

URBAN KEY PERFORMANCE INDICATORS

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INTRODUCTION

The Key Performance Indicators have been developed to evaluate and monitor the effectiveness of pilot actions, assessing technical, economic and environmental aspects.

A set of them has been identified giving to STORE4HUC PPs a consolidated tool for monitoring the successfulness of the pilots and to evaluate the potential impacts and benefits of their replicability in historical urban centres.

For each KPI a description sheet has been defined. These sheets contain a short introduction to the KPI, the field of applicability and the definition of the calculation method.

Each monitored indicator (KPI) must be evaluated at different stages of the HUC pilot actions, according to the contents and timeline included in D.T2.2.1 (template for HUC action report).



1. KEY PERFORMANCE INDICATORS (KPIs)

This paragraph reports on the KPIs identified to evaluate the impacts of the pilot actions on different aspects and benefits foreseen by the implementation of energy storages in HUCs.

KPIs are classified in 2 different categories:

- **Pilot specific KPIs**, specifically aimed to measure the performance and evaluate the results of the storage investment and the direct benefits of its application, coupled with a suitable control algorithm for their energy management. Each PP must identify its pilot specific KPIs, depending on the features of its pilot investment
- **Urban KPIs**, identified to measure or evaluate the benefits of the pilot action at urban level or other intermediate levels (for example: municipal properties). All PPs are required to monitor these common urban KPIs.

Complete list of KPIs

Indicator	Category	Description	Measurement Unit
KPI ₁ : External energy needs of the pilot system	Pilot specific KPI	Energy consumption supplied by external sources	[kWh]
KPI ₂ : External energy cost of the pilot system	Pilot specific KPI	Cost of the energy supplied by external sources	[€]
KPI ₃ : Yearly CO ₂ emission	Pilot specific / Urban KPI	CO ₂ emissions	[t CO ₂]
KPI ₄ : Autarky rate	Pilot specific / Urban KPI	Energy self-sufficiency	[%]
KPI ₅ : Use of energy from RES	Pilot specific / Urban KPI	RES self-consumed energy, associated to storage	[kWh]
KPI ₆ : Security of energy supply	Pilot specific KPI	Days without service interruptions/discomforts	[-]
KPI ₇ : Power peak	Pilot specific KPI	Average power peak	[kW]
KPI ₈ : Profitability	Pilot specific KPI	Net Present Value / Investment	[-]
KPI ₉ : Stimulation of the local economy	Urban KPI	New jobs created calculated through estimation of investment and replicability potential	[-]



In order to understand the meaning of the implemented indicators, a short introduction to the definition of the parameters referred to energy consumption is necessary.

In the following indicators these parameters have been defined:

- $E_{c,i}$: i-th thermal/electrical energy consumption of the pilot system, supplied by external source for one year [kWh]
- $E_{c,tot} = \sum E_{c,i}$: total thermal/electrical energy consumption of the pilot system, supplied by external sources for one year [kWh]
- $E_{self-RES,i}$: i-th consumed energy from self-production of local RES system in a year [kWh]
- $E_{self-RES} = \sum E_{self-RES,i}$: total consumed energy from self-production of local RES systems in a year [kWh]
- $E_{TOT} = E_{c,tot} + E_{self-RES}$: total thermal/electrical energy consumption of the pilot system for one year [kWh]

Moreover, to evaluate these indicators and compare the calculated values during the reporting period, a fixed set of conditions has to be defined in order to adjust the calculated values from their actual conditions to the common fixed set of conditions.

The adjustment terms should be defined from identifiable physical facts about the energy governing characteristics of equipment/system. Two types of adjustments are possible:

- Routine Adjustments - for any energy-governing factors, expected to change routinely during the period of calculation of the indicator, such as weather conditions, annual lift runs, hours of utilisation of the system.
- Non-Routine Adjustment - for those energy-governing factors which are not usually expected to change, such as the facility size, the heated volume or the use of the system.



1.1. KPI₁: External energy needs of the pilot system

Applicability for objects of assessment

Pilot specific KPI	Yes
Urban KPI	No
Thermal energy storage	Yes
Electric energy storage	Yes
RES system	Yes

Description	Energy consumption supplied by external sources
Input parameters & Calculation	<p>Calculation method:</p> <ol style="list-style-type: none"> Total thermal/electrical energy consumption of the pilot system, supplied by external sources for one year $E_{c,tot}$ [kWh] Calculation of Key Performance Indicator: $KPI_1 = E_{c,tot}$
Measurement Unit	[kWh]
References	Efficiency Valuation Organization, <i>International Performance Measurement and Verification Protocol</i> , 2017



1.2. KPI₂: External energy cost of the pilot system

Applicability for objects of assessment

Pilot specific KPI	Yes
Urban KPI	No
Thermal energy storage	Yes
Electric energy storage	Yes
RES system	Yes

Description	Cost of the energy supplied by external sources
Input parameters & Calculation	<p>Calculation method:</p> <ol style="list-style-type: none"> 1. External thermal/electrical energy cost¹ C_E [€], as function of yearly energy profile of each external energy source 2. Thermal/electrical energy consumption profile of the pilot system, supplied by external sources for one year $E_{c,tot}$ [kWh] 3. External thermal/electrical cost of peak power taken from external sources C_P [€], which also includes the contracted power delivery with the external source 4. Sequence of peak powers absorbed from the external sources on yearly basis P_{peak} [kW] 5. Calculation of Key Performance Indicator: $KPI_2 = \sum [C_E(E_{c,i}) + C_P(P_{peak})]$
Measurement Unit	[€]
References	-

¹ This cost must include all expenses related to energy purchasing, energy distribution and transportation, energy meter management, system charges and taxes.



1.3. KPI₃: Yearly CO₂ emissions

Applicability for objects of assessment

Pilot specific KPI	Yes
Urban KPI	Yes
Thermal energy storage	Yes
Electric energy storage	Yes
RES system	Yes

Description	CO ₂ emissions
Input parameters & Calculation	<p>Calculation method:</p> <ol style="list-style-type: none"> 1. Total thermal/electrical energy consumption of the pilot system, supplied by external sources for one year $E_{c,tot}$ [kWh] 2. CO₂ emission factor to be applied to the energy source EF [t CO₂/kWh], e.g IPCC emission factors 3. Calculation of Key Performance Indicator: $KPI_3 = E_{c,tot} \times EF$
Measurement Unit	[t CO ₂]
References	Covenant of Mayor: http://www.eumayors.eu/IMG/pdf/technical_annex_en.pdf



1.4. KPI₄: Autarky rate

Applicability for objects of assessment

Pilot specific KPI	Yes
Urban KPI	Yes
Thermal energy storage	Yes
Electric energy storage	Yes
RES system	Yes

Description	Energy self-sufficiency
Input parameters & Calculation	<p>Calculation method:</p> <ol style="list-style-type: none"> Consumed energy from self-production of local RES system in a year $E_{\text{self-RES}}$ [kWh] Total thermal/electrical energy consumption of the pilot system for one year E_{TOT} [kWh] Calculation of Key Performance Indicator: $\text{KPI}_4 = [E_{\text{self-RES}} / E_{\text{TOT}}] \times 100 \%$
Measurement Unit	[%]
References	Deliverable D.T3.2.4 “Validation report and establishment of the autarky rate tool & the checklist”



1.5. KPI₅: Use of energy from RES

Applicability for objects of assessment

Pilot specific KPI	Yes
Urban KPI	Yes
Thermal energy storage	Yes
Electric energy storage	Yes
RES system	Yes

Description	Consumed energy from self-production of local RES systems in a year
Input parameters & Calculation	<p>Calculation method:</p> <ol style="list-style-type: none"> Consumed energy produced by local RES systems in a year $E_{\text{self-RES}}$ [kWh] Calculation of Key Performance Indicator: $KPI_5 = E_{\text{self-RES}}$
Measurement Unit	[kWh]
References	-



1.6. KPI₆: Security of energy supply

Applicability for objects of assessment

Pilot specific KPI	Yes
Urban KPI	No
Thermal energy storage	Yes
Electric energy storage	Yes
RES system	Yes

Description	Percentage of time without interruptions/discomforts in terms of operation of local energy consumption system without service interruptions/discomforts
Input parameters & Calculation	<p>Calculation method:</p> <ol style="list-style-type: none"> 1. Number of hours without interruptions/discomforts on yearly basis $N_{no_interrupt}$ [h] 2. Total number of hours of local energy consumption systems operation on yearly basis N_{tot} [h] 3. Calculation of Key Performance Indicator: $KPI_6 = N_{no_interrupt} / N_{tot} \times 100 \%$
Measurement Unit	[%]
References	-



1.7. KPI₇: Peak power

Applicability for objects of assessment

Pilot specific KPI	Yes
Urban KPI	No
Thermal energy storage	Yes
Electric energy storage	Yes
RES system	Yes

Description	Average yearly peak power delivered from external energy sources
Input parameters & Calculation	<p>Calculation method:</p> <ol style="list-style-type: none"> Array of monthly peak powers delivered from external energy sources $P_{peak,month}$ [kW], where <i>month</i> goes from January to December [$P_{peak,January}$, $P_{peak,February}$, ... , $P_{peak,December}$] Calculation of Key Performance Indicator: $KPI_7 = \frac{1}{12} * \sum_{month=January}^{December} P_{peak,month}$
Measurement Unit	[kW]
References	-



1.8. KPI₈: Profitability

Applicability for objects of assessment

Pilot specific KPI	Yes
Urban KPI	No
Thermal energy storage	Yes
Electric energy storage	Yes
RES system	Yes

Description	Net Present Value / Investment
Input parameters & Calculation	<p>Calculation method:</p> <ol style="list-style-type: none"> Calculation of Net Present Value: $NPV = -I_0 + \sum_{t=0}^t \left[\frac{R_t}{(1+i)^t} \right]$ <p>NPV = Net Present Value [€] <i>I</i>₀ = investment [€] <i>R</i>_{<i>t</i>} = Net cash inflow-outflows during a single period <i>t</i> [€] <i>t</i> = numbers of time periods <i>i</i> = discount rate or return that could be earned in an alternative investment</p> Calculation of Key Performance: $KPI_8 = NPV / I_0$
Measurement Unit	[-]
References	-



1.9. KPI₉: Stimulation of the local economy

Applicability for objects of assessment

Pilot specific KPI	-
Urban KPI	X
Thermal energy storage	X
Electric energy storage	X
Only energy storage integrated by RES system	X

Description	New jobs created calculated through valuation of investment and its maintenance and operational costs
Input parameters & Calculation	<p>Calculation method:</p> <ol style="list-style-type: none"> 1. Total cumulated expense of the storage installed, calculated as the Investment (<i>CAPEX</i> [€]) + associated Operation&Maintainance costs (<i>OPEX</i> [€], evaluated on the system technical life: 20 years for electric pilot and 15 years for thermal pilot) 2. Constant <i>K</i> [€], equal to 200.000 €, that represents an empirical factor calculated as the ratio between a generic Company turnover and the number of company employees 3. <i>r</i>, equal to the number of the same storage solutions potentially installed in the district/region, considering a mid-term perspective of 5 years after the end of the pilot project. At the pre-investment stage consider this parameter equal to 1 4. Calculation of Key Perfomance Indicator: $KPI_9 = (CAPEX+OPEX) * r / K$
Measurement Unit	-
References	-