IGREENGrid Key Performance Indicators Methodology

"This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 308864".

ID & Title :	Key Performance Indicators Methodology		Number of pages :	11
Short Description (Max. 50 words):				
This document provides an overview of the methodology followed by IGREENGrid for the definition of the Key Performance Indicators used to evaluate the new Smart Grids solutions tested in the six IGREENGrid demonstrators.				
Version	**Date**	**Modifications' nature**	**Author**	
V0.2	08/06/2015	First Draft	M. Sebastian	
Accessibility:				
■ PU, Public				
☐ PP, Restricted to other program participants (including the Commission Services)				
☐ RE, Restricted to other a group specified by the consortium (including the Commission Services)				
☐ CO, Confidential, only for members of the consortium (including the Commission Services)				
If restricted, please specify here the group:				
Owner / Main responsible:				
ERDF				
Reviewed by:				
RSE				

Authors

Version	Date	Modifications´ nature	Author name (s)	Company
0.1	05/06/2015	Document Initialization	Maria Sebastian Viana Julia Chaniolleau	ERDF
0.2	11/06/2015	First Draft	Maria Sebastian Viana Julia Chaniolleau	ERDF
1.0	07/07/2015	Second Draft	Julia Chaniolleau	ERDF
			Marco Rossi	RSE
2.0	09/07/2015	Final version taking into account RWE comments	Maria Sebastian Viana Julia Chaniolleau	ERDF

1 Introduction and scope of the document

In Europe, the most important challenges in the different national electricity fields are analyzed by the European Electricity Grid Initiative (EEGI). According to IGREENGrid scope, the project covers all the requirements to be part of the EEGI support projects.
One of the Smart Grid evaluation tools promoted by the EEGI is represented by a set of Key Performance Indicators (KPIs). IGREENGrid has adopted this methodology for the assessment of the investigated control techniques and solutions devoted to the reliable integration of Distributed Renewable Energy Sources (DRES).

1.1 Objective

The objective of this document is to explain the approached followed to evaluate the KPIs and which KPIs have been selected by IGREENGrid from the EEGI list. .

1.2 Organisation of the document

The document is structured as follows:

- Section 2 presents the methodology followed to calculate the KPI.
- Section 3 discusses the selection of IGREENGrid KPIs from the EEGI list.

1.3 Notations, abbreviations and acronyms

EEGI	European Electricity Grid Initiative
DER	Dispersed Energy Resources
DRES	Distributed Renewable Energy Sources
KPI	Key Performance Indicator
SUT	Solution Under Test
R&I	Research & Innovation
BAU	Business as Usual
CapEx	Capital Expenditure
OpEx	Operational Expenditure

Table 1 (Acronyms)

2 Methodology for the calculation of KPI

IGREENGrid project has adopted a common and harmonized methodology based on performance indicators, to compare the different solutions tested on the demonstrators participating in the project.

Key Performance Indicators are a type of performance measurement tool that quantifies the success or the benefits of a solution. One of the requirements for the application of this methodology is the possibility to quantify the benefits deriving from the implementation of each Smart Grid solution. For IGREENGrid project, when it is feasible, we plan to quantify the benefits from the technical and economical point of view.

2.1 Evaluation of the technical benefit of a solution

The overall approach to evaluate the technical benefit of a distribution network solution requires the understanding of two scenarios:

- The Research and Innovation Scenario (R&I) corresponding to a situation under test exploring a new solution.
- The Business as Usual Scenario (BAU) corresponding to a situation when the solution is not operative, as it had never been installed.

The methodology of the evaluation follows three steps:

1. **Calculation of the benefits indicators $K_{R\&I}$ and K_{BAU}**

The first step consists in calculating the benefits in the case of the two scenarios, R&I and BAU. This task requires collecting the parameters corresponding to these two situations.

- IGREENGrid demonstrators (R&I scenarios) consist in the real field application of the Smart Grid solutions. Therefore, the parameters for the R&I scenario are accessible by measurements on the demonstrative network. Normally, field measurement devices are placed in specific nodes to access the parameters needed (voltage, current, active and reactive power, etc.).

- The parameters from the BAU scenario are accessible by:
  - Simulation-based tools can be used to remove the effects of the SUT from the R&I field measurements in order to obtain data referable to the network operated without the considered solution.
  - Real field measurements, which corresponds to measurements performed on the same network in a past time when the SUT was not operating and not even installed. A matching finder (weather conditions, load/generation profiles, etc.) is

used to extract the most similar BAU past condition to the measured R&I situation. For some demonstrators, the solution is applied intermittently (e.g. one day BAU and one day R&I) in order to have measurement of BAU and R&I referable to the same time frame.

Once the parameters are gathered, the benefits indicator calculation is made using the “indicator algorithm” as showed on the Figure 1.

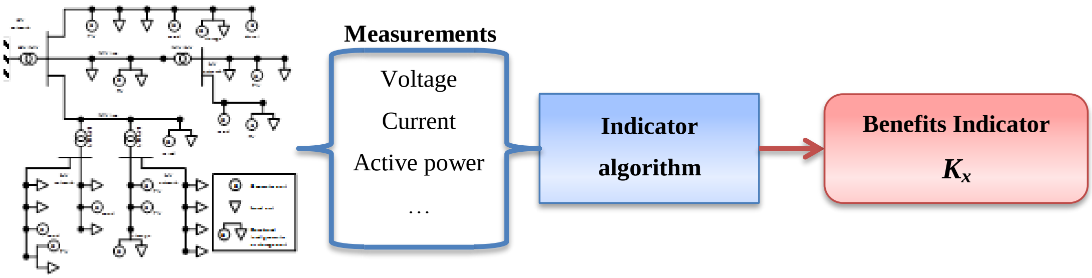

Figure 1 (Benefit indicator calculation architecture)

2. Calculation of the SUT performance by comparison between $K_{R\&I}$ and K_{BAU}

In order to evaluate the additional benefit the solution is bringing to the network in terms of integration of DRES, the two benefits indicators calculated in the two scenarios are compared as showed in Figure 2.

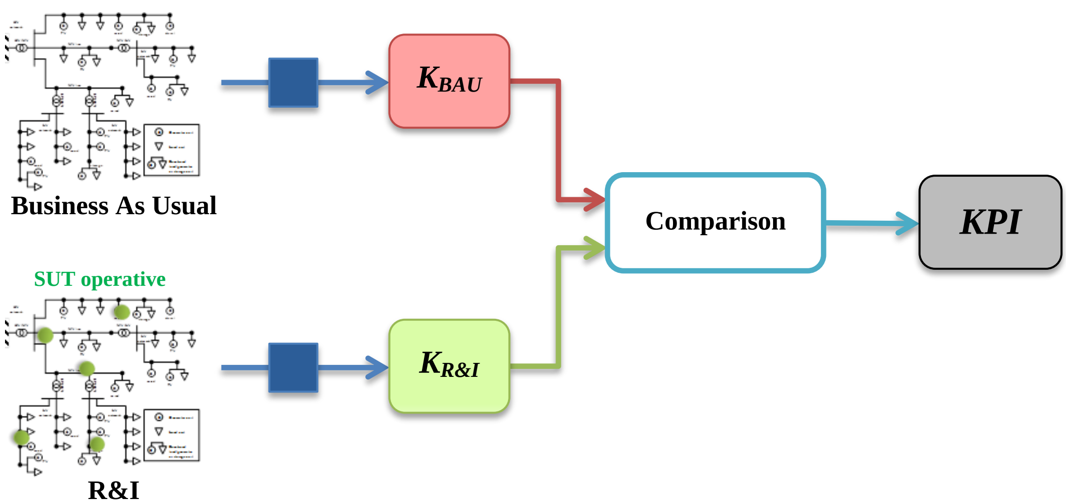

Figure 2 (Key Performance Indicators calculation architecture)

The Key Performance Indicator can be generally obtained by the next formula:

$$KPI = K_{R\&I} - K_{BAU}$$

3. Normalization of the KPI

Taking into account the different characteristics of the demonstrators, the performance indicators have to be opportunely normalized. When the normalization factors cannot be applied to the benefits indicators, the KPI formula described above is modified in the following one:

$$KPI_{\%} = \frac{K_{R\&I} - K_{BAU}}{K_{BAU}} \cdot 100\%$$

The normalization of the KPI provides an idea of the added value of the new solution.

2.2 Evaluation of the economical benefit of a solution

The economic benefit of a solution is quantified by the CapEx and OpEx. As it may require new devices and systems, R&I solutions may negatively impact the network economy because the installation, the operation and the maintenance costs may increase. Of course these costs have to be compared to the ones related to the traditional network reinforcement strategy. Therefore, in order to evaluate properly the cost-effectiveness of the solution, different definitions of the BAU and R&I scenarios should be taken as reference. For this purpose, Costs Benefits Analysis (CBA) seems to be more appropriate (and also more experienced) with respect to the KPI methodology. Of course, it should be also considered that the information directly extracted from the demonstrators have to be opportunely processed in order consider:

- The variance between prototyping and large-scale development of the solutions;
- The application of the SUT on large part of the distribution network;
- The increasing evolution of the loads and the expected integration of DRES.

2.3 Expected evolution trend of the benefits

Depending on the investigated performance, the expected evolution of the benefits introduced by a solution may be different. In fact, according to Figure 3, IGREENGrid consortium has noticed that the current technical performance of the tested solutions can be considered representative of an expected future situation (high penetration of DRES). On the contrary, when the investigation is focused on economic analysis, the current scenario has to be evaluated more carefully in order to consider the aspects pointed out in section 2.2. In fact, according to the practical experience in demonstration projects, new solutions are usually requiring large initial investments with positive returns in case of industrialization and large scale development (expected in the future).

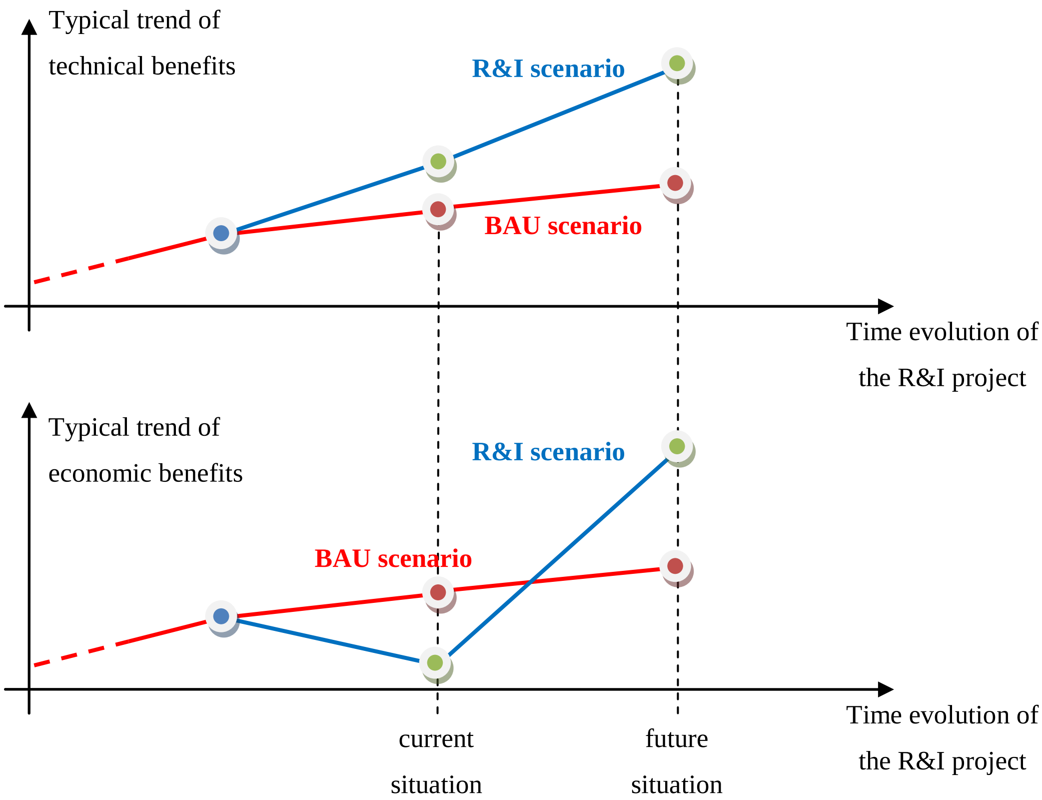

Figure 3 (Benefits from technical and economical point of view)

3 IGREENGrid KPI in link with EEGI roadmap

IGREENGrid KPIs have been designed on the basis of EEGI methodology and also taking into account the real situation in the demonstrators. In fact, because of the limitations due to the operation rules (that have to be satisfied even in demonstrators), the applicability of KPIs and the availability of measurements have to be evaluated. We will focus on EEGI approach to highlight which aspects are withheld or used by IGREENGrid project.

3.1 EEGI Approach

EEGI has created different types of KPIs depending on what they evaluate. The three levels of KPIs are showed in Figure 4.

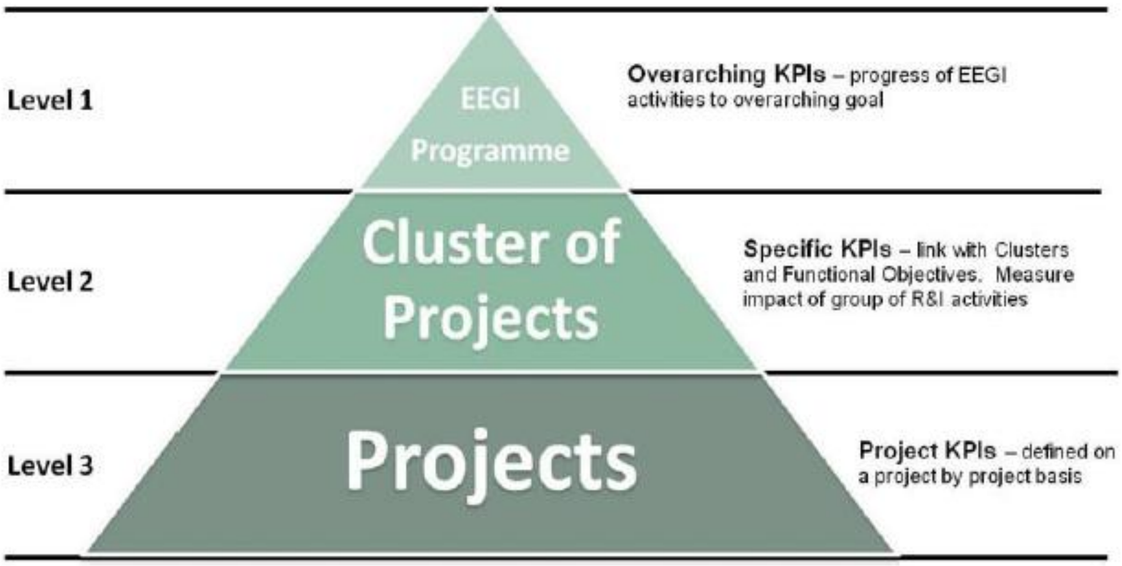

Figure 4 (EEGI KPI framework)

- Level 1 KPIs concern the evaluation of the overall activity of the organization and their progress in relation with EEGI goals.
- Level 2 KPIs are used to evaluate clusters of projects (like IGREENGrid) in line with EEGI roadmap.
- Level 3 KPIs focus on specific R&I activities and are defined for a specific project which is why they are not always applicable to other similar projects.

3.2 IGREENGrid Approach

IGREENGrid solutions can be evaluated by the second and third level of EEGI KPIs. Starting from the lowest level of indicators, the activity has been focused on the collection of the KPIs considered by each demonstration project. From their analysis and the identification of the functional objectives in common with IGREENGrid, a set of KPIs (second level) have been defined in order to be systematically applied (thanks to the design of a harmonized calculation procedure).

The selection of the KPIs has been also designed taking into account the common challenges defined in the European research and innovation projects. These challenges are discussed in the roadmaps released by the EEGI team, respectively in 2010 (first version) and 2013 (second and current version). Since the latest version was not available at the beginning of the project, both roadmaps have been considered and taken as reference for the definition of the IGREENGrid KPIs.

Among the wide list of the KPIs proposed by the EEGI roadmaps, IGREENGrid team has identified the expected benefits of the solutions tested in the physical demonstrators. The benefits identified by IGREENGrid and the withheld KPIs associated are summarized in Table 2.

Challenges from EEGI roadmap 2010-18	KPIs from EEGI roadmap 2013-22	KPIs from GRID+ project	IGREENGrid KPIs
Adequate distribution grid capacity to bring the electricity generated from all sources to consumers	Increased RES and DER hosting capacity. Reduced energy curtailment of RES and DER.	**B.1** Increased RES and DER hosting capacity	**$KPI_{IGG.1}$** – Increase of DRES hosting capacity
Harmonization and standardization of grid connection procedures giving access to any type of users	Reduction in time to connect news users Uniform grid connection rules	*no connection*	Not considered in IGREENGrid *The development level of the solutions is not mature enough to evaluate the harmonization yet. Efforts are concentrated on technical and economical performance*
Higher security and quality of supply	Reduction peak demand ratio Increased efficiency in preventive and emergency control Coordinated restoration after emergency Increase in coordinated operation between TSOs and DSOs Increased share of renewable per customers Increased voltage quality performance	**B.3** Power quality and quality of supply.	**$KPI_{IGG.2}$** – Quality of supply improvement
Enhanced energy efficiency and better service in electricity supply and grid operation	Reduction in network losses Increased demand side participation Enabling energy efficiency by end users Hosting Capacity of Electric Vehicle Increases availability of network components Actual availability of network capacity Availability of ancillary services across transmission and distribution grids	*no connection*	**$KPI_{IGG.3}$** – Increase of energy efficiency
Increased sustainability	Quantified reduction in CO_2 emission	*no connection*	**$KPI_{IGG.cat2.4}$** – Reduction of greenhouse gases emission

Table 2 (IGREENGrid expected benefits related to the selected KPIs)

3.3 IGREENGrid KPIs

IGREENGrid team classified their KPI according to their relevance in evaluating the benefits in terms of DRES integration. Two main categories have been proposed:

1. **The first category indicators**

These indicators, selected from the EEGI list, capture the most important technical aspects related to the integration of DRES in the distribution network.

- **DRES Hosting Capacity** that measures the amount of additional energy that can be injected in a selected network thanks to the implementation of the selected SUT;
- **Quality of Supply** that measures the ability of the SUT to maintain system operation within given specifications particularly oriented to the safety and performance of loads, generators and grid equipment;
- **Energy efficiency** that measured the ability of the SUT to decrease the technical losses related to the distribution of electricity (from generation units to the load).

2. The second category indicators

They represent the evaluation regarding additional goals that are also fundamental requirements for the achievement of the first category objectives. These KPIs are not closely linked to EEGI KPIs but from the experience gained in some demonstrators they are considered relevant for IGREENGrid goals:

- **R&I solution usage time** that measures the amount of time when the solution is operating on the network asset;
- **Reverse power flow** that measures the impact of the SUT on the reverse energy flows in substations;
- **Forecasting accuracy** that evaluates the impact of forecasting error on the operation of the network in presence of SUT;
- **Greenhouse gas emissions** that measures the CO_2 emissions saving provided by the SUT.

4 Conclusions

This document summarizes the IGREENGrid approach to evaluate KPIs and highlights its connection with the challenges and performance indicators proposed by EGGI. In fact, the IGREENGrid approach based on the evaluation of benefits from smart grid solutions for the integration of DRES follows the same calculation steps than EEGI. From EEGI experience and recommendations, IGREENGrid has selected three main KPIs to build its assessment methodology.