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REGIONE AUTÒNOMA DE SARDIGNA
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Sustainable MED Cities

Integrated tools and methodologies for sustainable Mediterranean cities

D 3.1.4. MED Passport and KPIs

This project has received funding from the European Union's ENI CBC Med Programme under Grant Contract C_B.4.3_0063

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Name of Author (S)	Organisation
K.G. Droutsa, C.A. Balaras, E.G. Dascalaki, S. Kontoyiannidis	Institute for Environmental Research & Sustainable Development (IERSD), National Observatory of Athens (NOA)

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1. Executive Summary

The majority of the world's population (55%) has been concentrated in large urban areas, a proportion that is expected to increase to 68% by 2050 (UN, 2018). At the same time, although cities account for less than 2% of the Earth's surface, they consume 78 % of the world's energy and produce more than 60 % of greenhouse gas emissions (GHG) and 70% of global waste, (UN Habitat), being both a challenge for global sustainability and a tool for its solution.

In the Mediterranean region, two thirds of the population live in urban areas, while by 2050, it is predicted that the urban population will grow to around 170 million in the countries on the northern shore and to over 300 million to the south and east. Currently, northern Mediterranean countries use more energy and have higher CO2 emissions than south-eastern countries, a trend that is expected to be reversed by 2040 by improving energy efficiency, exploiting renewables etc. Most global climate models project that the Mediterranean basin will be particularly sensitive to rising GHG concentrations and thus, vulnerable to climate change, which means that cities in the south and north Mediterranean will need to adapt existing infrastructure and build new ones.

The Sustainable MED Cities project, aims to provide an easy to use, harmonized methodology and open source tools to support Mediterranean municipalities in the assessment, planning and overall decision-making process for selecting the best sustainable renovation strategies that increase the quality of the built environment. The holistic assessment focuses on energy and GHGs emissions, and other environmental vectors like economic and social indicators. The tools are used to set common targets and to measure the overall progress in terms of key sustainability issues and decarburization efforts at different scales (i.e. building, neighbourhood and city). The common method and tools will be available in different languages, with their assessment and rating approach contextualized to national (local) needs and priorities.

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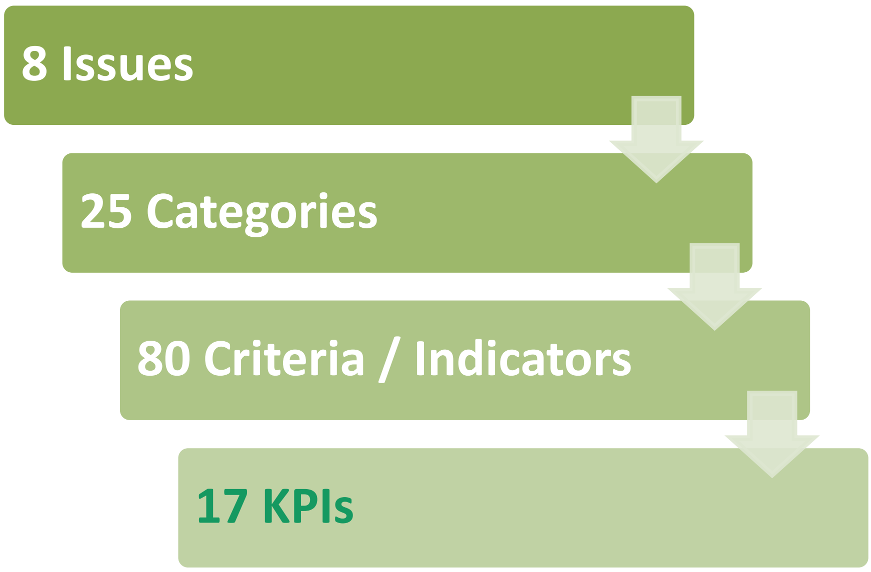
The approach taken in this work utilizes the CESBA MED system (CESBA MED Project – SBTool assessment system) that was developed as a generic framework, which includes an “exhaustive” list of sustainability indicators that cover all relevant themes, given that there is still no consensus on a specific number or types of indicators. In addition, some new indicators are included in order to address the priorities of the new partner cities in the MENA region. The resulting comprehensive database includes different performance indicators from which to select the ones that meet local priorities and needs, or best fit the project intent.

2. Key Performance Indicators (KPIs)

A minimum number of key performance indicators are defined and used in order to ensure that the core sustainability issues can be addressed in a satisfactory manner. The KPIs are defined and calculated following common standardized procedures. This work considered most of the LEVEL(s) indicators in the process of selecting the KPIs for the building scale. The results from the normative KPI calculations can then be used as a passport for comparing different buildings, neighbourhoods and cities, on a common basis.

2.1. Key Performance Indicators – Building Scale

The Building Scale is organized as follows:



Specifically, the KPIs for the building scale are:

- ✓ B1.1 Primary energy demand
- ✓ B1.2 Delivered thermal energy demand
- ✓ B1.3 Delivered electric energy demand

- ✓ B1.4 Energy from renewable sources in total thermal energy consumption
- ✓ B1.5 Energy from renewable sources in total electric energy consumption
- ✓ B1.6 Embodied non-renewable primary energy
- ✓ B3.4 Recycled materials
- ✓ B4.3 Potable water consumption for indoor uses
- ✓ C1.1 Embodied carbon
- ✓ C1.2 GHG gas emissions during operation
- ✓ D1.2 TVOC concentration
- ✓ D1.7 Mechanical Ventilation
- ✓ D2.3 Thermal comfort index
- ✓ D3.1 Daylight
- ✓ E1.2 Smart readiness indicator
- ✓ G1.4 Energy cost
- ✓ H1.2 Heat island effect

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2.1.1. B1.1 Primary energy demand

Issue	B. Energy & Resource Consumption	
Category	B1. Energy	
Criterion	B1.1 Primary energy demand	
Indicator	Primary energy demand per internal useful floor area per year	
Unit	kWh/m^2/yr	
Project stage	Design	In use
Data source	Estimation	Metering

Intent

Minimise the total primary energy consumption of the building.

Description

The indicator provides an understanding of a building's primary energy consumption. Primary energy is defined by Article 2(5) of the Energy Performance of Buildings Directive 6 as 'the energy that has not undergone any conversion in the transformation process, calculated by energy carrier using a primary energy factor'. It is the energy that is required to generate the electricity, heating and cooling used by a building.

Boundary and Scope

The assessment boundary is the building.

Energy can be imported or exported through the building from/to on-site, nearby and distant locations. Inside the assessment boundary, the system losses are taken into account explicitly in the conversion factor applied to the energy carrier, also referred to as a primary energy factor.

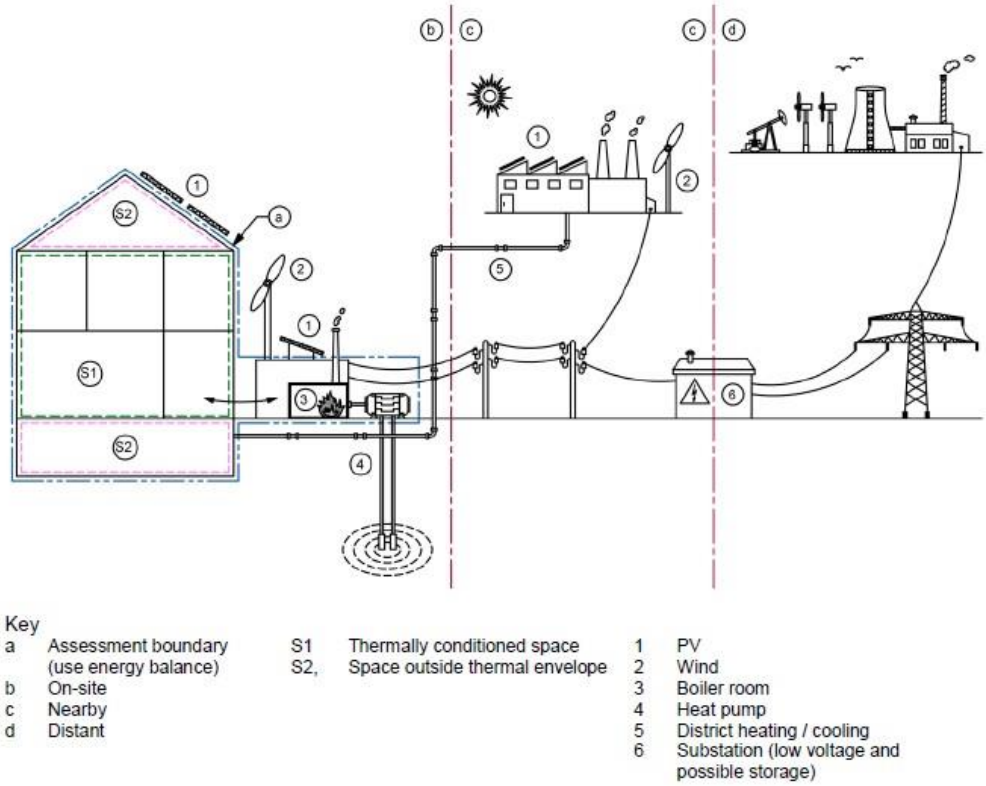

Figure. Building assessment boundary and energy balance locations Source: CEN (2017)

The calculations include the overall efficiency of the building; envelope, technical systems and energy carriers used. The following energy uses are taken into account, which are also referred to as technical building services:

- heating
- cooling
- ventilation
- domestic hot water
- lighting
- auxiliaries

Assessment method

The calculation method is provided by the CEN standards series that support implementation of the Energy Performance of Buildings Directive (EPBD) across the EU.

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The CEN standards that currently form the basis for most of national calculation methods include EN 15603 (Energy performance of buildings. Overall energy use and definition of energy ratings) and EN ISO 13790 (Energy performance of buildings. Calculation of energy use for space heating and cooling). National calculation methods that are aligned with the EN standards and are used for building performance assessment or Energy Performance Certificates (EPCs), can be used.

To perform the calculations, it is possible to use actual or estimated data. The actual energy consumption data for all energy carriers of a building may derive from monitoring, energy metering, bills or utilities for at least 12 consecutive months. It is preferable to average over longer records (e.g. three-year data) in order to remove the effects of varying weather conditions and average out other inherent fluctuations in the building occupancy. In all cases, the source of data must always be clearly declared.

The calculation steps are:

1. Calculate the indoor useful area
2. Calculate the average annual thermal energy consumption per fuel or district heat/cold, for the energy uses taken into account (see B1.2)
3. Calculate the average annual electrical energy consumption (see B.1.3)
4. Use national conversion factors per fuel, district heat/cold and electricity to calculate the total primary energy consumption

$$PEU = \sum_{1}^{i} \left(EU_{th,i} \cdot F_i\right) + \left(EU_d \cdot F_d\right) + \left(EU_e \cdot F_e\right)$$

where

$EU_{th,i}$ = annual thermal energy consumption of i-th fuel delivered to the building

F_i = national conversion factor of the i-th fuel

EU_d = annual thermal energy consumption used by a district heating/cooling network to generate the heat/cold delivered to the building

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F_d = national conversion factor for the fuel used by a district heating/cooling network

EU_e = annual electrical energy consumption for the electricity delivered to the building

F_e = national conversion factor of electricity from the main grid (depends on energy mix of main grid)

5. Calculate the indicator's value as: total primary energy consumption / indoor useful area

Standards and References

- EPBD:2018 - Energy Performance of Buildings Directive, 2018/844/EU. Brussels: European Parliament and the Council of the European Union.
- EN 15603:2008 - Energy performance of buildings. Overall energy use and definition of energy ratings. Brussels: European Committee for Standardization.
- EN 13790 - Energy performance of buildings. Calculation of energy use for space heating and cooling. Brussels: European Committee for Standardization.
- ASHRAE Standard 100: 2018. Energy Efficiency in Existing Buildings. Atlanta: ASHRAE.
- Level(s) Part 1-2 – Beta version. Brussels: European Commission.
- Clean energy for all Europeans package.
- Potential data sources

Data item	**Potential source**	
	Default EU values	**National, regional or locally specific values**
Conditions of use and occupancy	EN ISO 13790 (Annex G8) ISO/TR 52000-1/2 EN ISO 52016-1	National or regional calculation method
Thermal envelope description	EN ISO 13790 (Annex G) EN ISO 52016-1	National or regional calculation method: certified products and details
Building services description	EN ISO 13790 (Annex G) EN ISO 52016-1	National or regional calculation method: certified products
Reference year	Three climate	National or regional

climate file	zones (EN 15265 test cases)	calculation method Member State Meteorological Offices
Primary energy factors	EN 15603 (Annex E) EN 52000-1 (Annex B.10)	National or regional calculation method
Internal temperature set points	EN ISO 13790 (Annex G) EN ISO 52016-1	National or regional calculation method
Ventilation and infiltration rates	EN 15241 EN 15242	National or regional calculation method
Internal gains as heat flows	EN ISO 13790 (Annex J) EN ISO 52016-1	National or regional calculation method
Heating/cooling system characteristics and capacity	-	National or regional calculation method: certified products

2.1.2. B1.2 Delivered thermal energy demand

Issue	B. Energy & Resource Consumption	
Category	B1. Energy	
Criterion	B1.2 Delivered thermal energy demand	
Indicator	Delivered thermal energy demand per internal useful floor area per year	
Unit	kWh/m²/yr	
Project stage	Design	Occupation
Data source	Estimation	Metering

Intent

Minimise the total thermal energy consumption of the building.

Description

Thermal energy is delivered to the building in the form of fuel and district heat/cold, in order to satisfy uses within the building (heating, cooling, ventilation, domestic hot water). The 'delivered energy' is the one metered by the utilities.

Boundary and Scope

The assessment boundary is the building.

The calculations include the following energy uses, which are also referred to as technical building services:

- heating
- cooling
- ventilation
- domestic hot water

Assessment method

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The calculation method is provided by the CEN standards series that support implementation of the Energy Performance of Buildings Directive (EPBD) across the EU.

The CEN standards that currently form the basis for most of national calculation methods include EN 15603 (Energy performance of buildings. Overall energy use and definition of energy ratings) and EN ISO 13790 (Energy performance of buildings. Calculation of energy use for space heating and cooling). National calculation methods that are aligned with the EN standards and are used for building performance assessment or Energy Performance Certificates (EPCs), can be used.

To perform the calculations, it is possible to use actual or estimated data. The actual data on delivered thermal energy of a building may derive from monitoring, energy metering, bills or utilities for at least 12 consecutive months. It is preferable to average over longer records (e.g. three-year data) in order to remove the effects of varying weather conditions and average out other inherent fluctuations in the building occupancy. In all cases, the source of data must always be clearly declared.

The calculation steps are:

Use of estimated data:

1. Calculate the annual thermal energy consumption for the energy uses taken into account
2. Calculate the indoor useful area
3. Calculate the indicator's value as: annual total final thermal energy consumption/ indoor useful area

Use of metered data:

1. Collect actual data of each fuel (e.g. liters of oil, cubic meters of natural gas) or the heat/cold from district networks, for the energy uses taken into account and calculate the average annual consumptions
2. Calculate the indoor useful area
3. Convert the amount of fuels or district heat/cold to thermal energy consumption using their lower heating values

4. Sum the thermal energy of all fuels up to an annual total final thermal energy consumption
5. Calculate the indicator's value as: annual total final thermal energy consumption / indoor useful area

Standards and References

- EPBD:2018 - Energy Performance of Buildings Directive, 2018/844/EU. Brussels: European Parliament and the Council of the European Union.
- EN 15603:2008 - Energy performance of buildings. Overall energy use and definition of energy ratings. Brussels: European Committee for Standardization.
- EN 13790:2008 - Energy performance of buildings. Calculation of energy use for space heating and cooling. Brussels: European Committee for Standardization.
- Level(s) Part 1-2 – Beta version. Brussels: European Commission.

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2.1.3. B1.3 Delivered electrical energy demand

Issue	B. Energy & Resource Consumption	
Category	B1. Energy	
Criterion	B1.3 Delivered electrical energy demand	
Indicator	Delivered electrical energy demand per internal useful floor area per year	
Unit	$kWh/m^2/yr$	
Project stage	Design	Occupation
Data source	Estimation	Metering

Intent

Minimise the total electrical energy consumption of the building.

Description

Electricity is delivered from the main grid to the building to satisfy uses within the building (heating, cooling, ventilation, domestic hot water, built-in lighting, auxiliaries). The 'delivered energy' is generally the one metered by the utilities.

Boundary and Scope

The assessment boundary is the building.

The calculations include the following energy uses, which are also referred to as technical building services:

- heating
- cooling
- ventilation
- domestic hot water
- lighting
- auxiliaries

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Assessment method

The calculation method is provided by the CEN standards series that support implementation of the Energy Performance of Buildings Directive (EPBD) across the EU.

The CEN standards that currently form the basis for most of national calculation methods include EN 15603 (Energy performance of buildings. Overall energy use and definition of energy ratings) and EN ISO 13790 (Energy performance of buildings. Calculation of energy use for space heating and cooling). National calculation methods that are aligned with the EN standards and are used for building performance assessment or Energy Performance Certificates (EPCs), can be used.

To perform the calculations, it is possible to use actual or estimated data. The actual data on electricity use of a building may derive from monitoring, energy metering, bills or utilities for at least 12 consecutive months. It is preferable to average over longer records (e.g. three-year data) in order to remove the effects of varying weather conditions and average out other inherent fluctuations in the building occupancy. In all cases, the source of data must always be clearly declared.

The calculation steps are:

Use of estimated data:

1. Calculate the annual electricity use for the energy uses taken into account
2. Calculate the indoor useful area
3. Calculate the indicator's value as: annual total final electrical energy consumption/ indoor useful area

Use of metered data:

1. Collect actual data for the electricity consumption and calculate average annual electricity consumption
2. Calculate the indoor useful area
3. Calculate the indicator's value as: annual total final electrical energy consumption / indoor useful area

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Standards and References

- EPBD:2018 - Energy Performance of Buildings Directive, 2018/844/EU. Brussels: European Parliament and the Council of the European Union.
- EN 15603:2008 - Energy performance of buildings. Overall energy use and definition of energy ratings. Brussels: European Committee for Standardization.
- EN 13790:2008 - Energy performance of buildings. Calculation of energy use for space heating and cooling. Brussels: European Committee for Standardization.
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2.1.4. B1.4 Energy from renewable sources in total thermal energy consumption

Issue	B. Energy & Resource Consumption	
Category	B1. Energy	
Criterion	B1.4 Energy from renewable sources in total thermal energy consumption	
Indicator	Share of renewable energy in final thermal energy consumption	
Unit	%	
Project stage	Design	Occupation
Data source	Estimation	Metering

Intent

Maximize the use of renewable energy sources.

Description

This indicator assesses the share of renewable energy in final thermal energy consumption and thus, the degree to which renewable fuels have substituted fossil fuels and therefore contributed to the decarburization of the Mediterranean area economy. It also quantifies the progress towards the Europe 2020 & 2030 targets for renewable energies.

- *Solar Combi Systems. Solar thermal for hot water production (DHW + space heating)*
- *Solar Combi Plus Systems. Solar thermal for chilled water production (cooling) + (DHW + space heating)*
- *PV driven High efficiency heat pumps*
- *Biomass*

Boundary and Scope

The assessment boundary is the building.

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The calculations include the following energy uses, which are also referred to as technical building services:

- heating
- cooling
- ventilation
- domestic hot water

Assessment method

The calculation method is provided by the CEN standards series that support implementation of the Energy Performance of Buildings Directive (EPBD) across the EU.

The CEN standards that currently form the basis for most of national calculation methods include EN 15603 (Energy performance of buildings. Overall energy use and definition of energy ratings) and EN ISO 13790 (Energy performance of buildings. Calculation of energy use for space heating and cooling). According to the Renewables Energy Directive (RED 2018), energy from renewable sources means energy from renewable non-fossil sources, namely wind, solar, aerothermal, geothermal, hydrothermal and ocean energy, hydropower, biomass, landfill gas, sewage treatment plant gas and biogases. Heat pumps enabling the use of aerothermal, geothermal or hydrothermal heat at a useful temperature level need electricity or other auxiliary energy to function. The energy used to drive heat pumps should therefore be deducted from the total usable heat. Only heat pumps for which $SPF > 1{,}15 * 1/\eta$ shall be taken into account.

The annual thermal energy produced & used on-site from renewable sources is determined in relation to each energy carrier (fuel) that may replace. For example, the use of solar thermal collectors to produce hot water that is then used for space heating instead of an oil-fired boiler.

To perform the calculations, it is possible to use actual or estimated data. The actual thermal energy produced & used on-site from renewable sources can be monitored.

Heat meters can be used to measure delivered heat (e.g. from solar thermal collector array). The actual thermal energy used on-site from biomass can also be calculated from the quantity of wood pellets or chips delivered to a building. The actual thermal energy delivered to a building may derive from monitoring, energy metering, bills or utilities. If available, BEMS or BMS can provide valuable data with a breakdown of the actual thermal energy use of the different technical installations. Actual energy use data from at least 12 consecutive months is necessary. It is preferable to average over longer records (e.g. three-year data) in order to remove the effects of varying weather conditions and average out other inherent fluctuations in the building occupancy. In all cases, the source of data must always be clearly declared.

The calculation steps are:

1. Calculate the average annual thermal energy produced & used on-site from renewable sources (e.g. solar collectors, PV driven HPs, biomass) to cover the demand for the energy uses taken into account, using a 3year average value, from monitored data or calculations
2. Calculate the annual thermal energy consumption for the energy uses taken into account, from monitored / metered data or calculations
3. Calculate the indicator's value as the percentage ratio of the amount of annual thermal energy from RES to the total final thermal energy

Standards and References

- RED 2018**.** Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources (recast). Brussels: European Commission.

- 2013/114/EU: Commission Decision of 1 March 2013

- EN 15603:2008 - Energy performance of buildings. Overall energy use and definition of energy ratings. Brussels: European Committee for Standardization.

- EN 13790:2008 - Energy performance of buildings. Calculation of energy use for space heating and cooling. Brussels: European Committee for Standardization.

- Level(s) Part 1-2 – Beta version. Brussels: European Commission.

2.1.5. B1.5 Energy from renewable sources in total electrical energy consumption

Issue	B. Energy & Resource Consumption	
Category	B1. Energy	
Criterion	B1.5 Energy from renewable sources in total electrical energy consumption	
Indicator	Share of renewable energy in final electrical energy consumption	
Unit	%	
Project stage	Design	Occupation
Data source	Estimation	Metering

Intent

Maximize the use of renewable energy sources.

Description

This indicator assesses the share of renewable energy in final electrical energy consumption and thus, the degree to which renewable fuels have substituted fossil fuels and therefore contributed to the decarburization of the Mediterranean area economy. It also quantifies the progress towards the Europe 2020 & 2030 targets for renewable energies.

- *Photovoltaics (BIPV- Building Integrated Photovoltaics)*
- *Wind Turbines*

Boundary and Scope

The assessment boundary is the building.

The calculations include the following energy uses, which are also referred to as technical building services:

- heating
- cooling

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- ventilation
- domestic hot water
- lighting
- auxiliaries

Assessment method

The calculation method is provided by the CEN standards series that support implementation of the Energy Performance of Buildings Directive (EPBD) across the EU.

The CEN standards that currently form the basis for most of national calculation methods include EN 15603 (Energy performance of buildings. Overall energy use and definition of energy ratings) and EN ISO 13790 (Energy performance of buildings. Calculation of energy use for space heating and cooling). According to the Renewables Energy Directive (RED 2018), energy from renewable sources means energy from renewable non-fossil sources, namely wind, solar, aerothermal, geothermal, hydrothermal and ocean energy, hydropower, biomass, landfill gas, sewage treatment plant gas and biogases. Heat pumps enabling the use of aerothermal, geothermal or hydrothermal heat at a useful temperature level need electricity or other auxiliary energy to function. The energy used to drive heat pumps should therefore be deducted from the total usable heat. Only heat pumps for which SPF > 1,15 * 1/η shall be taken into account.

To perform the calculations, it is possible to use actual or estimated data. The actual electricity produced & used on-site from renewable sources is usually monitored (measured) by dedicated power or smart meters. The actual electricity use from the main power grid can also be monitored, or derive from electricity bills or utilities. If available, BEMS or BMS can provide valuable data with a breakdown of the actual electricity use of the different technical installations. Actual energy use data from at least 12 consecutive months is necessary. It is preferable to average over longer records (e.g. three-year data) in order to remove the effects of varying weather conditions and average out other inherent fluctuations in the building occupancy. In all cases, the source of data must always be clearly declared.

The calculation steps are:

1. Calculate the average annual thermal energy produced & used on-site from renewable sources (e.g. solar collectors, PV driven HPs, biomass) to cover the demand for the energy uses taken into account, using a 3year average value (if available), from monitored data or calculations. The actual electricity produced & used on-site from renewable sources is usually monitored (measured) by dedicated power or smart meters.
2. Calculate the average annual electricity delivered to the building from the main power grid, to cover the energy uses taken into account, from monitored / metered data or calculations
3. Calculate the indicator's value as the percentage ratio of the amount of total electrical energy from RES to the total final electrical energy

Standards and References

- RED 2018**.** Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources (recast). Brussels: European Commission.
- 2013/114/EU: Commission Decision of 1 March 2013
- EN 15603:2008 - Energy performance of buildings. Overall energy use and definition of energy ratings. Brussels: European Committee for Standardization.
- EN 13790:2008 - Energy performance of buildings. Calculation of energy use for space heating and cooling. Brussels: European Committee for Standardization.
- Level(s) Part 1-2 – Beta version. Brussels: European Commission.

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2.1.6. B1.6 Embodied non-renewable primary energy

Issue	B. Energy & Resource Consumption	
Category	B1. Energy	
Criterion	B1.6 Embodied non-renewable primary energy	
Indicator	Embodied primary non-renewable energy per internal useful floor area	
Unit	MJ/m^2	
Project stage	Design	Occupation
Data source	Estimation	Not applicable

Intent

Promote the use of construction materials with a low embodied energy.

Description

This indicator measures the embodied non-renewable primary energy of materials used for the building construction. The embodied energy is the energy consumed by all the processes associated with the production of construction materials, from the raw materials supply to manufacturing (cradle-to-gate), including the energy used for the acquisition of raw materials, processing, manufacturing and assembling building construction materials at the factory gate.

Cradle to Gate: energy used for the acquisition of raw materials, processing, manufacturing and assembling building construction materials at the factory gate.

Boundary and Scope

The assessment boundary is the building.

The scope encompasses the building materials <u>excluding the technical installations.</u> All the elements of the construction are taken in account: foundations, bearing structure, envelope, slabs.

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The minimum scope of the indicator includes the following building parts and elements:

Building parts	Related building elements
Shell (substructure and superstructure)	
Foundations (substructure)	Piles Basements Retaining walls
Load bearing structural frame	Frame (beams, columns and slabs) Upper floors External walls Balconies
Non-load bearing elements	Ground floor slab Internal walls, partitions and doors Stairs and ramps
Facades	External wall systems, cladding and shading devices Façade openings (including windows and external doors) External paints, coatings and renders
Roof	Structure Weatherproofing
Parking facilities	Underground

Assessment method

The indicator is only applicable at design stage. In case of new construction, the indicator must be calculated taking in account all the materials used for the building construction. In case of renovation of an existing building, the indicator must be calculated taking in account only the materials used for its renovation and not the ones pre-existent.

To calculate the value of the indicator it is necessary to compile a Bill of Materials (BoM) that is a mass-based inventory of the different materials (kg) that compose a building. The BoM is organized according to main elements composing a building. The starting point is the Bill of Quantities (BoQ) specifying the elements of a building (e.g. foundations, columns). The BoQ includes different categories of elements, which can have different functional performance characteristics. BoM differs from a BoQ in that it describes the different materials (e.g. concrete, steel, aluminium) that are contained in the various building elements. Once the BoM has been compiled, it is possible to calculate the value of the indicator.

The calculation steps are:

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1. Identify the basic composition of each building element. A breakdown of its constituent materials has to be carried out. The mass of each constituent material has to be estimated.
2. Aggregate by material: The mass for each constituent material should thereafter be aggregated to obtain the total mass for each type of material.
3. Calculate the embodied primary energy of each material by multiplying the specific mass with its corresponding embodied energy coefficient.
4. Sum the embodied energy of all materials to calculate the total embodied energy of the building
5. Calculate the total useful internal floor area
6. Calculate the indicator's value as: total embodied energy of the building / total useful internal floor area

Standards and References

- ISO 14040/44, EN 15804 (Sustainability of construction works. Environmental product declarations. Core rules for the product category of construction products)
- EN 15978 "Sustainability of construction works - Assessment of environmental performance of buildings - Calculation method"

2.1.7. B3.4 Recycled materials

Issue	B. Energy & Resource Consumption	
Category	B.3 Materials	
Criterion	B3.4 Recycled materials	
Indicator	Weight of recycled materials on total weight of materials	
Unit	%	
Project stage	Design	Occupation
Data source	Estimation	Not applicable

Intent

Reduce the environmental impact of construction materials.

Description

This indicator assesses the amount of recycled materials used in the building with regards to the total amount of building materials. The use of recycled materials allows to reduce the use and depletion of new materials.

Boundary and Scope

The assessment boundary is the building.

The scope encompasses the building materials excluding the technical installations. All the elements of the construction are taken in account: foundations, bearing structure, envelope, slabs.

It is possible to take in account both the postconsumer and pre-consumer recycled content of a material. The pre-consumer content is included in the calculation only if it isn't reused in the same industrial process.

The minimum scope of the indicator includes the following building parts and elements:

Building parts	Related building elements
Shell (substructure and superstructure)	
Foundations (substructure)	Piles Basements Retaining walls
Load bearing structural frame	Frame (beams, columns and slabs) Upper floors External walls Balconies
Non-load bearing elements	Ground floor slab Internal walls, partitions and doors Stairs and ramps
Facades	External wall systems, cladding and shading devices Façade openings (including windows and external doors) External paints, coatings and renders
Roof	Structure Weatherproofing
Parking facilities	Underground

Assessment method

The indicator is only applicable at design stage. In case of new construction, the indicator must be calculated taking in account all the materials used for the building construction. In case of renovation of an existing building, the indicator must be calculated taking in account only the materials used for its renovation and not the ones pre-existent.

To calculate the value of the indicator it is necessary to compile a Bill of Materials (BoM) that is a mass-based inventory of the different materials (kg) that compose a building. The BoM is organised according to main elements that a building is composed of. The starting point is the Bill of Quantities (BoQ) that specifies the elements of a building (e.g. foundations, columns). The BoQ comprises different categories of elements, which can have different functional performance characteristics. A BoM differs from a BoQ in that it describes the different materials (e.g. wood, steel, aluminium) that are contained in the various building elements. Once the BoM has been compiled, it is possible to calculate the value of the indicator.

The calculation steps are:

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1. Identify the basic composition of each building element. A breakdown of its constituent materials has to elaborated. The mass of each constituent material has to be estimated.
2. Aggregate by material: the mass of all constituent material should thereafter be aggregated to obtain the total mass of materials used in the building.
3. Identify the recycled content of each constituent material (in mass).
4. Aggregate by material: the recycled mass of all constituent materials should be aggregated to obtain the total recycled mass of materials used in the building.
5. The indicator's value is calculated as the percentage ratio of total recycled mass of materials to the total mass of materials

Standards and References

- EN ISO 14021 (Environmental labels and declarations - Self-declared environmental claims - Type II environmental labelling)

2.1.8. B4.3 Potable water consumption for indoor uses

Issue	B. Energy & Resource Consumption	
Category	B.4 Use of potable water, stormwater and greywater	
Criterion	B4.3 Potable water consumption for indoor uses	
Indicator	Potable water consumption per occupant per year	
Unit	m^3/occupant yr	
Project stage	Design	Occupation
Data source	Estimation	Metered

Intent

Make efficient use of water resources.

Description

This indicator assesses the water consumption of sanitary fittings/devices and water consuming appliances of a building. It can be applied to new, renovated or existing buildings in order to understand, and ultimately decrease the water demand.

Boundary and Scope

The assessment boundary is the building.

The indicator includes the use of potable water for:

- drinking water
- water for sanitation
- water for cleaning
- domestic hot water

Assessment method

To perform the calculations, it is possible to use actual or estimated data. In case of existing buildings, the actual potable water consumptions should be evaluated using data from metering. It is preferable to consider actual data from longer records (e.g. three year data) or at least 12 consecutive months. In all cases, the source of data must always be clearly declared.

In case of estimated data, the number of sanitary devices/fittings (i.e. toilets, taps and showers) and water using appliances (i.e dishwashers and washing machines) should be taken into account for the calculations. Consumption rates for different sanitary devices and fittings are determined through specific data from suppliers or libraries. The specific usage factors have to be established. The number of days that the building is expected to be occupied per year has to be defined by the user.

The principle of the per occupant potable water consumption calculation for taps and showers is as follows:

$$Total\ consumption\ \left(\frac{L}{occupant.d}\right) = Consumption\ rate\ \left(\frac{L}{min}\right) x\ Usage\ factor\ \left(\frac{min}{occupant.d}\right)$$

$$Total\ consumption\ \left(\frac{m^3}{ocucpant.year}\right) = Total\ consumption\ \left(\frac{L}{occupant.d}\right) x\ 0.001 \left(\frac{m^3}{L}\right) x\ occupancy\ rate\ \left(\frac{d}{year}\right)$$

The exact same principle applies for calculations for toilets (except that flushes are used instead of minutes).

For cleaning, the basis of the calculation is as follows:

$$Total\ consumption\ \left(\frac{L}{year}\right) = Consumption\ rate\ \left(\frac{L}{m^2}\right) x\ area\ (m^2)\ x\ no.cleans\ per\ year\ (year^{-1})$$

$$Total\ consumption\ \left(\frac{m3}{occupant.year}\right) = Total\ consumption\ \left(\frac{L}{year}\right) x\ 0.001 \left(\frac{m^3}{L}\right) \div\ full\ time\ eqivt.ocucpancy\ (occupant)$$

The calculation steps are:

1. a. Collect actual data of annual potable water consumption and calculate the average annual consumption. It is preferable to consider actual data from longer records (e.g. three year data) or at least 12 consecutive months. Exclude annual water consumption for uses not included in the scope of the indicator.

Or

b. Estimate the annual potable water consumption for the various sanitary devices/fittings (i.e. toilets, taps and showers) and water using appliances (i.e. dishwashers and washing machines).

2. Estimate the total number of building's occupants.
3. Calculate the indicator's value as: annual total potable water consumption / number of occupants.

Standards and References

- Level(s) Part 1-2 – Beta version. Brussels: European Commission.

2.1.9. C1.1 Embodied carbon

Issue	C. Environmental Loadings	
Category	C1. Greenhouse Gas Emissions	
Criterion	C1.1 Embodied carbon	
Indicator	Embodied carbon dioxide equivalents per internal useful floor area	
Unit	kg CO_2eq/m^2	
Project stage	Design	Occupation
Data source	Estimation	Not applicable

Intent

Promote the use of construction materials with a low embodied carbon.

Description

This indicator measures the embodied carbon of materials and construction processes used for the building construction. Embodied carbon is the amount of greenhouse gas (GHG) emissions that are generated by all the processes associated with the production of construction materials, from the acquisition of raw materials to manufacturing and assembling building construction materials at the factory gate (cradle-to-gate). The metric used for embodied carbon is the global warming potential (GWP) quantified in kilograms of CO_2 equivalent ($kgCO_2eq$) and then normalized per unit floor area ($kgCO_2eq/m^2$). The “equivalent” (eq) mass of CO_2 is used to express the equivalent impacts of all GHG gases, including the dominant contributor of CO_2 emissions. . By definition:

- GWP for $CO_2 = 1$
- GWP for methane CH_4 = 25 (GWP over 100 years is 25 times that of CO_2)
- GWP for nitrous oxide N_2O = 298 (GWP over 100 years is 298 times that of CO_2)

For some additional information on GWP also refer to C1.2.

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Embodied carbon is the carbon footprint of a building before it becomes operational. Most of the life cycle impacts (over 90%) refer to the cradle-to-gate and CO_2 emissions. Transportation to the building site accounts for about 7% more, while some recurrent amounts will also be added during maintenance and replacement of some elements, as needed. The final demolition at the end of a building's lifetime may account for about 1% of the life cycle impacts, depending on waste management. The exact percentages depend on the energy supply mix for electricity generation in different areas and countries that is used in manufacturing and the building construction practices.

Boundary and Scope

The assessment boundary is the building.

The scope encompasses the building materials excluding the technical installations. All the elements of the construction are taken in account: foundations, bearing structure, envelope, slabs.

The minimum scope of the indicator shall include the following building parts and elements:

Building parts	Related building elements
Shell (substructure and superstructure)	
Foundations (substructure)	Piles Basements Retaining walls
Load bearing structural frame	Frame (beams, columns and slabs) Upper floors External walls Balconies
Non-load bearing elements	Ground floor slab Internal walls, partitions and doors Stairs and ramps
Facades	External wall systems, cladding and shading devices Façade openings (including windows and external doors) External paints, coatings and renders
Roof	Structure Weatherproofing
Parking facilities	Underground

Assessment method

The indicator is only applicable at design stage. In case of new construction, the indicator must be calculated taking in account all the materials used for the building construction. In case of renovation of an existing building, the indicator must be calculated taking in account only the materials used for its renovation and not the ones pre-existent.

To calculate the value of the indicator it is necessary to compile a Bill of Materials (BoM) that is a mass-based inventory of the different materials (kg) that compose a building. The BoM is organised according to main elements that a building is composed of. The starting point is the Bill of Quantities (BoQ) that specifies the elements of a building (e.g. foundations, columns). The BoQ comprises different categories of elements, which can have different functional performance characteristics. BoM differs from a BoQ in that it describes the different materials (e.g. concrete, steel, aluminium) that are contained in the various building elements. Once the BoM has been compiled, it is possible to calculate the value of the indicator.

The calculation steps are:

1. Identify the basic composition of each building element. A breakdown of its constituent materials has to be carried out. The mass of each constituent material has to be estimated;
2. Aggregate by material: The mass for each constituent material should thereafter be aggregated to obtain the total mass for each type of material.
3. Calculate the embodied carbon of each material by multiplying the specific mass with its corresponding carbon coefficient (use national coefficients, if available or international data bases, for example, (ICE Database). The coefficients are quantified in kilograms of CO_2 equivalent ($kgCO_2eq$) per unit mass (kg) of the material or sometimes also expressed per unit area of material ($kgCO_2eq/m^2$)
4. Calculate the total useful internal floor area
5. Calculate the indicator's value as: total embodied carbon of the building / total useful internal floor area

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Standards and References

- EN 15978 "Sustainability of construction works - Assessment of environmental performance of buildings - Calculation method"
- European Platform on Life Cycle Assessment, European Commission. https://eplca.jrc.ec.europa.eu/?page_id=86
- ICE Database, Inventory of Carbon and Energy, Circular Ecology.
- IEA Evaluation of Embodied Energy and CO_2eq for Building Construction (Annex 57), International Energy Agency.
- ISO 14040/44, EN 15804 (Sustainability of construction works. Environmental product declarations. Core rules for the product category of construction products)

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2.1.10. C1.2 GHG gas emissions during operation

Issue	C. Environmental Loadings	
Category	C1. Greenhouse Gas Emissions	
Criterion	C1.2 GHG gas emissions during operation	
Indicator	CO_2 equivalent emissions per useful internal floor area per year	
Unit	kg CO_2eq/m^2 /yr	
Project stage	Design	Occupation
Data source	Estimation	Estimation

Intent

Minimise the total greenhouse gas emissions from buildings' operations.

Description

This indicator measures the contribution of the greenhouse gas (GHG) emissions associated with the building's operational phase on the earth's global warming. Global Warming Potential (GWP) is a relative measure of how much energy can be trapped in the atmosphere over a set time period by a mass of gas in comparison with the same mass of carbon dioxide (CO_2). A higher GWP means a larger warming effect in that period of time (e.g. 20, 100 years). For calculating CO_2 equivalence, emissions of those gases are valued in terms of CO_2 equivalent emissions. By definition:

- GWP for CO_2 = 1
- GWP for methane CH_4 = 25 (GWP over 100 years is 25 times that of CO_2)
- GWP for nitrous oxide N_2O = 298 (GWP over 100 years is 298 times that of CO_2)

Boundary and Scope

The assessment boundary is the building.

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The scope of the indicator includes the emissions related to the following energy end-uses, which are also referred to as technical building services:

- heating,
- cooling,
- ventilation,
- domestic hot water,
- lighting,
- auxiliaries

Assessment method

To calculate the value of the indicator, the annual quantities of fuels, electric energy from the grid and energy from district heating/cooling should be metered or estimated. The source of data must always be clearly declared.

The calculation steps are:

1. Calculate the total emissions of CO_2 eq. related to building operations, using the following formula

$$E = \frac{\sum_1^i \left(Q_{fuel,i} \cdot LHV_i \cdot k_{em,i}\right) + \left(Q_{el} \cdot k_{em}\right) + \left(Q_{dhc} \cdot k_{em.dhc}\right)}{A_u}$$

   where
   $Q_{fuel,i}$ = total quantity of annual fuel consumption of i-th fuel (e.g. m^3 for gas or lt for oil)
   LHV_i = lower heating value of the i-th fuel (e.g. kWh_{th}/m^3 or kWh_{th}/lt)
   $k_{em,i}$ = LCA CO_2 eq. emission factor of the i-th fuel (kg CO_2 eq./kWh_{th})
   Q_{el} = total quantity of annual electrical energy from the grid (kWh_e)
   k_{em} = LCA CO_2 eq. emission factor of the electrical energy from the grid (kg CO_2 eq./kWh_e)
   Q_{dhc} = total quantity of annual energy from district heating/cooling (kWh_{th})
   $k_{em,dhc}$ = LCA CO_2 eq. emission factor of energy from district heating/cooling (kg CO_2eq./kWh_{th})
   A_u = useful internal floor area (m^2)

2. Calculate the useful internal floor area of the building

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3. Calculate the indicator's value as the ratio of the total emissions of CO_2 eq. related to building operations to the useful internal floor area

Standards and References

- EN 15603 - Energy performance of buildings - Overall energy use and definition of energy ratings
- ISO 14067:2013 - Greenhouse gases -- Carbon footprint of products -- Requirements and guidelines for quantification and communication. Geneva: International Organization for Standardization
- Level(s) Part 1-2 – Beta version Brussels: European Commission.

2.1.11. D1.2 TVOC concentration

Issue	D. Indoor Environmental Quality	
Category	D1. Indoor Air Quality and Ventilation	
Criterion	D1.2 TVOC concentration	
Indicator	TVOC concentration in indoor air	
Unit	µg/ m^3	
Project stage	Design	Occupation
Data source	Not applicable	Metering

Intent

Facilitate the assessment of indoor air quality.

Description

This indicator measure one of the most significant potential hazards to human health that can impact indoor air, the Total Volatile Organic Compounds (TVOC). In an air tight, modern building, the most significant direct emissions sources related to building construction material & products and other building finish materials may originate from:

- paints and varnishes,
- textile furnishings,
- floor coverings,
- associated adhesives and sealants, and
- finish materials that incorporate particle board

After the completion of a building, it is important to evaluate the internal air TVOCs concentration level for the health of future occupants.

Boundary and Scope

The assessment boundary is the building.

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For buildings in the design phase, product testing can be used as a mean of source control. For new or retrofitted buildings, the indicator should be evaluated in the post completion phase, prior to occupation.

Assessment method (Post completion / In-use phase):

The measurement can be performed both in presence of mechanical ventilation and in case of natural ventilation.

The measurements of the TVOCs concentration levels must be performed in all spaces with characteristic functions of the building (e.g. office spaces, meeting room, cafeteria), different orientations (e.g. on the side of a façade facing the street), and floors (e.g. first, middle and last floor). The indicator value for the building is then calculated as a weighted average of the corresponding measurements. For each pollutant measured, the quantitative increase of the indoor air value in relation to the external air value has to be checked.

The calculation steps are:

1. Calculate the TVOC concentration in each selected characteristic space
2. Calculate the internal floor area of each characteristic space
3. Calculate the total internal floor area of the selected characteristic spaces
4. Sum of products of the TVOC concentrations measured in each characteristic space multiplied by the corresponding floor area
5. Calculate the weighted value of the TVOC concentration for the building as the ratio of the sum of products of the TVOC concentration to the total internal floor area of the selected characteristic spaces

The instruments to be utilised for the measurement may vary in relation to what pollutant is necessary to assess, in most cases VOCs detectors are used, located on tripod at a height of 1.5 metres.

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It is recommended to perform the measurement for a period sufficient to establish the TVOCs concentration level trend (not less than a week).

Standards and References

- Level(s) (the European framework for sustainable buildings) indicator 4.1: Indoor air quality. Document developed by European Commission - Joint Research Centre, January 2021
- EN 16516**:** construction products: Assessment of release of dangerous substances - Determination of emissions into indoor air
- ISO 16000-6:2021 - Indoor air — Part 6: Determination of organic compounds (VVOC, VOC, SVOC) in indoor and test chamber air by active sampling on sorbent tubes, thermal desorption and gas chromatography using MS or MS FID

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2.1.12. D1.7 Mechanical Ventilation

Issue	D. Indoor Environmental Quality	
Category	D1. Indoor Air Quality and Ventilation	
Criterion	D1.7 Mechanical Ventilation	
Indicator	Mechanical ventilation rate per useful internal floor area	
Unit	l/s/m^2	
Project stage	Design	Occupation
Data source	Estimation	Metering

Intent

Ensure an effective air exchange rate facilitating high indoor air quality and sufficient indoor thermal comfort conditions.

Description

This indicator measures the number of times every hour that outdoor air enters a room and is mixed and exchanged with indoor air.

Boundary and Scope

The assessment boundary is the building.

The indicator is assessed only in buildings equipped with a mechanical ventilation system.

For an occupied building, the measurements are performed in all spaces with characteristic functions of the building (e.g. office spaces, meeting room, cafeteria), different orientations (e.g. on the side of a façade facing the street), and floors (e.g. first, middle and last floor). The indicator value for the building is then calculated as a weighted average of the corresponding measurements.

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For the design phase, the indicator must be calculated for all mechanical ventilation systems in the building. The indicator value for the building is then calculated as a weighted average of the corresponding estimated or measured values.

Assessment method

<u>Design phase</u>:

The calculation method for the ventilation rate is provided by the "EN 16798-1 - Energy performance of buildings - Ventilation for buildings - Part 1: Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics".

The standard defines three different methods for the assessment of the air quality.

Method 1: based on perceived air quality.

Method 2: based on the use of limit values for the concentration of pollutants.

Method 3: based on pre-defined ventilation flow rates.

In terms of accuracy, method 1 is the one to be preferred and the calculation methodology is described in short below.

The ventilation rate is calculated by combining the required share of ventilation to dilute and/or remove pollutants produced by occupants and buildings materials, furniture, components, etc., and by the installations in order to control the indoor thermal conditions as required by the heating and cooling loads.

<u>In-use phase</u>:

The metering strategies for the measurement of the ventilation rate in as-built performance and in-use phase are different, but all useful to evaluate the real performance of the building. The reference standard to be used is the **EN 12599: 2012** which provides test methods and measuring instruments to assess the air flow injected by the terminals of a mechanical ventilation system measuring the velocity of the outgoing air using different methodologies (different kind of anemometers could be used).

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The standard applies to ventilation and air conditioning systems designed for the maintenance of comfort conditions in buildings.

Testing during occupation captures any additional impacts on IAQ caused by the activities of occupants and the installation of furniture and equipment.

The calculation steps are:

1. Calculate the mechanical ventilation rate in each selected characteristic space
2. Calculate the internal floor area of each characteristic space
3. Calculate the total internal floor area of the selected characteristic spaces
4. Sum of products of the mechanical ventilation rate in each characteristic space multiplied by the corresponding floor area
5. Calculate the weighted value of mechanical ventilation rate for the building as the ratio of the sum of products of the ventilation rate to the total internal floor area of the selected characteristic spaces

Standards and References

- Level(s) (the European framework for sustainable buildings) indicator 4.1: Indoor air quality. Document developed by European Commission - Joint Research Centre, January 2021
- EN 16516**:** construction products: Assessment of release of dangerous substances - Determination of emissions into indoor air
- ISO 16000-6:2021 - Indoor air — Part 6: Determination of organic compounds (VVOC, VOC, SVOC) in indoor and test chamber air by active sampling on sorbent tubes, thermal desorption and gas chromatography using MS or MS FID
- EN 16798-1: 2019 Energy performance of buildings - Ventilation for buildings - Part 1: Indoor environmental input parameters for design and assessment of

energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics.

- CEN/TR 16798-2 **- E**nergy performance of buildings - Ventilation for buildings - Part 2: Interpretation of the requirements in EN 16798-1 - Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics

2.1.13. D2.3 Thermal comfort index

Issue	D. Indoor Environmental Quality	
Category	D2. Air Temperature and Relative Humidity	
Criterion	D2.3 Thermal comfort index	
Indicator	Predicted Percentage of Dissatisfied (PPD)	
Unit	%	
Project stage	Design	Occupation
Data source	Estimation	Measurement

Intent

Facilitate the assessment of indoor thermal comfort conditions

Description

The thermal comfort indicator Predicted Percentage Dissatisfied (PPD), allows the prediction of the general thermal sensation and degree of discomfort (thermal dissatisfaction) of people exposed to moderate thermal environments. It enables the analytical determination and interpretation of indoor thermal comfort, giving the environmental conditions considered acceptable for general thermal comfort as well as those representing local discomfort.

Boundary and Scope

The assessment boundary is the building.

Calculations are performed in all spaces with characteristic functions of the building (e.g. office spaces, meeting room, cafeteria), different orientations (e.g. on the side of a façade facing the street), and floors (e.g. first, middle and last floor). Calculations are also performed in spaces where the most extreme values of the thermal parameters are observed or anticipated (e.g. occupied areas near windows, diffuser outlets, corners, entries). The indicator value for the building is then calculated as a weighted average of the corresponding measurements.

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The indicator is calculated for <u>summer or winter periods</u> considering different prevailing conditions, clothing etc. This is based on the main priorities in terms of thermal discomfort conditions during summer or winter. Accordingly, the time period (summer or winter) considered in the calculations must be clearly stated and considered during the analysis. In addition, this KPI must be cautiously used during cross comparisons between different cities or regions with different priorities, at least in terms of the seasonal nature of the issue for thermal discomfort.

Assessment method

The Predicted Percentage Dissatisfied (PPD) value is estimated or measured in summer or winter conditions.

The calculation steps are:

1. Estimate or Measure PMV in each selected space
2. Calculate PPD in each selected space
3. Calculate the internal floor area of each space
4. Calculate the total internal floor area of the selected spaces
5. Sum the PPD in each space multiplied by the corresponding area to calculate the weighted PPD
6. Calculate the indicator's value as the ratio of the weighted PPD to the total internal floor area

<u>Design phase - (mechanically conditioned)</u>:

For each selected space

1. Estimate PMV
   - Select the design air temperature (dry bulb-db) and relative humidity for the main space function

- Select the design indoor air speed
- Calculate the mean radiant temperature of indoor wall surfaces (°C)
- Determine the main physical activity of the occupants (related to the metabolic rate)
- Determine the typical type of clothing ensembles
- Calculate the PMV value using the equation described in EN ISO 7730 standard.

2. Estimate PPD using the equation described in EN ISO 7730 standard

   $PPD = 100 – 95 * \exp[-(0.03353 * PMV^4 + 0.2179 * PMV^2)]$

Design phase - (naturally conditioned):

1. Calculate the running mean of outdoor temperature (Trm)

$$T_{rm} = \frac{(T_{od-1}+0.8T_{od-2}+0.6T_{od-3}+0.5T_{od-4}+0.4T_{od-5}+0.3T_{od-6}+0.2T_{od-7})}{3.8}$$

where Tod is the daily mean outdoor temperature for the previous day (Tod-1), the day before (Tod-2) and so on

2. Calculate the operative temperature (To) using building simulations to predict indoor conditions
1. Select the thermal comfort category and verify the PPD value.

	Upper Limit $T_{i,max}$ (°C)	Lower Limit $T_{i,max}$ (°C)	T_o Variance (Adaptive method)	PPD(%)	PMV
Category I	$0.33\ T_{rm} + 18.8 + 2$	$0.33\ T_{rm} + 18.8 - 2$	±2	≤6	-0.2 ≤ PMV ≤ 0.2
Category II	**$0.33\ T_{rm} + 18.8 + 3$**	$0.33\ T_{rm} + 18.8 - 3$	±3	≤10	-0.5 ≤ PMV ≤ 0.5
Category III	$0.33\ T_{rm} + 18.8 + 4$	$0.33\ T_{rm} + 18.8 - 4$	±4	≤15	-0.7 ≤ PMV ≤ 0.7

Occupancy phase:

1. Measure the PPD, using a PMV/PPD meter to record indoor conditions and predict the prevailing thermal comfort conditions.

   Thermal environment measurements are made in the building at a representative sample of locations, i.e:

   - The center of the room or space;

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- 1m inward from the center of each of the room's walls and if there are windows, the measurements are taken 1m inward from the center of the largest window.

Measurement periods cover several hours, representative of total occupancy (e.g. season, typical day)

Standards and References

- EN ISO 7730 – Ergonomics of the thermal environment – Analytical determination and interpretation of thermal comfort using calculation of the PMV and PPD indices and local thermal comfort criteria
- EN 16798-1:2017 - Energy performance of buildings - Part 1: Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics - Module M1-6 (revision of EN 15251). Brussels: European Committee for Standardization
- Level(s) Part 1-2 – Beta version. Brussels: European Commission.
- ASHRAE Standard 55:2017 - Thermal Environmental Conditions for Human Occupancy. Atlanta: ASHRAE

2.1.14. D3.1 Daylight

Issue	D. Indoor Environmental Quality	
Category	D3. Daylighting and Illumination	
Criterion	D3.1 Daylight	
Indicator	Mean Daylight Factor	
Unit	%	
Project stage	Design	Occupation
Data source	Estimation	Measurement

Intent

Ensure an adequate level of daylighting in all primary occupied spaces

Description

Daylight factor (DF) is a daylight availability metric that expresses the amount of daylight available inside a room (on a work plane) compared to the amount of unobstructed daylight available outside under overcast sky conditions.

Boundary and Scope

The assessment boundary is the building.

The indicator must be calculated in all spaces with characteristic functions of the building (e.g. office spaces, meeting room, cafeteria), different orientations (e.g. on the side of a façade facing the street), and floors (e.g. first, middle and last floor). The indicator value for the building is then calculated as a weighted average of the corresponding measurements.

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Assessment method

Design phase:

The daylight provision is calculated in new buildings and under major renovation buildings accordingly to EN 17037. Paragraph 5.1.3 fully describes the two possible calculation methods:

The calculation steps are:

Method 1) Calculation method using daylight factors on the reference plane.

1. Identify the grid of points on the plane
2. Predict the daylight factors across the plane
3. Calculate the target daylight factor D_T and D_{TM}
4. Ensure that the daylight factors equal or exceed the target values (D_{TM} and D_T).

Method 2) Calculation method of illuminance levels on the reference plane using climatic data for the given site and an adequate time step.

1. Simulate illuminance values on the reference plane based on hourly internal daylight illuminance values
2. Ensure that the targeted illuminance levels are achieved or exceeded.

Annex A gives values for target illuminances and minimum target illuminances to be achieved.

Annex B describes recommendations for the daylight calculations using the two methods

Post completion & Occupancy phase:

After the completion of a building, it is important to verify the compliance of the as built performance with what stated in the design phase for the daylight provision.

The calculation steps are:

1. Identify several measuring points in each selected space of the building

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2. Conduct the measurements with a luxmeter
3. At the same time measure the external values (best in overcast conditions with no direct solar radiation). In addition to the luxmeter and if necessary, a shadow ring could be used.
4. Calculate the average daylight factor in each selected space, making a ratio between the average indoor values measured and the average outdoor values.
5. Calculate the internal floor area of each space
6. Calculate the total internal floor area of the selected spaces
7. Sum the average daylight factor in each space multiplied by the corresponding area to calculate the weighted daylight factor
8. Calculate the indicator's value as the ratio of the weighted daylight factor to the total internal floor area

In case of the in-use building, some adjusting must be adopted to obtain an accurate measurement (curtains drawn, obstruction resulting from the furniture, absence of occupants, etc.).

Standards and References

- EN 17037 – Daylighting in buildings, paragraph 5.1.2 Criteria for daylight provision and paragraph 5.1.3 Daylight Provision Calculation Methods

2.1.15. E1.2 Smart Readiness Indicator

Issue	E. Service Quality	
Category	E1. Controllability	
Criterion	E1.2 Smart Readiness Indicator	
Indicator	Total smart readiness of buildings for responding to the needs of occupants, optimizing energy performance, and interacting with energy grids	
Unit	%	
Project stage	Design	Occupation
Data source	Estimation	Estimation

Intent

Reach more energy efficient, environmentally friendly, healthy and comfortable indoor environments. Assesses the smartness of a building.

Description

A common EU scheme for rating the smart readiness of buildings. Smart Readiness Indicator (SRI) assesses how smart a building is in terms of:

- Responding to the needs of the occupant (e.g. health, comfort, well-being, etc.)
- Using energy efficient control strategies
- Interacting with energy grids (energy flexibility / demand response and system integration)

Boundary and Scope

The assessment boundary is the building.

The scope of the indicator includes the following energy uses, which are also referred to as **technical building services (domains)**:

- heating,

- cooling,
- ventilation,
- domestic hot water,
- lighting,
- dynamic building envelope,
- electricity,
- electric vehicle charging,
- monitoring and control.

Assessment method

The underlying calculation method for the Smart Readiness Indicator (SRI) was developed for the European Commission in response to an EPBD mandate. To characterize the indicator's value may follow one of the two assessment methods that focus on qualitative approaches of various building services based on an expert assessment.

The calculation steps are:

Method A - Simplified method (e.g. Existing buildings with low complexity)

1. Use with a simplified service catalogue (Verbeke et al. 2020) that includes only 27 pre-defined services for existing residential buildings or small non-residential buildings that have low complexity
2. Use a check-list
3. Complete assessment in less than an hour
4. Suitable for a self-assessment of a building

Method B – Detailed method (e.g. New buildings with high complexity)

1. Use with a detailed service catalogue that includes 54 pre-defined services for new buildings and non-residential buildings that have a higher complexity

2. On-site inspection and walk-through audit
3. Complete in about a day
4. Need an expert and engage building's facility manager

The methodology for calculating the SRI is based on the assessment of smart-ready services present or planned at design stage in a building or building unit, and of smart-ready services that are considered relevant for that building or building unit.

The SRI is expressed as a percentage that represents the ratio between the smart readiness of the building or building unit compared to the maximum smart readiness that it could reach. The calculation relies on the assessment of the smart-ready services that are present, or planned at design stage, and on their functionality level.

The smart-ready services that can be present in a building are listed in a pre-defined smart-ready service catalogue that is used by experts as the basis for identifying and assessing smart-ready features, and are organised in nine pre-defined technical services (domains), i.e. heating, cooling, ventilation, domestic hot water, lighting, dynamic building envelope, electricity, electric vehicle charging, monitoring and control.

The calculation of smart readiness scores is made in accordance with the following protocol:

(a) each smart-ready service that is present in a building is assessed and the functionality level is determined according to the various features included in the predefined catalogue

(b) for each smart readiness impact criterion, the individual score I(d,ic) of each major building service (domain) is determined, as follows:

$$I(d,ic) = \sum_{i=1}^{Nd} I_{ic}(FL(S_{i,d}))$$

where, d is the number of the major building service (domain) under assessment, ic is the number of the impact criterion under consideration, Nd is the total number of the different functions in a technical domain d, $S_{i,d}$ is function i of technical domain d, $FL(S_{i,d})$ is the functionality level of function $S_{i,d}$ as available in the building or building unit, $I_{ic}(FL(S_{i,d}))$ is the score of function $S_{i,d}$ for impact criterion number ic, according to the service's functionality level.

In accordance with the predefined catalogue of smart-ready functions, the maximum score of each technical domain for each

impact criterion $I_{max}(d,ic)$ is determined, as follows:

$$I_{max}(d,ic) = \sum_{i=1}^{Nd} I_{ic}(FL_{max}(S_{i,d}))$$

where, $FL_{max}(S_{i,d})$ is the highest functionality level that function $S_{i,d}$ could have according to the smart-ready service catalogue, $I_{ic}(FL_{max}(S_{i,d}))$ is the score of function $S_{i,d}$ for its highest functionality level, which means the maximum score of function $S_{i,d}$ for impact criterion number ic.

The smart readiness score is calculated as a percentage for each of the impact criterion SR_{ic} using the weighting factors as follows:

$$SR_{ic} = \frac{\sum_{d=1}^{N} W_{d,ic}\, I(d,ic)}{\sum_{d=1}^{N} W_{d,ic}\, I_{mx}(d,ic)} \cdot 100$$

where, d is the number of the major building service (domain) under assessment, N is the total number of technical domains, $W_{d,ic}$ is the weighting factor expressed as a percentage of the major building service number d for impact criterion number ic.

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The smart readiness scores along the three major building functionalities are determined using the corresponding weighting factors, as follows:

$$SR_f = \sum_{ic=1}^{M} W_f\,(ic) \cdot SR_{ic}$$

where, M is the total number of impact criteria, $W_f(ic)$ is the weighting factor expressed in percentage of impact criterion number ic for key functionality f, SR_{ic} is the smart readiness score for impact criterion number ic.

The total smart readiness score is calculated as a weighted sum of the key functionalities' smart readiness scores, as follows:

$$SRI = \sum W_f \cdot SR_f$$

where, SR_f is the smart readiness score for key functionality f, W_f is the weight of key functionality f in the calculation of the total smart readiness scores, with $\Sigma W_f = 1$.

The calculations are performed using a calculation sheet that is available from an EU assessment package, which also includes the smart-ready service catalogues and a practical guide, and are available on request from the dedicated website.

Standards and References

- Adopted by the revised Energy Performance of Buildings Directive 2018 EPBD and its subsequent regulations (Delegated Regulation and Implementing Regulation)
- EU assessment package (available on request):
  - Calculation sheet
  - Catalogues
  - Practical guide

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- Verbeke S., Aerts D., Reynders G., Ma Y., Waide P. 2020. Final Report on the Technical Support to the Development of a Smart Readiness Indicator for Buildings, Directorate-General for Energy, European Commission, Brussels.

2.1.16. G1.4 Energy cost

Issue	G. Cost and Economic Aspects	
Category	G1. Cost and Economics	
Criterion	G1.4 Energy cost	
Indicator	Annual energy cost per useful internal floor area	
Unit	€/m^2/year	
Project stage	Design	Occupation
Data source	Estimation	Measurement

Intent

Optimize the operating cost of buildings to reflect the potential for long term performance

Description

The focus of the indicator is on the costs of **thermal** and **electric** energy during operation for all uses.

Boundary and Scope

The assessment boundary is the building.

The scope of the indicator includes the following energy uses, also referred to **as end-uses** and **technical building services** of the building:

- heating,
- cooling,
- ventilation,
- domestic hot water,
- lighting,
- auxiliaries,
- appliances,

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- elevators
- cooking appliances

Assessment method

The calculation steps are:

1. Calculate the annual energy cost of the building (based on the thermal and electrical energy use of the building, from calculations, bills, or metering and the fuel/electricity cost)
2. Calculate the useful internal floor area
3. Calculate the value of the indicator as the annual energy cost devided by the useful internal floor area

Standards and References

- Level(s) Part 1-2 – Beta version. Brussels: European Commission.

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2.1.17. H1.2 Heat island effect

Issue	H. Adaptation to Climate Change	
Category	H1. Climatic action: increase of temperature	
Criterion	H1.2 Heat island effect	
Indicator	Mean Solar Reflectance Index of paved surfaces and roofs in the area	
Unit	-	
Project stage	Design	Occupation
Data source	Estimation	Estimation

Intent

Reduce the heat island effect in order to reduce the discomfort at ground level during summer

Description

The value of the solar reflectance index varies from 0 (i.e. for a material that will absorb all incident solar radiation like a black body) to 100 (i.e. for a material that reflects all the incident solar radiation).

Boundary and Scope

The assessment boundary is the building lot.

The minimum scope of the indicator shall include all horizontal surfaces (roofs included) of the building envelope and the building lot

Assessment method

The calculation steps are:

1. Identify the boundaries of the building being assessed
2. Identify all the horizontal surfaces and roofs in the area

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3. Calculate the area of each surface identified and classify them in relation to the cover material
4. Multiply each surface previously identified by the corresponding solar reflectance index
5. Sum the weighed surfaces obtained
6. Calculate the weighted value of the index for the building as the ratio of the sum of products to the total area of all horizontal surfaces and roofs.

Standards and References

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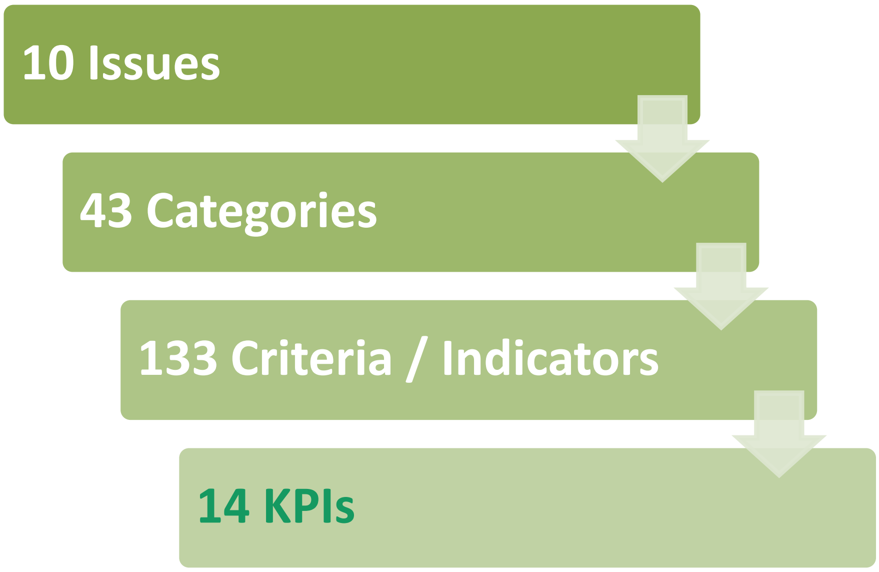
2.2. Key Performance Indicators – Neibourhood Scale

The Neighbourhood Scale is organized as follows:



Specifically, the KPIs for the neighbourhood scale are:

- ✓ B2.1 Total final thermal energy consumption for building operations
- ✓ B2.4 Total final electrical energy consumption for building operations
- ✓ B2.7 Total primary energy demand for building operations
- ✓ B3.1 Share of renewable energy on-site, relative to total final thermal energy consumption for building operations
- ✓ B3.4 Share of renewable energy on-site, relative to final electric energy consumption
- ✓ B3.7 Share of renewable energy on-site, relative to total primary energy consumption for building operations
- ✓ C2.3 Consumption of potable water in residential buildings
- ✓ D2.2 Access to solid waste and recycling collection points
- ✓ E1.2 Particulate matter (PM10) concentration
- ✓ F1.1 Performance of the public transport system

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- ✓ F2.3 Bicycle network
- ✓ G3.1 Availability and proximity of key services
- ✓ I1.1 Greenhouse gas emissions
- ✓ I3.3 Permeability of land

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2.2.1. B2.1 Total final thermal energy consumption for building operations

Issue	B. Energy	
Category	B2. Energy consumptions	
Criterion	B2.1 Total final thermal energy consumption for building operations	
Indicator	Aggregated annual total final thermal energy consumption per aggregated indoor useful floor area	
Unit	$kWh/m^2/yr$	
Project stage	Design	In use
Data source	Estimation	Metering

Intent

Estimate and minimize thermal energy consumption for all buildings in the neighbourhood.

Description

The indicator provides an understanding of a building's thermal energy consumption. Operational energy consumptions are in general responsible for most of life cycle energy use in the case of buildings constructed before the turn of the millennium

Boundary and Scope

The assessment boundary includes all buildings in the neighbourhood.

In the calculation of the final thermal energy consumption, the following energy uses should be considered:

- heating
- cooling
- mechanical ventilation
- domestic hot water

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Assessment method

For the calculations it is possible to use metered or estimated data. For the evaluation of the actual performance of the urban area it is preferable to use metered data. If metered data aren't available, estimated data shall be used. Estimated data shall be used for evaluating alternative scenarios in planning and decision-making processes. The source of data must always be clearly declared.

The calculation steps are:

Use of estimated data:

1. For each building in the neighborhood calculate the annual thermal energy consumption for the energy uses taken into account
2. For each building in the neighborhood calculate the indoor useful area
3. Sum the annual final thermal energy consumption of each building up to an aggregated total annual final thermal energy consumption
4. Sum the indoor useful area of each building in the area up to an aggregated indoor useful area value
5. Calculate the indicator's value as: aggregated annual total final thermal energy consumption/ aggregated indoor useful area

Note: Calculations are based on EN 13790 using the quasi-steady state monthly method.

Use of metered data:

1. For each building in the neighborhood collect actual data of each fuel (e.g. liters of oil, cubic meters of natural gas) or the heat/cold from district networks, for the energy uses taken into account and calculate the average annual consumptions
2. For each building in the neighborhood calculate the indoor useful area
3. Sum the annual fuel (or heat/cold from district networks) of each building up to an aggregated total annual consumption per fuel or district heat/cold

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4. Convert the amount of fuels or district heat/cold to thermal energy consumption using their lower heating values
5. Sum the thermal energy of all fuels up to an aggregated total annual final thermal energy consumption
6. Sum the indoor useful area of each building in the area up to an aggregated total indoor useful area
7. Calculate the indicator's value as: aggregated annual total final thermal energy consumption / aggregated indoor useful area

Note: Collected data for final non-renewable thermal energy consumption can be obtained from:

- ✓ Monitoring (Provides the best quality data). Measure all quantities of fuel delivered to the building and provide measured energy consumption data from at least 12 consecutive months
- ✓ Bills or Utilities. Average over longer periods if available (e.g. 3year records)

Standards and References

- ➢ EN 13790 - Energy performance of buildings. Calculation of energy use for space heating and cooling. Brussels: European Committee for Standardization.

2.2.2. B2.4 Total final electrical energy consumption for building operations

Issue	B. Energy	
Category	B2. Energy consumptions	
Criterion	B2.4 Total final electrical energy consumption for building operations	
Indicator	Aggregated annual total final electric energy consumption per aggregated internal useful floor area	
Unit	$kWh/m^2/yr$	
Project stage	Design	In use
Data source	Estimation	Metering

Intent

Estimate and minimize urban electric energy consumption for building operations.

Description

The indicator provides an understanding of a building's electrical energy consumption. Operational energy consumptions are in general responsible for most of life cycle energy use in the case of buildings constructed before the turn of the millennium

Boundary and Scope

The assessment boundary includes all buildings in the neighbourhood.

In the calculation of the final thermal energy consumption, the following energy uses should be considered:

- heating
- cooling
- mechanical ventilation
- domestic hot water
- lighting

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- auxiliaries

Assessment method

For the calculations it is possible to use metered or estimated data. For the evaluation of the actual performance of the urban area it is preferable to use metered data. If metered data aren't available, estimated data shall be used. Estimated data shall be used for evaluating alternative scenarios in planning and decision-making processes. The source of data must always be clearly declared.

The calculation steps are:

Use of estimated data:

1. For each building in the neighborhood calculate the annual electricity use for the energy uses taken into account
2. For each building in the neighborhood calculate the indoor useful area
3. Sum the annual final electrical energy consumption of each building up to an aggregated total annual final electrical energy consumption
4. Sum the indoor useful area of each building in the area up to an aggregated indoor useful area value
5. Calculate the indicator's value as: aggregated annual total final electrical energy consumption/ aggregated indoor useful area

Note: Calculations are based on EN 13790 using the quasi-steady state monthly method.

Use of metered data:

1. For each building in the neighborhood collect actual data for the electricity consumption and calculate average annual electricity consumption
2. For each building in the neighborhood calculate the indoor useful area
3. Sum the average annual electricity consumption of each building up to an aggregated total annual final electrical energy consumption
4. Sum the indoor useful area of each building in the area up to an aggregated total indoor useful area

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5. Calculate the indicator’s value as: aggregated annual total final electrical energy consumption / aggregated indoor useful area

Note: Can use data from monitoring or from electricity bills or utilities, for a 3years-period. If needed, desegregate collected data for different end-uses with survey results

Standards and References

- EN 13790 - Energy performance of buildings. Calculation of energy use for space heating and cooling. Brussels: European Committee for Standardization.

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2.2.3. B2.7 Total primary energy demand for building operations

Issue	B. Energy	
Category	B2. Energy consumptions	
Criterion	B2.7 Total primary energy demand for building operations	
Indicator	Aggregated annual total primary energy consumption per aggregated internal useful floor area	
Unit	kWh/m^2/yr	
Project stage	Design	In use
Data source	Estimation	Metering

Intent

Estimate and minimize primary energy consumption for building operations.

Description

The indicator provides an understanding of buildings' primary energy consumption. Primary energy is defined by Article 2(5) of the Energy Performance of Buildings Directive 6 as 'the energy that has not undergone any conversion in the transformation process, calculated by energy carrier using a primary energy factor'. It is the energy that is required to generate the electricity, heating and cooling used by a building

Boundary and Scope

The assessment boundary includes all buildings in the neighbourhood.

In the calculation of the final thermal energy consumption, the following energy uses should be considered:

- heating
- cooling
- mechanical ventilation

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- domestic hot water
- lighting
- auxiliaries

Assessment method

For the calculations it is possible to use metered or estimated data. For the evaluation of the actual performance of the urban area it is preferable to use metered data. If metered data aren't available, estimated data shall be used. Estimated data shall be used for evaluating alternative scenarios in planning and decision-making processes. The source of data must always be clearly declared.

The calculation steps are:

1. For each building in the neighborhood calculate the indoor useful area
2. For each building in the neighborhood calculate the average annual thermal energy consumption per fuel or district heat/cold, for the energy uses taken into account (see B.1.2)
3. For each building in the neighborhood calculate the average annual electrical energy consumption (see B.1.3)
4. Sum the average annual thermal energy consumption per fuel or district heat/cold for all the buildings in the neighborhood
5. Sum the average annual electrical energy consumption for all the buildings in the neighborhood
6. Use national conversion factors per fuel, district heat/cold and electricity to calculate the total primary energy consumption for all buildings of the neighborhood

$$PEU = \sum_{1}^{i} \left(EU_{th,i} \cdot F_i \right) + \left(EU_d \cdot F_d \right) + \left(EU_e \cdot F_e \right)$$

where

$EU_{th,i}$ = annual thermal energy consumption of i-th fuel delivered to all buildings of the neighbourhood

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F_i = national conversion factor of the i-th fuel

EU_d = annual thermal energy consumption used by a district heating/cooling network to generate the heat/cold delivered to all buildings of the neighbourhood

F_d = national conversion factor for the fuel used by a district heating/cooling network

EU_e = annual electrical energy consumption for the electricity delivered to all buildings of the neighbourhood

F_e = national conversion factor of electricity from the main grid (depends on energy mix of main grid)

7. Sum the indoor useful area of each building in the area up to an aggregated total indoor useful area
8. Calculate the indicator's value as: total primary energy consumption / aggregated indoor useful area

Standards and References

- EN 13790 - Energy performance of buildings. Calculation of energy use for space heating and cooling. Brussels: European Committee for Standardization.

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2.2.4. B3.1 Share of renewable energy on-site in total final thermal energy consumption for building operations

Issue	B. Energy	
Category	B3. Renewable energy	
Criterion	B3.1 Share of renewable energy on-site in total final thermal energy consumption for building operations	
Indicator	Total consumption of final thermal energy generated from renewable sources on-site divided by total final thermal energy consumption	
Unit	%	
Project stage	Design	In use
Data source	Estimation	Metering

Intent

Maximize the use of renewable energy sources.

Description

The indicator assesses the share of renewable thermal energy in final thermal energy consumption of buildings and, by implication, the degree to which renewable fuels have substituted fossil and/or nuclear fuels and therefore contributed to the decarbonisation of the Mediterranean area economy.

It also shows what is the progress towards Europe 2020 and 2030 target for renewable energies.

Boundary and Scope

The assessment boundary includes all buildings in the neighbourhood.

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In the calculation of the final thermal energy consumption, the following energy uses should be considered:

- heating
- cooling
- mechanical ventilation
- domestic hot water

Assessment method

For the calculations it is possible to use metered or estimated data. For the evaluation of the actual performance of the urban area it is preferable to use metered data. If metered data aren't available, estimated data shall be used. Estimated data shall be used for evaluating alternative scenarios in planning and decision-making processes. The source of data must always be clearly declared.

According to the Renewables Energy Directive (RED 2018), energy from renewable sources means energy from renewable non-fossil sources, namely wind, solar, aerothermal, geothermal, hydrothermal and ocean energy, hydropower, biomass, landfill gas, sewage treatment plant gas and biogases. Heat pumps enabling the use of aerothermal, geothermal or hydrothermal heat at a useful temperature level need electricity or other auxiliary energy to function. The energy used to drive heat pumps should therefore be deducted from the total usable heat. Only heat pumps for which SPF > 1,15 * 1/η shall be taken into account.

The calculation steps are:

1. For each building in the neighborhood calculate the average annual thermal energy produced & used on-site from renewable sources (e.g. solar collectors, PV driven HPs, biomass) to cover the demand for the energy uses taken into account, using a 3year average value, from monitored data or calculations (see B.1.4)

2. For each building in the neighborhood calculate the annual thermal energy consumption for the energy uses taken into account, from monitored / metered data or calculations (see B.1.2)
3. Sum the annual thermal energy produced & used on-site from renewable sources of each building up to an aggregated total thermal energy from RES
4. Sum the annual thermal energy of each building up to an aggregated total thermal energy
5. Calculate the indicator's value as the percentage ratio of the amount of total thermal energy from RES to the total final thermal energy

Note: Calculations are based on EN 13790 using the quasi-steady state monthly method.

Standards and References

- RED 2018. Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources (recast). Brussels: European Commission.
- EN 13790 - Energy performance of buildings. Calculation of energy use for space heating and cooling. Brussels: European Committee for Standardization.
- Level(s) Part 1-2 – Beta version. Brussels: European Commission.

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2.2.5. B3.4 Share of renewable energy on-site in total final electrical energy consumption

Issue	B. Energy	
Category	B3. Renewable energy	
Criterion	B3.4 Share of renewable energy on-site in total final electrical energy consumption for building operations	
Indicator	Total consumption of final electrical energy generated from renewable sources on-site divided by total final electrical energy consumption	
Unit	%	
Project stage	Design	In use
Data source	Estimation	Metering

Intent

Maximize the use of renewable energy sources.

Description

The indicator assesses the share of renewable electrical energy in final electrical energy consumption and, by implication, the degree to which renewable fuels have substituted fossil and/or nuclear fuels and therefore contributed to the decarbonisation of the Mediterranean area economy.

It also shows what is the progress towards Europe 2020 and 2030 target for renewable energies.

Boundary and Scope

The assessment boundary includes all buildings in the neighbourhood.

In the calculation of the final electrical energy consumption, the following energy uses should be considered:

- heating
- cooling
- mechanical ventilation
- domestic hot water
- lighting
- auxiliaries

Assessment method

For the calculations it is possible to use metered or estimated data. For the evaluation of the actual performance of the urban area it is preferable to use metered data. If metered data aren't available, estimated data shall be used. Estimated data shall be used for evaluating alternative scenarios in planning and decision-making processes. The source of data must always be clearly declared.

According to the Renewables Energy Directive (RED 2018), energy from renewable sources means energy from renewable non-fossil sources, namely wind, solar, aerothermal, geothermal, hydrothermal and ocean energy, hydropower, biomass, landfill gas, sewage treatment plant gas and biogases. Heat pumps enabling the use of aerothermal, geothermal or hydrothermal heat at a useful temperature level need electricity or other auxiliary energy to function. The energy used to drive heat pumps should therefore be deducted from the total usable heat. Only heat pumps for which SPF > 1,15 * 1/η shall be taken into account.

The calculation steps are:

1. For each building in the neighborhood calculate the average annual thermal energy produced & used on-site from renewable sources (e.g. solar collectors, PV driven HPs, biomass) to cover the demand for the energy uses taken into account, using a 3year average value (if available), from monitored data or calculations (see B.1.5). The actual electricity produced & used on-site from renewable sources is usually monitored (measured) by dedicated power or smart meters.

2. For each building in the neighborhood calculate the average annual electricity delivered to the building from the main power grid, to cover the energy uses taken into account, from monitored / metered data or calculations (see B.1.5)
3. Sum the annual electricity produced & used on-site from renewable sources of each building up to an aggregated total electrical energy from RES
4. Sum the annual electrical energy consumption of each building up to an aggregated total electrical energy consumption from grid
5. Calculate the indicator's value as the percentage ratio of the amount of total electrical energy from RES to the total final electrical energy

Note: Calculations are based on EN 13790 using the quasi-steady state monthly method.

Standards and References

- RED 2018**.** Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources (recast). Brussels: European Commission.
- EN 13790 - Energy performance of buildings. Calculation of energy use for space heating and cooling. Brussels: European Committee for Standardization.
- Level(s) Part 1-2 – Beta version. Brussels: European Commission.

2.2.6. B3.7 Share of renewable energy on-site in total primary energy consumption for building operations

Issue	B. Energy	
Category	B3. Renewable energy	
Criterion	B3.7 Share of renewable energy on-site in total primary energy consumption for building operations	
Indicator	Total consumption of primary energy generated from renewable sources on-site divided by total primary energy consumption	
Unit	%	
Project stage	Design	In use
Data source	Estimation	Metering

Intent

Maximize the use of renewable energy sources.

Description

The indicator assesses the share of renewable energy in primary energy consumption of the buildings and, by implication, the degree to which renewable fuels have substituted fossil and/or nuclear fuels and therefore contributed to the decarbonisation of the Mediterranean area economy.

It also shows what is the progress towards Europe 2020 and 2030 target for renewable energies.

Boundary and Scope

The assessment boundary includes all buildings in the neighbourhood.

In the calculation of the final thermal energy consumption, the following energy uses should be considered:

- heating
- cooling
- mechanical ventilation
- domestic hot water
- lighting
- auxiliaries

Assessment method

For the calculations it is possible to use metered or estimated data. For the evaluation of the actual performance of the urban area it is preferable to use metered data. If metered data aren't available, estimated data shall be used. Estimated data shall be used for evaluating alternative scenarios in planning and decision-making processes. The source of data must always be clearly declared.

According to the Renewables Energy Directive (RED 2018), energy from renewable sources means energy from renewable non-fossil sources, namely wind, solar, aerothermal, geothermal, hydrothermal and ocean energy, hydropower, biomass, landfill gas, sewage treatment plant gas and biogases. Heat pumps enabling the use of aerothermal, geothermal or hydrothermal heat at a useful temperature level need electricity or other auxiliary energy to function. The energy used to drive heat pumps should therefore be deducted from the total usable heat. Only heat pumps for which $SPF > 1,15 * 1/\eta$ shall be taken into account.

The calculation steps are:

1. For each building in the neighborhood (residential and non-residential) collect /calculate the following data:
   a) the annual total renewable thermal energy produced on site <u>for each energy carrier that may be replaced</u>, (as described in B.1.4 – Energy from renewable sources in total thermal energy consumption)
   b) the annual total renewable electrical energy produced on site (as described in B.1.5 – Energy from renewable sources in total electrical energy consumption)

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c) the annual final thermal energy consumption for building operations <u>for each energy carrier</u> separately (as described in B.1.2 - Delivered thermal energy demand)

d) the annual final electrical energy consumption from the gird for building operations (as described in B.1.3 - Delivered electrical energy demand)

2. For all buildings in the neighborhood sum up:

a) the annual total renewable thermal energy per <u>energy carrier</u> produced on site, to calculate the aggregated renewable thermal energy per <u>energy carrier</u> produced on site

b) the annual total renewable electrical energy produced on site, to calculate the aggregated renewable electrical energy produced on site

c) the annual final thermal energy consumption for building operations for each energy carrier, to calculate the aggregated thermal energy consumption <u>per energy carrier</u>

d) the annual final electrical energy consumption, to calculate the aggregated electrical energy consumption

3. Calculate the total primary energy renewable thermal energy consumption summing up the aggregated renewable thermal energy per energy carrier multiplied with the appropriate primary energy factor
4. Calculate the total primary renewable electrical energy consumption summing up the aggregated electrical energy consumption multiplied with the appropriate primary energy factor
5. Calculate the total primary thermal energy consumption summing up the aggregated thermal energy consumption per energy carrier multiplied with the appropriate primary energy factor
6. Calculate the total primary electrical energy consumption summing up the aggregated electrical energy consumption multiplied with the appropriate primary energy factor

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7. Calculate the total annual primary energy from renewables, Ep,Ren, adding the total primary energy renewable thermal energy consumption and the total primary renewable electrical energy consumption
8. Calculate the total annual primary energy consumption Ep, adding the total primary thermal energy consumption and the total primary electrical energy consumption
9. Calculate the indicator's value as the percentage ratio of total annual primary energy from on-site renewables to the total annual primary energy consumption

Standards and References

- RED 2018**.** Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources (recast). Brussels: European Commission.
- EN 13790 - Energy performance of buildings. Calculation of energy use for space heating and cooling. Brussels: European Committee for Standardization.

This project has received funding from the European Union's ENI CBC Med Programme under Grant Contract C_B.4.3_0063

2.2.7. C2.3 Consumption of potable water in residential buildings

Issue	C. Water	
Category	C2. Water consumption	
Criterion	C2.3 Consumption of potable water in residential buildings	
Indicator	Annual potable water consumption per occupant	
Unit	l/occupant	
Project stage	Design	In use
Data source	Estimation	Metering

Intent

Make efficient use of water resources

Description

The indicator measures the potable water consumption of sanitary fittings/devices and water consuming appliances by residential population.

Boundary and Scope

The assessment boundary includes all residential buildings in the neighbourhood.

The potable water consumption is calculated based on **metered data from water consuming appliances** and sanitary fittings in the buildings.

The scope of the indicator includes the use of potable water for:

- drinking water
- water for sanitation
- domestic hot water
- water for washing machine

- water for cleaning

Not taken into account

- Water consumption in the common use spaces of residential buildings
- Water consumption for watering

Assessment method

For the calculations it is possible to use metered or estimated data. For the evaluation of the actual performance of the urban area it is preferable to use metered data. If metered data aren't available, estimated data shall be used. Estimated data shall be used for evaluating alternative scenarios in planning and decision-making processes. The source of data must always be clearly declared.

The calculation steps are:

1. For each residential building in the neighborhood

Using meter data:

a) collect actual data of annual potable water consumption and calculate the average annual consumption. It is preferable to consider actual data from longer records (e.g. three year data) or at least 12 consecutive months. Exclude the water consumption for uses that are not included in the scope.

Using estimated data:

b) estimate the annual potable water consumption for the various sanitary devices/fittings (i.e. toilets, taps and showers) and water using appliances (i.e. dishwashers and washing machines). Consumption rates are determined through specific data from manufacturer specifications on labels or from data libraries. The specific usage factors as well as the annual operation of the building have to be defined by the user.

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2. Sum the annual potable water consumption of each building up to an aggregated annual total potable water consumption.
3. Estimate the total number of residential buildings' occupants.
4. Calculate the indicator's value as: annual total potable water consumption / number of occupants.

Standards and References

- Council Directive 98/83/EC on the quality of water intended for human consumption, Brussels: European Council.
- COM(2017) 753 final 2017/0332 (COD). Proposal for a Directive of the European parliament on the quality of water intended for human consumption (recast). Brussels: European Commission.
- Directive (EU) 2020/2184 of the European parliament on the quality of water intended for human consumption (Recast). Brussels: European Commission.
- EU Environment - Water, European Commission.

2.2.8. D2.2 Access to solid waste and recycling collection points

Issue	D. Solid Waste
Category	D2. Solid waste management
Criterion	D2.2 Separate collection of solid waste for recycling
Indicator	Percentage of inhabitants with access to solid waste and recycling collection points within 400 meters walking distance
Unit	%
Project stage	Design In use
Data source	Estimation Metering

Intent

Improve separate collection disposal, avoiding to burn waste

Description

Municipal waste includes waste originating from households, commerce and trade, private and public services, institutions including schools and hospitals, and often from small craft or small industrial enterprises. This definition excludes waste from municipal sewage networks and treatment or municipal construction and demolition waste.

Boundary and Scope

The assessment boundary includes all buildings in the neighborhood.

The scope includes the seven reference categories of solid waste:

- Paper
- Plastic
- Metal
- Glass
- Wet waste (organic waste)

- Textiles

Assessment method

The calculation steps are:

1. Calculate the inhabitant living with 400m access to the solid waste and recycling collection points in the neighborhood
2. Calculate the neighborhood's population
3. Calculate the indicator's value as the percentage ratio of inhabitant living with 400m access to the solid waste and recycling collection points to the neighborhood's population

Standards and References

- Directive (EU) 2018/851 of the European Parliament and of the Council of 30 May 2018 on Waste. Brussels: European Commission.
- UNECE - Collection Methodology for Key Performance Indicators for Smart Sustainable Cities.

This project has received funding from the European Union's ENI CBC Med Programme under Grant Contract C_B.4.3_0063

2.2.9. E1.2 Particulate matter (PM_{10}) concentration

Issue	E. Environmental quality	
Category	E1. Air quality	
Criterion	E1.2 Particulate matter (PM10) concentration	
Indicator	Total number of days within a year that PM10 concentration exceeds the daily limit	
Unit	days / y	
Project stage	Design	In use
Data source	Metering	Metering

Intent

Assess the long-term ambient air quality with respect to particulates <10 μm (PM10) in the neighborhood

Description

Particulate matter (PM) consists of a complex mixture of solid and liquid particles of organic and inorganic substances suspended in the air, sulfate, nitrates, ammonia, sodium chloride, black carbon, mineral dust and water. PM affects more people than any other pollutant.

Coarse particles are greater than 2.5 μm and less than or equal to 10 μm in diameter and are defined as “respirable particulate matter” or PM10. Sources of coarse particles include crushing or grinding operations, and dust from paved or unpaved roads.

Boundary and Scope

The assessment boundary includes the whole neighborhood.

For the calculations, the location of the monitoring station should be defined in order to convey the local representativeness of the measured values

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Assessment method

The calculation steps are:

1. Collect daily test air samples of PM10 concentrations in accordance with national or regional procedures over a one-year period
2. Calculate the average daily PM10 concentration
3. Calculate the total number of days within a year, that average daily PM10 concentration exceeds the limit]

Standards and References

- ISO 37120, Second edition 2018-07, "Sustainable cities and communities — Indicators for city services and quality of life"
- UNECE - Collection Methodology for Key Performance Indicators for Smart Sustainable Cities

This project has received funding from the European Union's ENI CBC Med Programme under Grant Contract C_B.4.3_0063

2.2.10. F1.1 Performance of the public transport system

Issue	F. Transportation and mobility	
Category	F1. Performance of mobility service	
Criterion	F1.1 Performance of the public transport system	
Indicator	Percentage of inhabitants that are within 400 meters walking distance of at least one public transportation service stop	
Unit	%	
Project stage	Design	In use
Data source	Metering	Metering

Intent

Estimate the performance of the public / municipal transportation system

Description

Public Transport includes metro, bus, minibus and tram

The indicator assesses the quality of public / municipal transportation system, including the density of the route network.

The walking distance between building entrance and transport stop can be calculated by in situ measurements of by using maps.

Boundary and Scope

The assessment boundary includes the whole neighborhood.

For the calculations the followings should be considered:

- bus
- metro

- tram
- suburban rail

Assessment method

For the calculation of the indicator the following are considered:

- only residents of the neighbourhood and not working people in the area
- a stop must have a daily total service frequency of at least 20 trips

The calculation steps are:

1. Locate the public/municipal transport stops with daily total service frequency of at least 20 trips, that serve the neighborhood
2. Locate all the residential buildings in the neighborhood with a walking distance from their entrance to at least one of the located stops up to 400 meters.
3. Calculate the occupants of the selected buildings.
4. Calculate the total population of the neighborhood
5. Calculate the indicator's value as the percentage of the occupants of the selected buildings to the total population of the neighborhood

Standards and References

- Global Platform for Sustainable Cities – Urban Sustainability Frame
- UNECE - Collection Methodology for Key Performance Indicators for Smart Sustainable Cities.

2.2.11. F2.3 Bicycle network

Issue	F. Transportation and mobility	
Category	F2. Green mobility	
Criterion	F2.3 Bicycle network	
Indicator	Length of bicycle paths in the neighbourhood per inhabitant	
Unit	m/inhabitant	
Project stage	Design	In use
Data source	Metering	Metering

Intent

Promote cycling as an alternative to vehicle use by providing safe and efficient mobility networks

Description

The calculation of bicycle paths can be performed by in situ measurements or by using maps and geographic information system.

Boundary and Scope

The assessment boundary includes the whole neighborhood.

For the calculations, bicycle paths taken into account should be physically separated from traffic roads and not be part of a "shared space"

A "shared space" is an urban design approach that minimizes the segregation between modes of road user (car, pedestrian, bicycle, etc.) in order to make safe space for every type of mobility; the shared space is to be used by anyone. This can be done through minimizing traffic signs, road surface markings, enforcing speed reduction down to 15-20 km/h.

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Assessment method

The calculation steps are:

1. Calculate the total length of bicycle paths/lanes in the neighborhood
2. Estimate/Calculate the total number of inhabitants in the neighborhood
3. Calculate the indicator's value as the ratio of total length of bicycle paths to the total number of inhabitants in the neighborhood

Standards and References

- UNECE - Collection Methodology for Key Performance Indicators for Smart Sustainable Cities.

This project has received funding from the European Union's ENI CBC Med Programme under Grant Contract C_B.4.3_0063

2.2.12. G3.1 Availability and proximity of key services

Issue	G. Social Aspects	
Category	G3. Availability of public and private facilities and services	
Criterion	G3.1 Availability and proximity of key services	
Indicator	Percentage of inhabitants that are within 800 meters walking distance of at least 3 key services	
Unit	%	
Project stage	Design	In use
Data source	Metering	Metering

Intent

Determine the accessibility of local residents to key services (e.g. schools, sports facilities, supermarket, community buildings, etc.)

Description

Convenient locations of key services for access by local residents is a major factor in reducing the use of private vehicles and in ensuring that residents can obtain access to the services they need.

Indicative, key services include Education (e.g. schools of all levels, nurseries, training centers, etc.), Health (e.g. hospitals, clinics, health centers, etc.), Safety (e.g. police station, etc.), Food (e.g. Supermarkets, minimarkets, groceries, etc.), Sports facilities.

The calculation of walking distance between building entrance and key service can be performed by in situ measurements or by using maps and geographic information system.

Boundary and Scope

The assessment boundary includes the whole neighborhood.

Public and Private services can be considered. Key Services include the following categories:

- Education (schools, kindergartens, nurseries, education centers, etc.)
- Health center (hospitals, medical wards, medical centers, etc.)
- Law enforcement services (police station, etc.)
- Sport facilities
- Food shops
- Bank
- Post office
- Pharmacy
- Shopping center
- Culture and leisure facilities

At least three categories should be selected, while only one key service from each category should be considered.

Assessment method

For the calculations, only residents of the neighbourhood are considered and not working people in the area

The calculation steps are:

1. Locate the key services in the neighborhood
2. Locate all the residential buildings in the neighborhood with a walking distance from their entrance to at least three key services up to 800 meters.
3. Calculate the residents number of the selected buildings.
4. Calculate the total residents in the neighborhood
5. Calculate the indicator's value as the percentage ratio of the residents' number of the selected buildings to the total residents in the neighborhood

Standards and References

- Global Platform for Sustainable Cities, World Bank. 2018. “Urban Sustainability Framework.” 1st ed. Washington, DC: World Bank

2.2.13. I1.1 Greenhouse gas emissions

Issue	I. Social Aspects	
Category	I1. Climate change mitigation	
Criterion	I1.1 Greenhouse gas emissions	
Indicator	Total amount of greenhouse gases (equivalent carbon dioxide units) generated from buildings' operation over a calendar year per inhabitant	
Unit	t CO_2 eq./inhabitant	
Project stage	Design	In use
Data source	Estimation	Metering

Intent

Minimise the total greenhouse gas emissions from buildings' operations

Description

The indicator measures the contribution of the greenhouse gas (GHG) emissions associated with the building's operational phase on the earth's global warming or climate change.

The Global Warming Potential (GWP) was developed to allow for the comparison of the impact on global warming caused by different gases (such as carbon dioxide, methane, nitrous oxide, or chlorofluorocarbons). It is a measure of how much energy the emissions of 1 ton of a gas will absorb over a given period of time, relative to the emissions of 1 ton of carbon dioxide (CO_2). A higher GWP means a larger warming effect in that period of time (usually 100 years).

Boundary and Scope

The assessment boundary includes all buildings in the neighborhood.

In the calculations the following energy uses should be considered:

- heating

- cooling
- mechanical ventilation
- domestic hot water
- lighting
- auxilliaries

Assessment method

For the calculations, only residents in the neighbourhood are considered and not working people in the area.

The calculation steps are:

1. For all the buildings in the neighbourhood, sum the building's emissions of CO_2 eq., calculated using the following formula

$$E = \left[\sum (Q_{\mathrm{fuel},i} \cdot LHV_i \cdot k_{\mathrm{em},i}) + (Q_{\mathrm{el}} \cdot k_{\mathrm{em,el}}) + (Q_{\mathrm{dh}} \cdot k_{\mathrm{em,dh}})\right]$$

   Where:

   $Q_{\mathrm{fuel},i}$ = annual quantity of *i*-th fuel [m^3/a or kg/a]

   Q_{el} = annual quantity of electrical energy from the grid [kWh/a]

   Q_{dh} = annual quantity of energy from district heating/cooling [kWh/a]

   LHV_i = lower heating value of the *i*-th fuel [kWh/m^3 or kWh/kg]

   $k_{\mathrm{em},i}$ = CO_2 eq. emission factor of the *i*-th fuel [t CO_2/kWh]

   $k_{\mathrm{em,el}}$ = CO_2 eq. emission factor of the electrical energy from the grid [t CO_2/kWh]

   $k_{\mathrm{em,dh}}$ = CO_2 eq. emission factor of energy from district heating/cooling [t CO_2/kWh]

2. Calculate the current population of the neighbourhood (permanent residents)
3. Calculate the indicator's value as the ratio of the total emissions of CO_2 eq. related to building operations to the total neighbourhood's population

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Standards and References

- ISO 14067:2013 - Greenhouse gases -- Carbon footprint of products -- Requirements and guidelines for quantification and communication. Geneva: International Organization for Standardization.
- ISO 14040:2006 - Environmental management -- Life cycle assessment -- Principles and framework. Geneva: International Organization for Standardization.
- ISO 37120: Sustainable cities and communities - Indicators for city services and quality of life

2.2.14. I3.3 Permeability of land

Issue	I. Social Aspects	
Category	I3. Adaptation to the climatic action: pluvial flood	
Criterion	I3.3 Permeability of land	
Indicator	Percentage of weighted ground permeability	
Unit	%	
Project stage	Design	In use
Data source	Estimation	Metering

Intent

Improve the land permeability in order to reduce its impact on the hydrological cycle

Description

Permeability of land is the capacity to transmit water to the soil. It is a very important issue connected to the water recharging of aquifers and the reduction of effluents.

The calculation of distances can be performed by in situ measurements or by using maps and geographic information system

Boundary and Scope

The assessment boundary includes all buildings in the neighborhood.

Reference permeability coefficients:

- Grass = 1
- Gravel = 0.9
- Sand = 0.9
- Plastic gratings filled with land/grass = 0.8
- Concrete gratings leaning on the grass = 0.6

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- Concrete gratings leaning on gravel = 0.6
- Interlocking elements leaning on sand = 0.3
- Interlocking elements leaning on gravel = 0.3
- Interlocking elements leaning on concrete pavement = 0
- Continuous pavements leaning on concrete = 0
- Asphalt = 0

Assessment method

The calculation steps are:

1. Calculate the total surface area of the neighbourhood
2. Calculate the area of the various surfaces with different coverings or occupied by constructions in the urban area (i.e green areas, surfaces paved with asphalt, surfaces occupied by buildings, etc.). Include all the surfaces in the neighbourhood
3. Calculate the weighted surface of the neighbourhood, considering the permeability coefficients (αi) of the various surfaces(Ai)

$$\mathrm{A}_{\mathrm{N},p} = \sum_{i=1}^{n} (A_i \cdot \alpha_i)$$

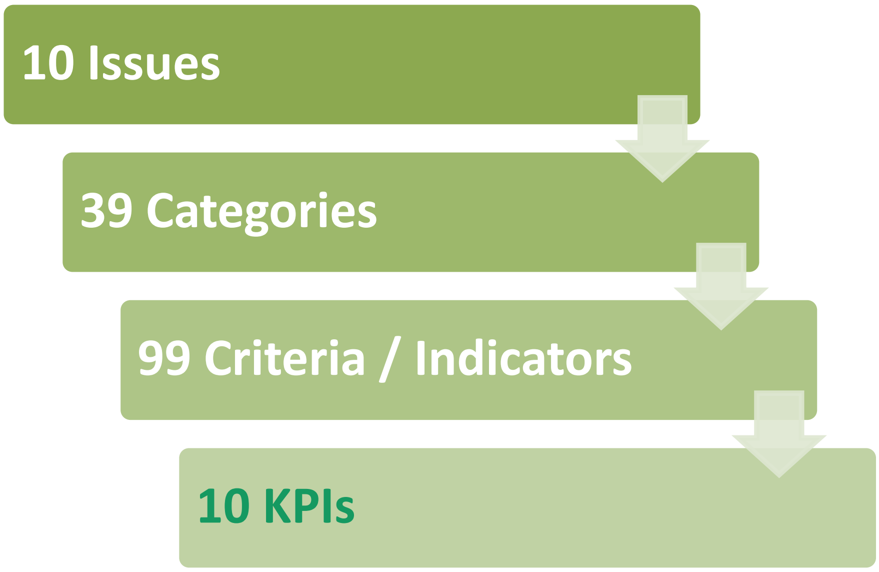
4. Calculate the indicator's value as the percentage of the of the weighted surface of the neighbourhood to total surface area of the neighbourhood

Standards and References

- Guidelines on best practice to limit mitigate or compensate soil sealing, European Union, 2012

2.3. Key Performance Indicators – City Scale

The City Scale is organized as follows:



Specifically, the KPIs for the city scale are:

- ✓ A2.1 Availability of green urban areas
- ✓ B2.1 Final energy consumption
- ✓ B3.1 Final energy derived from renewable sources
- ✓ C2.1 Total water consumption
- ✓ D2.2 Solid waste recycling
- ✓ E1.2 Particulate matter (PM10) concentration
- ✓ F1.1 Public transport network
- ✓ F2.4 Bicycle network
- ✓ I1.1 Greenhouse gas emissions
- ✓ I3.3 Permeability of land

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2.3.1. A2.1 Availability of green urban areas

Issue	A. Use of land and biodiversity	
Category	A2. Green urban areas	
Criterion	A2.1 Availability of green urban areas	
Indicator	Total amount of green urban areas in the city's boundaries divided by the total area of the city	
Unit	%	
Project stage	Design	In use
Data source	Estimation	Metering

Intent

Facilitate climate change adaptation and mitigation, to improve health and quality of life, favouring biodiversity conservation.

Description

Information on green area should be obtained from municipal recreation and parks departments, planning departments, forestry departments and census. Green areas can be defined from land use/land cover maps.

A green urban area is defined as an urban land covered by vegetation of any kind, for instance natural zones, parks, public and private garden.

Boundary and Scope

The assessment boundary includes the whole city.

For the calculations, green areas refer to the amount of vegetated and/or natural surface cover (public and private) in the city. Green or natural spaces areas should also include green roofs. Green area is broader than recreation space, and should include both public and private spaces.

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Areas that are without green or natural surface cover are assumed to be sealed (i.e. paved or impervious).

Assessment method

The calculation steps are:

1. Calculate the total surface area of the city
2. Calculate the total surface of green urban areas in the city
3. Calculate the indicator's value as the percentage ratio of total surface of green urban areas to the total surface area of the city.

Standards and References

- ISO 37120, Second edition 2018-07, "Sustainable cities and communities — Indicators for city services and quality of life"
- IEFCA 2019 edition – Calculation Guideline
- United for Smart Sustainable Cities (U4SSC) - Collection Methodology for Key Performance Indicators for Smart Sustainable Cities

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2.3.2. B2.1 Final energy consumption

Issue	B. Energy	
Category	B2. Energy consumption	
Criterion	B2.1 Final energy consumption	
Indicator	Total final energy consumed by a city divided by the total population of the city	
Unit	MWh/inhabitant/year	
Project stage	Design	In use
Data source	Estimation	Metering

Intent

Effectively manage the consumption and conservation of energy.

Description

Information on green area should be obtained from municipal recreation and parks departments, planning departments, forestry departments and census. Green areas can be defined from land use/land cover maps.

Boundary and Scope

The assessment boundary includes the whole city.

Total energy consumption includes all fuel types for all sectors.

End-use sectors include:

- residential
- commercial
- industrial
- transportation
- other

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Categories of fuel types include: electricity, fuel oil, natural gas, gasoline, diesel, biomass, coal, biofuels and other

Assessment method

The calculation steps are:

1. Calculate the total final energy consumption of the city based on energy consumption for all fuel types and sectors of the city
2. Calculate the total population of the the city, [inhabitants]
3. Calculate the indicator's value as the ratio of total final energy consumption to the total population of the city.

Standards and References

- ISO 37120**,** Second edition 2018-07, "Sustainable cities and communities — Indicators for city services and quality of life"
- United for Smart Sustainable Cities (U4SSC) - Collection Methodology for Key Performance Indicators for Smart Sustainable Cities

2.3.3. B3.1 Final energy derived from renewable sources

Issue	B. Energy	
Category	B3. Renewable energy	
Criterion	B3.1 Final energy derived from renewable sources	
Indicator	Share of renewable energies in final energy demand	
Unit	%	
Project stage	Design	In use
Data source	Estimation	Metering

Intent

Maximize the use of renewable energy sources.

Description

The indicator assesses the share of renewable thermal energy in final energy consumption and, by implication, the degree to which renewable fuels have substituted fossil and/or nuclear fuels and therefore contributed to the decarbonisation of the Mediterranean area economy.

It also shows what is the progress towards Europe 2020 and 2030 target for renewable energies.

Boundary and Scope

The assessment boundary includes the whole city.

Renewable energy sources should include geothermal, solar, wind, hydro, tide and wave energy, combustibles and biofuels such as biomass.

Total renewable energy consumption shall include both thermal energy and electrical energy from all sectors including residential, commercial, industrial, transportation and other.

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Assessment method

The calculation steps are:

1. Calculate the total final energy consumption of the city based on energy consumption for all fuel types and sectors of the city
2. Calculate the total consumption of end-use energy generated from renewable sources within the city]
3. Calculate the indicator's value as the percentage ratio of total consumption of end-use energy generated from renewable sources to the total final energy consumption of the city.

Standards and References

- ISO 37120**,** Second edition 2018-07, "Sustainable cities and communities — Indicators for city services and quality of life"
- United for Smart Sustainable Cities (U4SSC) - Collection Methodology for Key Performance Indicators for Smart Sustainable Cities

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2.3.4. C2.1 Total water consumption

Issue	C. Water	
Category	C2. Water consumption	
Criterion	C2.1 Total water consumption	
Indicator	Total amount of the city's daily water consumption divided by the total city population	
Unit	L/day/person	
Project stage	Design	In use
Data source	Estimation	Metering

Intent

Evaluate water resources in the city and make efficient use of water

Description

In many cities, potable water supply is not constant and households rely on a few hours to tap the available water during the day. Water consumption is much higher in cities of higher income countries. Water consumption must be in harmony with water resources to be sustainable. This harmony can be achieved through improvements in water supply systems and changes in water consumption patterns.

Boundary and Scope

The assessment boundary includes the whole city.

The scope of the indicator includes the use of potable water for:

- drinking
- sanitation
- domestic hot water
- washing

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- gardening
- commercial
- industrial
- agricultural

Assessment method

This information should be obtained from the main water supply companies. If metered data aren't available, estimated data shall be used. The source of data must always be clearly declared.

The calculation steps are:

1. Calculate the average daily total amount of the city's water consumption, [l/y]
2. Calculate the total population of the city, [inhabitants]
3. Calculate the indicator's value as the daily total amount of the city's water consumption divided by the total population of the city.

Standards and References

- ISO 37120, Second edition 2018-07, "Sustainable cities and communities — Indicators for city services and quality of life"
- United for Smart Sustainable Cities (U4SSC) - Collection Methodology for Key Performance Indicators for Smart Sustainable Cities

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2.3.5. D2.2 Solid waste recycling

Issue	D. Solid waste	
Category	D2. Solid waste management	
Criterion	D2.2 Separate collection of solid waste for recycling	
Indicator	Total amount of solid waste that is recycled divided by the total amount of solid waste produced in the city	
Unit	%	
Project stage	Design	In use
Data source	Estimation	Metering

Intent

Promote and develop sustainable waste management

Description

Municipal Solid Waste is generated by households, commercial and business establishments, institutions (e.g. schools, hospitals), public spaces (e.g. parks, streets) and construction sites. Generally, it is non-hazardous waste composed of food waste, garden waste, paper and cardboard, wood, textiles, nappies (disposable diapers), rubber and leather, plastics, metal, glass, construction and demolition waste etc. The priority is to minimize this waste, recycle as much as possible and properly treat the small remaining amounts.

Recycled materials shall refer to those materials diverted from the waste stream, recovered and processed into new products following local government permits and regulations.

Boundary and Scope

The assessment boundary includes the whole city.

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Generally, Municipal Solid Waste is non-hazardous waste composed of food waste, garden waste, paper and cardboard, wood, textiles, nappies (disposable diapers), rubber and leather, plastics, metal, glass, and refuse (i.e. ash, dirt and dust).

Assessment method

This information should be obtained from the main water supply companies. If metered data aren't available, estimated data shall be used. The source of data must always be clearly declared.

The calculation steps are:

1. Calculate the total annual amount of the city's solid waste that is recycled
2. Calculate the total annual amount of solid waste produced in the city
3. Calculate the indicator's value as the percentage ratio of total annual amount of the city's solid waste that is recycled to the total annual amount of solid waste produced in the city.

Standards and References

- ISO 37120, Second edition 2018-07, "Sustainable cities and communities — Indicators for city services and quality of life"
- United for Smart Sustainable Cities (U4SSC) - Collection Methodology for Key Performance Indicators for Smart Sustainable Cities

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2.3.6. E1.2 Particulate matter (PM_{10}) concentration

Issue	E. Environmental quality	
Category	E1. Air quality	
Criterion	E1.2 Particulate matter (PM10) concentration	
Indicator	Annual average fine particulate matter (PM10) concentration	
Unit	μg/m^3	
Project stage	Design	In use
Data source	Metering	Metering

Intent

Assess the long-term ambient air quality with respect to particulates <10 μm (PM10) in the city

Description

Particulate matter (PM) consists of a complex mixture of solid and liquid particles of organic and inorganic substances suspended in the air, sulfate, nitrates, ammonia, sodium chloride, black carbon, mineral dust and water. PM affects more people than any other pollutant.

Coarse particles are greater than 2.5 μm and less than or equal to 10 μm in diameter and are defined as "respirable particulate matter" or PM10. Sources of coarse particles include crushing or grinding operations, and dust from paved or unpaved roads.

Boundary and Scope

The assessment boundary includes the whole city.

The location of each monitoring station should be chosen to convey the local representativeness of the measured values (e.g. airport, city center, industrial park). Ideally, multiple station locations should be used to determine a spatial average for the city.

This project has received funding from the European Union's ENI CBC Med Programme under Grant Contract C_B.4.3_0063

Assessment method

The calculation steps are:

1. Collect the PM10 concentration measurements for one year, from each monitoring station installed in the city's
2. Calculate the annual mean of PM10 concentration values measured for each monitoring station installed in the city's
3. Sum the annual mean PM10 concentration values for all monitoring stations
4. Calculate the indicator's value as the sum of annual PM10 concentration values divided by the number of monitoring stations

Standards and References

- ISO 37120, Second edition 2018-07, "Sustainable cities and communities — Indicators for city services and quality of life"
- United for Smart Sustainable Cities (U4SSC) - Collection Methodology for Key Performance Indicators for Smart Sustainable Cities

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2.3.7. F1.1 Public transport network

Issue	F. Transportation and mobility	
Category	F1. Performance of mobility services	
Criterion	F1.1 Public transport network	
Indicator	Length of public transport system per 1000 population	
Unit	km/1000 inhabitants	
Project stage	Design	In use
Data source	Metering	Metering

Intent

Estimate the promote the use of public / municipal transportation

Description

The extent of a city's transportation network can provide insight into traffic congestion, transportation system flexibility and urban form. Cities with larger amounts of public transport might tend to be more geographically compact and supportive of non-motorized modes of transportation

Public Transport includes metro, bus, minibus and tram

Boundary and Scope

The assessment boundary includes the whole city.

In the calculations the following should be considered:

- rail metro
- subway systems
- BRT (Bus Rapid Transit) systems
- commuter rail systems
- light rail
- streetcars/tramways

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- buses
- trolleybuses
- other passenger transport services

Information on length of public transport can be gathered from municipal transport offices and local/regional transit authorities or can be calculated from computerized mapping, aerial photography or existing paper maps, all of which should be field-verified.

Assessment method

The calculation steps are:

1. Calculate the total length of public transport lines operating within the city
2. Calculate the total population of the city
3. Calculate the indicator's value as the ratio of the total length of the public transport systems operating within the city to the total population of the city,
4. Express per 1000 occupants

Only one-way length of public transport lines is considered

Transport systems that cover the same route should be counted separately. For example, if a bus and streetcar cover the same 1-km route, this counts for 2 km.

Standards and References

- ISO 37120, Second edition 2018-07, "Sustainable cities and communities — Indicators for city services and quality of life"
- United for Smart Sustainable Cities (U4SSC) - Collection Methodology for Key Performance Indicators for Smart Sustainable Cities

2.3.8. F2.4 Bicycle network

Issue	F. Transportation and mobility	
Category	F2. Green mobility	
Criterion	F2.4 Bicycle network	
Indicator	Total length of bicycle paths and lanes divided by the city's total population	
Unit	m/inhabitant	
Project stage	Design	In use
Data source	Metering	Metering

Intent

Promote cycling as an alternative to vehicle use by providing safe and efficient mobility networks

Description

The calculation of bicycle paths can be performed by in situ measurements or by using maps and geographic information system.

Boundary and Scope

The assessment boundary includes the whole city.

For the calculations, bicycle paths taken into account should be physically separated from traffic roads and not be part of a "shared space"

A "shared space" is an urban design approach that minimizes the segregation between modes of road user (car, pedestrian, bicycle, etc.) in order to make safe space for every type of mobility; the shared space is to be used by anyone. This can be done through minimizing traffic signs, road surface markings, enforcing speed reduction down to 15-20 km/h.

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Assessment method

The calculation steps are:

1. Calculate the total length of bicycle paths/lanes in the city
2. Estimate/Calculate the total population of the city
3. Calculate the indicator's value as the ratio of total length of bicycle paths to the total population of the city

Standards and References

- UNECE - Collection Methodology for Key Performance Indicators for Smart Sustainable Cities

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2.3.9. I1.1 Greenhouse gas emissions

Issue	I. Climate change: mitigation and adaptation	
Category	I1. Climate change mitigation	
Criterion	I1.1 Greenhouse gas emissions	
Indicator	Total amount of greenhouse gases (equivalent carbon dioxide units) generated over a calendar year for all sectors, divided by the current city population	
Unit	t CO_2 eq. / inhabitant	
Project stage	Design	In use
Data source	Metering	Metering

Intent

Minimise the total greenhouse gas (GHG) emissions from all activities within a city.

Description

The GHG emissions from all activities within the city are an indicator of the adverse contribution the city is making to climate change.

The Global Warming Potential (GWP) was developed to allow for the comparison of the impact on global warming caused by different gases (such as carbon dioxide, methane, nitrous oxide, or chlorofluorocarbons). It is a measure of how much energy the emissions of 1 ton of a gas will absorb over a given period of time, relative to the emissions of 1 ton of carbon dioxide (CO_2). A higher GWP means a larger warming effect in that period of time (usually 100 years).

Boundary and Scope

The assessment boundary includes the whole city as well as indirect emissions outside city boundaries.

End-use sectors include :

- residential

- commercial
- industrial
- transportation
- other

Assessment method

The calculation steps are:

1. Calculate the total annual final energy consumption per energy source, by all activities within the city
2. Calculate the total amount of greenhouse gases generated over a calendar year by all activities within the city, using national global warming potential for each energy source
3. Calculate the total population of the city (permanent residents)
4. Calculate the indicator's value as the ratio of the total amount of greenhouse gases to the total population of the city

Standards and References

- ISO 37120, Second edition 2018-07, "Sustainable cities and communities — Indicators for city services and quality of life"
- United for Smart Sustainable Cities (U4SSC) - Collection Methodology for Key Performance Indicators for Smart Sustainable Cities

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2.3.10. I3.1 Permeability of land

Issue	I. Climate change: mitigation and adaptation	
Category	I3. Adaptation to the climatic action: pluvial flood	
Criterion	I3.1 Permeability of land	
Indicator	Percentage of weighted ground permeability	
Unit	%	
Project stage	Design	In use
Data source	Estimation	Metering

Intent

Improve the land permeability in order to reduce its impact on the hydrological cycle

Description

Permeability of land is the capacity to transmit water to the soil. It is a very important issue connected to the water recharging of aquifers and the reduction of effluents.

The calculation of distances can be performed by in situ measurements or by using maps and geographic information system

Boundary and Scope

The assessment boundary includes the whole city.

Reference permeability coefficients:

- Grass = 1
- Gravel = 0.9
- Sand = 0.9
- Plastic gratings filled with land/grass = 0.8
- Concrete gratings leaning on the grass = 0.6

- Concrete gratings leaning on gravel = 0.6
- Interlocking elements leaning on sand = 0.3
- Interlocking elements leaning on gravel = 0.3
- Interlocking elements leaning on concrete pavement = 0
- Continuous pavements leaning on concrete = 0
- Asphalt = 0

Assessment method

The calculation steps are:

1. Calculate the total surface area of the city
2. Calculate the area of the various surfaces with different coverings or occupied by constructions (i.e green areas, surfaces paved with asphalt, surfaces occupied by buildings, etc.). Include all the surfaces in the city
3. Calculate the weighted surface of the city, considering the permeability coefficients (αi) of the various surfaces (Ai)

$$\mathrm{A}_{C,p} = \sum_{i=1}^{n} (A_i \cdot \alpha_i)$$

4. Calculate the indicator's value as the percentage of the of the weighted surface of the city to total surface area of the city

Standards and References

- ISO 37120, Second edition 2018-07, "Sustainable cities and communities — Indicators for city services and quality of life"
- United for Smart Sustainable Cities (U4SSC) - Collection Methodology for Key Performance Indicators for Smart Sustainable Cities

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3. SMC Passport

The sustainability score produced by SMC rating system is valid only for the specific geographical area, as it reflects the local priorities and construction practice. In order to be able to compare the sustainability performance between buildings, neighborhoods or cities in the different Mediterranean regions, it is necessary to use indicators expressed in absolute values instead of scores.

This is the key principle of the SMC Passport, which provides the absolute values of the SMC Key Performance Indicators (KPIs). The Passport is available for

- Buildings,
- Neighbourhoods and
- Cities.

The Passport template is a graphical visualisation of the main information concerning the assessment and it includes two different pages. The first one contains general information as well as maps and significant images, in order to better represent the features of the analysis. The second page of the Passport contains the list of the Key Performance Indicators, together with their code, criterion, unit of measure and value. The Passport templates for the three assessment scales are presented in the following sections.

The SMC Passport has a similar layout with the CESBA MED Passport, in order to ensure continuity from the previous work. The contents have been enhanced to include more information (e.g. building envelope, building installations, heating degree days, etc) along with the updated and enhanced list of KPIs.

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3.1. SMC Passport – Building Scale

Sustainable MED Cities

NAME OF PILOT BUILDING | **SMC PASSPORT BUILDING**

Name ....

Building use ....

General location ....

City ....

Short description

....

....

....

MAP

IMAGE

General

Total plot area .... m²

Gross floor area .... m²

Useful floor area .... m²

Other info ....

Climate

Annual precipitation .... mm

Solar irradiance on horizontal .....kWh/m² y

Winter/ Summer design temperature ....°C

Heating Degree Days (base 18°C) ....HDD

Envelope

U-value of external walls ......W/m²K

U-value of roof ......W/m²K

U-value of floor ......W/m²K

U-value of windows ......W/m²K

Other info ....

HVAC & RES

Heating system ....

Cooling system ....

DHW system ....

Lighting system ....

Ventilation ....

RES ....

Other info ....

Sustainable MED Cities

NAME OF PILOT BUILDING | **SMC PASSPORT BUILDING**

SUSTAINABILITY KEY PERFORMANCE INDICATORS

CODE	CRITERION	INDICATOR	VALUE	UNIT
B1.1	Primary energy demand	Primary energy demand per internal useful floor area per year	....	$kWh/m^2/yr$
B1.2	Delivered thermal energy demand	Delivered thermal energy demand per internal useful floor area per year	....	$kWh/m^2/yr$
B1.3	Delivered electrical energy demand	Delivered electrical energy demand per internal useful floor area per year	....	$kWh/m^2/yr$
B1.4	Energy from renewable sources in total thermal energy consumption	Share of renewable energy in final thermal energy consumption	....	%
B1.5	Energy from renewable sources in total electrical energy consumption	Share of renewable energy in final electrical energy consumption	....	%
B1.6	Embodied non-renewable primary energy	Embodied primary non-renewable energy per internal useful floor area	....	MJ/m^2
B3.4	Recycled materials	Weight of recycled materials on total weight of materials	....	%
B4.3	Potable water consumption for indoor uses	Potable water consumption per occupant per year	....	m^3/occupant/yr
C1.1	Embodied carbon	Embodied carbon dioxide equivalents per internal useful floor area	....	kg CO_2eq/m^2
C1.2	GHG gas emissions during operation	CO_2 equivalent emissions per useful internal floor area per year	....	kg $CO_2eq/m^2/yr$
D1.2	TVOC concentration	TVOC concentration in indoor air	....	$\mu g/m^3$
D1.7	Mechanical Ventilation	Mechanical ventilation rate per useful internal floor area	....	$l/s/m^2$
D2.3	Thermal comfort index	Predicted Percentage of Dissatisfied (PPD)	....	%
D3.1	Daylight	Mean Daylight Factor	....	%
E1.2	Smart Readiness Indicator	Total smart readiness of buildings in terms of three key functionalities, i.e. responding to the needs of occupants, optimizing energy performance, interacting with energy grids	....	%
G1.4	Energy cost	Annual energy cost per useful internal floor area	....	€/m^2/yr
H1.2	Heat island effect	Mean Solar Reflectance Index of paved surfaces and roofs in the area	....	

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3.2. SMC Passport – Neighborhood Scale

Sustainable MED Cities

NAME OF PILOT NEIGHBORHOOD

SMC PASSPORT NEIGHBORHOOD

Name	....
Total area (Km^2)	....
General location	....
City	....

Short description

....

....

....

MAP

IMAGE

Demography

Residential population in the area	.... inhab
Urban residential density	...... inhab /ha
Population working in the area	...... persons
Other info	

Climate

Annual precipitation	.... mm
Solar irradiance on horizontal	.....kWh/m^2 y
Winter/ Summer design temperature	...............°C
Heating Degree Days (base 18°C)	...........HDD

Building stock

Number of buildings in the area	......number
Gross area of Residential buildings	.... m^2
Gross area of Office buildings	.... m^2
Gross area of Retail/Commercial buildings	.... m^2
Total gross area of all buildings	.... m^2
Total gross area of buildings constructed before 1975	.... m^2
Average building density (total m^2 / land surface in m^2)	......number

Use of land and morphology

Percentage of consumed land area	..... %
Total length of urban streets with sidewalks	...... km
Total length of bicycle lanes	...... m
Other relevant info	

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Sustainable MED Cities

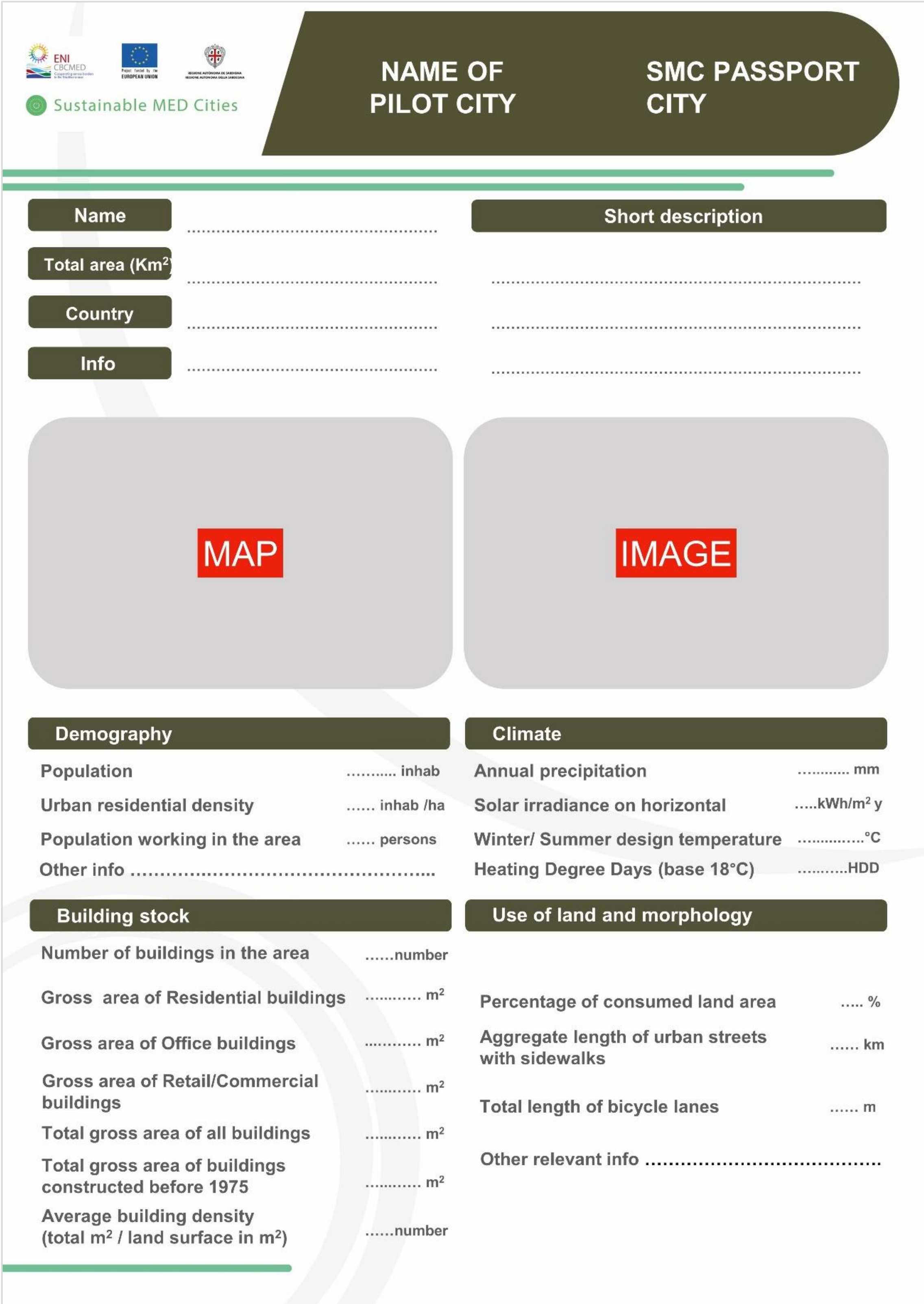
NAME OF PILOT NEIGHBORHOOD

SMC PASSPORT NEIGHBORHOOD

SUSTAINABILITY KEY PERFORMANCE INDICATORS

CODE	CRITERION	INDICATOR	VALUE	UNIT
B2.1	Total final thermal energy consumption for building operations	Aggregated annual total final thermal energy consumption per aggregated indoor useful floor area	....	kWh/m²/yr
B2.4	Total final electric energy consumption for building operations	Aggregated annual total final electric energy consumption per aggregated indoor useful floor area	....	kWh/m²/yr
B2.7	Total primary energy demand for building operations	Aggregated annual total primary energy consumption per aggregated indoor useful floor area	....	kWh/m²/yr
B3.1	Share of renewable energy on-site, in total final thermal energy consumption for building operations	Annual total thermal energy consumption from on-site renewable energy sources / annual total final thermal energy consumption	....	%
B3.4	Share of renewable energy on-site, in final electrical energy consumption for building operations	Annual total electrical energy consumption from on-site renewable energy sources / annual total electrical energy consumption	....	%
B3.7	Share of renewable energy on-site in total primary energy consumption for building operations	Annual total consumption of primary energy generated from renewable sources on-site / total primary energy consumption	....	%
C2.3	Consumption of potable water in residential buildings	Annual potable water consumption per occupant	....	L /occupant/yr
D2.2	Access to solid waste and recycling collection points	Percentage of inhabitants with access to solid waste and recycling collection points within 400 meters walking distance	....	%
E1.2	Particulate matter (PM10) concentration	Number of days within a year that PM10 concentration exceeds the daily limit	....	days/yr
F1.1	Performance of the public transport system	Percentage of inhabitants that are within 400 meters walking distance of at least one public transportation service stop	....	%
F2.3	Bicycle network	Length of bicycle paths in the neighborhood per inhabitant	....	m/inhabitant
G3.1	Availability and proximity of key services	Percentage of inhabitants that are within 800 meters walking distance of at least 3 key services	....	%
I1.1	Greenhouse gas emissions	Total amount of greenhouse gases (equivalent carbon dioxide units) generated from buildings' operation over a calendar year per inhabitant	....	t CO_2 eq./ inhabitant/yr
I3.3	Permeability of land	Percentage of weighted ground permeability	....	%

3.3. SMC Passport – City Scale



Sustainable MED Cities

NAME OF PILOT CITY

SMC PASSPORT CITY

Name ....

Total area (Km²) ....

Country ....

Info ....

Short description

....

....

....

MAP

IMAGE

Demography

Population .... inhab

Urban residential density ...... inhab /ha

Population working in the area ...... persons

Other info ....

Climate

Annual precipitation .... mm

Solar irradiance on horizontal .....kWh/m² y

Winter/ Summer design temperature ....°C

Heating Degree Days (base 18°C) ....HDD

Building stock

Number of buildings in the area ......number

Gross area of Residential buildings .... m²

Gross area of Office buildings .... m²

Gross area of Retail/Commercial buildings .... m²

Total gross area of all buildings .... m²

Total gross area of buildings constructed before 1975 .... m²

Average building density (total m² / land surface in m²) ......number

Use of land and morphology

Percentage of consumed land area ..... %

Aggregate length of urban streets with sidewalks ...... km

Total length of bicycle lanes ...... m

Other relevant info ....

Sustainable MED Cities

NAME OF PILOT CITY

SMC PASSPORT CITY

SUSTAINABILITY KEY PERFORMANCE INDICATORS

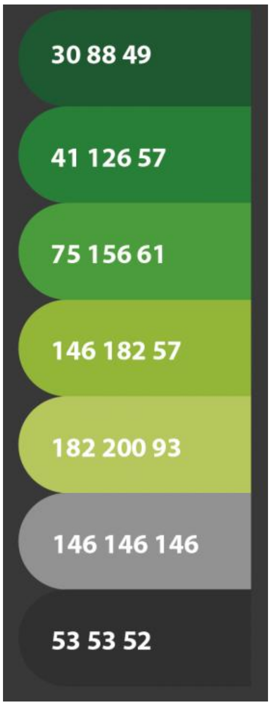
CODE	CRITERION	INDICATOR	VALUE	UNIT
A2.1	Availability of green urban areas	Total amount of green urban areas in the city's boundaries divided by the total area of the city	………..	%
B2.1	Final energy consumption	Total final energy consumed by a city divided by the total population of the city	………..	MWh/inhabitant/yr
B3.1	Final energy derived from renewable sources	Share of renewable energies in final energy demand	………..	%
C2.1	Total water consumption	Total amount of the city's daily water consumption divided by the total city population	………..	L/day/person
D2.2	Solid waste recycling	Total amount of solid waste that is recycled divided by the total amount of solid waste produced in the city	………..	%
E1.2	Particulate matter (PM10) concentration	Annual average fine particulate matter (PM10) concentration	………..	µg/m^3
F1.1	Public transport network	Length of public transport system per 1000 population	………..	km/1000 inhabitants
F2.4	Bicycle network	Total length of bicycle paths and lanes divided by the city's total population	………..	m/inhabitant
I1.1	Greenhouse gas emissions	Total amount of greenhouse gases (equivalent carbon dioxide units) generated over a calendar year for all sectors, divided by the current city population	………..	t CO_2 eq. /inhabitant/yr
I3.1	Permeability of land	Percentage of weighted ground permeability	………..	%

4. SMC Certificate

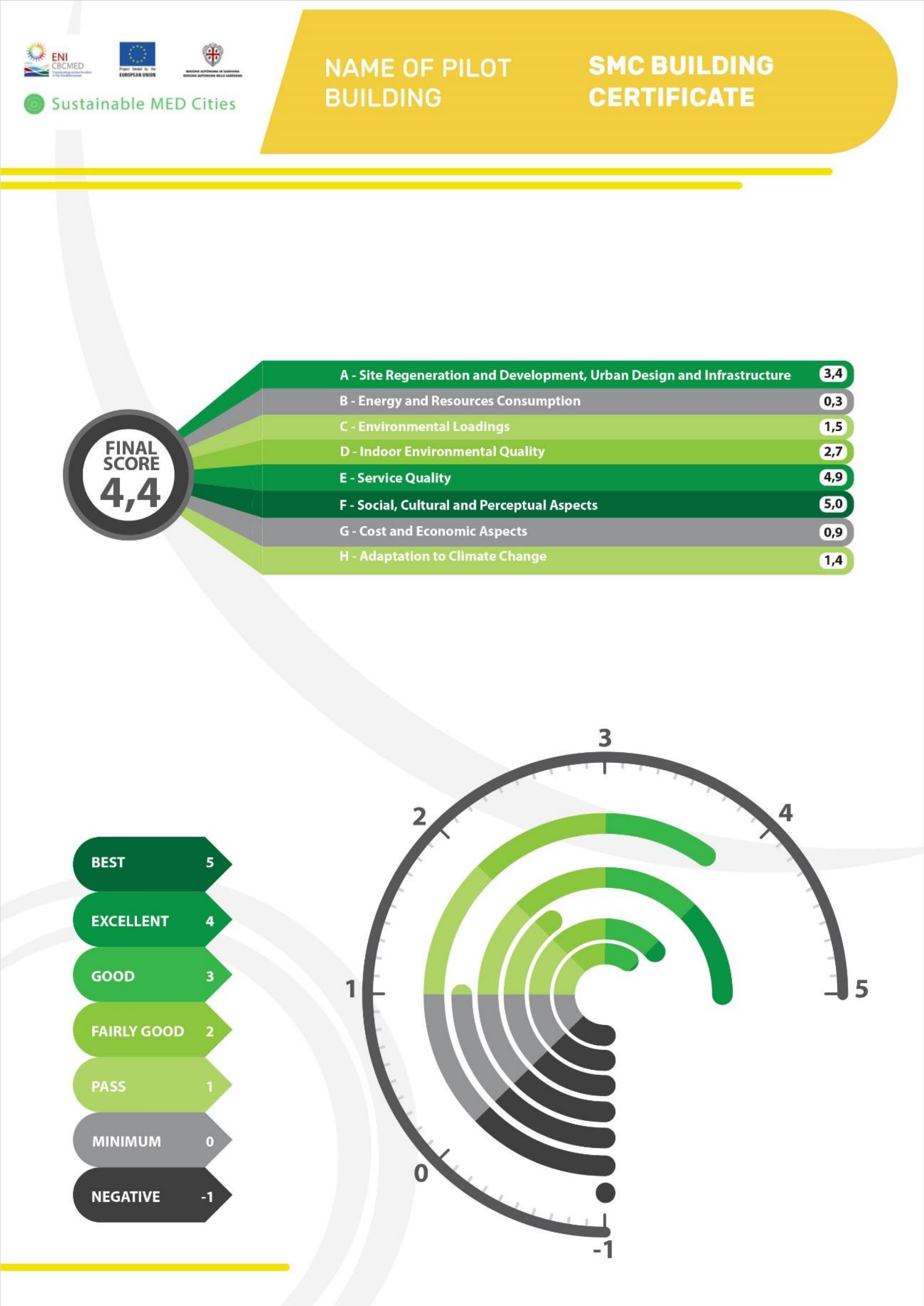
In addition to the Passport, the testing activity also produces a Certificate. The document summarizes the scores achieved in each area of the assessment system, giving the final score of the sustainability. Scores are then illustrated using a tachometer with a graduated scale which goes from the -1 (negative performance) to the 5 points (best performance).

The Certificate template is a graphic label which allows, in a visual way, to understand the sustainability performance obtained by the building, neighbourhood and city. The SMC Certificate has a similar layout with the CESBA MED Certificate, with some slight changes.

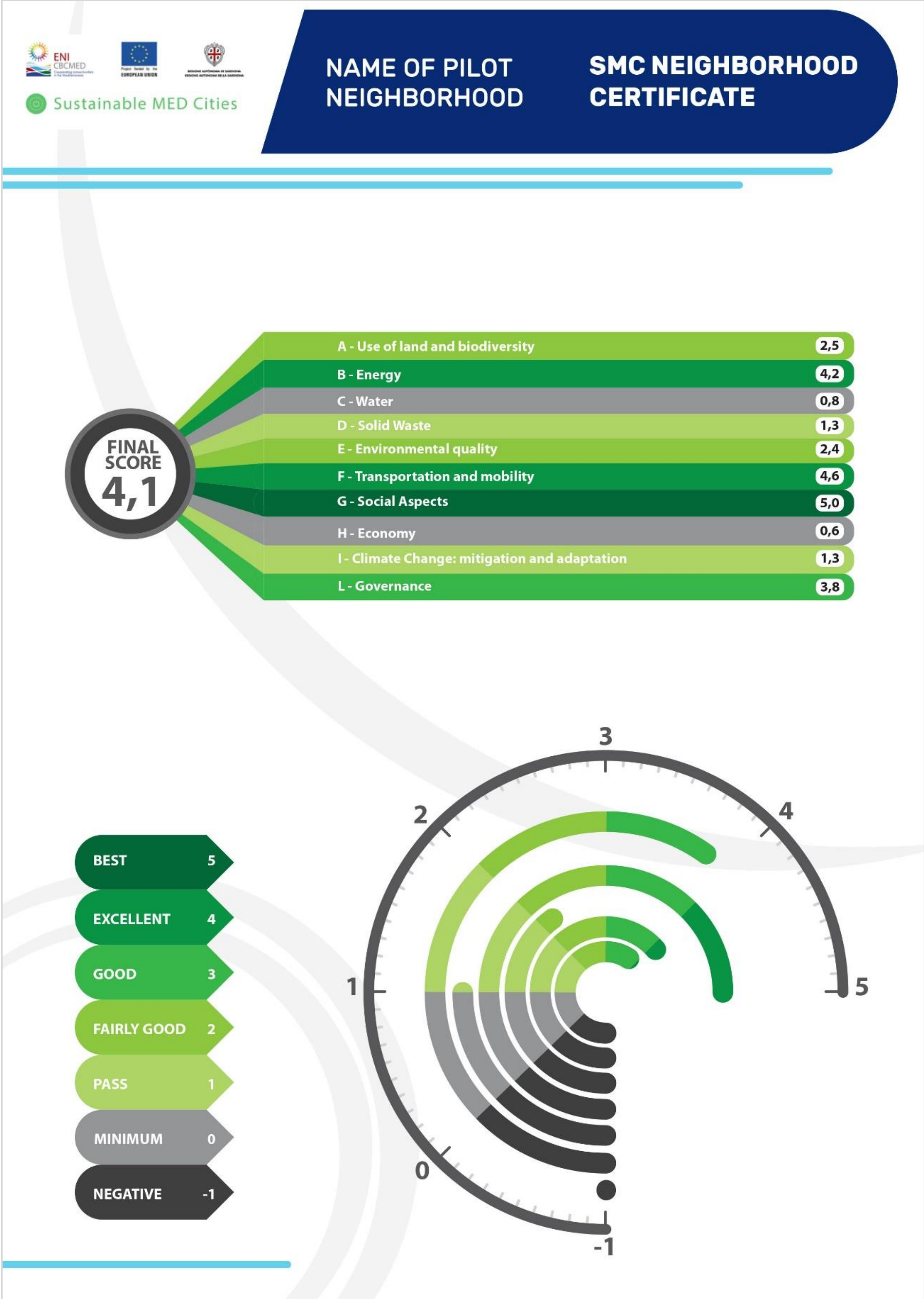
The image below describes the “Font colours” used for the Certificate.



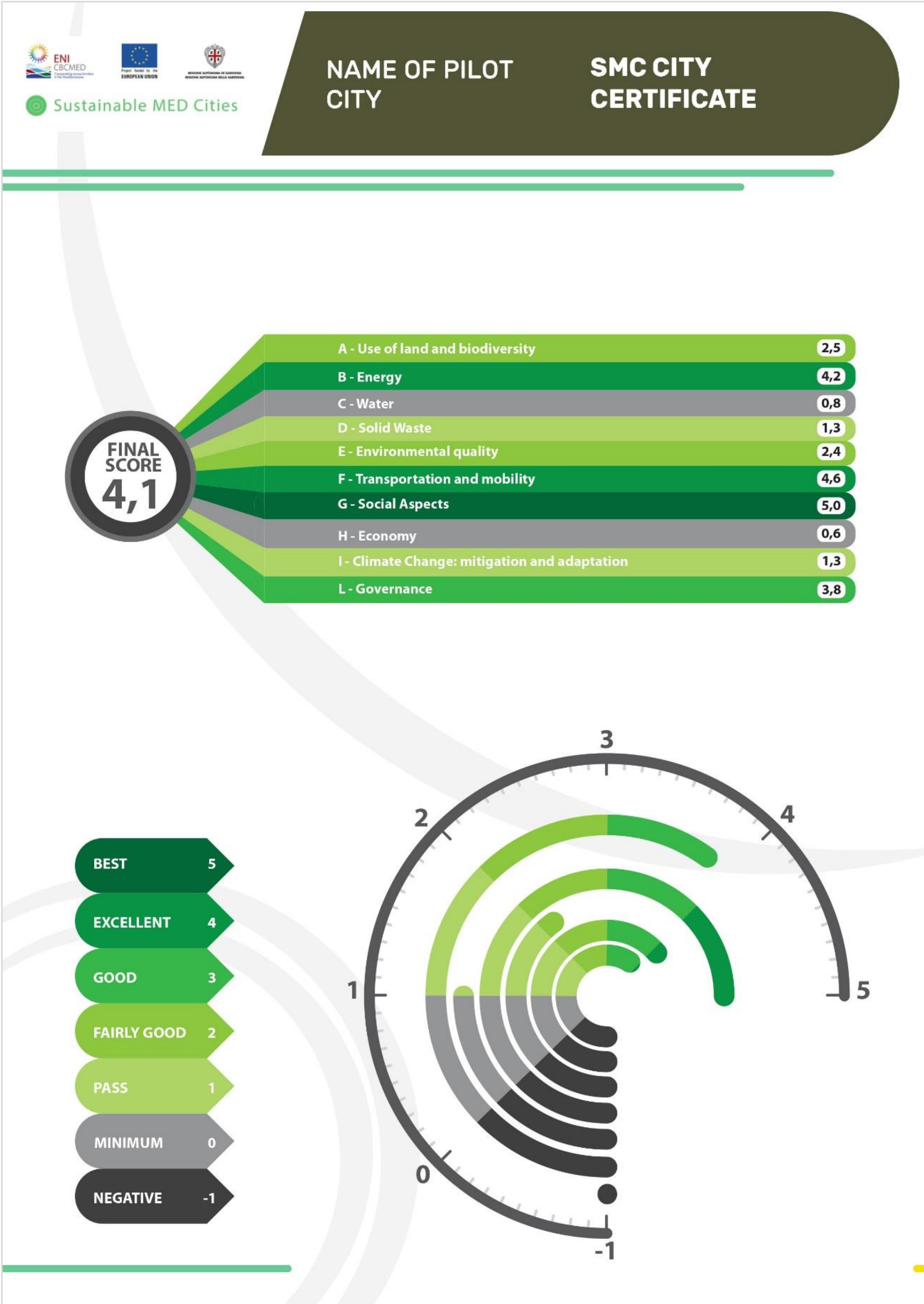
4.1. SMC Certificate – Building Scale



4.2. SMC Certificate – Neighbourhood Scale



4.3. SMC Certificate – City Scale



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