

The different case studies are briefly presented in each section. More details are available in D1.2 “Requirements and specification of input data process to evaluate user objectives and current conditions”.

4.1.1 Case Study 1: Cuatro de Marzo District (Spain)

The case study of Cuatro de Marzo is located in Valladolid, Spain. The district under study is a residential district composed of two different building typologies. The objective of the Municipality is to promote a district retrofitting project with a target of reducing by 60% the net fossil energy consumption and with a maximum public contribution of 2 million euros.

This case study is taken from the FP7-funded project R2CITIES (GA. No. 314473).

The indicators used by the case study stakeholders are mentioned in the table below together with the associated OptEEmAL DPIs.

Table 21: Relationships between case study 1’s DPIs and OptEEmAL DPIs

Case study	DPI used in the case study	Corresponding OptEEmAL DPI
CS1 - Cuatro de Marzo district – Valladolid (Spain)	Energy demand	ENE01
	Final energy consumption	ENE02
	Net fossil energy consumption	ENE06
	Energy demand covered by renewable sources	ENE09
	Energy use from PV	ENE15
	Total investment	ECO02
	Return of investment	ECO04
	Global warming potential - GWP	ENV01
	GWP reduction	ENV03

As mentioned in the table above, all the indicators used in this case study as decision support criteria are integrated in the OptEEmAL platform.

4.1.2 Case Study 2: Manisa Province District (Turkey)

This case study is located in the city of Soma, Turkey. The Manise Province District is a residential building composed of three different building typologies. In this case study, a public company wants to promote a district retrofitting project with a target of reducing by 70% the net fossil energy consumption. The use of the existing district heating is also an important factor to be considered in this project.

This case study is taken from the FP7-funded project CITyfiED (GA. No. 609129) [3].

The indicators used by the case study stakeholders are mentioned in the Table 22 below together with the associated OptEEmAL DPIs.

Table 22: Relationships between case study 2's DPIs and OptEEmAL DPIs

Case study	DPI used in the case study	Corresponding OptEEmAL DPI
CS2 – Manise Province District, Soma (Turkey)	Energy demand	ENE01
	Final energy consumption	ENE02
	Peak heat load	ENE04
	Energy demand covered by renewable sources	ENE09
	Energy use from district heating	ENE13
	Energy use from PVs	ENE15
	Energy use from solar thermal	ENE16
	Global warming potential - GWP	ENV01
	Global warming potential reduction	ENV03
	Investments	ECO02
	Return of investment	ECO04

As mentioned in the table above, all the indicators used in this case study as decision support criteria are integrated into the OptEEmAL platform.

4.1.3 Case Study 3: Part of Historic City District of Santiago de Compostela (Spain)

The case study 3 is located in Santiago de Compostela (Spain). The Old Town of Santiago de Compostela is a World Heritage site and is therefore highly protected by historic restrictions. The district under study includes different building typologies, tertiary and residential being the most common ones. The objective of this district retrofitting project is to reduce energy consumption while complying with the important historic restrictions of the different buildings.

This case study is taken from the FP7-funded project FASUDIR (GA. No. 609222) [2]. As a consequence, indicators used in this case study will be calculated using the FASUDIR tool (see comment below).

The indicators used by the case study stakeholders are mentioned in the table below together with the associated OptEEmAL DPIs

Table 23: Relationships between case study 3's DPIs and OptEEmAL DPIs

Case study	DPI used in the case study	Corresponding OptEEmAL DPI
CS3 - Historic city District, Santiago de Compostela (Spain)	Operational energy use	ENE02
	Share of renewable energy use	ENE09
	Global warming potential - GWP	ENV01
	Total primary energy demand	ENV04
	Embodied energy demand	ENV05
	Investments costs aggregated	ECO02
	Life cycle costs aggregated	ECO03
	Return on Investment	ECO04
	Acidification potential (AP)	-
	Ozone Depletion Potential (ODP)	-
	Eutrophication Potential (EP)	-
	Photochemical Ozone Creation Potential (POCP)	-
	Abiotic Depletion Potential Elements (ADPe)	-
	Intensity of Water treatment	-
	Soil sealing	-
	Parking facilities	-
	Infrastructure for innovative concepts: car sharing, charging infrastructure for electric / hybrid vehicles	-
	Internal Accessibility: Bus, Tram, Subway stops, Railway station	-
	Bicycle facilities	-
	Bicycle and Pedestrian network quality	-
	Barrier-Free Accessibility of the District	-
	Access to Services and Facilities	-
	Access to Parks and Open Spaces	-
	Percentage of building area over noise limit	-
	Outdoor temperature / Heat island effect	-
	Gentrification Index	-
	Running costs energy aggregated	-

	Running costs non-energy aggregated	-

The table above shows that an important number of DPIs used in this case study, such as mobility or district infrastructures-related DPIs, are not included in the OptEEmAL platform. This can be explained by two aspects; 1) this case study is taken from another project where the objective is to develop a tool for district retrofitting (for an earlier stage than OptEEmAL). The list of DPIs indicated above is the full list of DPIs that this tool is able to calculate, not necessarily the list of DPIs used by the stakeholders of this case study for decision making. 2) Some aspects considered in the FASUDIR project (such as mobility for instance) are not under study in the OptEEmAL project.

4.1.4 Case Study 4: Linero District (Sweden)

The Linero district is located in Lund (Sweden) which is a medium-sized university city with a research-intensive industry. The town dates back a thousand years, but the number of inhabitants has grown largely during the last century and a great stock of the buildings from the 1960s and 1970s now needs retrofitting. Almost 90% of the heat demand in the city is supplied by district heating, and the hospital and some office buildings are connected to a district cooling network. The Linero district has one building typology (residential apartment blocks) which is owned by the Lund municipality social housing company.

This case study is taken from the FP7-funded project CITyfiED (GA. No. 609129) [3].

The indicators used by the case study stakeholders are mentioned in the table below together with the associated OptEEmAL DPIs.

Table 24: Relationships between case study 4's DPIs and OptEEmAL DPIs

Case study	DPI used in the case study	Corresponding OptEEmAL DPI
CS4 - Linero District, Lund (Sweden)	Energy demand	ENE01
	Global warming potential - GWP	ENV01
	Primary energy consumption	ENV04
	Total investments	ECO02

As mentioned in the table above, all the indicators used in this case study as decision support criteria are integrated into the OptEEmAL platform and mainly refer to energy, environmental and economic matters.

4.1.5 Case Study 5: Mogel District (Spain)

The Mogel district is located in Eibar in the north west of Spain. It is mainly composed of residential buildings with a rectangular shape. The objective of the retrofitting project is to improve energy efficiency by 60%. To do so, different types of action are envisaged:

- Improvement of the building envelope (facades, roofs, window substitution, etc.).
- Installation of a hot water production system by means of solar panels with central storage system.
- Improvement of lighting efficiency in common areas

In addition to the expected improvements in terms of energy efficiency, it shall be noted that the retrofitting project also aims at installing lifts in the different buildings.

The indicators used by the case study stakeholders are mentioned in the table below together with the associated OptEEmAL DPIs.

Table 25: Relationships between case study 5's DPIs and OptEEmAL DPIs

Case study	DPI used in the case study	Corresponding OptEEmAL DPI
CS5 - Mogel District, Eibar (Spain)	Primary energy used from energy need in building	ENE01
	Building on-site generation systems connected to the energy infrastructure (PV, Solar thermal)	Related to ENE15 and ENE16
	Greenhouse gas emissions from energy need in building	ENV01
	Total energy cost in present value	ECO01
	Investment cost	ECO02
	Maintenance	Included in ECO03
	Total cost in present value	ECO03
	Environmental performance	Related to environmental DPIs
	Cost	Related to economic DPIs
	Energy generation	Considered in energy DPIs
	Existing energy infrastructure connected to the building (District heating, National electricity mix, Natural gas boiler, Wood pellets burner)	Considered in energy DPIs
	Existing energy infrastructure connected to the building (District heating, National electricity mix, Natural gas boiler, Wood pellets burner)	Considered in energy DPIs
	Energy storage on-site (Heating)	Considered in energy DPIs

As indicated in the table above, most of the indicators considered in the case study will be integrated into the OptEEmAL platform. In addition, it shall be highlighted that some indicators of this case study are not directly presented in the OptEEmAL platform but are considered in the assessment provided in OptEEmAL. For instance, the "energy generation" indicator is not directly presented in OptEEmAL but energy generation is included in OptEEmAL DPIs related to energy.

4.1.6 Case Study 6: Sneinton District (United Kingdom)

The Sneinton District is located in Nottingham, United Kingdom. The district is composed of a vast majority of residential buildings (bedroom flats to three bedroom terraced houses) with very low levels of commercial buildings such as local shops. An intensive retrofitting project will be deployed in the Sneinton district in order to achieve a low energy district with several targets:

- Density of final energy demand < 25 kWh/m^2.yr.
- Primary energy consumption < 120 kWh/m^2.yr.
- Investments < 720,000 €
- Energy production costs < 80% of current EPCs

- Improvement of the local thermal comfort
- District heating implementation.

The Sneinton case study is part of the H2020-funded project REMOURBAN (GA. No 646511) [4].

The indicators used by the case study stakeholders are mentioned in the table below together with the associated OptEEmAL DPIs.

Table 26: Relationships between case study 6's DPIs and OptEEmAL DPIs

Case study	DPI used in the case study	Corresponding OptEEmAL DPI
CS6 - Sneinton District, Nottingham (UK)	Energy demand	ENE01
	Final energy consumption	ENE02
	Net fossil energy consumption	ENE06
	Energy use from district heating	ENE13
	Local thermal comfort	COM01
	Percentage outside range	COM02
	Indoor air quality	COM03
	Visual comfort	COM04
	Global warming potential - GWP	ENV01
	Investments	ECO02
	Return of investment	ECO04

As mentioned in the table above, all the indicators used in this case study as decision support criteria are integrated into the OptEEmAL platform.

4.2 Conclusions about the DPIs used in the Case Studies

From the previous section we can deduce that not all the indicators are needed in every situation considered; which shows that in refurbishment projects different sets of DPIs will be considered depending on the desired results. This fact will have implications in the iteration of the scenarios that will be done, since the evaluation of each generated scenario implies to calculate each one of the chosen DPIs and thus, it will have repercussions on the calculation time as well as in the models complexity.

An interesting fact is that there are indicators that will not be calculated by the OptEEmAL platform but are desired to be calculated in some specific cases. A closer look to these indicators shows us that they are related to other aspects different from energy efficiency, which is the main aim of the OptEEmAL platform. Some of these other aspects considered in the case studies are: mobility aspects, energy used in transportation, energy used for infrastructure maintenance among others, which will not be considered in OptEEmAL.

It is possible to see that the platform will be able to tackle different kinds of residential districts; the challenge is to be able to be useful in a wide spectrum of district typologies as can be the ones shown in this section The fact that the sets of indicators needed are similar among the different case studies is a sign that the platform design is going to comply with the challenge.

5 Conclusions

This deliverable has provided throughout its different sections insight about a very important element inside the OptEEmAL platform: the District Performance Indicators. Their relevance inside the platform has been proven in this document, since they represent an unbiased framework for the comparison of scenarios according to their achieved performance in seven different fields: energy, comfort, environment, economic, social, urban and global. This enables a holistic assessment of the situation and supports the decision making process in district retrofitting.

How the selection of the DPIs has been carried out was presented in section 2, where important reference initiatives, standards and projects have been taken into account; as well as the background coming from different partners and cross-checking all these data with real-life application of the DPIs, which are represented by the case studies used in OptEEmAL.

To be able to provide reliable DPI results, several calculation methodologies have been explored and the accuracy of the results checked in order to determine the necessary input that needs to be provided to each envisaged external tool. Also the steps in which the calculations have to take place has been explored in section three.

Moreover, in section four the relation the DPIs have to the case studies has been presented, since, as it was exposed before, they are the main testing mechanism of these indicators and their effectiveness, as they deal with real-life interventions.

The District Performance Indicator definition can be considered a closed aspect once these studies and validations have been carried out. However, these measure values are intricately related to other aspects inside the OptEEmAL platform: simulation processes, optimisation process etc.

For all of these reasons, even though the definition of the indicators has ended, a lot of aspects, which are closely related to the DPIs, are still to be worked on in the platform.

6 References

[01] CITYFIED Consortium: D2.25: Methodology for city renovation at district level. Systemic approach, March 2016.

[02] REMOURBAN Consortium: D2.2 Report on high-value energy products, July 2016.

[03] REMOURBAN Consortium: D5.1 “Integrated methodology development for energy efficient district renovation”, December 2015.

[04] R2CITIES Consortium: D2.2 Evaluation protocols and indicators, December 2016.

[05] R2CITIES Consortium: D3.1 “Characterisation report of European Cities”, June 2016.

[06] Covenant of Mayors for Climate & Energy. Available online: http://www.covenantofmayors.eu/The-Covenant-of-Mayors-for-Climate.html [Accessed: 28 April 2016].

[07] NZEB definitions across Europe (BPIE factsheet). Available online: http://bpie.eu/wp-content/uploads/2015/09/BPIE_factsheet_nZEB_definitions_across_Europe.pdf [Accessed: August 2016].

[08] OPTEEMAL Consortium: D1.2 Requirements and Specification of input data process to evaluate users’ objectives and current conditions, Feb 2016.

[09] OPTEEMAL Consortium: D2.1 Requirements and Specification for the District Data model, Feb 2016.

[10] OPTEEMAL Consortium: D3.2 ECMs catalogue. Foundations, design and implementation, August 2016.

[11] OPTEEMAL Consortium: D4.1 Requirements and design of the optimisation module, August 2016.

[12] OPTEEMAL Consortium: D4.4 Requirements and design of the simulation model input generator module, August 2016.

[13] Directive 2012/27/EU, (2012).European Parliament and of the Council of 25 October 2012 On Energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC.

Annex 1: Summary of DPI information

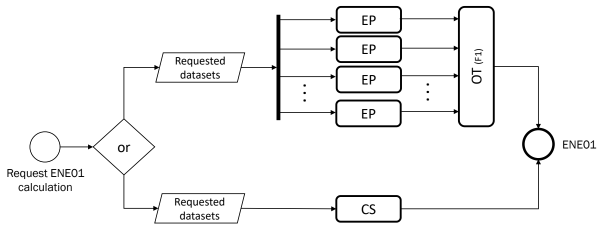
1. Energy DPIs

Table 27: Summary ENE01 – Energy demand

ENE 01	Energy demand	D	E
Definition:	Total energy required in order to maintain predefined conditions to all of the conditioned building spaces in the district.		
Category:	1 – ENERGY (ENE)		

Indicator summary

Description:	The total energy required in order to maintain predefined conditions to all of the conditioned building spaces in the district is captured by the Energy Demand DPI. The boundaries of conditioned building spaces extend beyond the physical building room boundaries including multiple rooms or room parts. In order to maintain the predefined conditions (temperature, humidity…), ideal energy systems of infinite capacity and 100 % efficiency are considered in every conditioned building space in the district.
Unit of measurement:	kWh/m²
Scale:	District
Calculation / Creation method:	$Energy\ demand = \sum_{i=1}^{N} \frac{Building_i's\ Energy\ Demand\ (kWh)}{Building_i's\ Total\ Floor\ Area\ (m^2)}$ Where *N* is the number of buildings in the district.



Indicator requirements

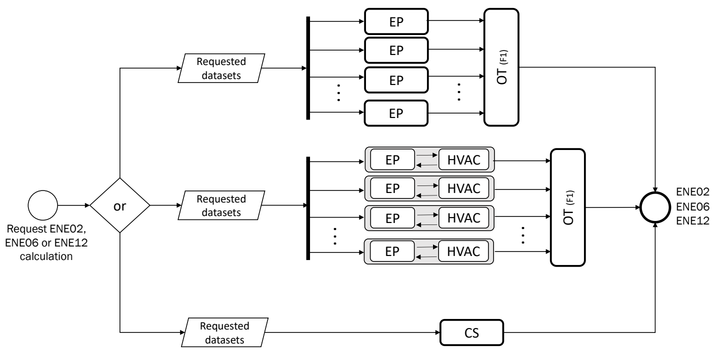
Requirements for calculation:	Type of data needed: simulation parameters, building geometry, building materials, weather data, and internal gains.
Data source(s):	CityGML data, BIM data, contextual data and ECM catalogue.
DPIs needed for its calculation:	None
Tool(s) used:	Energy Plus (EP) and OptEEmAL Tool (OT) or CitySim (CS)
DPI needed to calculate:	URB01, URB02, URB03
Additional notes:	The calculation tool used will depend on the available datasets introduced into the platform.

Table 28: Summary ENE02 – Final energy consumption

ENE 02	Final energy consumption	D	E
Definition:	Addition of all individual energy consumptions of the reals systems installed in the building spaces of the district.		
Category:	1 – ENERGY (ENE)		

Indicator summary

Description:	In contrast to the Energy Demand DPI, the Final Energy Consumption DPI is evaluated by adding all the individual energy consumptions of the real systems installed in the building spaces of the district taking into account their efficiencies and all the associated energy losses. The specifications of the installed building systems are derived either from system templates or are based on the manufacturer's detailed description.
Unit of measurement:	kWh/m²
Scale:	District
Calculation / Creation method:	$Final\ Energy\ Consumption = \sum_{i=1}^{N} \frac{Building_i's\ Total\ Energy\ Consumption\ (kWh)}{Building_i's\ Total\ Floor\ Area\ (m^2)}$ Where *N* is the number of buildings in the district.



Indicator requirements

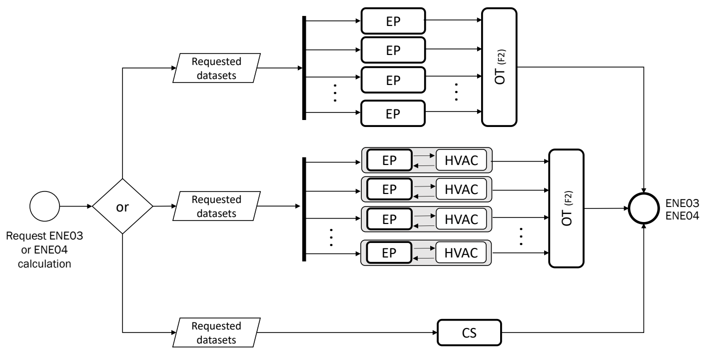
Requirements for calculation:	Type of data needed: simulation parameters, building geometry, building materials, weather data, schedules, internal gains, energy systems, exterior equipment, renewable energy systems, source energy factors, conversion factors, GWP/FU
Data source(s):	CityGML data, BIM data, contextual data and ECM catalogue.
DPIs needed for its calculation:	None
Tool(s) used:	Energy Plus (EP) and OptEEmAL Tool (OT) or CitySim (CS)
DPI needed to calculate:	ENV01, ENV04, ECO01, ENE13, ENE14, ENE15, ENE16, ENE17, ENE18, ENE19
Additional notes:	The calculation tool used will depend on the available datasets introduced into the platform.

Table 29: Summary ENE03 – Peak load and profile of electricity demand

ENE 03	Peak load and profile of electricity demand	D	E
Definition:	Peak electricity power load in watts for every building space in the district and the electricity power profile of the district as a whole for a considered period of time.		
Category:	1 – ENERGY (ENE)		

Indicator summary

Description:	This DPI contains peak electricity power load in Watts for every building space in the district as well as, the electricity power profile of the overall district for a considered period of time. The peak electricity load of the overall district is the maximum of the peak electricity power loads of all the conditioned building spaces in the district.
Unit of measurement:	kW
Scale:	District
Calculation / Creation method:	$Profile\ of\ Electricity\ Demand = [\ Electic\ Load\ (1), Electic\ Load\ (2), \ldots, Electic\ Load\ (T)]$ $Peak\ electricity\ load = \max(Electic\ Load\ (1), Electic\ Load\ (2), \ldots, Electic\ Load\ (T))$ where, $Electic\ Load\ (t)\ = \sum_{i=1}^{N} Building_i's\ Electic\ Demand\ (t)(kW), \quad t = 1, 2, \ldots, T$, T is the number of time instances and N is the number of buildings in the district



Indicator requirements

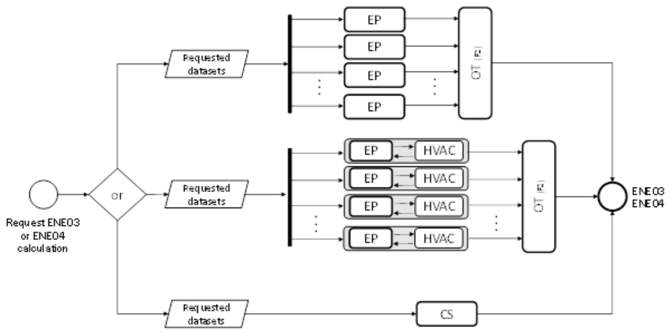
Requirements for calculation:	Type of data needed: simulation parameters, building geometry, building materials, weather data, schedules, internal gains, energy systems, exterior equipment, renewable energy systems, source energy factors, conversion factors, GWP/FU
Data source(s):	CityGML data, BIM data, contextual data and ECM catalogue.
DPIs needed for its calculation:	None
Tool(s) used:	Energy Plus (EP) and OptEEmAL Tool (OT) or CitySim (CS)
DPI needed to calculate:	URB02, URB03, ECO01
Additional notes:	The calculation tool used will depend on the available datasets introduced into the platform.

Table 30: Summary ENE04 – Peak load and profile of thermal energy demand

ENE 04	Peak load and profile of thermal energy demand	D	E
Definition:	Peak thermal power load in watts for every building space in the district and the thermal power profile of the district as a whole for a considered period of time.		
Category:	1 – ENERGY (ENE)		

Indicator summary

Description:	Similar to DPI ENE03, this DPI contains peak thermal power load in Watts for every building space in the district as well as, the thermal power profile of the overall district for a considered period of time. The peak thermal load of the overall district is the maximum of the peak thermal power loads of all the conditioned building spaces in the district.
Unit of measurement:	kW
Scale:	District
Calculation / Creation method:	$Profile\ of\ Thermal\ Demand = [\,Thermal\ Load\ (1), \dots, Thermal\ Load\ (T)]$ $Peak\ thermal\ load = \max(\,Thermal\ Load\ (1), \dots, Thermal\ Load\ (T))$ where, $Thermal\ Load\ (t)\ = \sum_{i=1}^{N} Building_i's\ Thermal\ Demand\ (t)(kW), \quad t = 1, 2, \dots, T,\ \ T$ is the number of time instances and *N* is the number of buildings in the district



Indicator requirements

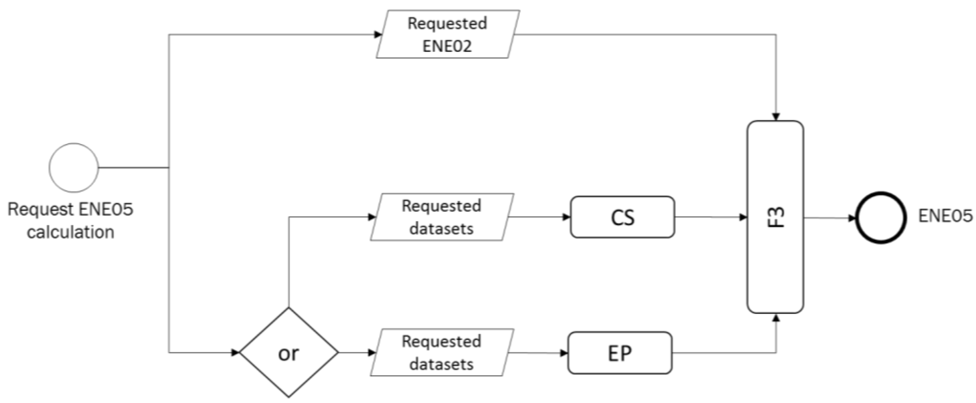
Requirements for calculation:	Type of data needed: simulation parameters, building geometry, building materials, weather data, schedules, internal gains, energy systems, exterior equipment, renewable energy systems, source energy factors, conversion factors, GWP/FU
Data source(s):	CityGML data, BIM data, contextual data and ECM catalogue.
DPIs needed for its calculation:	None
Tool(s) used:	Energy Plus (EP) and OptEEmAL Tool (OT) or CitySim (CS)
DPI needed to calculate:	URB02, URB03, ECO01
Additional notes:	The calculation tool used will depend on the available datasets introduced into the platform.

Table 31: Summary ENE05 – Degree of energetic self-supply

ENE 05	Degree of energetic self-supply	D	E
Definition:	Measurement of the ratio of local energy produced energy and the local consumption over a period of time.		
Category:	1 – ENERGY (ENE)		

Indicator summary

Description:	The degree of energetic self-supply is defined as ratio of locally produced energy and the local consumption over a period of time. If the district relies on its own energy production, then is considered energy independent and achieves the highest degree of energetic self-supply. On the contrary if the district relies on only external energy sources is totally energy dependent and has the lowest degree of energetic self-supply.
Unit of measurement:	kWh/kWh
Scale:	District
Calculation / Creation method:	$Degree\ of\ energetic\ self-supply = \frac{Local\ energy\ produced\ (kWh)}{Local\ energy\ consumed\ (kWh)}$



Indicator requirements

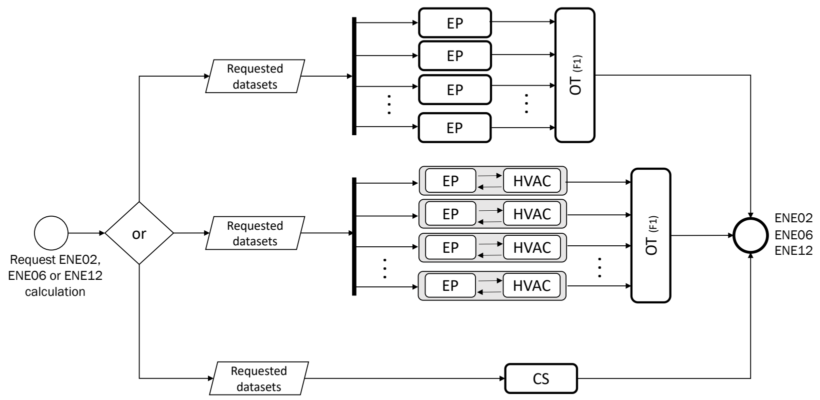
Requirements for calculation:	Type of data needed: simulation parameters, building geometry, building materials, weather data, schedules, internal gains, energy systems, exterior equipment, renewable energy systems, source energy factors, conversion factors, GWP/FU
Data source(s):	CityGML data, BIM data, contextual data and ECM catalogue.
DPIs needed for its calculation:	None
Tool(s) used:	Energy Plus (EP), CitySim (CS), OptEEmAL Tool (OT)
DPI needed to calculate:	None
Additional notes:	---

Table 32: Summary ENE06 – Net fossil energy consumed

ENE 06	Net fossil energy consumed	D	E
Definition:	Energy consumed by the district directly from fossil fuel.		
Category:	1 – ENERGY (ENE)		

Indicator summary

Description:	This DPI includes the energy consumed by the district which comes directly from fossil fuel. Fossil fuels are materials which contain high concentration of carbon such as coal, petroleum and natural gas.
Unit of measurement:	kWh/m²
Scale:	District
Calculation / Creation method:	$$Fossil\ Energy\ Consumption = \sum_{i=1}^{N} \frac{Building_i's\ Fossil\ Consumption\ (kWh)}{Building_i's\ Total\ Floor\ Area\ (m^2)}$$ Where *N* is the number of buildings in the district.



Indicator requirements

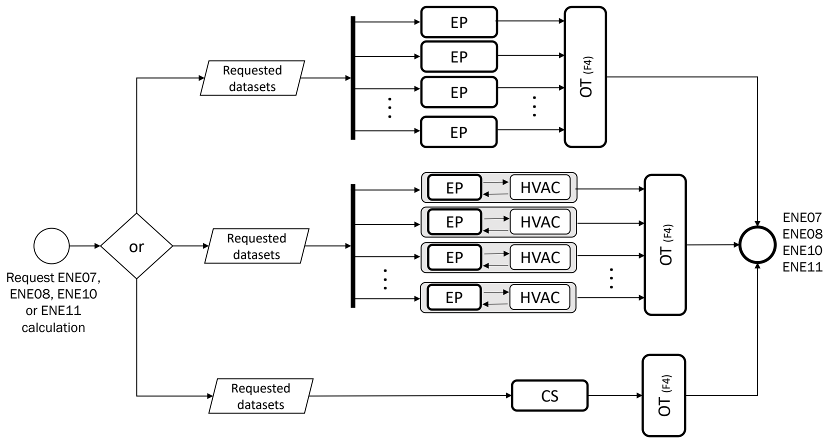
Requirements for calculation:	Type of data needed: simulation parameters, building geometry, building materials, weather data, schedules, internal gains, energy systems, exterior equipment, renewable energy systems, source energy factors, conversion factors, GWP/FU
Data source(s):	CityGML data, BIM data, contextual data and ECM catalogue.
DPIs needed for its calculation:	None
Tool(s) used:	Energy Plus (EP) and OptEEmAL Tool (OT) or CitySim (CS)
DPI needed to calculate:	None
Additional notes:	The calculation tool used will depend on the available datasets introduced into the platform.

Table 33: Summary ENE07 – Total energy use per capita

ENE 07	Total energy use per capita	D	E
Definition:	Use of primary energy before transformation to other end-use fuels calculated per capita.		
Category:	1 – ENERGY (ENE)		

Indicator summary

Description:	Energy use refers to the use of primary energy before transformation to other end-use fuels. This amount equals to indigenous production from renewable energy sources, plus energy imports, minus energy exports and the energy storage per year. This amount is divided by the number of inhabitants in the district.
Unit of measurement:	kWh/year· hab
Scale:	District
Calculation / Creation method:	$Energy\ use/\ capita = \frac{Energy(renewables + imports) - energy\ (exports + storage)}{Number\ of\ inhabitants\ in\ the\ district}$



Indicator requirements

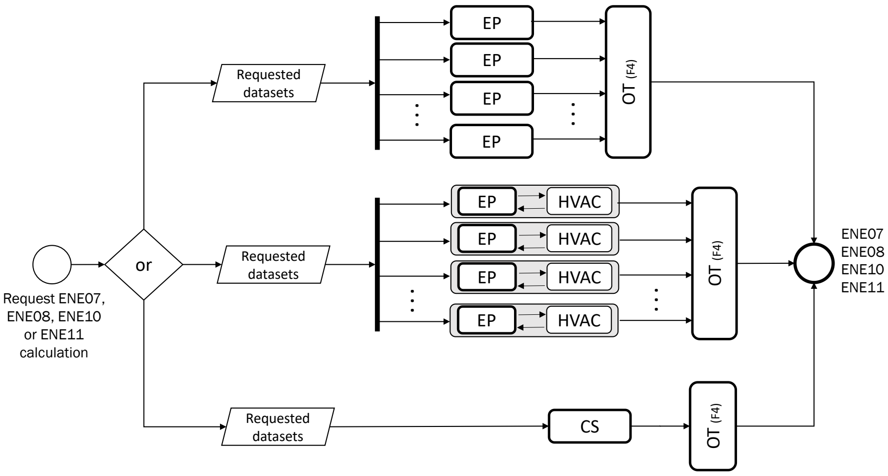
Requirements for calculation:	Type of data needed: simulation parameters, building geometry, building materials, weather data, schedules, internal gains, energy systems, exterior equipment, renewable energy systems, source energy factors, conversion factors, GWP/FU
Data source(s):	CityGML data, BIM data, contextual data and ECM catalogue.
DPIs needed for its calculation:	None
Tool(s) used:	Energy Plus (EP) and OptEEmAL Tool (OT) or CitySim (CS) and OptEEmAL Tool (OT)
DPI needed to calculate:	SOC01
Additional notes:	The calculation tool used will depend on the available datasets introduced into the platform.

Table 34: Summary ENE08 – Total residential energy use per capita

ENE 08	Total residential electrical energy use per capita	D	E
Definition:	Use of electric energy in residential buildings in the district calculated per capita.		
Category:	1 – ENERGY (ENE)		

Indicator summary

Description:	The total residential electrical energy use per capita, is the part of the total energy use, which refers to electric energy which is used for residential buildings in the district. This amount is divided by the total number of residents of the district.
Unit of measurement:	kWh/year · hab
Scale:	District
Calculation / Creation method:	$Res.elect.energy\ use/capita = \frac{Electric\ energy\ used\ in\ residential\ buildings\ (kWh)}{Number\ of\ inhabitants\ in\ the\ district}$



Indicator requirements

Requirements for calculation:	Type of data needed: simulation parameters, building geometry, building materials, weather data, schedules, internal gains, energy systems, exterior equipment, renewable energy systems, source energy factors, conversion factors, GWP/FU
Data source(s):	CityGML data, BIM data, contextual data and ECM catalogue.
DPIs needed for its calculation:	None
Tool(s) used:	Energy Plus (EP) and OptEEmAL Tool (OT) or CitySim (CS) and OptEEmAL Tool (OT)
DPI needed to calculate:	None
Additional notes:	The calculation tool used will depend on the available datasets introduced into the platform.

Table 35: Summary ENE09 – Energy demand covered by renewable sources

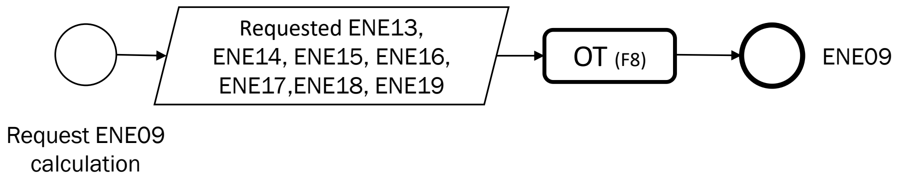
ENE 09	Energy demand covered by renewable sources	D	E
Definition:	Measurement of the demand covered by locally produced energy through renewable resources.		
Category:	1 – ENERGY (ENE)		

Indicator summary

Description: This DPI refers to the part of the total energy demand of the district which is covered by renewable sources of energy such as solar, wind and geothermal sources of energy.

Calculation / Creation method:

$$Energy\ demand\ covered\ by\ ren.\ sources = \frac{Energy\ demand\ in\ district\ (kWh)}{Local\ energy\ by\ ren.\ sources\ (kWh)}\ x\ 100$$



Unit of measurement: %

Scale: District

Indicator requirements

Requirements for calculation:

- Type of data needed: simulation parameters, building geometry, building materials, weather data, schedules, internal gains, energy systems, exterior equipment, renewable energy systems, source energy factors, conversion factors, GWP/FU
- DPI calculations performed in steps two or three have been completed.

Data source(s): CityGML data, BIM data, contextual data and ECM catalogue.

DPIs needed for its calculation: ENE13, ENE14, ENE15, ENE16, ENE17, ENE18, ENE19

Tool(s) used: OptEEmAL Tool (OT)

DPI needed to calculate: URB04

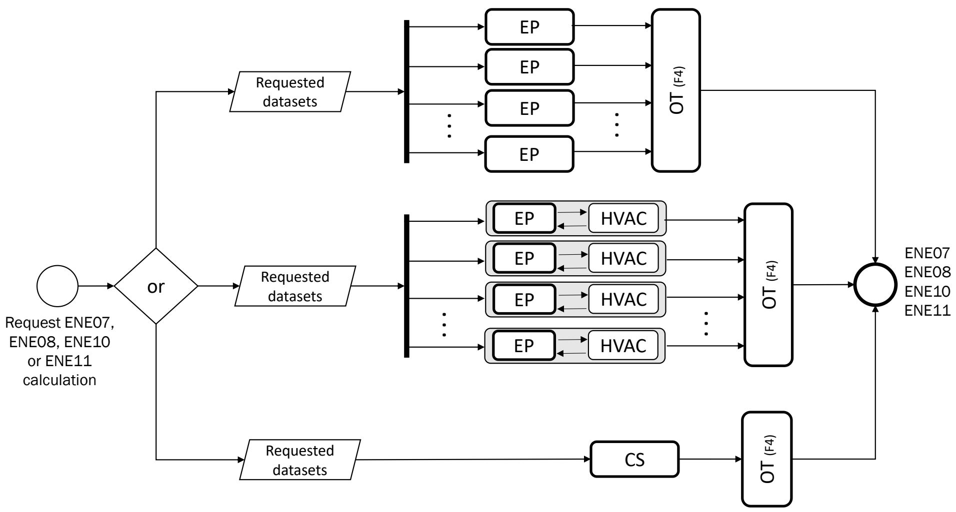
Additional notes: ---

Table 36: Summary ENE10 – Total residential natural gas energy use per capita

ENE 10	Total residential natural gas energy use per capita	D	E
Definition:	Amount of the total residential energy use obtained from natural gas per capita.		
Category:	1 – ENERGY (ENE)		

Indicator summary

Description:	The total residential natural gas energy use per capita, is the part of the total energy use per year, which refers to energy originating from natural gas use and is used for the residential part of the district. This amount is divided by the total number of residents of the district.
Unit of measurement:	kWh/year · hab
Scale:	District
Calculation / Creation method:	$Res.natural\ gas\ \ use/capita = \frac{Natural\ gas\ used\ in\ residential\ buildings\ (kWh)}{Number\ of\ inhabitants\ in\ the\ district}$



Indicator requirements

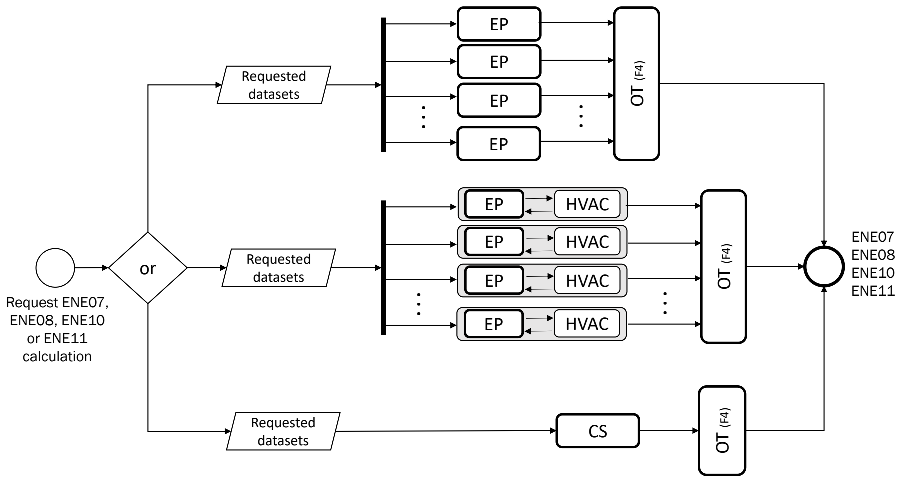
Requirements for calculation:	Type of data needed: simulation parameters, building geometry, building materials, weather data, schedules, internal gains, energy systems, exterior equipment, renewable energy systems, source energy factors, conversion factors, GWP/FU
Data source(s):	CityGML data, BIM data, contextual data and ECM catalogue.
DPIs needed for its calculation:	None
Tool(s) used:	Energy Plus (EP) and OptEEmAL Tool (OT) or CitySim (CS) and OptEEmAL Tool (OT)
DPI needed to calculate:	None
Additional notes:	The calculation tool used will depend on the available datasets introduced into the platform.

Table 37: Summary ENE11 – Total residential butane gas energy use per capita

ENE 11	Total residential butane gas energy use per capita	D	E
Definition:	Amount of the total residential energy use obtained from butane gas per capita.		
Category:	1 – ENERGY (ENE)		

Indicator summary

Description:	The total residential butane gas energy use per capita, is the part of the total energy use, which refers to energy originating from butane gas use and is used for the residential part of the district. This amount is divided by the total number of residents of the district.
Unit of measurement:	kWh/year · hab
Scale:	District
Calculation / Creation method:	$Res. butane\ gas\ \ use/capita\ = \frac{Butane\ gas\ used\ in\ residential\ buildings\ (kWh)}{Number\ of\ inhabitants\ in\ the\ district}$



Indicator requirements

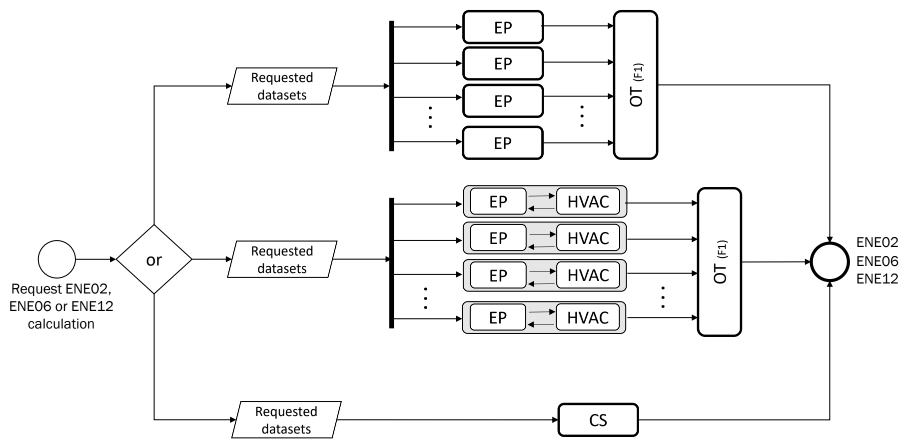
Requirements for calculation:	Type of data needed: simulation parameters, building geometry, building materials, weather data, schedules, internal gains, energy systems, exterior equipment, renewable energy systems, source energy factors, conversion factors, GWP/FU
Data source(s):	CityGML data, BIM data, contextual data and ECM catalogue.
DPIs needed for its calculation:	None
Tool(s) used:	Energy Plus (EP) and OptEEmAL Tool (OT) or CitySim (CS) and OptEEmAL Tool (OT)
DPI needed to calculate:	None
Additional notes:	The calculation tool used will depend on the available datasets introduced into the platform.

Table 38: Summary ENE12 –Energy consumption of public buildings per year

ENE 12	Energy consumption of public buildings per year	D	E
Definition:	Total energy consumption of public buildings for a single year period.		
Category:	1 – ENERGY (ENE)		

Indicator summary

Description:	The energy consumption of public buildings per year is the part of the total energy consumption (DPI ENE02) which refers to public buildings in the district, for a single year period.
Unit of measurement:	kWh/year · m²
Scale:	District
Calculation / Creation method:	$Public\ build.energy\ consump./\ year = \frac{Public\ building\ energy\ consumption\ (kWh)/year}{Total\ public\ building\ surface\ (m^2)}$



Indicator requirements

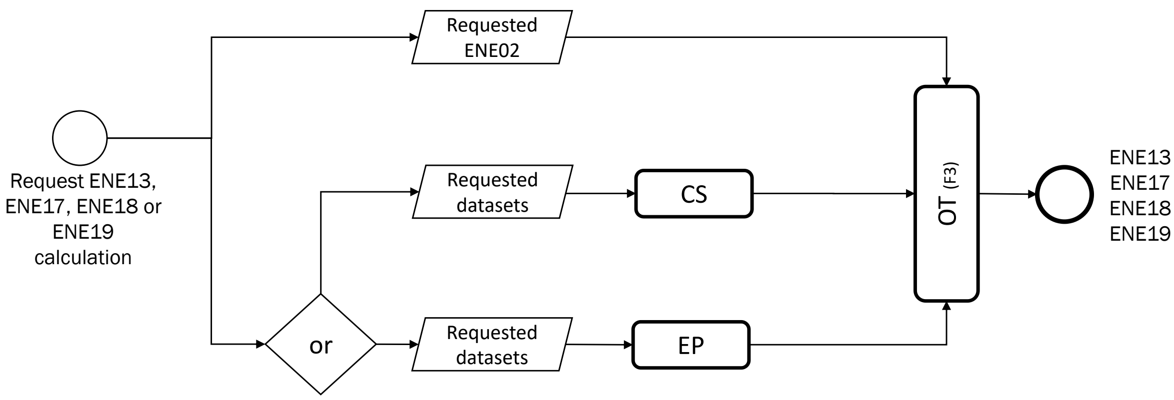
Requirements for calculation:	Type of data needed: simulation parameters, building geometry, building materials, weather data, schedules, internal gains, energy systems, exterior equipment, renewable energy systems, source energy factors, conversion factors, GWP/FU
Data source(s):	CityGML data, BIM data, contextual data and ECM catalogue.
DPIs needed for its calculation:	None
Tool(s) used:	Energy Plus (EP) and OptEEmAL Tool (OT) or CitySim (CS)
DPI needed to calculate:	None
Additional notes:	The calculation tool used will depend on the available datasets introduced into the platform.

Table 39: Summary ENE13 – Energy use from district heating

ENE 13	Energy use from district heating	D	E
Definition:	Amount of the total district energy use obtained from District Heating.		
Category:	1 – ENERGY (ENE)		

Indicator summary

Description:	This is the amount of total district energy use which is originated from District heating per year.
Unit of measurement:	kWh/year · m²
Scale:	District
Calculation / Creation method:	$$Energy\ Use\ from\ dist.heating = \sum_{i=1}^{N} \frac{Building_i's\ Energy\ Use\ from\ dist.heating}{Building_i's\ Total\ Floor\ Area\ (m^2)}$$ Where *N* is the number of buildings in the district.



Indicator requirements

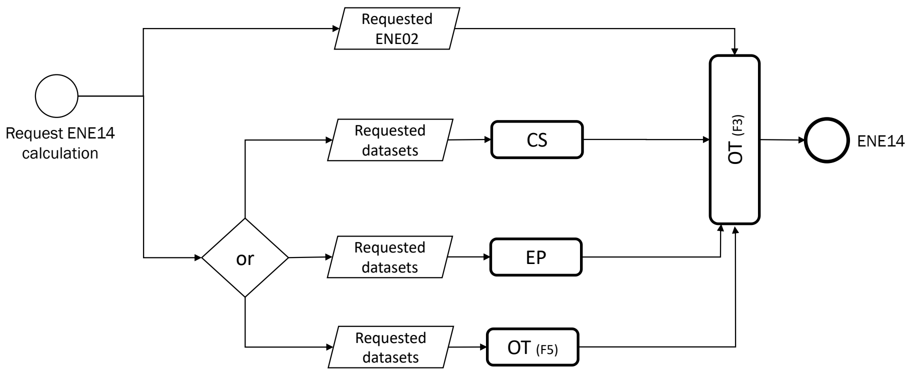
Requirements for calculation:	- Type of data needed: simulation parameters, building geometry, building materials, weather data, schedules, internal gains, energy systems, exterior equipment, renewable energy systems, source energy factors, conversion factors, GWP/FU - DPI calculations performed in steps one or two have been completed.
Data source(s):	CityGML data, BIM data, contextual data and ECM catalogue.
DPIs needed for its calculation:	ENE02
Tool(s) used:	Energy Plus (EP) and OptEEmAL Tool (OT) or CitySim (CS) and OptEEmAL Tool (OT)
DPI needed to calculate:	ENE09
Additional notes:	The calculation tool used will depend on the available datasets introduced into the platform.

Table 40: Summary ENE14 – Energy use from biomass

ENE 14	Energy use from biomass	D	E
Definition:	Amount of the total district energy use obtained from the use of biomass materials.		
Category:	1 – ENERGY (ENE)		

Indicator summary

Description:	This DPI refers to the part of the total district energy use per year, where the energy is obtained directly from biomass materials.
Unit of measurement:	kWh/year · m²
Scale:	District
Calculation / Creation method:	$$Energy\ Use\ from\ biomass = \sum_{i=1}^{N} \frac{Building_i's\ Energy\ Use\ from\ biomass}{Building_i's\ Total\ Floor\ Area\ (m^2)}$$ Where *N* is the number of buildings in the district.



Indicator requirements

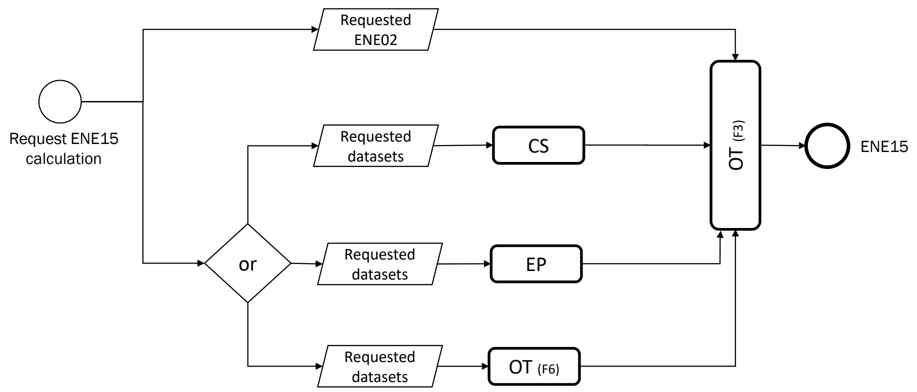
Requirements for calculation:	- Type of data needed: simulation parameters, building geometry, building materials, weather data, schedules, internal gains, energy systems, exterior equipment, renewable energy systems, source energy factors, conversion factors, GWP/FU - DPI calculations performed in steps one or two have been completed.
Data source(s):	CityGML data, BIM data, contextual data and ECM catalogue.
DPIs needed for its calculation:	ENE02
Tool(s) used:	CitySim (CS) and OptEEmAL Tool (OT), Energy Plus (EP) and OptEEmAL Tool (OT) or OptEEmAL Tool (OT)
DPI needed to calculate:	ENE09
Additional notes:	The calculation tool used will depend on the available datasets introduced into the platform.

Table 41: Summary ENE15 – Energy use from PV

ENE 15	Energy use from PV	D	E
Definition:	Amount of the total district energy use obtained from the use of solar photovoltaic panels.		
Category:	1 – ENERGY (ENE)		

Indicator summary

Description:	This DPI refers to the part of the total district energy use per year, where the energy is obtained directly from solar photovoltaic panels, installed in the buildings.
Unit of measurement:	kWh/year · m²
Scale:	District
Calculation / Creation method:	$Energy\ Use\ from\ PV = \sum_{i=1}^{N} \frac{Building_i's\ Energy\ Use\ from\ PV}{Building_i's\ Total\ Floor\ Area\ (m^2)}$ Where *N* is the number of buildings in the district.



Indicator requirements

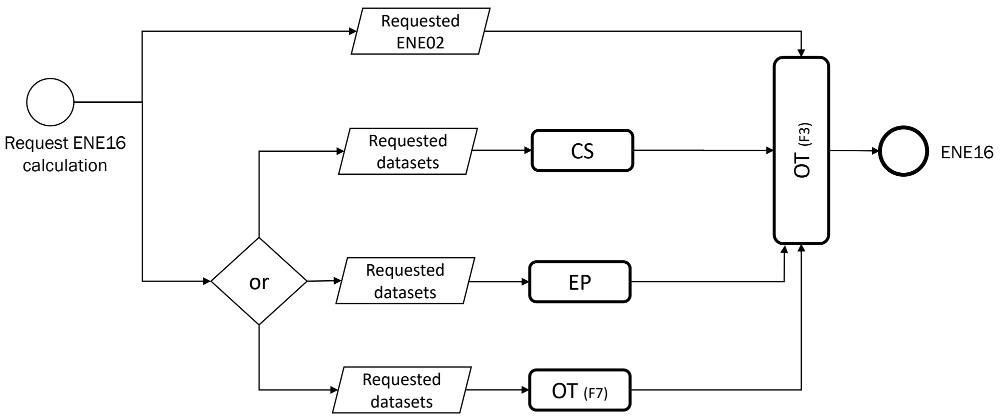
Requirements for calculation:	- Type of data needed: simulation parameters, building geometry, building materials, weather data, schedules, internal gains, energy systems, exterior equipment, renewable energy systems, source energy factors, conversion factors, GWP/FU - DPI calculations performed in steps one or two have been completed.
Data source(s):	CityGML data, BIM data, contextual data and ECM catalogue.
DPIs needed for its calculation:	ENE02
Tool(s) used:	CitySim (CS) and OptEEmAL Tool (OT), Energy Plus (EP) and OptEEmAL Tool (OT) or OptEEmAL Tool (OT)
DPI needed to calculate:	ENE09
Additional notes:	The calculation tool used will depend on the available datasets introduced into the platform

Table 42: Summary ENE16 – Energy use from solar thermal

ENE 16	Energy use from solar thermal	D	E
Definition:	Amount of the total district energy use obtained from the use of solar thermal panels.		
Category:	1 – ENERGY (ENE)		

Indicator summary

Description:	This DPI refers to the component of the total district energy use per year, the energy of which is obtained directly from solar thermal panels, installed in the buildings.
Unit of measurement:	kWh/year · m²
Scale:	District
Calculation / Creation method:	$Energy\ Use\ from\ solar\ thermal = \sum_{i=1}^{N} \frac{Building_i's\ Energy\ Use\ from\ solar\ thermal}{Building_i's\ Total\ Floor\ Area\ (m^2)}$ Where *N* is the number of buildings in the district.



Indicator requirements

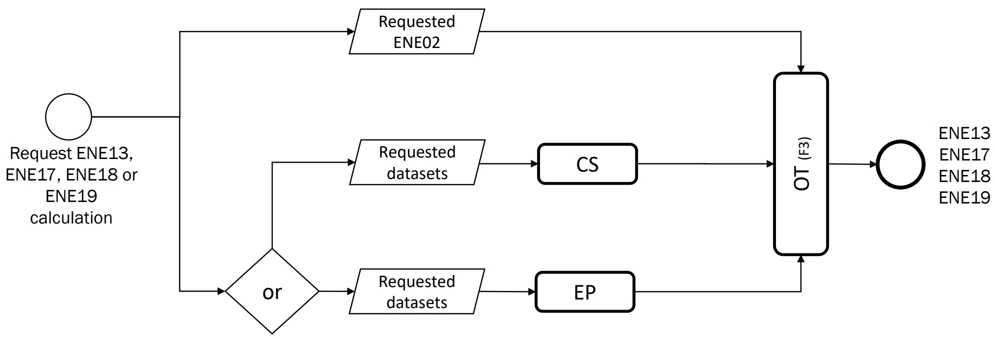
Requirements for calculation:	- Type of data needed: simulation parameters, building geometry, building materials, weather data, schedules, internal gains, energy systems, exterior equipment, renewable energy systems, source energy factors, conversion factors, GWP/FU - DPI calculations performed in steps one or two have been completed.
Data source(s):	CityGML data, BIM data, contextual data and ECM catalogue.
DPIs needed for its calculation:	ENE02
Tool(s) used:	CitySim (CS) and OptEEmAL Tool (OT), Energy Plus (EP) and OptEEmAL Tool (OT) or OptEEmAL Tool (OT)
DPI needed to calculate:	ENE09
Additional notes:	The calculation tool used will depend on the available datasets introduced into the platform

Table 43: Summary ENE17 – Energy use from hydraulic

ENE 17	Energy use from hydraulic	D	E
Definition:	Amount of the total district energy use obtained from the use of hydraulic.		
Category:	1 – ENERGY (ENE)		

Indicator summary

Description:	This DPI refers to the part of the total district energy use per year, the energy of which is originated from hydraulic generators.
Unit of measurement:	kWh/year · m²
Scale:	District
Calculation / Creation method:	$$Energy\ Use\ from\ hydraulic = \sum_{i=1}^{N} \frac{Building_i's\ Energy\ Use\ from\ hydraulic}{Building_i's\ Total\ Floor\ Area\ (m^2)}$$ Where *N* is the number of buildings in the district.



Indicator requirements

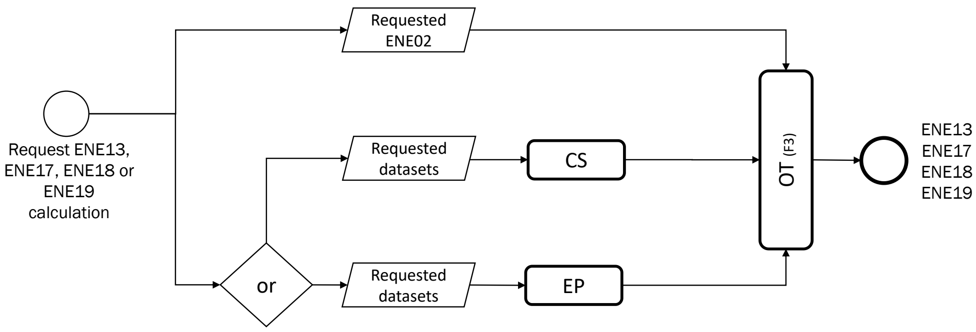
Requirements for calculation:	- Type of data needed: simulation parameters, building geometry, building materials, weather data, schedules, internal gains, energy systems, exterior equipment, renewable energy systems, source energy factors, conversion factors, GWP/FU - DPI calculations performed in steps one or two have been completed.
Data source(s):	CityGML data, BIM data, contextual data and ECM catalogue.
DPIs needed for its calculation:	ENE02
Tool(s) used:	Energy Plus (EP) and OptEEmAL Tool (OT) or CitySim (CS) and OptEEmAL Tool (OT)
DPI needed to calculate:	ENE09
Additional notes:	The calculation tool used will depend on the available datasets introduced into the platform.

Table 44: Summary ENE18 – Energy use from mini-eolica

ENE 18	Energy use from mini-eolica	D	E
Definition:	Amount of the total district energy use obtained from the use of wind turbine generators		
Category:	1 – ENERGY (ENE)		

Indicator summary

Description:	This DPI refers to the part of the total district energy use per year, the energy of which is originated from wind turbine generators.
Unit of measurement:	kWh/year · m²
Scale:	District
Calculation / Creation method:	$Energy\ Use\ from\ mini-eolica = \sum_{i=1}^{N} \frac{Building_i's\ Energy\ Use\ from\ mini-eolica}{Building_i's\ Total\ Floor\ Area\ (m^2)}$ Where *N* is the number of buildings in the district.



Indicator requirements

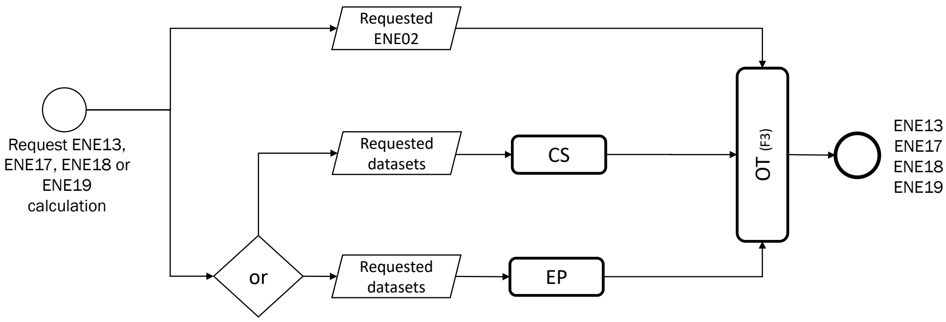
Requirements for calculation:	- Type of data needed: simulation parameters, building geometry, building materials, weather data, schedules, internal gains, energy systems, exterior equipment, renewable energy systems, source energy factors, conversion factors, GWP/FU - DPI calculations performed in steps one or two have been completed.
Data source(s):	CityGML data, BIM data, contextual data and ECM catalogue.
DPIs needed for its calculation:	ENE02
Tool(s) used:	Energy Plus (EP) and OptEEmAL Tool (OT) or CitySim (CS) and OptEEmAL Tool (OT)
DPI needed to calculate:	ENE09
Additional notes:	The calculation tool used will depend on the available datasets introduced into the platform.

Table 45: Summary ENE19 – Energy use from geothermal

ENE 19	Energy use from geothermal	D	E
Definition:	kWh/year · m²		
Category:	1 – ENERGY (ENE)		

Indicator summary

Description:	This DPI refers to the part of the total district energy use per year, the energy of which is originated from geothermal installations.
Unit of measurement:	kWh/year · m²
Scale:	District
Calculation / Creation method:	$$Energy\ Use\ from\ geothermal = \sum_{i=1}^{N} \frac{Building_i's\ Energy\ Use\ from\ geothermal}{Building_i's\ Total\ Floor\ Area\ (m^2)}$$ Where *N* is the number of buildings in the district.



Indicator requirements

Requirements for calculation:	- Type of data needed: simulation parameters, building geometry, building materials, weather data, schedules, internal gains, energy systems, exterior equipment, renewable energy systems, source energy factors, conversion factors, GWP/FU - DPI calculations performed in steps one or two have been completed.
Data source(s):	CityGML data, BIM data, contextual data and ECM catalogue.
DPIs needed for its calculation:	ENE02
Tool(s) used:	Energy Plus (EP) and OptEEmAL Tool (OT) or CitySim (CS) and OptEEmAL Tool (OT)
DPI needed to calculate:	ENE09
Additional notes:	The calculation tool used will depend on the available datasets introduced into the platform.

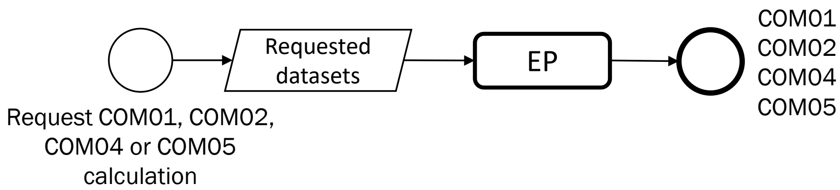
2. Comfort DPIs

Table 46: Summary COM01 – Local thermal comfort

COM 01	Local thermal comfort	D	E
Definition:	Indicator which measures the level of satisfaction of the occupants with the thermal environment.		
Category:	2 – COMFORT (COM)		

Indicator summary

Description:	Local thermal comfort is calculated through the Predicted Mean Vote (PMV) and Predicted Percentage of Dissatisfied (PPD) in order to measure “that condition of mind which expresses satisfaction with the thermal environment, i.e. the thermal comfort level of the occupants. This thermal comfort level is estimated from air temperature, air velocity, metabolic rate, clothing and humidity.
Unit of measurement:	Level
Scale:	District
Calculation / Creation method:	$PMV = 3.155[0.303\exp(-0.114M) + 0.028]L$ M is the metabolic rate, [W/m²] and L is the thermal load of the body [W] defined as the difference between internal heat production and heat loss to the environment $PPD = 100 - 95\exp[-(0.03353PMV^4 + 0.2179PMV^2)]$



Indicator requirements

Requirements for calculation:	Type of data needed: simulation parameters, building geometry, building materials, weather data, schedules, internal gains, energy systems, building management systems, clothing value, metabolic rate, air velocity and acceptable range.
Data source(s):	CityGML data, BIM data, contextual data, ECM catalogue, and ASHRAE Standards.
DPIs needed for its calculation:	None
Tool(s) used:	Energy Plus (EP)
DPI needed to calculate:	None
Additional notes:	---

Table 47: Summary COM02 – Local thermal deviation from set-point

COM 02	Local temperature deviation from set-point D E
Definition:	Deviation of building and zone temperatures from desired values in terms of percentage of time outside a predefined comfort band.
Category:	2 – COMFORT (COM)
Indicator summary	
Description:	This DPI quantifies the thermal comfort calculating the average deviation between the desired temperature and the measured value across the considered time interval. The desired temperature is the set-point given to the HVAC system. The temperature data can be simulated with a time step of one hour, whereas the average temperature deviation will be calculated over a 24 hours' time interval or longer.
Unit of measurement:	°C
Scale:	District
Calculation / Creation method:	$\Delta T = \frac{\sum_{n=1}^{N}[T_{zone}(n)-T_{sp}]dt_n}{\sum_{n=1}^{N} dt_n}$
Indicator requirements	
Requirements for calculation:	Type of data needed: simulation parameters, building geometry, building materials, weather data, schedules, internal gains, energy systems, building management systems, clothing value, metabolic rate, air velocity and acceptable range.
Data source(s):	CityGML data, BIM data, contextual data and ECM catalogue.
DPIs needed for its calculation:	None
Tool(s) used:	Energy Plus (EP)
DPI needed to calculate:	COM03
Additional notes:	This DPI will be used to derive immediate information about comfort which can be used to evaluate performances and convenience of different HVAC operation modes and controls.

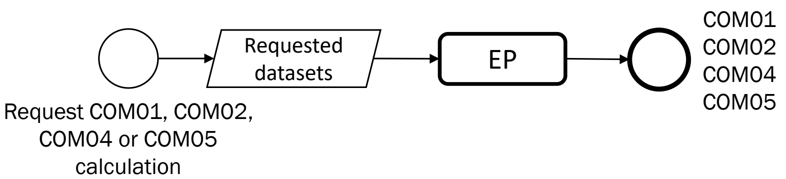
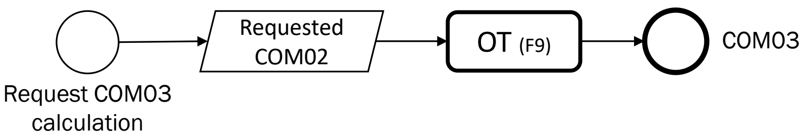


Table 48: Summary COM03 – Percentage outside range

COM 03	Percentage outside range	D	E
Definition:	Percentage of time outside the comfort zone.		
Category:	2 – COMFORT (COM)		

Indicator summary

Description:	This DPI refers to the percentage of time outside the comfort zone. Standard comfort zones are established and comfort DPIs such as COM01 will be used to calculate COM02. The percentage of time outside the comfort zone needs to be normalized by the magnitude of the deviation to obtain meaningful values for COM02.
Unit of measurement:	%, Δ(COM0i) ×time
Scale:	District
Calculation / Creation method:	$\mathrm{COM03} = \sum_{n=1}^{N} \left\| COM0i^{n} - COM0i^{n}_{target} \right\| dt_{n}$



Indicator requirements

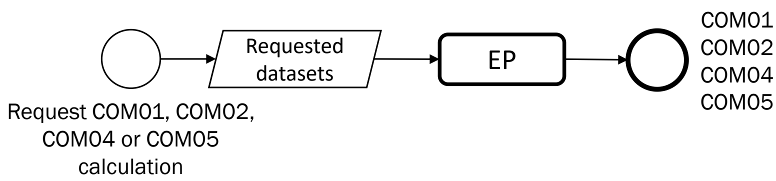
Requirements for calculation:	- Type of data needed: simulation parameters, building geometry, building materials, weather data, schedules, internal gains, energy systems, building management systems, clothing value, metabolic rate, air velocity and acceptable range. - DPI calculations performed in step two have been completed.
Data source(s):	CityGML data, BIM data, contextual data and ECM catalogue.
DPIs needed for its calculation:	COM02
Tool(s) used:	OptEEmAL Tool (OT)
DPI needed to calculate:	URB02, URB03
Additional notes:	---

Table 49: Summary COM04 – Indoor air quality

COM 04	Indoor air quality	D	E
Definition:	Indicator which estimates the clearness of the air inside all the conditioned building spaces.		
Category:	2 – COMFORT (COM)		

Indicator summary

Description:	Estimation of the clearness of the air inside all the conditioned building spaces. This air clearness is affected by the presence of various air pollutants, such as CO_2, the concentration of which is estimated and added in order to evaluate the total air quality.
Unit of measurement:	ppm
Scale:	District
Calculation / Creation method:	$COM04 = \frac{\sum_{n=1}^{N} C_{CO2}^{n} \times surface\ area^{n}}{\sum_{n=1}^{N} surface\ area^{n}}$ C_{CO2}^{n} is the concentration of CO2 in zone/building n



Indicator requirements

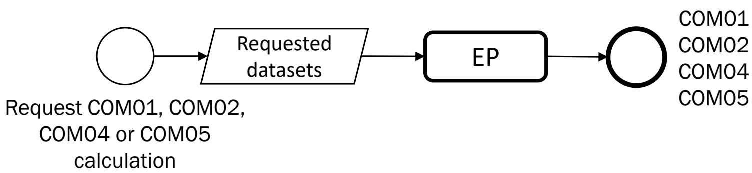
Requirements for calculation:	Type of data needed: simulation parameters, building geometry, building materials, weather data, schedules, internal gains, energy systems, building management systems, clothing value, metabolic rate, air velocity and acceptable range.
Data source(s):	CityGML data, BIM data, contextual data and ECM catalogue.
DPIs needed for its calculation:	None
Tool(s) used:	Energy Plus (EP)
DPI needed to calculate:	URB02, URB03
Additional notes:	---

Table 50: Summary COM05 – Visual comfort

COM 05	Visual comfort	D	E
Definition:	Evaluation of the visual comfort level of the users of the conditioned building spaces of the district.		
Category:	2 – COMFORT (COM)		

Indicator summary

Description:	Evaluation of the visual comfort level of the users of the conditioned building spaces of the district. This comfort level can be estimated based on the amount of light measured in lumens entering the building space which is originated from natural sources such as the sun or artificial sources such as building lights.
Unit of measurement:	lux
Scale:	District
Calculation / Creation method:	$COM05 = \frac{\sum_{n=1}^{N} VC^n \times surface\ area^n}{\sum_{n=1}^{N} surface\ area^n}$ *VC^n is the visual comfort of zone/building n obtained as an output of the simulation tool*



Indicator requirements

Requirements for calculation:	Type of data needed: simulation parameters, building geometry, building materials, weather data, schedules, internal gains, energy systems, building management systems, clothing value, metabolic rate, air velocity and acceptable range.
Data source(s):	CityGML data, BIM data, contextual data and ECM catalogue.
DPIs needed for its calculation:	None
Tool(s) used:	Energy Plus (EP)
DPI needed to calculate:	None
Additional notes:	---

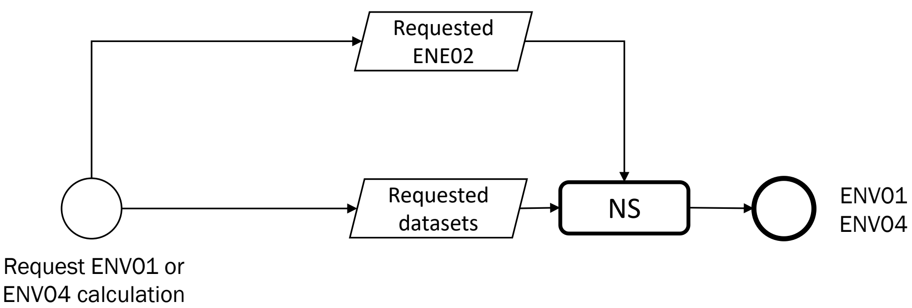
3. Environmental DPIs

Table 51: Summary ENV01 – Global Warming Potential (GWP)

ENV 01	Global Warming Potential (GWP)	D	E
Definition:	Estimation of the total CO_2 equivalent emissions (in kg CO_2 eq) due to the energy consumption and the use of construction materials in the district.		
Category:	3 – ENVIRONMENTAL (ENV)		

Indicator summary

Description:	Estimation of the total CO_2 equivalent emissions (in kg CO_2 eq) due to the energy consumption and the use of construction materials in the district. For energy consumption, the final energy consumption values of different energy types are multiplied by appropriate conversion factors to estimate the CO_2 equivalent emissions. For construction materials, Greenhouse Gas emissions are accounted all along their lifecycle and then multiplied by the relevant conversion factors. Greenhouse Gases are all gases which have an influence on Global Warming namely carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), etc
Unit of measurement:	kg CO_2 eq/m^2/year
Scale:	District
Calculation / Creation method:	$\mathrm{ENV1} = \frac{\sum_i (ECM_i * GWP_i)}{S * LT} + \frac{\sum_j (\mathrm{ENE2}_j * \mathrm{GWP}_j)}{S}$ With: ECM_i: Quantity of ECM i (Functional Unit, FU) GWP_i: GWP impact per unit of ECM i (kg CO_2eq.FU^{-1}) $\mathrm{ENE2}_j$: Energy source j consumption (kWh) GWP_j: GWP impact per unit of energy source j (kg CO_2eq.kWh^{-1}) S: Total building surface (in the district) (m^2) LT: District lifetime (years)



Indicator requirements

Requirements for calculation:	- Type of data needed: quantity of ECM, GWP impact per ECM, other DPIs, total surface of buildings and district lifetime. - DPI calculations performed in steps one or two have been completed.
Data source(s):	CityGML data, contextual data, ECM catalogue and project data..
DPIs needed for its calculation:	ENE02
Tool(s) used:	Nest (NS)
DPI needed to calculate:	ENV03
Additional notes:	---

Table 52: Summary ENV02 – Global warming potential investment

ENV 02	Global warming potential investment	-	E
Definition:	Global Warming Potential related to the retrofitting materials of a given scenario.		
Category:	3 – ENVIRONMENTAL (ENV)		

Indicator summary

Description:	The GWP Investment is the GWP related to the retrofitting materials of a given scenario. It only accounts for building materials (ECMs in the case of OptEEmAL) used in a given retrofitting scenario. In OptEEmAL, this indicator will be expressed in kg CO_2 equivalent per square meter of building (kg CO_2 eq/m^2). It will be calculated only for retrofitting scenarios as it is equal to zero in the diagnosis step (no retrofitting materials used).
Unit of measurement:	kg CO_2 eq/m^2
Scale:	District
Calculation / Creation method:	$ENV2 = \frac{\sum_i (ECM_i * GWP_i)}{S}$ With: EMC_i: Quantity of ECM i (Functional Unit, FU) GWP_i: GWP impact per unit of ECM i (kg CO_2eq.FU^{-1}) S: Total building surface (in the district) (m^2)

Indicator requirements

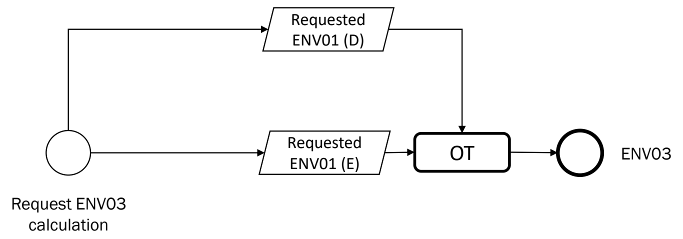
Requirements for calculation:	Type of data needed: quantity of ECM, GWP impact per ECM and total surface of buildings.
Data source(s):	CityGML data, contextual data, ECM catalogue and project data.
DPIs needed for its calculation:	None
Tool(s) used:	Nest (NS)
DPI needed to calculate:	None
Additional notes:	---

Table 53: Summary ENV03 – Global warming potential reduction

ENV 03	Global warming potential reduction	-	E
Definition:	Difference between the GWP of the baseline and the GWP of a given retrofitting scenarios. It accounts both for energy consumption and construction materials.		
Category:	3 – ENVIRONMENTAL (ENV)		

Indicator summary

Description:	The GWP Reduction is the difference between the GWP of the baseline and the GWP of a given retrofitting scenarios. It accounts both for energy consumption and construction materials.In OptEEmAL, this indicator will be expressed in kg CO_2 equivalent per year (kg CO_2 eq/m^2/year). It will be calculated only for retrofitting scenarios.
Unit of measurement:	kg CO_2 eq/m^2/year
Scale:	District
Calculation / Creation method:	$ENV3 = (ENV1_{diagnosis} - ENV1_{evalution\ scenario\ i}) * S$ With: $ENV1_{diagnosis}$: ENV1 for diagnosis ($kgCO_2 eq.m^{-2}.yr^{-1}$) $ENV1_{evaluation\ scenario\ i}$: ENV1 for scenario i ($kgCO_2 eq.m^{-2}.yr^{-1}$) S: Total building surface (in the district) (m^2)



Indicator requirements

Requirements for calculation:	- Type of data needed: other DPIs. - DPI calculations performed in step two or three have been completed.
Data source(s):	CityGML data, contextual data, ECM catalogue and project data.
DPIs needed for its calculation:	ENV01 (diagnosis and evaluation)
Tool(s) used:	OptEEmAL Tool (OT)
DPI needed to calculate:	GLO02
Additional notes:	---

Table 54: Summary ENV05 – Primary energy consumption

ENV 04	Primary energy consumption	D	E
Definition:	The consumption of the intrinsic energy in a primary product or resource.		
Category:	3 – ENVIRONMENTAL (ENV)		

Indicator summary

Description:

Life cycle energy consumption is usually expressed in Primary Energy rather than delivered energy (or final energy) units. The primary energy is defined as the intrinsic energy in a primary product or resource. The primary energy contained in a block of coal used to fire a power station will be many times greater than the delivered electrical energy at a premise due to heat losses at the power plant and transmission losses in the electricity grid.

In the building sector, the total life cycle energy is composed of two components:

- Operational Energy: the energy consumed by a building during its life from commissioning to demolition.
- Embodied Energy: the energy requirement to construct and maintain the building (see below for more details).

In OptEEmAL, this indicator will be expressed in MJ of primary energy per square meter of building and per year (MJ/m²/year). It will be calculated for the diagnosis step as well as for all retrofitting scenarios.

Unit of measurement: MJ/m² ·year

Scale: District

Calculation / Creation method:

$$ENV4 = \frac{\sum_i (ECM_i * PEC_i)}{S * LT} + \frac{\sum_j (\mathrm{ENE2}_j * \mathrm{PEC}_j)}{S}$$

With:

ECM_i: Quantity of ECM i (Functional Unit, FU)

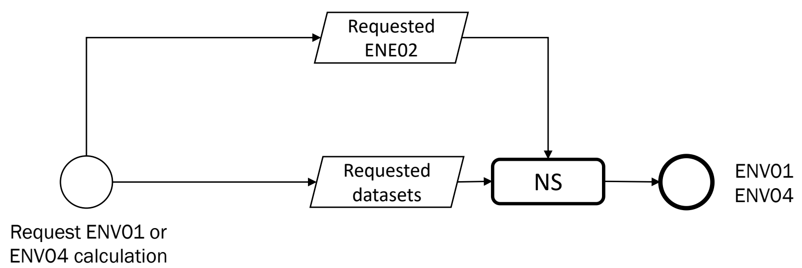
PEC_i: Primary Energy Consumption (PEC) impact per unit of ECM i ($MJ.FU^{-1}$)

$ENE2_j$: Energy source j consumption ($kWh.yr^{-1}$)

PEC_j: PEC impact per unit of energy source j ($MJ.kWh^{-1}$)

S: Total building surface (in the district) (m^2)

LT: District lifetime (years)



Indicator requirements

Requirements for calculation:	- Type of data needed: quantity of ECM, PEC impact per ECM, other DPIs, PEC impact per energy source, total surface of buildings and district lifetime. - DPI calculations performed in steps one or two have been completed.
Data source(s):	CityGML data, contextual data, ECM catalogue and project data.
DPIs needed for its calculation:	ENE02
Tool(s) used:	Nest (NS)
DPI needed to calculate:	ENV06, URB04, GLO01
Additional notes:	---

Table 55: Summary ENV05 – Embodied energy of refurbishment scenarios

ENV 05	Embodied energy of refurbishment scenarios	-	E
Definition:	Necessary energy to construct and maintain the building in the refurbishment scenarios.		
Category:	3 – ENVIRONMENTAL (ENV)		

Indicator summary

Description:	The Embodied Energy is the energy requirement to construct and maintain the building. For instance, for a brick wall, it is the energy required to make the bricks, transport them to site, lay them, plaster them and if necessary paint and re-plaster over the wall's life cycle. The Embodied Energy of refurbishment scenarios is the equivalent of ENV02 (related to CO2 emissions) but for energy. In OptEEmAL, this indicator will be expressed in MJ of primary energy per square meter of building (MJ/m2). It will be calculated only for retrofitting scenarios as it is equal to zero in the diagnosis step (no retrofitting materials used).
Unit of measurement:	MJ/m^2
Scale:	District
Calculation / Creation method:	$ENV5 = \frac{\sum_i (ECM_i * PEC_i)}{S}$ With: EMC_i: Quantity of ECM i (Functional Unit, FU) PEC_i: PEC impact per unit of ECM i ($MJ.FU^{-1}$) S: Total building surface (in the district) (m^2)

Indicator requirements

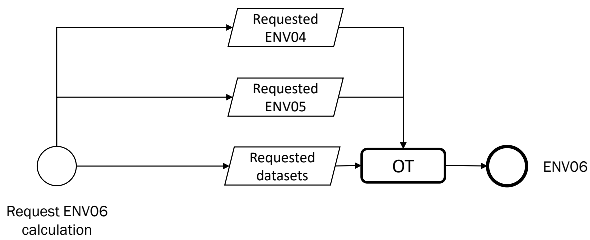
Requirements for calculation:	Type of data needed: quantity of ECM, PEC impact per ECM, other DPIs and total surface of buildings.
Data source(s):	CityGML data, contextual data, ECM catalogue and project data.
DPIs needed for its calculation:	None
Tool(s) used:	Nest (NS)
DPI needed to calculate:	ENV06
Additional notes:	---

Table 56: Summary ENV06 – Energy payback time

ENV 06	Energy payback time	-	E
Definition:	Time needed to save the amount of primary energy "invested" in the life cycle of retrofitting materials (production, transport, end-of-life, etc.) with the energy consumption reduction due to the retrofitting process.		
Category:	3 – ENVIRONMENTAL (ENV)		

Indicator summary

Description:	The Energy Payback Time is the time needed to save the amount of primary energy "invested" in the life cycle of retrofitting materials (production, transport, end-of-life, etc) with the energy consumption reduction due to the retrofitting process. It is the ratio of the energy "invested" over the energy "saved".
Unit of measurement:	Years
Scale:	District
Calculation / Creation method:	$ENV6 = \frac{ENV5_{scenario\ i}}{ENV4_{diagnosis} - ENV4_{evaluation\ scenario\ i})}$ With: $ENV4_{diagnosis}$: ENV4 for diagnosis ($MJ.m^2.yr^{-1}$) $ENV4_{evaluation\ scenario\ i}$: ENV4 for scenario i ($MJ.m^2.yr^{-1}$) ENV5: ENV5 for scenario i ($MJ.m^{-2}$)



Indicator requirements

Requirements for calculation:	- Type of data needed: other DPIs. - DPI calculations performed in steps two or three have been completed.
Data source(s):	CityGML data, contextual data, ECM catalogue and project data.
DPIs needed for its calculation:	ENV04, ENV05
Tool(s) used:	OptEEmAL Tool (OT)
DPI needed to calculate:	None
Additional notes:	---

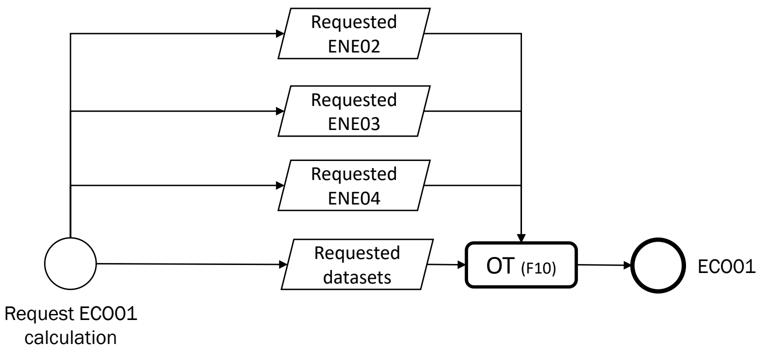
4. Economic DPIs

Table 57: Summary ECO01 – Operational energy cost

ECO 01	Operational energy cost	D	E
Definition:	Amount of monetary units required during the operation of a particular district refurbishment solution.		
Category:	4 – ECONOMIC (ECO)		

Indicator summary

Description:	The operational energy cost is the amount of monetary units required during the operation of a particular district refurbishment solution. It is calculated as the energy consumption per type of fuel multiplied to the energy cost per type of fuel. This DPI is needed to calculate the Life Cycle Cost, the Payback period and the ROI.
Unit of measurement:	€/year/m²
Scale:	District
Calculation / Creation method:	$Op.energy\ cost = Energy\ consumption\ (kWh/year)\ \ x\ energy\ cost\ (€/kWh)(per\ fuel)$



Indicator requirements

Requirements for calculation:	- Type of data needed: conversion factors and other DPIs. - DPI calculations performed in steps one or two have been completed.
Data source(s):	CityGML data or BIM data, contextual data, ECM catalogue and project data.
DPIs needed for its calculation:	ENE02, ENE03, ENE04
Tool(s) used:	OptEEmAL Tool (OT)
DPI needed to calculate:	SOC01, ECO03, ECO05
Additional notes:	---

Table 58: Summary ECO02 – Investments

ECO 02	Investments	-	E
Definition:	Total monetary assets related to each refurbishment scenario.		
Category:	4 – ECONOMIC (ECO)		

Indicator summary

Description:	Investments are the total monetary assets related to each refurbishment scenario. This DPI is an evaluation DPI and it will be calculated multiplying COST/FU of ECM and quantity of this ECM within the refurbishment scenario. Alternatively, this value will be expressed in relation to the total square meters refurbishment surface (reflected in the equation below).
Unit of measurement:	€, €/m2 of refurbished surface
Scale:	District
Calculation / Creation method:	$Investments = \frac{cost\ per\ FU\ (ECMs)\ (€)\ x\ quantity\ of\ ECM\ applied\ in\ scenario}{refurbishment\ surface\ (m2)}$

Indicator requirements

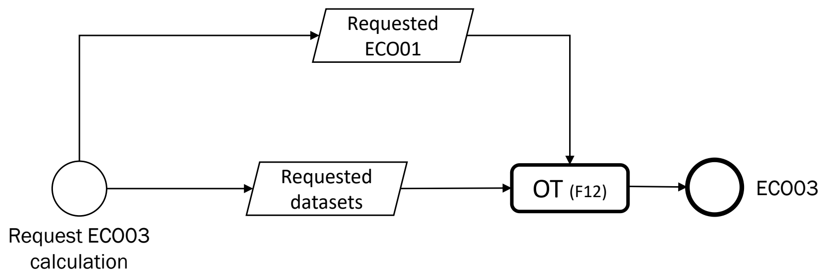
Requirements for calculation:	Type of data needed: building geometry, type of ECM and quantity and investment, performance, fuel type and maintenance cost.
Data source(s):	CityGML data or BIM data,, contextual data, ECM catalogue and project data.
DPIs needed for its calculation:	None
Tool(s) used:	OptEEmAL Tool (OT)
DPI needed to calculate:	GLO01, GLO02, ECO03, ECO04, ECO05
Additional notes:	---

Table 59: Summary ECO03 – Life cycle cost

ECO 03	Life cycle cost	-	E
Definition:	Amount of monetary units required for the initial installation, operational energy cost and maintenance of a particular refurbishment scenario.		
Category:	4 – ECONOMIC (ECO)		

Indicator summary

Description:	The life cycle cost measured by this DPI, is the amount of monetary units required for the initial installation, operational energy cost and maintenance of a particular refurbishment scenario.
Unit of measurement:	€, €/m2 of refurbished surface
Scale:	District
Calculation / Creation method:	$Life\ cycle\ cost = \sum Monetary\ units\ \ (installation +\ op.energy\ cost + maintenance)$



Indicator requirements

Requirements for calculation:	- Type of data needed: building geometry, other DPIs, type of ECM and quantity, investment cost, performance, fuel type and maintenance cost - DPI calculations performed in steps two or three have been completed.
Data source(s):	CityGML data or BIM data, contextual data, ECM catalogue and project data.
DPIs needed for its calculation:	ECO01
Tool(s) used:	OptEEmAL Tool (OT)
DPI needed to calculate:	ECO04
Additional notes:	---

Table 60: Summary ECO04 – Return on investment

ECO 04	Return on investment	-	E
Definition:	Clear gain in monetary units associated with a particular refurbishment scenario (gain minus the total cost), relative to the total cost of this refurbishment scenario.		
Category:	4 – ECONOMIC (ECO)		

Indicator summary

Description: The return on investment is the clear gain in monetary units associated with a particular refurbishment scenario (gain minus the total cost), relative to the total cost of this refurbishment scenario.

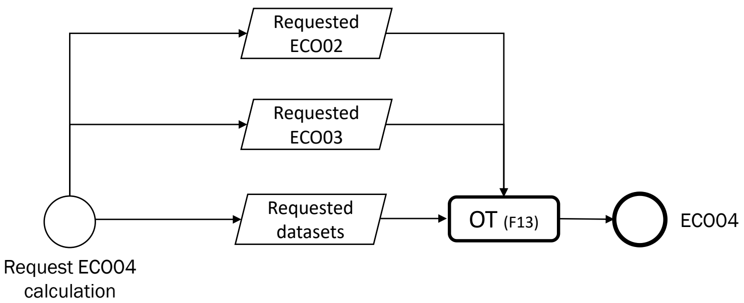
In OptEEmAL the return on investment is the ratio of the difference of the gain minus the life cycle cost divided by the total life cycle cost of the refurbishment scenario.

Unit of measurement: %

Scale: District

Calculation / Creation method:

$$Return\ on\ investment = \frac{Gain\ (€) - Life\ cycle\ cost\ (€)}{Life\ cycle\ cost\ (€)} x\ 100$$



Indicator requirements

Requirements for calculation:
- Type of data needed: other DPIs, Investment cost, performance, fuel type and maintenance cost.
- DPI calculations performed in steps three or four have been completed.

Data source(s): CityGML data or BIM data,, contextual data, ECM catalogue and project data.

DPIs needed for its calculation: ECO02, ECO03

Tool(s) used: OptEEmAL Tool (OT)

DPI needed to calculate: None

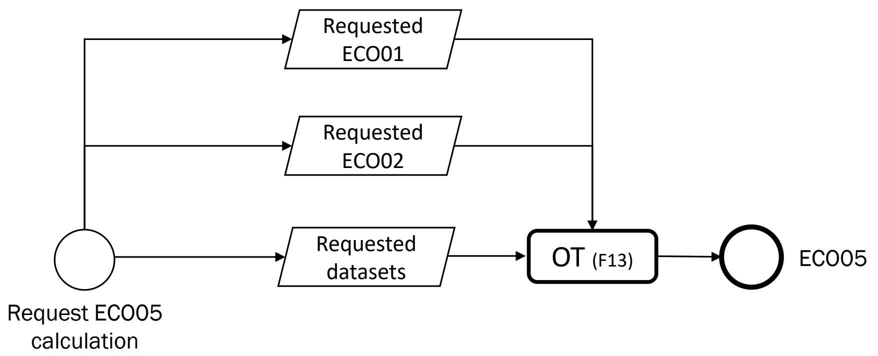
Additional notes: ---

Table 61: Summary ECO05 – Payback period

ECO 05	Payback period	-	E
Definition:	Measurement of the time it takes to cover the investment costs.		
Category:	4 – ECONOMIC (ECO)		

Indicator summary

Description:	The payback period is the time it takes to cover investment costs. It can be calculated from the number of years elapsed between the initial investment, its subsequent operating costs and the point in time when cumulative savings offset the investment.
Unit of measurement:	years
Scale:	District
Calculation / Creation method:	$$Payback\ period = \frac{investments\ +\ operating\ costs}{annual\ savings}$$



Indicator requirements

Requirements for calculation:	- Type of data needed: other DPIs, investment cost, performance, fuel type and maintenance cost. - DPI calculations performed in steps two or three have been completed.
Data source(s):	CityGML data or BIM data, contextual data, ECM catalogue and project data.
DPIs needed for its calculation:	ECO01, ECO02
Tool(s) used:	OptEEmAL Tool (OT)
DPI needed to calculate:	None
Additional notes:	---

5. Social DPIs

Table 62: Summary SOC01 – Energy poverty: % of inhabitants that use more than 10% of their incomes to pay energy bills

SOC 01	Energy poverty % of inhabitants that use more than 10% of their incomes to pay energy bills	D	E
Definition:	Estimation of the ability of the district inhabitants to pay for the energy bills.		
Category:	5 – SOCIAL (SOC)		

Indicator summary

Description: Estimation of the ability of the district inhabitants to pay energy bills. It is expressed as the percentage of people that are in energy poverty: "Situation in which a household has to spend more than one tenth of its income to pay bills to heat its dwelling to an acceptable standard" based on WHO-recommended levels".

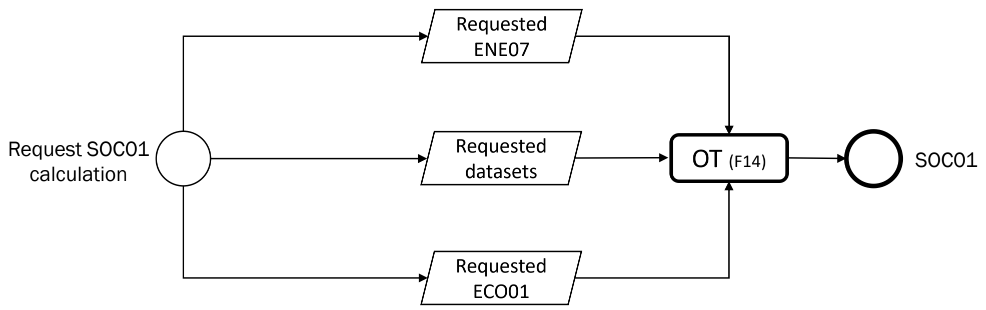
Calculation / Creation method:

$$Cost\ Energy\ per\ inhabitant = \frac{Energy\ consumption\ x\ energy\ price}{total\ of\ inhabitants}$$

$$f(n) = \begin{cases} 0, & Incomes\ of\ inhabitan\ n < 10\% * Cost\ Energy\ per\ inhabitant \\ 1, & Incomes\ of\ inhabitan\ n \geq 10\% * Cost\ Energy\ per\ inhabitant \end{cases}$$

$$Number\ of\ Energetically\ deprived\ inhabitants = \sum_{n=1}^{total\ of\ inhabitants} f(n)$$

$$Energy\ poverty = \frac{Number\ of\ Energetically\ Pover\ inhabitants}{total\ of\ inhabitants} x100$$



Unit of measurement: %

Scale: District

Indicator requirements

Requirements for calculation:	- Type of data needed: average incomes, other DPIs, number of inhabitants. - DPI calculations performed in steps two or three have been completed.
Data source(s):	CityGML data or BIM data, contextual data, ECM catalogue and project data.
DPIs needed for its calculation:	ENE07, ECO01
Tool(s) used:	OptEEmAL Tool (OT)
DPI needed to calculate:	None
Additional notes:	Incomes of inhabitants could be provided directly to the platform or through estimated data with the use of geo-clustering techniques.

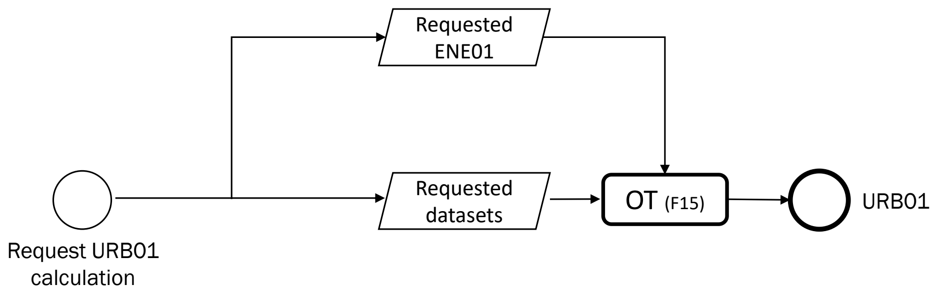
6. Urban DPIs

Table 63: Summary URB01 – Percentage of buildings with an A rating in the Energy Performance Certificate (EPC)

URB 01	Percentage of buildings with an A rating in the Energy Performance Certificate (EPC)	D	E
Definition:	Approximate calculation of the percentage of buildings that can reach an A rating in the Energy Performance Certificate (EPC).		
Category:	6 – URBAN (URB)		

Indicator summary

Description:	This indicator is devoted to the calculation of the percentage of buildings that can reach an A rating in the Energy Performance Certificate (EPC). In OptEEmAL its calculation is carried out in an approximate way, by taking as reference value of the performance of the scenarios the results of ENE01 “Energy demand”, since it is the most common reference value used by European countries, and afterwards comparing them to a fixed reference value in the platform of 25kWh/m^{2}y.
Unit of measurement:	%
Scale:	District
Calculation / Creation method:	$\%\ buildings\ with\ A\ rating = \frac{Surface\ of\ number\ of\ buildings\ with\ A\ rating}{Total\ surface} x100$



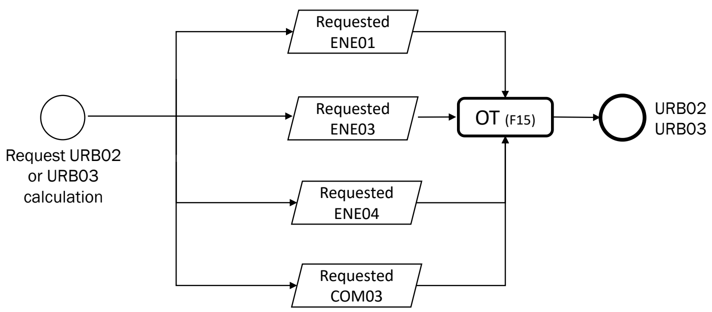
Indicator requirements	
Requirements for calculation:	- Type of data needed: building geometry, building typologies, other DPIs. - DPI calculations performed in step one or two have been completed.
Data source(s):	CityGML data or BIM data and project data.
DPIs needed for its calculation:	ENE01
Tool(s) used:	OptEEmAL Tool (OT)
DPI needed to calculate:	URB04
Additional notes:	- The reference value of 25kWh/m²y has been obtained by analysing the different scales established by European countries to evaluate these ratings and finding a reasonable value that complies with most restrictive countries' requirements. - The calculation of this DPI is based on an approximation on the two abovementioned issues and as such the user will be informed appropriately when viewing the results of this DPI.

Table 64: Summary URB02 – Percentage of buildings compliant with PassivHaus standards

URB 02	Percentage of buildings compliant with PassivHaus standards	D	E
Definition:	Calculation of the percentage of buildings compliant with adapted PassivHaus standards.		
Category:	6 – URBAN (URB)		

Indicator summary

Description:	This indicator will calculate the percentage of buildings compliant with adapted PassivHaus standards. It will be based on the comparison of other indicators calculated within OptEEmAL (listed below) to satisfy the requirements established by the PassivHaus Institute for a determined dwelling or premise to be certified as PassivHaus. The adapted requirements established by the PassivHaus Institute for PassivHaus certification used in OptEEmAL are the following: 1. Space heating and cooling energy demand (kWh/m^{2}y) <15kWh/m^{2}y (measured with ENE01) 2. Primary energy demand (kWh/m^2): ENE03 + ENE04 < 120kWh /m^{2}y 3. Thermal comfort <10% (measured with COM03)
Unit of measurement:	%
Scale:	District
Calculation / Creation method:	[*creaction method based on comparing values and ensuring that all categories are fulfilled*]



Indicator requirements

Requirements for calculation:	- Type of data needed: building geometry, building typologies, other DPIs. - DPI calculations performed in steps one or two have been completed.
Data source(s):	CityGML data or BIM data and project data.
DPIs needed for its calculation:	ENE01, ENE03, ENE04, COM03
Tool(s) used:	OptEEmAL Tool (OT)
DPI needed to calculate:	None
Additional notes:	The calculation of this DPI is based on an approximation and as such the user will be informed appropriately when viewing the results of this DPI.

Table 65: Summary URB03 – Percentage of buildings compliant with EnerPhit standards

URB 03	Percentage of buildings compliant with EnerPhit standards	D	E
Definition:	Calculation of the percentage of buildings compliant with adapted EnerPhit standards.		
Category:	6 – URBAN (URB)		

Indicator summary

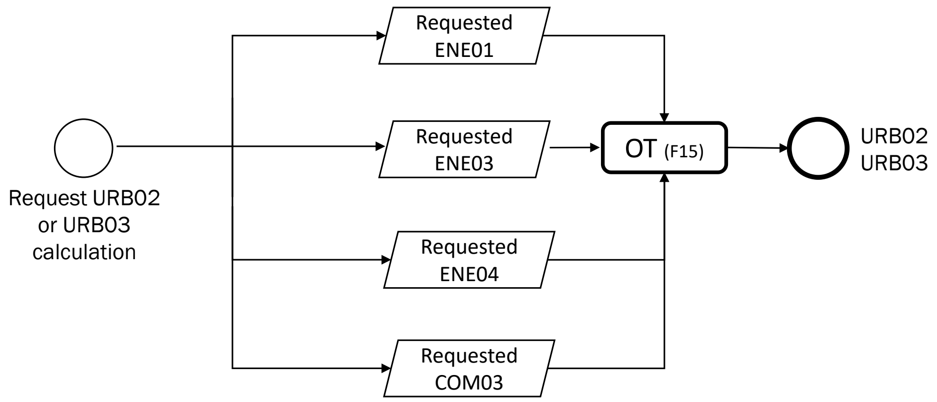
Description: This indicator will calculate the percentage of buildings compliant with adapted EnerPhit standards, which are comparable to the ones established for PassivHaus, but applied to refurbished buildings. This indicator will be based on the comparison of other indicators calculated within OptEEmAL (listed below) to satisfy the requirements established by the PassivHaus Institute for a determined dwelling or premise to be certified as EnerPhit. The adapted requirements from the ones established by the PassivHaus Institute for EnerPhit certification to be used in OptEEmAL are the following:

1. Space heating energy demand (kWh/m^{2}y) <25kWh/m^{2}y (measured with ENE01)
2. Space cooling energy demand (kWh/m^{2}y) <25kWh/m^{2}y (measured with ENE01)
3. Primary energy demand (kWh/m^2): ENE03 + ENE04 < 120kWh /m^{2}y + (space heating demand -15) x1,2
4. Thermal comfort <10% (measured with COM03)

Unit of measurement: %

Scale: District

Calculation / Creation method: $[creaction\ method\ based\ on\ comparing\ values\ and\ ensuring\ that\ all\ categories\ are\ fulfilled]$



Indicator requirements	
Requirements for calculation:	- Type of data needed: building geometry, building typologies, other DPIs. - DPI calculations performed in steps one or two have been completed.
Data source(s):	CityGML data or BIM data and project data.
DPIs needed for its calculation:	ENE01, ENE03, ENE04, COM03
Tool(s) used:	OptEEmAL Tool (OT)
DPI needed to calculate:	None
Additional notes:	The calculation of this DPI is based on an approximation and as such the user will be informed appropriately when viewing the results of this DPI.

Table 66: Summary URB04 – Percentage of buildings compliant with nZEB standards

URB 04	Percentage of buildings compliant with nZEB standards	D	E
Definition:	Percentage of the district buildings compliant with nearly Zero Energy Building's standards, defined within OptEEmAL.		
Category:	6 – URBAN (URB)		

Indicator summary

Description: This indicator will calculate the percentage of the district buildings compliant with nearly Zero Energy Building's standards, which are defined within the platform, since there is no fixed definition of this type of buildings at European level.

To be able to classify the district buildings as compliant, some reference values have been estimated by analysing the definition approaches by European countries and taking the most restrictive values. These will be related to DPIs to be calculated within the platform, which will have to undergo a minor processing.

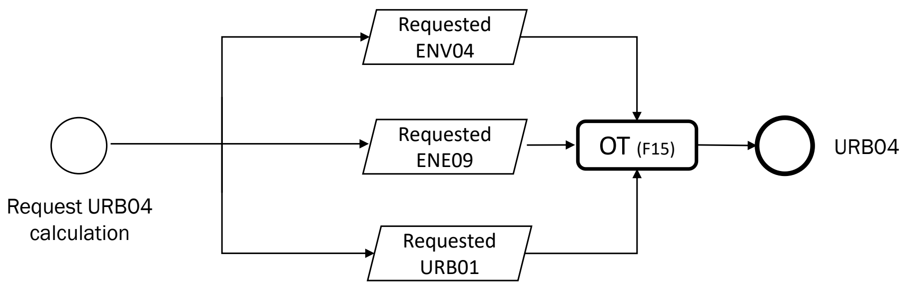
Table 67: Parameters for nZEB definition in OptEEmAL

Parameter	Building typology	Value	Related DPI in OptEEmAL
Very high energy performance	All	A rating according to URB01	URB01
Maximum primary energy (kWh/m2y)	Residential	<20	ENV04 *
	Non-residential	<25	ENV04 *
Share of renewable energy (%)	District	20%	ENE05 *

Unit of measurement: %

Scale: District

Calculation / Creation method: [*creaction method based on comparing values and ensuring that all categories are fulfilled*]



Indicator requirements

Requirements for calculation:	- Type of data needed: building geometry, building typologies, other DPIs. - DPI calculations performed in step three or four have been completed.
Data source(s):	CityGML data or BIM data and project data.
DPIs needed for its calculation:	ENV04, ENE09, URB01
Tool(s) used:	OptEEmAL Tool (OT)
DPI needed to calculate:	None
Additional notes:	- The results of some of the DPIs used in the calculations (ENV04 and ENV05) will have to be processed to separate residential typologies from non-residential ones. - The calculation of this DPI is based on an approximation and as such the user will be informed appropriately when viewing the results of this DPI.

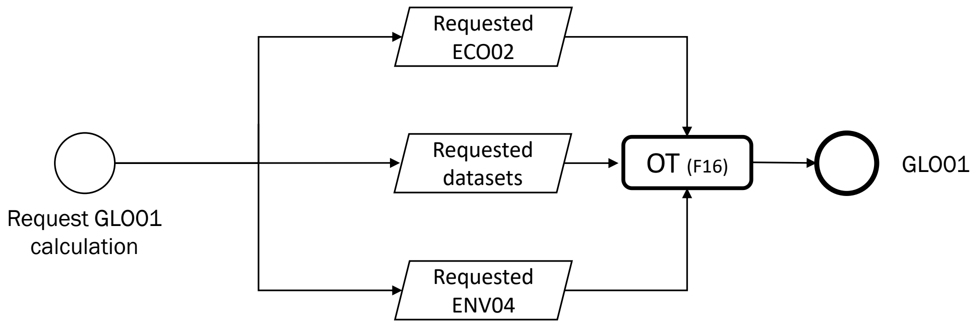
7. Global DPIs

Table 68: Summary GLO01 – kWh energy saved / euro invested

GLO 01	kWh energy saved / euro invested	-	E
Definition:	Ratio of the estimated energy savings of a particular refurbishment scenario divided by the total monetary amount in euros invested to this scenario.		
Category:	7 – GLOBAL (GLO)		

Indicator summary

Description:	This DPI measures the ratio of the estimated energy savings of a particular refurbishment scenario divided by the total monetary amount in euros invested to this scenario. It brings into relation two previously calculated DPIs, namely: ENE02 (evaluation and diagnosis) “Final energy consumption” and ECO02 “Investments”.
Unit of measurement:	kWh / €
Scale:	District
Calculation / Creation method:	$kWh\ en.saved/euro\ invested = \frac{Initial\ energy\ consump.–Final\ energy\ consump.(kWh)}{€\ invested}$



Indicator requirements

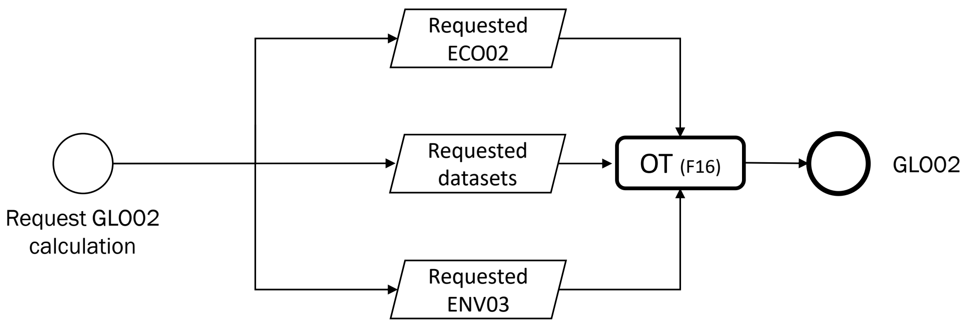
Requirements for calculation:	- Type of data needed: other DPIs. - DPI calculations performed in step two or three have been completed.
Data source(s):	Project data.
DPIs needed for its calculation:	ENV04, ECO02
Tool(s) used:	OptEEmAL Tool (OT)
DPI needed to calculate:	None
Additional notes:	---

Table 69: Summary GLO02 – C02 energy saved / euro invested

GLO 02	C02 saved / euro invested	-	E
Definition:	Ratio of the estimated c02 savings of a particular refurbishment scenario divided by the total monetary amount in euros invested to this scenario.		
Category:	7 – GLOBAL (GLO)		

Indicator summary

Description:	This DPI measures the ratio of the estimated C02 savings of a particular refurbishment scenario divided by the total monetary amount in euros invested to this scenario. It brings into relation two previously calculated DPIs, namely: ENV03 “GWP reduction” and ECO02 “Investments”.
Unit of measurement:	kg CO_2/y/m² /€
Scale:	District
Calculation / Creation method:	$C02\ \ saved/euro\ invested = \dfrac{Initial\ GWP\ \ - Final\ GWP\ (kg\ C02/a\ )}{€\ invested}$



Indicator requirements

Requirements for calculation:	- Type of data needed: building geometry, building typologies, other DPIs. - DPI calculations performed in steps three or four have been completed.
Data source(s):	CityGML data or BIM data and project data.
DPIs needed for its calculation:	ENV03, ECO02
Tool(s) used:	OptEEmAL Tool (OT)
DPI needed to calculate:	None
Additional notes:	---