MONITORING KPI GUIDE

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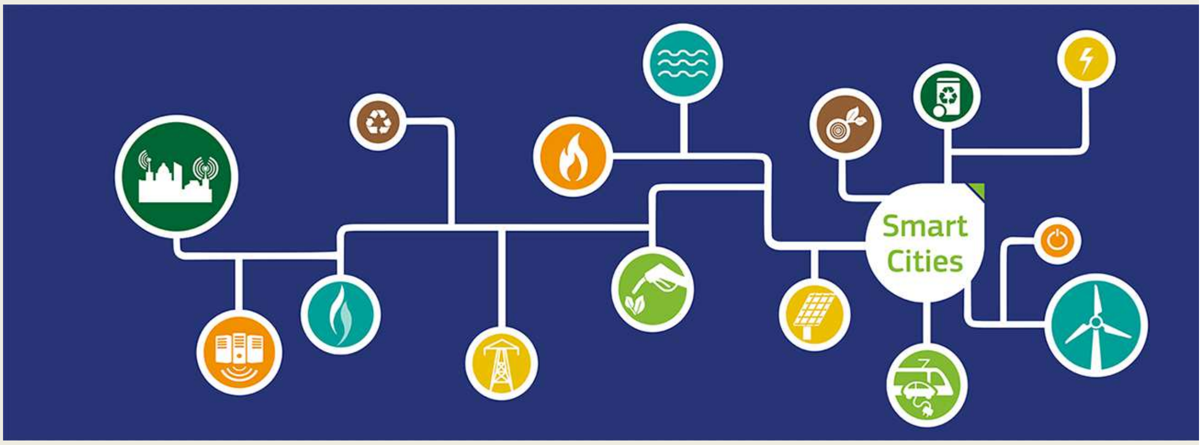

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EXECUTIVE SUMMARY

The objective of this guide is to give a description of SCIS key performance indicators and their application to the different objects of assessment, identify the data requirements for their calculation and describe the methodology for the calculation of these indicators.

This updated guide develops further the indicator methodology that originates from the CONCERTO programs and that was significantly expanded by the SCIS 1 consortium. The need for this update was the expanding scope for the projects funded in the field of the energy transition of the built environment like EeB and the Smart City and Community projects. Especially the latter included mobility and ICT related topics.

This new version is based on the previous guide and three important events that took place in the first half year of 2018:

- Eurocities Knowledge Society Forum workshop, April 17, 2018, Gent (BE), organized by Eurocities
- SCIS Indicator workshop with external participation (ISO TC 268 Sustainable Cities & Communities), March 13, 2018
- SCIS Meeting with EU project officer on May 16, 2018

The first two events were used to collect feedback from "the field" on the indicator set that needed to be further developed, being the Mobility and Transport and ICT related indicators. These were already described in the previous guide, but not yet implemented in the SCIS platform. General feedback was to be prudent with indicators and to keep them manageable. The draft ISO Standard on Smart Cities and Communities[1] (TC 268) contains about 400 city indicators and this immense amount has been one of the reasons to send it back to the drawing board.

The team therefore reviewed the available indicators and made them more applicable to the projects in scope. The renewed list has been discussed with the SCIS project officer. The list has been approved and is now being implemented.

In this KPI guide, maximum alignment is pursued with the implementation in the Self Reporting Tool (SRT). The KPI guide is therefore a useful addition to the SRT Guide, giving more background to the indicators and the methodologies for turning measurements into indicators.

[1]https://www.iso.org/standard/69050.html

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1 INTRODUCTION

1.1 Objectives

The objective of this guide is to give a description of SCIS key performance indicators and their application to the different objects of assessment, identify the data requirements for their calculation and describe the methodology for the calculation of these indicators.

SCIS focuses on the development of indicators to measure technical and economic aspects of energy, mobility and ICT related measures in projects. These should be applicable to European funded demonstration projects for Smart Cities and Communities (SCC), Energy Efficient buildings (EeB) and designated projects funded under the calls for Energy Efficiency (EE).

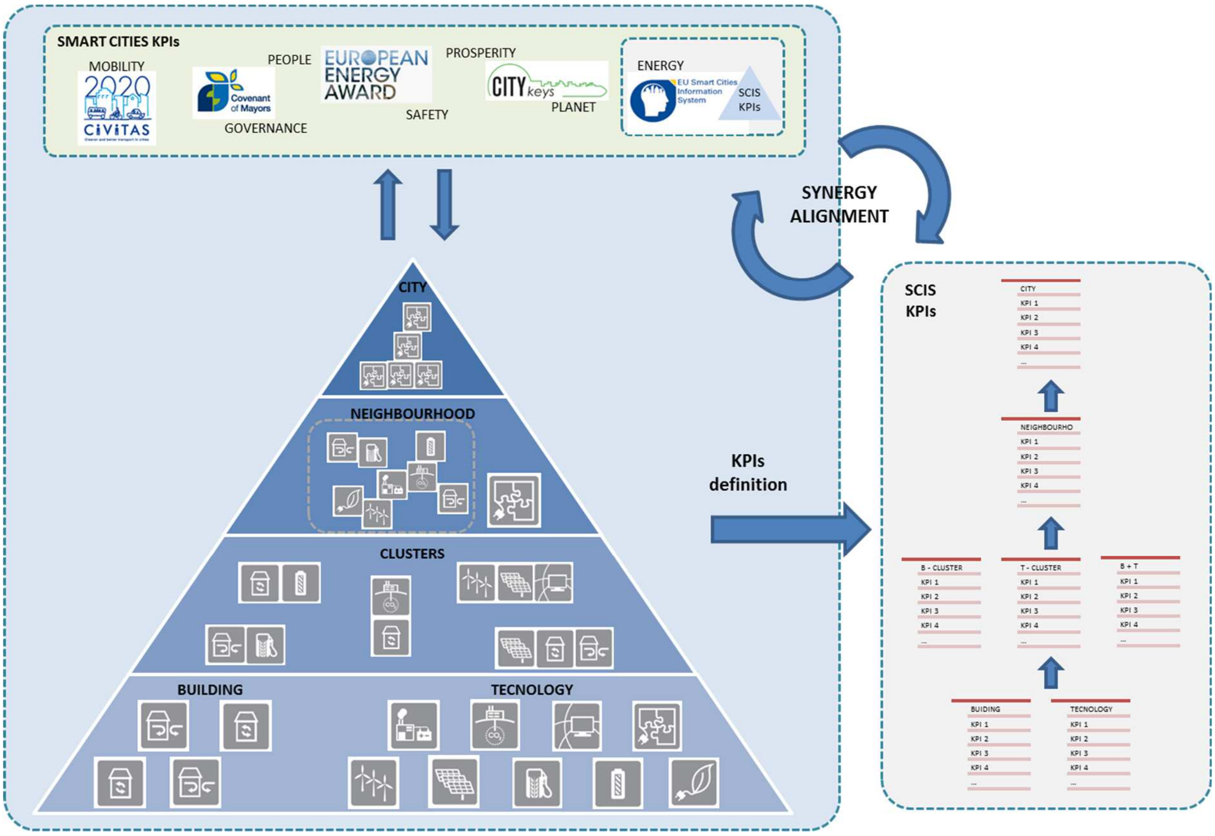

Figure 1-1: SCIS KPIs framework development

Figure 1-1 shows how the SCIS KPIs framework has been initially developed by SCIS 1, through alignment with other initiatives and projects at European level as well as the consulting of ISO officials by SCIS 2[2]. In this figure, it can be observed that due to the complexity and variety of the projects in scope, the indicators will be calculated for different aggregation levels (building, set of buildings, energy supply unit, set of energy supply units, neighbourhood…). Some of the KPIs at the upper levels can be calculated from simple addition of the lower levels, while some other KPIs are specific of each level.

[2] Bernard Gindroz

SCIS will contribute to a general Smart Cities KPIs framework through the definition of indicators with a focus on energy, mobility and related ICT aspects. Additionally, other indicators are being developed by other initiatives focusing on other city aspects such as governance, people, safety and prosperity. These are not the focus of SCIS. It is worth emphasizing that SCIS focuses on demonstration projects and not on entire cities. The indicators implemented reflect this.

1.2 Sources for KPIs

The implementation of SCIS indicators has been done through alignment with other initiatives and already existing indicator sets. Different frameworks for KPIs have been analysed and compared. Indicators focusing on energy and environmental aspects from different projects have been collected and additional ones have been included through the analysis of demonstration projects in scope. The main aim of this indicator list is to allow for comparability between projects.

The following sources have been used:

- CONCERTO Premium Indicator Guide
- CONCERTO Premium Guidebook for Assessment
- H2020 work programme, 2016-2017. 10. 'Secure, Clean and Efficient Energy'
- ISO 37120: 2014_Sustainable development of communities – Indicators for city services and quality of life [ISO 37120]
- Citykeys project
- European Innovation Partnership on Smart Cities and Communities - Operational Implementation Plan [EIP - OIP]
- Specific Project KPIs from CELSIUS SCC project and CiTyFied FP7 project
- International Telecommunication Union - Focus Group on Smart Sustainable Cities: Key performance indicators related to the use of information and communication technology in smart sustainable cities [ITU-T]
- “Ideal grid for all- IDE4L project”, funded by the European Electrical Grid Initiative
- European Energy Award [eea]
- Covenant of Mayors [CoM]
- CIVITAS
- GRID+
- DIN EN 15603:2008-07
- Workshop with Bermard Gindroz of ISO

Although most indicators related to buildings and energy provision were initially taken over from CONCERTO Premium, the explanation provided by projects (i.e. CiTyFied, CELSIUS) gave a better insight into the practical application of KPIs and has therefore been preferred as definition in most of the cases. This was in line with the bottom-up approach followed by SCIS in the definition of indicators.

1.3 Reference systems

For the calculation of indicators and the assessment of the energy performance, different sets of data are needed. These include baseline scenario, design data and monitoring data. When this guide refers to reference systems, it compares the actual system object of assessment with:

- System before the invervention when a retroffiting intervention is being assesed.
- Reference or standard system in the same category as the specific demo system when a new system is being assesed. E.g. standard building that is designed exactly in accordance with the requirements and regulations that were in place for this building type when the building was designed.

The indicators defined in this guide can also be calculated as a reduction or increase of, for example, the energy performance in comparison with the baseline or the designed data. Therefore, this will allow the comparison between:

- Design data and baseline scenario: foreseen improvement compared to the typical solution.
- Monitoring data and baseline scenario: real improvement compared to the typical solution
- Monitoring data and design data: comparison of achieved performance against prediction, this can also be defined as a separate indicator (quality of prediction).

A detailed explanation of each of the cases can be found in APPENDIX III.

1.4 Structure

KPIs can be divided in two clusters:

- Core KPIs: those KPIs identified as the most relevant for SCIS and which should be implemented by the projects in scope of SCIS. Some of these KPIs may not apply to all projects.
- Supporting KPIs: relevant for SCIS, their use is recommended.

2 CORE KPIS

2.1 General technical performance indicators

2.1.1 Energy demand and consumption

Applicability for objects of assessment

Building	X
Set of Buildings	X
Energy Supply Unit	

Set of Energy Supply Units	
Neighbourhood	X
City	X

<table>
<tr><td>Definition</td><td>The energy demand/consumption corresponds to the energy entering the system in order to keep operation parameters (e.g. comfort levels). The energy demand is based on the calculated (e.g. simulated) figures and the energy consumption is based on the monitored data. To enable the comparability between systems, the total energy demand/consumption is related to the size of the system and the time interval. This indicator can be used to assess the energy efficiency of a system.</td></tr>
<tr><td>Input Parameters & Calculation</td><td><u>At Building Level</u>

• $E_d = \frac{TE_d + EE_d}{A_b}$

E_d Energy demand (simulated)
TE_d Thermal energy demand (simulated) [kWh/ (month); kWh/ (year)]
EE_d Electrical energy demand (simulated) [kWh/ (month); kWh/(year)]
A_b Floor area of the building [m^2]

• $E_c = \frac{TE_c + EE_c}{A_b}$

$E1_c$ Energy consumption (monitored)
TE_c Thermal energy consumption (monitored) [kWh/(month) ; kWh/(year) MWh/(year)]
EE_c Electrical energy consumption (monitored) [kWh/(month) ; kWh/(year) MWh/(year)]
A_b Floor area of the building [m^2]

<u>At district level</u>

$E_{district\ demand}$ Energy demand (simulated) of the district (buildings, excluding mobility & infrastructure) (weighted average over the buildings)</td></tr>
</table>

	• $E_{district\ demand} = \sum(E_d * A_b)/A_{total}$ Energy consumption (monitored) of the district (buildings, excluding mobility & infrastructure) (weighted average over the buildings) • $E_{district\ consumption} = \sum(E_c * A_b)/A_{total}$
Unit	kWh/ (m^2 month); kWh/(m^2 year)
References	• Cityfied project. • DIN EN 15603:2008-07. (2008) Energy performance of buildings – Overall energy use and definition of energy ratings
Source	• Vasallo A.: CITyFiED KPIs Monitoring update v5, p.7

2.1.2 Energy savings

Applicability for objects of assessment

Building	X		Set of Energy Supply Units	
Set of Buildings	X		Neighbourhood	X
Energy Supply Unit			City	X

Definition	This KPI determines the reduction of the energy consumption to reach the same services (e.g. comfort levels) after the interventions, taking into consideration the energy consumption from the reference period. ES may be calculated separately determined for thermal (heating or cooling) energy and electricity, or as an addition of both to consider the whole savings.
Input Parameters & Calculation	$$ES_T = ER_T - TE_C$$ ES_T Thermal energy savings TE_c Thermal energy consumption of the demonstration-site [kWh/(m^2 year) MWh/(year)] ER_T Thermal energy reference demand or consumption (simulated or monitored) of demonstration-site [kWh/(m^2 year); MWh/(year)]. $$ES_E = ER_E - EE_C$$ ES_E Electrical energy savings EE_c Electrical energy consumption of the demonstration-site [kWh/(m^2 year) MWh/(year)] ER_E Electrical energy reference demand or consumption (simulated or monitored) of the demonstration-site [kWh/(m^2 year) MWh/(year)].
Unit	kWh/(m^2 year); MWh/(year)

References	• CITyFiED project.
Source	• Vasallo A.: CITyFiED KPIs Monitoring update v5, p.8

2.1.3 Degree of energetic self-supply by RES

Applicability for objects of assessment

Building	X
Set of Buildings	X
Energy Supply Unit	

Set of Energy Supply Units	
Neighbourhood	X
City	X

Definition	The degree of energetic self-supply by RES is defined as ratio of locally produced energy from RES and the energy consumption over a period of time (e.g. month, year). DE is separately determined for thermal (heating or cooling) energy and electricity. The quantity of locally produced energy is interpreted as by renewable energy sources (RES) produced energy.
Input Parameters & Calculation	• $DE_T = \frac{LPE_T}{TE_c}*100$ DE_T Degree of thermal energy self-supply based on RES LPE_T Locally produced thermal energy [kWh/month ; kWh/year] TE_c Thermal energy consumption (monitored) [kWh/(month) ; kWh/(year)] **Formula**: • $DE_E = \frac{LPE_E}{EE_c} * 100$ DE_E Degree of electrical energy self-supply based on RES LPE_E Locally produced electrical energy [kWh/month ; kWh/year] EE_c Electrical energy consumption (monitored) [kWh/(month) ; kWh/(year)]
Unit	%
References	• CITyFiED project.
Source	• Vasallo A.: CITyFiED KPIs Monitoring update v5, p.13

2.2 General environmental performance indicators

2.2.1 Greenhouse Gas Emissions

Applicability for objects of assessment

Building	X
Set of Buildings	X
Energy Supply Unit	X

Set of Energy Supply Units	X
Neighbourhood	X
City	X

Definition	The greenhouse gas, particulate matter, NO_x and SO_2 emissions of a system correspond to the emissions that are caused by different areas of application. In different variants of this indicator the emissions caused by the production of the system components are included or excluded. SCIS only excludes these emissions. To enable the comparability between systems, the emissions can be related to the size of the system (e.g. gross floor area or net floor area, heated floor area) and the considered interval of time (e.g. month, year). The greenhouse gases are considered as unit of mass (tones, kg.) of CO_2 or CO_2 equivalents.
Input Parameters and Calculation	<u>District Level:</u> $$GGE = \frac{TE_c \cdot GEF_T + EE_c \cdot GEF_E}{A_b}$$ GGE Greenhouse gas emissions for buildings TE_c Thermal energy consumption (monitored) of the demonstration site [kWh/ (month); kWh/ (year)] EE_c Electrical energy consumption (monitored) of the demonstration site [kWh/ (month); kWh/ (year)] GEF_T Greenhouse gas emission factor for thermal energy (weighted average based on thermal energy production source/fuel mix) (kg CO2eq/kWh consumed) GEF_E Greenhouse gas emission factor for electrical energy (weighted average based on electricity production source/fuel mix) (kg CO2eq/kWh consumed) A_b Floor area of the building [m^2]
Unit	kg CO2eq/ (m^2 *month); kg CO2eq/ (m^2 *year) kg CO2eq/ (kWh *year)
References	• DIN EN 15603:2008-07. (2008) Energy performance of buildings – Overall energy use and definition of energy rating • CITyFiED project.
Source	• Vasallo A.: CITyFiED KPIs Monitoring update v5, p.9

2.2.2 Primary Energy Demand and Consumption

Applicability for objects of assessment

Building	X
Set of Buildings	X
Energy Supply Unit	X

Set of Energy Supply Units	X
Neighbourhood	X
City	X

Definition	The primary energy demand/consumption of a system encompasses all the naturally available energy that is consumed in the supply chains of the used energy carriers. To enable the comparability between systems, the total primary energy demand/consumption can be related to the size of the system (e.g. conditioned area) and the considered time interval (e.g. month, year). (Demand is here defined as "design consumption". Consumption is actual/monitored energy consumption.)
Input Parameters & Calculation	<u>At building level</u> • $PE_d = \frac{TE_d \cdot PEF_T + EE_d \cdot PEF_E}{A_b}$ PE_d Primary energy demand (simulated) TE_d Thermal energy demand (simulated) [kWh/(month) ; kWh/(year)] EE_d Electrical energy demand (simulated) [kWh/(month) ; kWh/(year)] PEF_T Primary energy factor for thermal energy (weighted average based on source/fuel mix in production) PEF_E Primary energy factor for electrical energy (weighted average based on source/fuel mix in production) A_b Floor area of the building [m²] Formula: • $PE_c = \frac{TE_c \cdot PEF_T + EE_c \cdot PEF_E}{A_b}$ PE_c Primary energy consumption (monitored) TE_c Thermal energy consumption (monitored) [kWh/(month) ; kWh/(year)] EE_c Electrical energy consumption (monitored) [kWh/(month) ; kWh/(year)] PEF_T Primary energy factor for thermal energy (weighted average based on source/fuel mix in production) PEF_E Primary energy factor for electrical energy (weighted average based on source/fuel mix in production) A_b Floor area of the building [m²] <u>At district level:</u> $PE_{district\ primary\ demand}$ Primary energy demand (simulated) of the district • $PE_{district\ primary\ demand} = \sum \mathrm{PE}_d$ $PE_{district\ primary\ consumption}$ Primary energy consumption (monitored) of the district.

	• $PE_{district\ primary\ consumption} = \sum PE_c$
Unit	kWh/(m^2 * Year);
References	• CITyFiED project • DIN EN 15603:2008-07. (2008) Energy performance of buildings – Overall energy use and definition of energy ratings.
Source	• Vasallo A.: CITyFiED KPIs Monitoring update v5, p.8

2.2.3 Carbon dioxide Emission Reduction

Applicability for objects of assessment

Building	X
Set of Buildings	X
Energy Supply Unit	X

Set of Energy Supply Units	X
Neighbourhood	X
City	X

Definition	Greenhouse gases (GHGs) are gases in the atmosphere that absorb infrared radiation that would otherwise escape to space; thereby contributing to rising surface temperatures. There are six major GHGs: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF_6) (ISI/DIS 37120, 2013). The warming potential for these gases varies from several years to decades to centuries. CO2 accounts for a major share of Green House Gas emissions in urban areas. The main sources for CO2 emissions are combustion processes related to energy generation and transport. CO2 emissions can therefore be considered a useful indicator to assess the contribution of urban development on climate change.
Input Parameters & Calculation	The emitted mass of CO2 is calculated from the delivered and exported energy for each energy carrier: $m_{CO_2} = \sum(E_{del,i} K_{del,i}) - \sum(E_{exp,i} K_{exp,i})$ Where $E_{del,i}$ *is the delivered energy for energy carrier i* into object of assessment; $E_{exp,i}$ *is the exported energy for energy carrier i* out of object of assessment; $K_{del,i}$ *is the CO2 emission coefficient for delivered energy carrier i*; $K_{exp,i}$ *is the CO2 emission coefficient for the exported energy carrier i*. The indicator is calculated as the direct (operational) reduction of the CO2 emissions over a period of time. The result may be expressed as a percentage when divided by the reference CO2 emissions. To calculate the direct CO2 emissions, the total energy reduced, can be translated to CO2 emission figures by using conversion factors for

different energy forms as described in below tables: National and European emission factors for consumed electricity (source: Covenant of Mayors).

National and European emission factors for

Country	Standard emission factor ($t\ CO_2/MWh_e$)
Austria	0.209
Belgium	0.285
Germany	0.624
Denmark	0.461
Spain	0.440
Finland	0.216
France	0.056
United Kingdom	0.543
Greece	1.149
Ireland	0.732
Italy	0.483
Netherlands	0.435
Portugal	0.369
Sweden	0.023
Bulgaria	0.819
Cyprus	0.874
Czech Republic	0.950
Estonia	0.908
Hungary	0.566
Lithuania	0.153
Latvia	0.109
Poland	1.191
Romania	0.701
Slovenia	0.557
Slovakia	0.252
EU-27	**0.460**

Standard Emission factors for fuel combustion – most common fuel types (IPCC, 2006)

Standard CO2 emission factors (from IPCC, 2006) and CO2-equivalent LCA emission factors (from ELCD) for most common fuel types

Type	Standard emission factor [$t\ CO_2/MWh$]	LCA emission factor [$t\ CO_2$-eq/MWh]
Motor Gasoline	0.249	0.299
Gas oil, diesel	0.267	0.305
Residual Fuel Oil	0.279	0.310
Anthracite	0.354	0.393
Other Bituminous Coal	0.341	0.380
Sub-Bituminous Coal	0.346	0.385
Lignite	0.364	0.375
Natural Gas	0.202	0.237
Municipal Wastes (non-biomass fraction)	0.330	0.330
Wood [a]	0 – 0.403	0.002[b] – 0.405

a Lower value if wood is harvested in a sustainable manner, higher if harvesting is unsustainable.
b The figure reflects the production and local/regional transport of wood, representative for Germany, assuming: spruce log with bark; reforested managed forest; production mix entry to saw mill, at plant;

	and 44% water content. The local authority using this emission factor is recommended to check that it is representative for the local circumstances and to develop an own emission factor if the circumstances are different.
Unit	tonnes/(year), kg/year
References	• ISO/DIS 37120 (2013). Sustainable development and resilience of communities — Indicators for city services and quality of life. ICS 13.020.20 • Covenant of Mayor: http://www.eumayors.eu/IMG/pdf/technical_annex_en.pdf • CITYkeys project
Source	• Covenant of Mayors (http://www.eumayors.eu/IMG/pdf/technical_annex_en.pdf p.3), quoted in: Citykeys indicators for smart city projects and smart cities (p.101-103)

2.3 General economic performance indicators:

2.3.1 Total Investments

Applicability for objects of assessment

Building	X
Set of Buildings	X
Energy Supply Unit	X

Set of Energy Supply Units	X
Neighbourhood	X
City	X

Definition	An investment is defined as an asset or item that is purchased or implement with the aim to generate payments or savings over time. The investment in a newly constructed system is defined as cumulated payments until the initial operation of the system. The investment in the refurbishment of an existing system is defined as cumulated payments until the initial operation of the system after the refurbishment. (grants are not subtracted) Within SCIS, total investments apply to the energy aspects of the system (e.g. high efficient envelope in a building) and exclude investments non-energy related (e.g. refurbishment of bathrooms). To be meaningful, within SCIS, also the investments for a business as usual case is taken into account.
Input Parameters & Calculation	$$EPI_{BR} = \frac{I_{BR}}{A_d}$$ EPI_{BR} Total investment for all the interventions related to energy aspects in the district per conditioned area [€/m^2] I_{BR} Total investment for all the interventions related to energy aspects [€] A_d Total floor area of the system renovated [m^2] $$EPI_{ER} = \frac{I_{ER}}{A_d}$$ EPI_{ER} Total investment for all the interventions related to energy retrofitting (in the district) per conditioned area [€/m^2] I_{ER} Total investment for all the interventions related to energy retrofitting [€]

	A_d Total floor area of the district renovated $[\mathrm{m}^2]$ (subscript ER means energy retrofitting, subscript BR means building retrofitting)
Unit	€/m² (building company); €/kW (energy company)
References	• Bergknut, P. Elmgren, J. & Hentzel, M. (1993) Investering. I teori och praktik. Femte upplagan. Lund: Studentlitteratur. • CITyFiED project. • European Committee of Construction Economists. (2008). CEEC Code of Measurement for Cost Planning. • DIN 276-1:2008-12. (2008). Code DIN 276-1:2008-12 Building Costs - Part 1- Building Construction. • VDI 2067 – Part 1: (2000) Economic efficiency of building installations Fundamentals and economic calculation Economic efficiency of building installations.
Source	• Bergknut, P. Elmgren, J. & Hentzel, M. (1993) Investering. I teori och praktik. Femte upplagan. Lund: Studentlitteratur, quoted in: Vasallo A.: CITyFiED KPIs Monitoring update v5, p.7

2.3.2 Grants

Applicability for objects of assessment

Building	X		Set of Energy Supply Units	X
Set of Buildings	X		Neighbourhood	X
Energy Supply Unit	X		City	X

Definition	Grants are non-repayable funds that a grant maker, such as the government, provides to a recipient, e.g. a business, for ideas and projects to provide public services and stimulate the economy. In order to receive a grant, an applicant must submit a proposal or an application to the potential funder. This could be either on the applicant's own initiative or in response to a request for proposal from the funder.
Input Parameters & Calculation	$$Gr_{BR} = \frac{G_{BR} * 100}{I_{BR}}$$ Gr_{BR} Share of the investment in building retrofitting that is covered by grants [%] G_{BR} Total grants received for the building retrofitting of the district [€] I_{BR} Total investment for all the interventions related to building retrofitting [€] $$Gr_{ER} = \frac{G_{ER*100}}{I_{ER}}$$ Gr_{ER} Share of the investment in energy retrofitting that is covered by grants [%] G_{ER} Total grants received for the energy retrofitting of the district [€] I_{ER} Total investment for all the interventions related to energy retrofitting [€]

Unit	%
References	• Grants (2015) http://www.grants.gov/web/grants/learn-grants/grants-101.html • CITyFiED project
Source	• http://www.grants.gov/web/grants/learn-grants/grants-101.html, quoted in: Vasallo A.: CITyFiED KPIs Monitoring update v5, p.16

2.3.3 Total Annual costs

Applicability for objects of assessment

Building	X		Set of Energy Supply Units	X
Set of Buildings	X		Neighbourhood	X
Energy Supply Unit	X		City	X

Definition	The total annual costs are defined as the sum of capital-related annual costs (e.g. interests and repairs caused by the investment), requirement-related costs (e.g. power costs), operation related costs (e.g. costs of using the installation, i.e. maintenance) and other costs (e.g. insurance). These costs (can) vary for each year. – Capital related costs encompass depreciation, interests and repairs caused by the investment. – Requirement-related costs include power costs, auxiliary power costs, fuel costs, and costs for operating resources and in some cases external costs. – Operation-related costs include among other things the costs of using the installation and costs of servicing and inspection. – Other costs include costs of insurance, general output, uncollected taxes etc. The total annual costs are related to the considered interval of time (year). To make different objects comparable the same types of costs have to be included in the calculation.
Input Parameters & Calculation	$$TAC_{before} = C_E + C_{O\&M}$$ TAC_{before} Total annual energy cost of the reference system (i.e. energy, operation & maintenance) [€/yr] C_E Total annual cost of the system supply [€/yr] $C_{O\&M}$ Total annual cost of the operation and maintenance of the system [€/yr] $$TAC_{after} = C_E + C_{O\&M} + C_F$$ TAC_{after} Total annual energy cost of the system after the intervention (i.e. energy, operation & maintenance, financial) [€/yr] C_E Total annual cost of the system supply [€/yr] $C_{O\&M}$ Total annual cost of the operation and maintenance of the facility [€/yr] C_F Total annual financing cost, if applies [€/yr]

Unit	€/year
References	• CONCERTO Premium (2012) Indicator Guide Version 4 • CITyFiED project
Source	• CONCERTO Premium (2012) Indicator Guide Version 4, quoted in: Vasallo A.: CITyFiED KPIs Monitoring update v5, p.17

2.3.4 Payback period

Applicability for objects of assessment

Building	X		Set of Energy Supply Units	X
Set of Buildings	X		Neighbourhood	X
Energy Supply Unit	X		City	X

Definition	The payback period is the time it takes to cover investment costs. It can be calculated from the number of years elapsed between the initial investment and the time at which cumulative savings offset the investment. Simple payback takes real (non-discounted) values for future monies. Discounted payback uses present values. Payback in general ignores all costs and savings that occur after payback has been reached. Payback period is usually considered as an additional criterion to assess the investment, especially to assess the risks. Investments with a short payback period are considered safer than those with a longer payback period. As the invested capital flows back slower, the risk that the market changes and the invested capital can only be recovered later or not at all increases. On the other hand, costs and savings that occur after the investment has paid back are not considered. This is why sometimes decisions that are based on payback periods are not optimal and it is recommended to also consult other indicators.
Input Parameters & Calculation	Economic payback, EPP, type A static $$\mathrm{EPP} = \frac{EPI_{BR}}{\mathrm{m}}$$ M can be calculated as average annual costs in use savings (€/a) $$\mathrm{m} = \mathrm{TAC_{after}} - \mathrm{TAC_{before}}$$ Type B dynamic $$\mathrm{EPP} = \frac{\ln\big(\mathrm{m}\cdot(1+\mathrm{i})\big) - \ln(EPI_{BR} - EPI_{BR}\cdot(1+\mathrm{i}) + \mathrm{m})}{\ln(1+\mathrm{i})} - 1$$ Type C dynamic with energy price increase rate $$\mathrm{EPP} = \frac{\ln\big(\mathrm{m}\cdot(1+\mathrm{i})\big) - \ln(EPI_{BR}\cdot(1+\mathrm{p}) - EPI_{BR}\cdot(1+\mathrm{i}) + (1+\mathrm{p})\cdot\mathrm{m})}{\ln(1+\mathrm{i}) - \ln(1+\mathrm{p})} - 1$$ EPI_{BR} (€) Energy-related investment i (%) Discount rate

	p (%) Energy price increase rate i should be unequal to p
Unit	Years
References	• 2013 - 12 CONCERTO Premium Guidebook for Assessment Part I - Methodology
Source	• 2013 - 12 CONCERTO Premium Guidebook for Assessment Part I – Methodology, p.64-65

2.3.5 Return on Investment (ROI)

Applicability for objects of assessment

Building	X		Set of Energy Supply Units	X
Set of Buildings	X		Neighbourhood	X
Energy Supply Unit	X		City	X

Definition	The return on investment (ROI) is an economic variable that enables the evaluation of the feasibility of an investment or the comparison between different possible investments. This parameter is defined as the ratio between the total incomes/net profit and the total investment of the project, usually expressed in %.
Input Parameters & Calculation	$ROI_T = \frac{\sum_{t=1}^{T}\left(In_t - TAC_{after_t}\right) - (I_{BR} + I_{ER})}{I_{BR} + I_{ER}} * 100$ ROI_T Return on Investment [%] (0% means that the investment is fully recovered) In_t Income in year t T Duration of the economic analysis period: T=10, 15 and 20 [yr], depending on common practice in the area
Unit	%
References	• CITyFiED project
Source	• Vasallo A.: CITyFiED KPIs Monitoring update v5, p.19

2.4 General performance indicators for ICT related technologies

ICT interventions have a double- environmental impact. There are mainly two orders of effect regarding environmental impacts of ICTs:

- **First order effects:** the environmental load of ICTs, this is, the impacts associated to the physical existence of ICT and the processes involved, e.g. GHG emissions or use of hazardous substances.
- **Second order effects:** the environmental load reduction achieved by ICTs, this is, the impacts achieved thanks to the use and application of ICTs.

SCIS will focus on the assessment of second order effects.

2.4.1 Increased reliability

Applicability for objects of assessment

Building	
Set of Buildings	
Energy Supply Unit	X

Set of Energy Supply Units	X
Neighborhood	X
City	X

Definition	Avoiding failures revert on higher reliability, meaning fewer stops on the normal operation of the building and associated systems. With the application of ICT measures it is possible to correct a potential misbehaviour of the system and avoid unexpected stops. In SCIS, the indicator will be measured as the relative improvement in the number of interruptions: The failures can be caused by e.g. of grid congestion.
Input Parameters & Calculation	$$Reliability = \frac{Number\ of\ failures\ avoided}{Total\ number\ of\ failures\ in\ the\ baseline\ situation} * 100$$
Unit	%
References	• ISO 37120:2014, • CONCERTO
Source	• SCIS

2.4.2 Increased Power Quality and Quality of Supply (DSO+TSO)

Applicability for objects of assessment

Building	
Set of Buildings	
Energy Supply Unit	X

Set of Energy Supply Units	X
Neighborhood	X
City	X

Definition	Average time needed for awareness, localization and isolation of grid fault.
Input Parameters & Calculation	$$\Delta T_{fault} = \frac{T_{fault,baseline} - T_{fault,SG}}{T_{fault,baseline}} * 100$$

	T_{fault} is the average time required for fault awareness, localization and isolation. $T_{fault,SG}$ is the average time required for fault awareness, localization and isolation with Smart Grid Solutions $T_{fault,Baseline}$ is the average time required for fault awareness, localization and isolation in Baseline situation
Unit	[%]
References	• IDE4L
Source	• IDE4L project - IDEAL GRID FOR ALL – Deliverable D7.1:KPI Definition (2014), p.16, B.3c

2.4.3 Increased system flexibility for energy players

Applicability for objects of assessment

Building	
Set of Buildings	
Energy Supply Unit	

Set of Energy Supply Units	
Neighborhood	X
City	X

Definition	Additional flexibility capacity gained for energy players. It measures the progress brought by R&I activities relative to the new clusters and functional objectives, assessing the additional electrical power that can be modulated in the selected framework, such as the connection of new RES generation, to enhance an interconnection, to solve congestion, or even all the transmission capacity of a TSO. This KPI is an indication of the ability of the system to respond to – as well as stabilize and balance – supply and demand in real time, as a measure of the demand side participation in energy markets and in energy efficiency intervention. - Stability refers to the maintaining of voltage and frequency of a given power system within acceptable levels.
Input Parameters & Calculation	$\Delta SF = \frac{SF_{SG} - SF_{Baseline}}{SF_{Baseline}} * 100$ SF is the amount of load capacity participating in demand side management [MW]. ΔSF is the percentage improvement.
Unit	[%];
References	• GRID+ • IDE4L. • European Commission Smart Grid Task Force

Source	• IDE4L project - IDEAL GRID FOR ALL – Deliverable D7.1:KPI Definition (2014), p.13

2.4.4 Reduction of energy price by ICT related technologies

Applicability for objects of assessment

Building	X		Set of Energy Supply Units	X
Set of Buildings	X		Neighborhood	X
Energy Supply Unit	X		City	X

Definition	This KPI is intended to assess the economic benefits of a scheduling strategy for prosumers coordinated by an aggregator. The KPI will measure the price of the energy traded by an aggregator, both as a baseline and when ICT are implemented, e.g. the effect of shifting the level of consumption from the grid when the electricity price is lower.
Input Parameters & Calculation	$$\text{Energyprice}_{\text{REDUCTION}} = \frac{\text{Energyprice}_{SG} - \text{Energyprice}_{Baseline}}{\text{Energyprice}_{Baseline}}$$ Energyprice is the electricity price at a given period of time.
Unit	[%] (for the improvement)
References	• IDE4L
Source	• IDE4L project - IDEAL GRID FOR ALL – Deliverable D7.1:KPI Definition (2014), p.110, 6.16

2.4.5 Peak load reduction

Applicability for objects of assessment

Building	X		Set of Energy Supply Units	
Set of Buildings	X		Neighborhood	X
Energy Supply Unit			City	X

Definition	Compare the peak demand before the aggregator implementation (baseline) with the peak demand after the aggregator implementation (per final consumer, per feeder, per network). E.g. Peak load is the maximum power consumption of a building or a group of buildings to provide certain comfort levels. With the correct application of ICT systems, the peak load can be reduced on a high extent and therefore the dimension of the supply system. In SCIS, the indicator is used to analyse the maximum power demand of a system in comparison with the average power.
Input Parameters & Calculation	$\% = (1 - \frac{\text{P}_{\text{peak,R\&I}}}{\text{P}_{\text{BAU}}})*100$
Unit	[%]

References	• H2020 work programme, 2016-2017. 10. 'Secure, Clean and Efficient Energy'
Source	• SCIS

2.4.6 Increased hosting capacity for RES, electric vehicles and other new loads

Applicability for objects of assessment

Building	
Set of Buildings	
Energy Supply Unit	

Set of Energy Supply Units	
Neighborhood	X
City	X

Definition	This KPI is intended to give a statement about the additional loads that can be installed in the network, when R&I solutions are applied, and compared to the Baseline scenario.
Input Parameters & Calculation	This improvement can be quantified by means of the following percentage: $$\mathrm{EHC}_{\%} = \frac{\mathrm{HC}_{\mathrm{R\&I}} - \mathrm{HC}_{\mathrm{Baseline}}}{\mathrm{HC}_{\mathrm{Baseline}}} * 100$$ Being EHC is the enhanced hosting capacity of new loads when R&I solutions are applied with respect to BAU scenario. HC is the additional hosting capacity of new loads applied with respect to currently connected generation (GW or MW).
Unit	[%]
References	• GRID+
Source	• Project GRID+ - Define EEGI Project and Program KPIs, p.43

2.4.7 Consumers engagement

Applicability for objects of assessment

Building	X
Set of Buildings	X
Energy Supply Unit	

Set of Energy Supply Units	
Neighborhood	X
City	X

Definition	This indicator measures the involvement of users in the control over the energy use in the building. A variety of physical measures can be implemented, from the installation of metering systems to give the user feedback, to the involvement of the user in the management of their energy consumption.
Input Parameters & Calculation	• Number of final users involved • Number of people with increased ability to manage their energy consumption

Unit	[number]
References	• H2020 work programme, 2016-2017. 10. 'Secure, Clean and Efficient Energy'
Source	• SCIS

2.5 General performance indicators for mobility related technologies

2.5.1 Energy consumption data aggregated by sector fuel

Applicability for objects of assessment

Building	
Set of Buildings	
Energy Supply Unit	

Set of Energy Supply Units	
Neighborhood	X
City	X

Definition	Energy consumption of the mobility sector. It should be assessed for public transport (BEFORE and AFTER) as well as for private vehicles (BEFORE and AFTER).
Input Parameters & Calculation	Mode: - LPG - Motor Spirit - Kerosene - Jet Fuels - Diesel Oil - Heavy Fuel Oil - Natural gas - Biodiesel - Electricity - grid - Electricity - RES
Unit	[GJ]
References	• SEAP, Covenant of Mayors
Source	• SEAP, Covenant of Mayors

2.5.2 Kilometres of high capacity public transport system per 100 000 population

Applicability for objects of assessment

Building	
Set of Buildings	
Energy Supply Unit	

Set of Energy Supply Units	
Neighbourhood	X
City	X

Definition	The KPI includes subway systems, computer rails systems and heavy rail metro, but excludes buses (km of infrastructure). It is to give an expression to the percentage of people using transport other than a personal vehicle. Typically a large transit systems are crossing the city borders, which may lead to complications in the measurement of this data.
Input Parameters & Calculation	$$KHCPTS = \frac{HCTS}{100\ 000th\ of\ the\ City's\ total\ population}$$ $KHCPTS$ Kilometres of high capacity public transport system per 100 000 population $HCTS$ the kilometres of high capacity public transport systems operating within the city (numerator)
Unit	[km], (improvement in %)
References	• ISO 37120: 2014
Source	• ISO 37120: 2014

2.5.3 Passenger-kilometres public transport and private vehicle

Applicability for objects of assessment

Building		Set of Energy Supply Units	
Set of Buildings		Neighborhood	X
Energy Supply Unit		City	X

Definition	It should be assessed for public transport (BEFORE and AFTER) as well as for private vehicles (BEFORE and AFTER)
Input Parameters & Calculation	- Passenger-kilometre - Private vehicle-kilometre
Unit	[km]
References	• H2020 work programme, 2016-2017. 10. 'Secure, Clean and Efficient Energy'
Source	• SCIS

2.5.4 Number of efficient and clean (biofuel and hydrogen) vehicles deployed in the area

Applicability for objects of assessment

Building		Set of Energy Supply Units	
Set of Buildings		Neighborhood	X
Energy Supply Unit		City	X

Definition	Amount of PHEV, pure electric, biofuel and hydrogen cars registered in the area
Input Parameters & Calculation	Information from transport authorities, to be assessed before and after
Unit	Number
References	• H2020 work programme, 2016-2017. 10. 'Secure, Clean and Efficient Energy'
Source	• SCIS

2.5.5 Number of e-charging stations deployed in the area

Applicability for objects of assessment

Building	
Set of Buildings	
Energy Supply Unit	

Set of Energy Supply Units	
Neighborhood	X
City	X

Definition	Number of e-charging stations, public and private and fast chargers. To be assessed before and after
Input Parameters & Calculation	Amount before the intervention and after the intervention
Unit	Number
References	• H2020 work programme, 2016-2017. 10. 'Secure, Clean and Efficient Energy'
Source	• SCIS

2.5.6 Impact of ICT apps into mobility

Applicability for objects of assessment

Building	
Set of Buildings	
Energy Supply Unit	

Set of Energy Supply Units	
Neighborhood	X
City	X

Definition	Impact of ICT apps into switching from non-sustainable mobility into sustainable mobility, this is, change on modal split.
Input Parameters & Calculation	Non-sustainable mobility before and after.
Unit	E.g. % point increase in sustainable/unsustainable ratio (as the result of ICT apps)

References	• CIVITAS • H2020 work programme, 2016-2017. 10. 'Secure, Clean and Efficient Energy'
Source	• SCIS

2.5.7 Carpooling locations

Applicability for objects of assessment

Building	
Set of Buildings	
Energy Supply Unit	

Set of Energy Supply Units	
Neighborhood	X
City	X

Definition	The number of carpooling/ car sharing locations. To be assessed before and after.
Input Parameters & Calculation	Measured amount of carpooling/ car sharing locations.
Unit	number
References	• CIVITAS • H2020 work programme, 2016-2017. 10. 'Secure, Clean and Efficient Energy'
Source	• SCIS

2.5.8 Clean mobility utilization

Applicability for objects of assessment

Building	
Set of Buildings	
Energy Supply Unit	

Set of Energy Supply Units	
Neighborhood	X
City	X

Definition	Amount of km in clean vehicles, and number of trips in clean vehicles. To be assessed before and after.
Input Parameters & Calculation	To be assessed by project interviews, measurements
Unit	Number, [km]
References	• CIVITAS • H2020 work programme, 2016-2017. 10. 'Secure, Clean and Efficient Energy'
Source	• SCIS

2.5.9 Modal split

Applicability for objects of assessment

Building	
Set of Buildings	
Energy Supply Unit	

Set of Energy Supply Units	
Neighborhood	X
City	X

Definition	The distribution of transport over the modalities public and collective transport, private vehicles, and biking and walking. To be assessed before and after.
Input Parameters & Calculation	Values from own measurements or statistics
Unit	%
References	• CIVITAS • H2020 work programme, 2016-2017. 10. 'Secure, Clean and Efficient Energy'
Source	• SCIS

3 SUPPORTING KPIs

The following KPIs can be recommended as an extension of the basic assessment. The respective source is indicated below the name of the KPI.

KPI Name	Sources
Increase in Local Renewable Energy Generation	ITU-T L.1430 (2013) https://www.itu.int/rec/T-REC-L.1430 ISO 37120: 2014 https://www.iso.org/standard/62436.html
Reduced energy curtailment of RES and DER	IDE4L KPI-Guide http://webhotel2.tut.fi/units/set/ide4l/IDE4L_D7%201_KPI%20Definition_v1%202_Final.pdf
Smart Homes	Smart City Index Master http://smartcitiescouncil.com/resources/smart-city-index-master-indicators-survey
Improved competitiveness of electricity market	IDE4L KPI-Guide http://webhotel2.tut.fi/units/set/ide4l/IDE4L_D7%201_KPI%20Definition_v1%202_Final.pdf
Open Solutions	KPI-Guide of the RUGGEDISED Lighthouse Project www.ruggedised.eu
Average number of electrical interruptions per consumer per year	ISO 37120: 2014 https://www.iso.org/standard/62436.html
Average length of electrical interruptions	ISO 37120: 2014 https://www.iso.org/standard/62436.html
Annual number of public transport per capita	ISO 37120: 2014 https://www.iso.org/standard/62436.html
Kilometres of bicycle paths and lanes per 100 000 population	ISO 37120: 2014 https://www.iso.org/standard/62436.html
Number of personal automobiles per capita	ISO 37120: 2014 https://www.iso.org/standard/62436.html

4 ANNEX I

In this annex, some KPIs are included that generally apply to the overall Demo site.

Heating Degree Days (HDD)

Building	
Set of Buildings	
Energy Supply Unit	

Set of Energy Supply Units	
Neighbourhood	
City	X

Definition	For normalizing heating energy consumption in different climate conditions, the so called "heating degree days" (HDD) are used and well established. However, their definition differs and two main algorithms are known: one implementing the building's threshold heating temperature alone, the other one implementing the targeted set temperature of the building additionally. Both methods calculate the sum of a temperature difference on all days, when the heating has to be turned on (heating day). On non-heating days the temperature difference is not included into the sum. When looking at European countries you will find different application of the methodology and with both different threshold and different set temperatures. That hampers a unified calculation. In 1996 the European Commission asked for an assessment of climatic correction methods applied in various member states. Eurostat presented the findings to the Energy Statistics Committee and the Member States in principle approved a common method for heating-temperature correction. It employs the first described formula and defines 15°C as the heating threshold temperature and 18°C as the heating set temperature. The average daily temperature is defined as the arithmetic mean of the minimum and maximum air temperature of that specific day.
Input Parameters and Calculation	$HDD_{18/15} = \sum_{1}^{z}(18°C - t_a) \qquad with \quad t_a = \frac{t_{min} + t_{max}}{2}$ $Q_{normalised} = \left(\frac{HDD_{reference}}{HDD_{actual}}\right) \cdot Q_{actual}$

Unit	**Name**	**Symbol**	**Unit**
	Number of heating days in the time period	z	-
	Daily average ambient air temperature	t_a	[°C]
	Heating energy demand before correction	Q_{actual}	[kWh/year]
	Heating energy demand after correction	$Q_{normalised}$	[kWh/year]
	HDD for a reference climate	$HDD_{reference}$	[Kelvin*days/year]
	HDD for the actual climate	HDD_{actual}	[Kelvin*days /year]
References	• CONCERTO Premium Guidebook for Assessment Part I – Methodology • European Commission - Eurostat (2007)		
Source	• CONCERTO Premium Guidebook for Assessment Part I – Methodology, p.32-33 • European Commission - Eurostat (2007)		

Cooling Degree Days (CDD)

Building	
Set of Buildings	
Energy Supply Unit	

Set of Energy Supply Units	
Neighbourhood	
City	X

Definition	There is no standardized method for cooling degree days available and Eurostat doesn't propose a procedure either. However, in literature and different projects a method has become commonly accepted. The calculation is analogue to the heating degree-days and as it is applied to air-conditioning systems very often there is no distinction between ambient air temperature and room set temperature. The supply air with a specific set temperature has to be cooled down exactly at the time when the temperature of the ambient air temperature exceeds that value (no averaging with temperatures below the set point. According to the common use, the base temperature is defined as 18°C (65°F). So for example, if the base temperature is 18 degrees, and the outside air temperature is 30 degrees for eight hours (one third of a day), then that represents 4 cooling degree days ((30-18) x 1/3 = 4)		
Input Parameters and Calculation	$$CDD_{st} = \sum_{1}^{z}(t_a - 18°C)$$		
Unit	**Name**	**Symbol**	**Unit**
	Number of cooling days in time period	z	-
	Daily average ambient temperature	t_a	[°C]
	CDD for a reference climate	$CDD_{reference}$	Kelvin*days/year]
	CDD for the actual climate	CDD_{actual}	[Kelvin*days/year]
References	• CONCERTO Premium Guidebook for Assessment Part I – Methodology		
Source	• CONCERTO Premium Guidebook for Assessment Part I – Methodology, p.33-34		

5 ANNEX II

This annex provides explanation on objects of assessment. In the projects to be assessed there are different levels of spatial aggregation which go from single entities to a whole neighbourhood or city. In order to allow the assessment of these projects, a classification into different typologies has been done. The two main entities are buildings and energy supply units. Additionally, and due to the special characteristics of the intervention in scope of SCIS, ICT and mobility have been defined as an own entity.

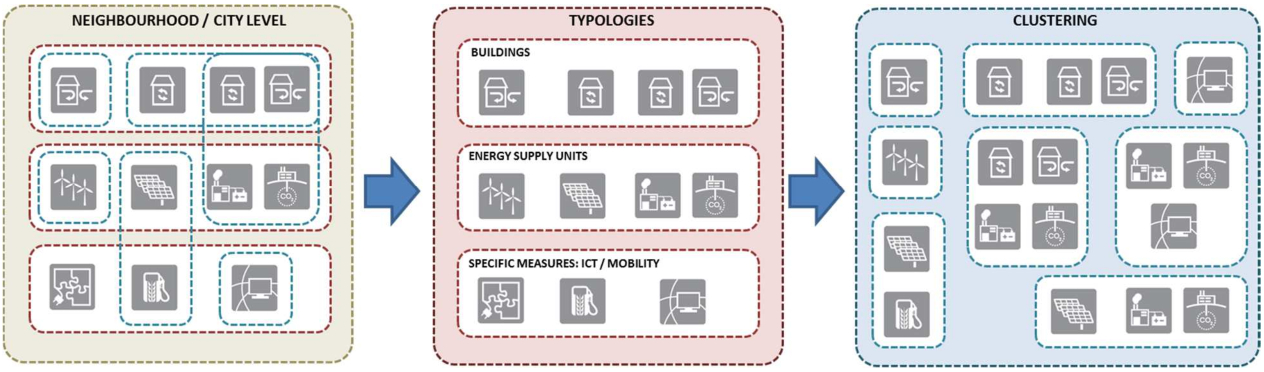

Figure 5-1: Classification of assessment typologies and clustering

The different levels of aggregation (city, district, neighbourhood, implementation area…) are then defined by the combination and clustering of these typologies. The following combinations are possible:

- Building
- Set of buildings
- Energy supply unit
- Set of energy supply units
- Buildings + energy supply units
- ICT measures at the building level
- ICT measures at the energy supply unit level
- ICT measures at the neighbourhood / city level
- Mobility measures at the building level
- Mobility measures at the neighbourhood / city level

5.1 Buildings

The assessment boundary at the building level is depicted in Figure 5-2. According to EN 15603, the energy performance of the building is the balance of:

- The delivered energy, required to meet the energy needs
- The exported energy.

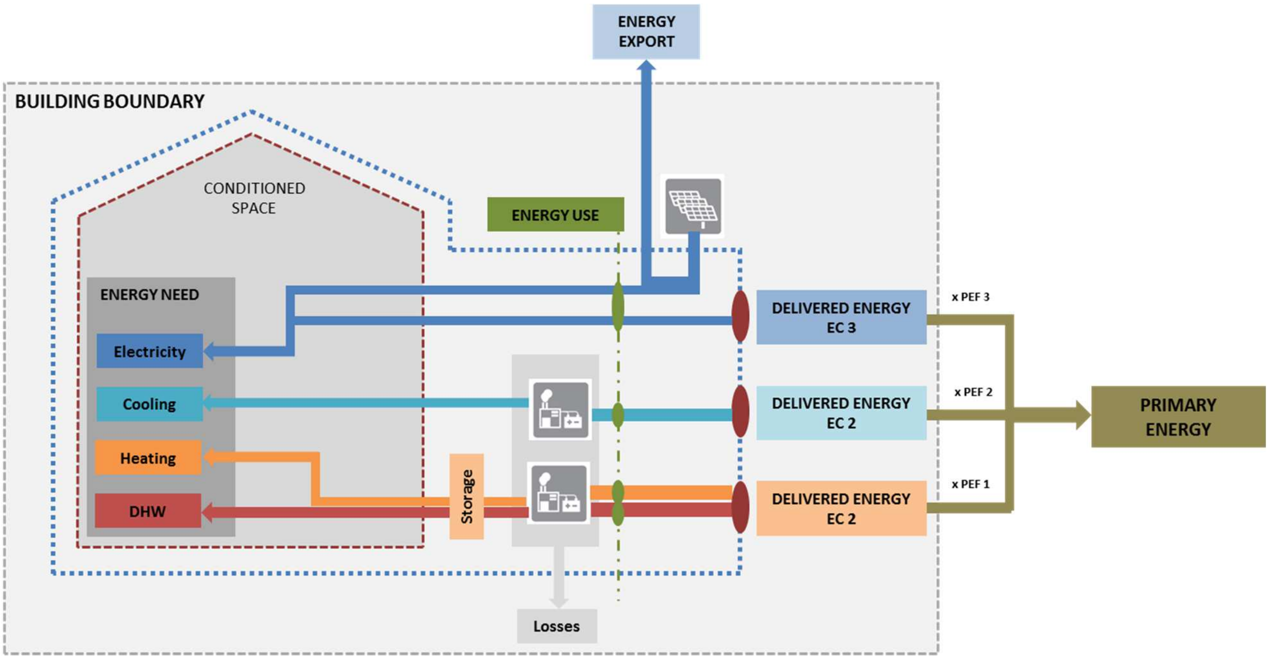

Figure 5-2: Energy flows and terminology at the building level

The delivered energy is to be expressed per energy carrier. If part of this delivered energy is allocated to energy export, it also needs to be specified in the data collection (e.g. gas fired CHP, where the electricity produced is not used in the building. In this case the corresponding amount of gas allocated to electricity production shall be specified in order to be able to calculate the energy performance of the building).

At the building level the data required is (calculation procedure goes from the energy needs to the primary energy):

- Energy needs per area of application (heating, cooling, DHW…)
- Energy technologies supplying these energy needs
- Energy storage units
- Delivered energy to each energy supply units expressed per energy carrier

5.2 Set of Buildings

The assessment for a set of buildings is done by aggregation of building units. The indicators can then be calculated for the sum of the buildings as a group.

5.3 Energy Supply Units

At the Energy Supply Unit level the approach followed is similar to the building level. Delivered energy per energy carrier and output energy allocated to energy carrier need to be specified. Additionally and depending on the energy supply unit different indicators can be calculated.

This assessment object refers to building integrated energy supply units as well as large-scale energy supply units.

5.4 Set of Energy Supply Units

The assessment for a set of ESU is done by aggregation of energy supply units. The indicators can then be calculated for the sum of the energy supply units.

5.5 Neighbourhood / City

The level of implementation area or neighbourhood is composed by the aggregation of different entities.

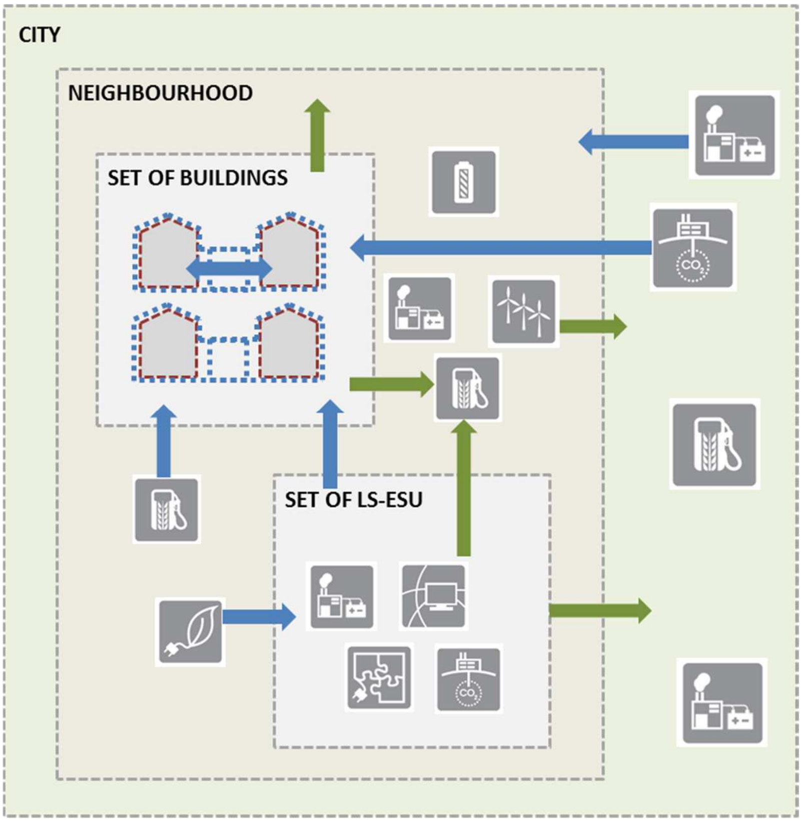

Figure 5-3: Objects of assessment and boundary conditions

The energy flows at this point also need to be defined. The following information is required to define the energy system:

- Energy carriers used at the implementation area level and the primary energy factors corresponding to this area
- Demonstration units involved (buildings, energy supply units, storage units and distribution systems)
- Delivered energy to each ESU and building allocated to the corresponding energy carrier
- Output energy of each ESU and, if applicable, output energy exported out of the boundary allocated to the amount of delivered energy carrier
- Energy flows between technologies and buildings (which ESU is supplying which building or ESU).

Due to the complexity of these systems, indicators can only be calculated if a full set of data is available.

6 ANNEX III

This annex provides explanation on data requirements and comparability in projects. For the calculation of indicators and the assessment of the energy performance different sets of data are needed. These include baseline scenario, design data and monitoring data. The division into these three data sets will allow the comparison between:

- Design data and baseline scenario: improvement compared to the typical solution
- Monitoring data and baseline scenario: real improvement compared to the typical solution
- Monitoring data and design data: comparison of achieved performance against prediction, this can also be defined as a separate indicator (quality of prediction).

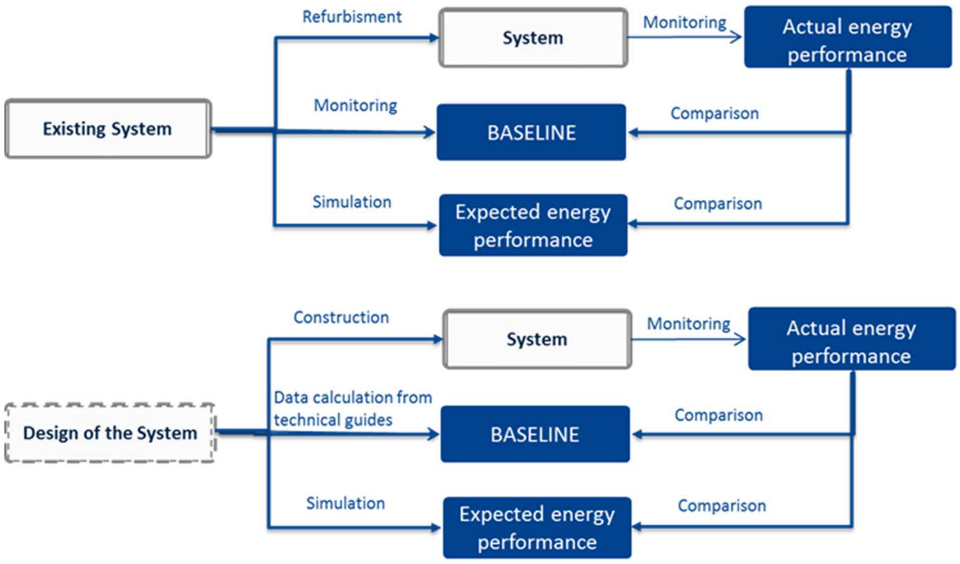

Figure 6-1: Comparison of data on energy performance

The indicators defined in this guide can also be calculated as a reduction or increase of, for example, the energy performance in comparison with the baseline or the designed data. A detailed explanation of each of the cases can be found below. For additional information regarding the monitoring data please refer to the SCIS Technical Monitoring Guide.

6.1 Baseline scenario

When defining a baseline, it is important to differentiate between new projects and retrofitting projects. For both project types, a baseline should be defined to further compare the performance of the different systems involved in the demonstration project:

1. Projects dealing with existing systems: if the demonstration project is a refurbishment / retrofit, an improvement of existing technology or building, or either is a substitution of previous system for a high efficiency one, it is important to meter all energy consumption data of the building before the refurbishment works start: final energy demand for heating, domestic hot water, cooling, electrical appliances in kWh/ month.
2. New projects. Since there is no real data to compare the performance of new systems, it is important to define a baseline based on the energy performance of similar buildings.

According to this classification, the baseline of the project has to be defined in the following way:

1. One year of monitoring of the existing system. In case of refurbished/retrofitted buildings it is important to meter all energy consumption data of the building before construction works start: Final energy demand for heating, domestic hot water, cooling, electrical appliances in kWh/month. If not metering was possible, data from energy bills can be used to define the status before refurbishment.
2. One year of synthetic data, reflecting the typical scenario. These data have to be calculated according to regulations, technical guides or similar projects.

6.2 Design Data

In the first phase of the monitoring it is also important to calculate, via modelling and simulation tools, the energy performance that is expected from the design of the system. Both the baseline and the design data will be later used to compare the actual energy performance of the building. Hereby, the energy efficiency improvements can be demonstrated and the deviations from the design can be detected.

6.3 Monitoring Data

The purpose of the monitoring is to demonstrate the energy performance of the implementation area. Therefore, it is important to collect all sampled data at the same time period in a consistent way. Monthly metered values of energy consumption and energy generation should be provided.

Once the construction is finished and the systems start to work under real conditions, the 1st year of monitoring will support the implementation progress of the energy system. This process is important for the analysis and optimization of the operating system.

Afterwards it is possible to check the actual consumption against expected, calculated data and to analyse and evaluate the energy performance. In case of refurbishments it is possible to compare the data collected/metered before refurbishment against the data metered after refurbishment.

6.4 Comparability between objects of assessment

Buildings

To enable the comparability between buildings, the performance indicator is related to the size of the building (e.g. gross floor area or net floor area, heated floor area) and the considered time interval (e.g. year)

Energy Supply Units

To enable the comparability between energy supply units, the total energy performance indicator is related to the energy output of the energy supply unit (e.g. electricity, heat, cold). In case of cogeneration the input is matched to the output using an exergy based approach. This indicator represents the reciprocal efficiency of the energy supply unit.

6.5 Economic corrections

6.5.1 Construction costs

Definition

Construction costs are figures that underlie temporal and spatial price levels. Therefore, the comparability of construction costs requires a correction regarding time and space:

- Corrections for temporal dispersions to a common price level can be performed using price indices of official statistics.
- Corrections for spatial dispersions to a common price level can be performed using factors accounting for differences of local price levels. In Germany, the Baukosteninformationszentrum Deutscher Architektenkammern (BKI) annually publishes so-called regional factors. Furthermore, factors for EU-wide corrections are given on country-level.

Input parameters

Name	Symbol	Unit
Costs in year t corrected to base year 0 in country j	$K_{0,t,j}$	[€/a]
Invoiced costs in year t in country j	$K_{t,j}$	[€/a]
Construction cost index of country j that corrects costs of year t to costs of base year 0	$P_{0,t,j}$	[-]
Costs in year t corrected from country j to reference country i	$K_{i,j,t}$	[€/a]
Invoiced costs in year t in country j	$K_{t,j}$	[€/a]
BKI factor that corrects costs of country j to costs of reference country I in year t	$RF_{i,j,t}$	[-]

Calculation

Temporal dispersions

$$K_{0,t,j} = \frac{K_{t,j}}{P_{0,t,j}}$$

Spatial dispersions

$$K_{i,j,t} = \frac{K_{t,j}}{RF_{i,j,t}}$$

Combined correction

$$K_{i,j,0,t} = \frac{K_{t,j}}{RF_{i,j,t} \cdot P_{0,t,j}}$$

7 GLOSSARY FOR SCIS

Term	Description	Comment
CONCERTO-plus	Predecessor of CONCERTO Premium	
CONCERTO-Premium	Predecessor of SCIS project	
SCIS	Smart Cities and Communities Information System	
CEN	European Committee for Standardization (Comité Européen de Normalisation)	
Self-Reporting	Refers in the SCIS to the development of a user friendly and flexible input mask that enables project managers to provide the data	
Auto-Analysis	Refers to the provision of general data and automated default detection during the self-reporting. The goal is to support project manager during the self-reporting and get complete and plausible data sets	
Measure	A measure is defined as implementation of technologies	
Technology Group	A Technology Group is defined as	
Indicator	An indicator is a calculated parameter	
EeB	Energy and Efficient Building	
SCC	Smart Cities and Communities	
EII	European Industrial Initiative	
EIP	European Innovation Partnership	
PPP	Public Private Partnership	
KPI	Key Performance Indicators	
TMD	Technical Monitoring Data Base	
EED	Energy Efficiency Directive	
EPBD	Energy Performance of Buildings Directive	
PT	Passenger Transport	
Vkm	Vehicle kilometre	

Pkm	Passenger kilometer
DES	Distributed Energy Resource
TSO	Transmission system operator
DSO	Distribution system operator
MV	Medium Voltage
LV	Low Voltage