Innovation Action

inteGRIDy

integrated Smart GRID Cross-Functional Solutions for Optimized Synergetic Energy Distribution, Utilization & Storage Technologies

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WP1 – inteGRIDy Domain Analysis, Specifications & Architecture

D 1.4. - inteGRIDy Global Evaluation Metrics and KPIs

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Abstract:	Based on the requirements elicitated in T1.2 and use-case scenarios defined in T1.3, in this deliverable, a global framework for the inteGRIDy evaluation and impact assessment is defined, covering technical, economic, environmental and social aspects. There are two main factors that make the inteGRIDy evaluation activities complex, namely (i) to cover different Smart Grid topologies and typologies and (ii) to adapt inteGRIDy KPIs and evaluation metrics to variable weather conditions in Europe, different building use profiles, diverse business and social characteristics and DERs, evolving market models and regulation restrictions. To address these needs, a global bundle of KPIs and metrics is defined to properly address specificities of each pilot case, but also retain a uniform (and comparative) evaluation of the project results. Use-case (and pilot) specific KPIs are introduced to address unique characteristics, such as response failures in DR dispatch signals or effectiveness of inteGRIDy forecasts and optimizations.
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Executive Summary

The assessment of the performance of inteGRIDy is tightly connected with the variety of conditions, requirements and applied technologies in the 10 different pilots of the project. There are two main factors that make the inteGRIDy evaluation activities complex, (i) they cover different Smart Grid topologies and typologies and (ii) the inteGRIDy KPIs and evaluation metrics need to be adapted to variable weather conditions in Europe, different building use profiles, diverse business and social characteristics and DERs, evolving market models and regulation restrictions.

Energy Performance management is a popular topic which has been addressed by many researchers, while various reviews have been published, covering among other topics the energy performance and smart grid operation. In addition, E.U. initiatives are promoting the work towards the definition of a concrete set of key performance indicators in the smartgrids domain.

However, the multi-dimension approach of inteGRIDy, as examined at the pilot sites and applied architectures, necessitates a carefully selected set of indicators, specifically addressing the focus and the scope of performance (in technical, economic, environmental and social terms) in the inteGRIDy project. Establishing a global framework for the inteGRIDy evaluation and impact assessment is the focus of in this document. The definition of a performance framework sets the dimensions for the analysis in the project.

By defining this framework, the document provides a thorough review of the performance aspects and subsequently defines a complete set of performance indicators and metrics that can be utilized by the different pilots in the inteGRIDy project. The Performance Indicators will be used to measure the impact of the different energy management strategies implemented within the pilots and to support the development of strongly focused corrective and preventative framework. The indicators are characterized by clarity and transparency, and reflect in the best possible manner the performance in the most important dimensions of the project.

Along with the definition of the list of KPIs that consist of the inteGRIDy evaluation and impact assessment framework (and further taxonomy to the different domains examined in the project), we need to further define the data sources required for KPI calculation. A hybrid approach (*measurements based* considering the installation of hardware equipment to measure energy and contextual data and *model based* approach by defining the configuration parameters and mathematical formulas required for Key Performance Indicators analysis) is adopted towards acquiring the data required for KPI calculation, and this approach is presented as part of the inteGRIDy KPI analysis.

The proposed methodology and overall framework also targets other R&I projects and experts involved in monitoring or updating activities related to the smart grid. The KPIs can also be used at the project definition stage to detail the expected impacts from the proposed R&I activities. This is part of the work performed in WP3 to the definition of ***Definition of Indicators & Benefit categories for CBA/CEA.*** Therefore the definition of KPIs in this document addresses the real time or short-term evaluation of inteGRIDy activities (impact assessment analysis of project use cases) while the macro term CBA/CEA evaluation of the inteGRIDy platform will be reported as part of the work in T3.2. In addition, the early definition of inteGRIDy KPIs as part of the overall evaluation framework, will further enable the Overall Evaluation & Impact Assessment analysis of the project in WP8. (More specifically, the definition of KPIs will further trigger the work in T8.1 Detailed Pilot Evaluation Framework through pilot specific evaluation analysis definition).

This document will continually evolve as to build on the results of the related Work Packages and should be considered as a living document, since the experience gained at defining the

proposed list of KPIs will enable to further define the inteGRIDy evaluation framework in the future elements of the project.

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List of Acronyms and Abbreviations

Term	Description
AMR	Automated Meter Reading
API	Application Programming Interface
ATC	Available transfer capability
BAS	Building Automation System
BRP	Balance Responsible Party
BSP	Balance Service Provider
CBA	Cost Benefit Analysis
CEA	Cost Effectiveness Analysis
CHP	Combined Heat and Power
CFP	Cross-Functional Platform
DC	Direct Current
DG	Distribution Grid
DR	Demand Response
DER	Distributed Energy Resources
DOA	Description of Action
DSM	Demand-Side Management
DSO	Distribution System Operator
EC	European Commission
EEGI	European Electricity Grid Initiative
EPA	United States Environmental Protection Agency
EPE	Environmental Performance Evaluation
EPI	Environmental Performance Indicators
EROI	Return on Energy Investment
ESCO	Energy Service Company
EV	Electric Vehicle
FTP	File Transfer Protocol
GER	Gross primary energy requirement
GWP	Global Worming Potential
HVAC	Heating, ventilation, and air conditioning
ICT	Information and Communication Technology
KPI	Key Performance Indicator
KRI	Key Results Indicators
LCA	Life Cycle Analysis
LSE	Load Serving Entity
LV	Low Voltage
MO	Market Operator
MV	Medium Voltage
NER	Net Energy Ratio
PI	Performance Indicators
PM	Performance Metrics

PMU	Phasor Measurement Unit
RES	Renewable Energy Sources
RMS	Root Mean Squared
ROI	Return on Investment
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SCADA	Supervisory Control & Data Acquisition
SOC	State of Charge
SOH	State of Health
THD	Total Harmonic Distortion
TSO	Transmission Systems Operator
VA	Volt-Ampere
VAr	Volt-Ampere reactive
VES	Virtual Energy Storage
VPP	Virtual Power Plant

1 Introduction

1.1 Scope and objectives of the deliverable

As specified in the DoA, the goal of the project is to achieve the following:

- to integrate cutting-edge technologies, solutions and mechanisms
- in a scalable Cross-Functional Platform (CFP) of replicable solutions
- towards connecting existing energy networks with diverse stakeholders with enhanced observability of both generation and consumption profiles

Through the establishment of the inteGRIDy framework will further facilitate:

- the optimal and dynamic operation of the Distribution Grid,
- fostering grid stability and coordinating Distributed Energy Resources (DERs), Virtual Power Plants (VPPs) and collaborative Storage schemes
- within a continuously increased share of Renewable Energy (RES)

It is clear that the inteGRIDy KPI framework is dynamic to adapt to the specific needs and requirements of the business stakeholders. As part of inteGRIDy project foundations definition in WP1, the purpose of this deliverable is to define the holistic suite of KPI's to meet the overall project objectives as stated above. More specifically, based on the requirements elicitated in T1.2 and use-case scenarios definition in T1.3, this task defines a global framework for the inteGRIDy evaluation and impact assessment in **technical**, **economic**, **environmental** and **social** terms.

There are two main factors that make the inteGRIDy evaluation activities complex, (i) they cover **different Smart Grid topologies and typologies** and (ii) the inteGRIDy **KPIs and evaluation metrics need to be adapted to variable** weather **conditions** in Europe, different building use profiles, diverse business and social characteristics and DERs, evolving market models and regulation restrictions. To address these needs, a global bundle of KPIs and metrics is defined as part of the work in this task, further instantiated and aligned to the different pilot cases to address the specifics of each pilot site. Use-case specific KPIs are also introduced to address unique characteristics of the inteGRIDy platform as defined per pilot case scenario.

This deliverable is unique in the context of Work Package 1 as it does not provide any new technical insight, rather it provides a framework on the way to monitor and measure how the inteGRIDy Framework has met the overall objectives. The user requirement and functional description of the pilots (the fundamental building blocks of the whole inteGRIDy project) are reported in Deliverables D1.2 and D1.3 respectively setting the landscape for establishing the KPI's for inteGRIDy base analysis.

The outcome of this work will also facilitate: 1) the definition of macro level CBA(Cost Benefit Analysis)/CEA(Cost Effectiveness Analysis)key performance indicators in WP3 (T3.2) 2) the definition of Pilot Evaluation Framework in WP8 (T8.1) by instantiating the list of KPIs to be evaluated per demo site and further the definition of the holistic pilot evaluation framework of the inteGRIDy project.

1.2 Structure of the deliverable

Considering the main objectives of the task for the reporting period, the structure of the document is as follows:

- In **Chapter 1** sets the introductory section for the definition of the work in this deliverable

- **Chapter 2** describes the methodological framework about performance management and how this has been applied to the inteGRIDy project. The chapter provides an overview of Suggested Methodologies and Best Practices and how these may be applied in inteGRIDy.
- **Chapter 3** sets the performance framework of the inteGRIDy project by taking into account E.U. Energy Initiatives and the literature. The section defines the different domains of interest in the project that set the viewpoints for the inteGRIDy performance evaluation analysis.
- **Chapter 4** presents an overview of the KPIs and metrics selected in the project. The KPIs suggested for each pilot have been synthesized to set the holistic inteGRIDy performance evaluation framework, covering both global and local viewpoints.
- **Chapter 5** discusses how the data required for KPI calculation should be collected, stored and analyzed. This is the main challenge for the task, as we need to ensure that the KPIs selected can be measured or calculated through the collected data. Making sure the data collection process is complete and consistent is a tricky task. Thus, the chapter defines the process for ensuring consistency and accuracy for the collected data.
- Finally, **Chapter 6** concludes the work performed in T1.4 Definition of Key Performance Indicators (KPIs) & Evaluation Metrics and provides links to other tasks.

A pilot specific approach has been chosen for the selection of KPIs and metrics definition, screening that way the landscape for the definition of project evaluation framework in WP8.

1.3 Relation to Other Tasks and Deliverables

The proposed methodology and overall framework also targets other R&I projects and experts involved in monitoring or updating activities related to the smart grid. The KPIs can also be used at the project definition stage to detail the expected impacts from the proposed R&I activities. This is part of the work performed in WP3 to the definition of ***Definition of Indicators & Benefit categories for CBA/CEA.*** Therefore the definition of KPIs in this document addresses the real time or short-term evaluation of inteGRIDy activities (impact assessment analysis of project use cases) while the macro term CBA/CEA evaluation of the inteGRIDy platform will be reported as part of the work in T3.2. In addition, the early definition of inteGRIDy KPIs as part of the overall evaluation framework, will further enable the Overall Evaluation & Impact Assessment analysis of the project in WP8. (More specifically, the definition of KPIs will further trigger the work in T8.1 Detailed Pilot Evaluation Framework through pilot specific evaluation analysis definition).

This document will continually evolve as to build on the results of the related Work Packages and should be considered as a living document, since the experience gained at defining the proposed list of KPIs will enable to further define the inteGRIDy evaluation framework in the future elements of the project.

2 Methodological Background

Distribution System Operators (DSOs) should adjust their grid operations and functionality to support newly developed energy generation or enhancement technologies. The problem the DSOs face, is to be able to combine these new technologies, that use different communication protocols and energy supply profiles, on the same network, in order to deliver a cost-effective energy service, matching energy supply with variable energy demand. [GAU14]. The challenge DSOs are facing is one, indicative, among many others the stakeholders of inteGRIDy are facing, in the course of setting up and operate 10 different pilots, with many different use cases and technologies involved. Decisions should be made on the basis of solid and easily understandable information and this is what the KPIs are offering.

Key Performance Indicators (KPIs) are methods/systems that measure how effective a project is in achieving its key objectives [API17]. The process of selecting KPIs also help to clarify project objectives measures of success. [GAR16]. This chapter is timely in providing a measurement and KPI approach for the inteGRIDy technology suite. This work is introduced in the framework on inteGRIDy project where, different system and market operators, policy bodies and governance across European Union comes together to develop an integrated smart grid, cross-functional solution, for optimized, synergetic, energy distribution, utilization and storage technologies.

In the following paragraph, a summarized literature review is presented, on the way to identify and evaluate the most meaningful “lessons learned” on Smart Grid performance measurement. The expected outcome, augmented with contributions from the consortium members, will support the documentation of inteGRIDy performance framework (Chapter **Error! Reference source not found.**) and the selection of the KPIs (Chapter **Error! Reference source not found.**).

2.1 Smart Grid Evaluation Frameworks in the Literature

The project team have selected projects analogous to inteGRIDy for input to the best way of defining KPI’s. These projects are: “*Distributed Renewable resources Exploitation in electric grids through Advanced hierarchical Management – DREAM*” [GAR16], “*Definition and Calculation Methodology of Project KPIs – the DISCERN approach*” [BIR15], “*Integrating Active, Flexible and Responsive Tertiary Prosumers into a Smart Distribution Grid – INERTIA*” [INE13] and “*Energy Positive Neighbourhoods Infrastructure – EPICHUB*” [EPI12]. Additional literature resources have been reviewed and the most relevant have been taken in to consideration, providing an inclusive summary of the background knowledge on Smart Grid Evaluation Frameworks [MIA16], [STF12], [THA13].

The aim of DREAM project was to build and demonstrate an industry-quality reference solution for DER aggregation-level control and coordination, based on commonly available ICT components, standards, and platforms for all actors (DER owners, grid operators, etc...) of the Smart Grids.

- A concept and architecture phase, devoted to the establishment of principles and methods to accommodate the functions required to cope with project challenges;
- A design and development phase, devoted to the development of the support system for the new operational characteristics for the distribution grids;
- A validation and demonstration phase, building and operating five sites for test cases in France, Greece, Italy and The Netherlands.

The KPIs in DREAM supported the definition of objectives for the solutions and the measurement of their success. In an effort to get exportable, comparable and industry relevant results DREAM introduced KPIs which were mapping and enriching goals and metrics, according to the EEGI roadmap. The challenges and lessons learned from the DREAM KPI approach are either approach & content related or organizational.

In specific three were the main challenges related with the approach or the content selected. First was the choice between two possible approaches for KPI development: either the KPIs selection and definition should begin from the use case goals and then move to the trial sites/demo site goals or the other way around: begin with trial sites/demo site goals and develop KPIs and use case solutions accordingly. Finally, the use of both approaches in an iterative process has been promoted.

Second, as at the beginning of research-driven projects, not all information about the final use cases (tested in trials) is available and they (the use cases) naturally evolve after closer interaction with the trial sites, it is difficult the KPIs to be planned early in a one-time effort. Therefore, the discussion of goals and KPIs in one-on-one sessions per demo site (moderated by KPI development leaders) has been promoted, for a later stage in the project. The outcome would be checked across use cases and harmonize with them.

Third, as the demo site leaders had difficulties in specifying what they wanted to achieve, especially early on in the project, a good set of KPIs existing from other similar projects has been proposed as a start.

In the organizational level, the challenge was on how to engage stakeholders to contribute to the KPI definition process. The task and the consortium leaders, in order to motivate the stakeholders, they emphasized on the importance of KPI definition and collection not only for the partners, but also for the advertisement of the entire project towards EC.

The "*DISCERN*" project looked at cost effective network solutions for future network development. The starting point for DISCERN was the EEGI framework [EEG13] which was adopted for practical purposes and operational use by the DSOs. DISCERN used organized structured and detailed workshops aimed at refining the list of KPIs from EEGI, developing the KPI framework and their detailed definitions. These workshops included all the DSOs to present a consolidated partners' points of view within the respective countries and regulatory frameworks represented in the project.

The DISCERN KPI process elaboration stages were as follows:

- Create Structure and Methodology
- Agree on Content
- Collect Data

The stages provided an excellent methodology for DISCERN to bring out partners' view and this presented the basis of establishing KPI's and project assessment.

INERTIA project addressed the "structural inertia" of existing Distribution Grids by introducing more active elements combined with the necessary control and distributed coordination mechanisms. To this end INERTIA adopted the Internet of Things/Services principles to the Distribution Grid Control Operations. INERTIA project was an EU FP7-ICT funded project, consisting of 10 complementary partners from 6 different European Countries.

INERTIA provided an overlay network for coordination and active grid control, running on top of the existing grid and consisting of distributed and autonomous intelligent Commercial Prosumer Hubs. This way, it addressed the "structural inertia" of the Distribution Grid, by introducing more active elements, combined with the necessary control and distributed coordination mechanisms.

In assessing the performance of INERTIA, a list of thoroughly defined indicators had to be delivered to evaluate the performance of the Local Hubs, as single entities and as active components of a holistic Demand Response framework. The Performance Indicators were used to measure the success of the different energy management strategies implemented within the project and to support the development of strongly focused corrective and preventative actions. The control approach proposed by INERTIA comprised a holistic framework that examined all aspects stemming both from the Aggregators as well as the Local Level view.

As a lesson learned, (mainly in the Demand Response field, which was the core interest of INERTIA) the project established an Integrated Energy Performance Model that extended existing Energy Performance Models, by incorporating and integrating multiple dimensions: the physical sub-system (buildings and their energy-consuming equipment), the human sub-system (occupants, with their occupancy and usage behaviour), the Enterprise sub-system (enterprise processes and business goals, and the way they impact human behaviour and the cost/benefit analysis of energy usage) and the general surrounding environment. By directly incorporating the Enterprise as a specific actor, this performance model was better adjusted to specific business domains and provided the basis for the optimal balance between Demand Side Management, Energy Performance and Enterprise Performance.

Lastly, the goal of EPIC-HUB was to develop new methodology, architecture and services able to provide improved Energy Performances to Neighbourhoods (NBH), combining Energy-Hub-based Energy Optimization capabilities with a Seamless Integration of pre-existing energy ICT systems and other ICT system deployed. EPIC-HUB focused on efficient Management, Control and Decision-Support Energy Policies at neighbourhood-level, defining an interoperable Middleware solution and a structured vision for the communities to use and share renewable energy sources, energy storage, and micro-generation, to consistently realise energy savings, reduce CO_2 emissions and optimize energy usage.

The focus of the project's performance measurement was energy consumption. The ”Energy” KPIs of the project provided to the end users (i.e. buildings in general, airports, enterprises, etc.) the most important energy performance information, to enable them to understand their energy performance level. Therefore, the KPIs should help to monitor the execution of the different planned energy strategies with the purpose of achieving a global decrease in energy consumption.

The main lessons learned from the specific project include a distinction of the performance measures in three types: Key Results Indicators (KRI), Performance Indicators (PI) and Key Performance Indicators (KPI) and the concomitant use of them according with different aspects and dimensions of the project, such as the time. The specific distinction provides a useful and functional taxonomy that can be used in the establishment of a complete and multi-dimensional performance framework. In the lessons learned should be also included, the adopted by the project, data collection methodology, which is mainly non-residential and aiming to enable the gathering of consistent and complete Energy Efficiency reports, that could be easily compared to the results of other EU projects.

Other worth mentioning scientific works include the paper of Mia Ala-Juusela et al., titled “Defining and operationalising the concept of an energy positive neighbourhood”. . The research presented in this paper is the first work, which explicitly defines the concept of an energy positive neighbourhood and the metrics and tools to measure the energy positivity level of an area. In addition, it presents an energy positivity label to enable the visualisation of the progress of an area towards becoming energy positive. In doing so it extends the systems limits of current approaches to energy analysis for urban sustainability. The energy positivity level of an area is estimated with calculating energy matching indicators: on-site energy ratio, annual mismatch ratio and other mismatch indicators.

The definition of an assessment framework for projects of common interest in the field of smart grids is the topic of the manual published by the Smart Grids Task Force Expert Group 4, on Infrastructure Development. The goal of the report was to define an assessment framework for the evaluation of Smart Grid projects against a set of criteria in line with the requirements put forward by the European Commission (EC) in the Proposal for a regulation on guidelines for trans-European energy infrastructure (COM(2011)658) [EC 2011a]. The report suggested the use of key performance indicators (KPIs) for the measurement against six different criteria, which were reflecting the contribution of the project to six functions (these functions are indicated as 'services' in [EC Task Force for Smart Grids 2010a] of the "ideal" Smart Grid.

Due to the remarkable variation in demand response systems, it becomes a challenge to evaluate and compare the effectiveness of different DR programs holistically. In the scientific work of Thanos and al, "Evaluating Demand Response Programs By Means Of Key Performance Indicators", a number of different performance metrics are defined, that could be used to evaluate DR programs based on peak reduction, demand variation and reshaping, and economic benefits.

2.2 Suggested Methodologies and Best Practices

The background knowledge on Smart Grid Evaluation Framework enables the definition of best practices to be followed in inteGRIDy can be summarized as follows:

- The Performance Indicators should be used to measure the success of the different energy management strategies implemented within the project and to support the development of strongly focused corrective and preventative actions.
- The establishment of an Integrated Performance Model and methodology should be able to reflect appropriately multiple dimensions, such as technical, economic, environmental and social and to weigh their importance on the overall score.
- At the beginning of research-driven projects, not all information about the final use cases (tested in trials) is available and they (the use cases) naturally evolve after closer interaction with the trial sites. Hence it is difficult the KPIs to be planned early in one-time effort and an iterative approach is rather advisable. Thus, a generic (global) set of KPIs should be defined to adapt to any case scenario.
- Because the demo site leaders usually have difficulties in specifying what exactly they need, early on in a project, a good set of KPIs, existing from other similar projects can been proposed as a start, and then build on top of that, as the scope of the pilots and the use cases become clearer.
- A concrete data collection methodology should be defined at the project level, aiming to enable the gathering of consistent and complete reports (such as of energy efficiency, quality of service and other aspects), that could be easily compared to the results of other EU projects.

To this end:

The objective of the proposed framework is to describe the list of performance indicators to measure the technical, economic and environmental aspects examined in the project and how these will apply in each pilot site and use case. The selection should be carried out by assigning a priority level to the KPIs that apply most to the different situations, and are able to address in each specific context the benefits achieved by the adoption of the system.

3 The inteGRIDy Performance Framework

Following the high level presentation of the state of the art about the evaluation and performance analysis of smartgrid projects, the inteGRIDy Performance Methodology is presented in this chapter. The overall aim is to define a holistic set of KPIs to meet the project objectives, as summarized in section 1.1. Prior to this, the holistic methodological framework for KPIs definition in inteGRIDy project is presented.

3.1 inteGRIDy Performance Hierarchy

One of the main aspects of the project is the ten pilot sites (Isle of Wight, Terni, San Severino Marche, Barcelona, St Jean, Nicosia, Lisboa, Xanthi, Ploiesti and Thessaloniki) in which the novel solutions are going to be evaluated. In order to address the main parameters that affect the InteGRIDy performance, we need to list KPIs into global and local; the global KPIs are applicable to different demonstration sites (we define this set of KPIs as the generic KPI framework) while local KPIs correspond to individual pilot sites, addressing that way technology or location specific particularities (site specific KPI framework). The distinction between global and local KPIs is essential towards balancing the differing objectives and constraints under different scenarios and perspectives. More specifically:

- On the global level, inteGRIDy KPIs capture metrics which enable a comparative analysis of the performance achieved between the pilot sites. These include for instance KPIs about the overall energy system performance (e.g. energy consumption over the dimension of time, the energy consumption reduction) towards the evaluation of the high-level business objectives defined in the inteGRIDy project (e.g. the demand flexibility ratio, the average value of the reward paid from the aggregator to facility managers for the provision of DR services).
- Local KPIs are metrics that are attached to specific technologies or they are applicable to a combination of thematic pillars (e.g. Demand Response, Smartening the distribution grid, Energy storage, Smart integration of grid users from transport) that can be found in individual sites. Examples of local KPIs are for example the metrics for the evaluation of electric vehicles technology; demonstrated at a subset of pilot sites.

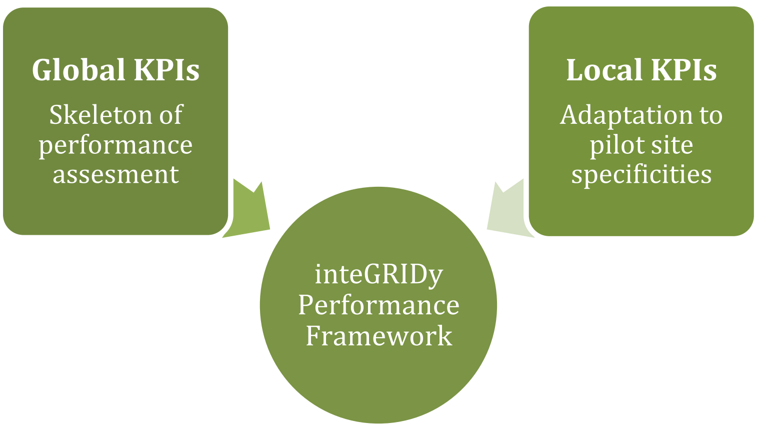

Figure 1. Global and Local KPIs taxonomy

The Global and Local KPIs set the high-level hierarchy of the inteGRIDy performance framework. The performance framework is applicable to the four thematic pillars, the performance domains and business objectives that encompass the inteGRIDy project.

3.2 inteGRIDy Performance Thematic Pillars

The inteGRIDy project has four thematic pillars describing smart networks:

Table 1. inteGRIDy pillars.

Demand Response (DR) including energy efficiency, demand shifting and shaving		**Smartening the Distribution Grid,** towards providing smart services to DSOs for better monitoring and management of the distribution grid	
Energy storage, either direct electricity storage in batteries or conversion to other forms of energy which could be stored more affordably (e.g. mechanical – flywheel, chemical – hydrogen, etc.)		**Smart Integration of grid users from Transport,** mainly through the penetration of electric vehicles in the electricity network.	

This high-level segmentation of inteGRIDy framework sets the first methodological layer for KPI analysis.

A detailed presentation of the different thematic pillars is provided in D1.3, screening the landscape for the different technologies (DR, energy storage, electric vehicles etc...) to be examined and further evaluated in the InteGRIDy project and thus no need to provide additional documentation about the specific business objectives. Nevertheless, this high level taxonomy of business objectives is defined as a main aspect of the performance methodological layer for KPI analysis.

3.3 InteGRIDy Performance Domain Analysis

In addition to the high-level taxonomy of KPIs to global and local KPIs (as part of the InteGRIDy performance methodology), we further consider KPIs taxonomy to the different project domains identified in the project namely: technical, economic, environmental and social. These dimensions (or domains) are complementing each other to set the holistic performance framework as depicted in the following figure

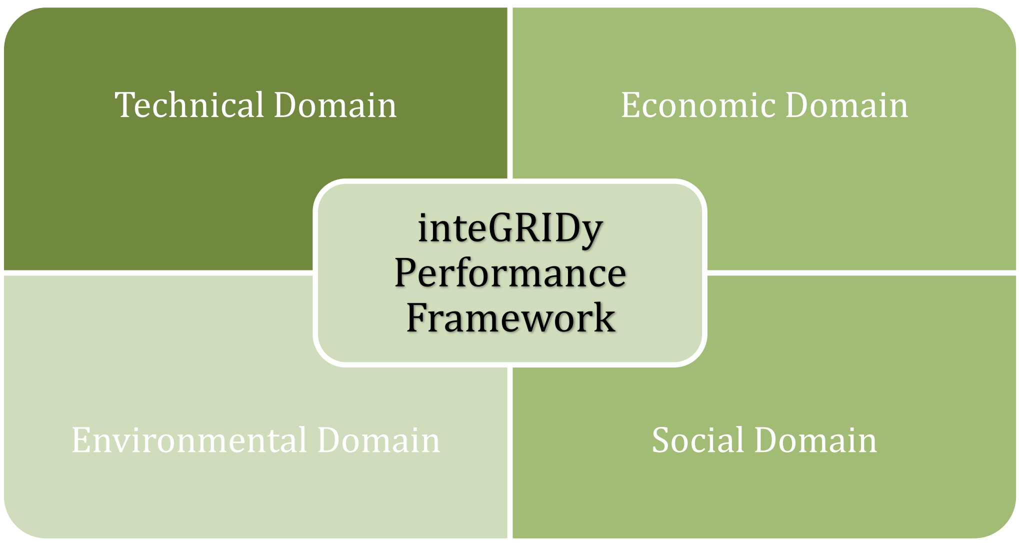

Figure 2. inteGRIDy Performance Domains

More specifically, the inteGRIDy KPIs performance domains are defined as:

- **KPIs measuring Technical Performance aspects**, such as the energy consumption, the RES generation ratio, the peak load reduction etc.
- **KPIs measuring Economic Performance**, e.g. Average cost of energy consumption, the average estimation of cost savings etc.
- **KPIs of Environmental Performance**, such as CO2 emissions reduction
- **KPIs of Social Performance** such as the degree of users' satisfaction from DR services.

In the following sections, short description of the performance domains and stakeholders' perspectives are aiming to highlight the relationship among them and how should be both accommodated in InteGRIDy performance context.

3.3.1 Technical Performance Domain

KPI's in Technical Performance Domain measure the effectiveness of a given use case with respect to the operating parameters and technical constraints acting on the MV/LV grid and active/passive users. They identify and quantify the benefits that the inteGRIDy's architecture offers to existing assets and on the quality of service provided to customers.

Technical KPIs are obtained by capturing the electrical metrics on the network (e.g. voltages/currents collected along feeders and active/reactive powers measured at the interface with the transmission system) and on customers and producers (e.g., the active/reactive energy/power exchanged with the network). In some cases, the KPIs need to be supported by numerical simulations on the basis of a grid model and the actual measurements collected on the grid (for example, of the KPIs aiming at evaluating the technical performance of a particular asset e.g. batteries or the model based evaluation of DER capacity in a local network).

The interest in these KPI's changes depending on the different stakeholder perspectives the inteGRIDy project: for example, system operators (DSOs) are mainly concerned about KPIs related to the MV/LV network's operation, while customers are focused on KPIs assessing the performance of a new approach/strategy at their premises. However, other factors exist that could affect the relevance of the KPIs considered in the different situations: for example, the regulatory framework in force (which could promote an improvement of the quality of service with reference to specific technical indexes, e.g. SAIDI/SAIFI), or the business cases applying in each particular scenario (also in relationship with the target performances defined in the economic domain).

3.3.2 Economic Performance Domain

The economic performance evaluation should take into account the business efficiency of each application and usage scenario from the market stakeholders perspective. The different pilots offer different value propositions to the inteGRIDy stakeholders and thus special focus should be delivered to the definition of KPIs that reflect this specific viewpoint. The aim objective of the project is to provide market viable solutions, and though the CBA/CEA analysis is performed in WP3, we need to define business oriented KPIs to evaluate the day to day performance of the InteGRIDy tools and applications.

For example, the residents of apartments would like to have a view of the economic benefit produced by their flexible consumption behaviour. They may be willing to sacrifice part of their comfort to achieve lower energy bills and they would like to know what the cost/benefit ratio is. Likewise, the business stakeholder (DR Aggregator) will like to know the actual benefit from the implementation of DR strategies in a portfolio of customers.

Once again, the overall business and economic analysis is closely related to the definition of business stakeholders in the project, along with the selection of business models and associated scenarios to be examined at the demonstration sites of the project (as defined in D1.3).

3.3.3 Environmental Performance Domain

KPI's in the Environmental Domain are important understanding and managing the environmental impact of energy investments and are important for system planning. inteGRIDy will adopt the Environmental performance evaluation (EPE) process and management tool to provide management with reliable and verifiable information on an ongoing basis to determine whether a system environmental performance meets a set of environmental criteria pre-set by the energy systems configurators and evaluators.

Environmental performance indicators, EPIs are defined according to the ISO 14031and can be grouped in the following categories:

- Operational performance indicators,
- Management performance indicators and
- Environmental condition indicators.

In inteGRIDy project, the environmental KPIs determine the efficiency of the energy systems demonstrated in the pilots in environmental terms. For example, there are KPIs that refer to the infrastructure phase (Life Cycle CO_2 emissions, Embodied energy for infrastructure of materials and for the building system, Gross primary energy requirement), to the operational phase (Reduction of the direct CO_2 emissions, Avoided CO_2 emissions, Cumulative energy demand, Primary Energy Ratio, The Global Warming Potential), as well as to the end-of-life phase (EROI, CO2 equivalent Payback Time, Gross primary energy requirement). The main focus is on operational phase evaluation through the definition of KPIs that set the framework for day to day evaluation while the Life Cycle Analysis (LCA) methodology will be applied for the determination of environmental aspects and potential impacts of a product or system from raw material extraction through production, use and disposal. More information about the applied LCA methodology and its basic principles described in D3.1.

3.3.4 Social Performance Domain

The social aspects of energy projects were found to be popular among the employed KPIs in previous studies. The Social KPIs are typically based on the perception of stakeholders directly affecting and affected by the project, regarding to the attitudes towards energy. The chosen indicators reveal that attitudes towards energy are interrelated with demand response mechanisms [KYL16] and how the end users are willing to participate. This is a core aspect of the inteGRIDy as the project aims to investigate the potential of end customers to actively participate in demand response schemes.

The most popular approach used in literature for expressing the social KPIs was the Likert scale. In more details, for the measurement of the reported social KPIs, a 5-point Likert scale based interviews of the involved stakeholders were used. The questionnaires presented in this project included social KPIs concerning the attitudes towards energy.

Another social aspect examined in the project is Occupant's Comfort - describing the level of comfort provided by the building (and its services) to its end users. The role of building occupants is considered as a core aspect in the inteGRIDy Framework and thus the occupant's related aspects should be examined in detail.

We presented above the inteGRIDy performance framework from the domain point of view. Note that the environmental and social domains are very complementarity and therefore, in the following sections they will be occasionally treated as a common domain. Considering the business objectives of the project, the KPI taxonomy from a business stakeholder's point of view is provided in the next section.

3.4 inteGRIDy Stakeholders Perspective

The KPIs selected establish a mechanism for continuous monitoring and control to the inteGRIDy pilots, providing useful insight to the stakeholders involved at the different business scenarios.

To further understand the inteGRIDy performance framework, KPIs relevance to the different business stakeholders' groups is considered. inteGRIDy stakeholders' groups have been identified in deliverables D1.2 'inteGRIDy Stakeholders and Market Needs Report'. Nevertheless, a short description of the inteGRIDy stakeholders and their goals would help us to identify and define their relation to and interest in the overall inteGRIDy system performance.

Distribution System Operator (DSO)

A DSO is responsible for the management and operation of the distribution network of electricity. To this end, the DSO is responsible for control rooms and various ICT systems for distribution management and automation. Also, depending on the legislation of each country, a DSO might be responsible for energy consumption reduction requests; in the competitive electricity market the distribution of electricity is usually a monopoly controlled by the regulating authorities.

While DSOs are actively involvedparticipate in InteGRIDy pilots with the main interest to optimally operate their local grid, it is of high interest for the project to evaluate InteGRIDy system performance from **Distribution System Operators** point of view.

Prosumers – Consumers (End Users)

It is well understood that the role of the customer in the energy system is changing: from a passive user, simply using energy from the energy system to an active participant in the energy system, reacting to signals in the market and delivering energy services to the grid and market participants.

Even further, we now have the term of 'prosumers' as the agents that both consume and locally produce energy. With the growth of small and medium-sized agents using solar photovoltaic panels, smart meters, vehicle-to-grid electric vehicles, home batteries and other 'smart' devices, we raise flexibility in the electricity networks. As the number of prosumers increases, the electricity sector is likely to undergo significant changes over the coming years, offering possibilities for greening of the system. However, demand reduction implications on the grid have not been fully thought through; managing a grid is largely a fixed cost and as the use of the grid reduces, so the costs increase to the remaining users of the grid.

This is actually the main objective of InteGRIDy project, to ensure the active participation of end users in market and grid operations, thus special focus is delivered to the evaluation of End Users performance within the context of InteGRIDy project.

Market Operator (MO)

In this category, we consider the traditional utility operators and the new business roles: ESCOs and DR Aggregators as the responsible parties to manage the technology to perform DR and negotiate on behalf of their customers with the operator for the provided services.

ESCOs, Aggregators and retailers are interested to monitor and analyse the behaviour of the end – users, to validate the operational credibility of the technological installations supporting alternative DR schemas, to identify potential profile deviations and to evaluate the impact of the benefits generated by the applied policies. Towards this direction, it is essential for the project to evaluate the impact of the different strategies (Demand Response, Storage and EV management) to the different market stakeholders.

Policies Bodies and Governance

As a key conclusion from D1.1, we suggest that the biggest impediment to the smart electric grid transition is neither technical nor economic. Instead, the transition to a deregulated market environment is limited due to regulatory barriers and disincentives. The current regulators are an important stakeholder group to consider.

A clear and consistent vision for the smart grid has not been adopted by legislators or regulators. Much has been said about individual technologies such as renewables or about specific energy issues (e.g. environmental impact), but little has been said about the overall vision for a modernized grid – a vision that integrates the appropriate technologies, solves the grid related issues, and provides the desired benefits to the stakeholders and society. [BOR13].

To this end, we need to take into account also Policies Bodies and Governance perspective towards KPIs definition within the InteGRIDy project. We have to point out that Policies Bodies and Governance view will be mainly considered to CBA/CEA evaluation analysis (macro leve business oriented view presented in WP3) though the non-direct impact to KPIs performance analysis is highlighted in this document.

By briefly presenting the different business stakeholders of the inteGRIDy project, we may further link them to the different project and subsequently to the Performance KPIs defined in the project. The next table presents the taxonomy of KPIs to the inteGRIDy domains as specified in previous section.

Table 2. Taxonomy of business stakeholders to the inteGRIDy domains

	Stakeholders				
	DSOs	**Prosumers**	**Consumers**	**Market Operators**	**Policies Bodies and Governance**
Technical domain	DSOs are mostly interested in ensuring an adequate level of quality of supply to the grid's customers. Moreover, critical peaks of demand should be avoided, constantly monitoring users' consumption to avoid grid breakdowns and efficiently address fraud challenges. In other words, DSOs are interested on the operational impact of any scenario to the grid conditions.	High levels of quality of service allow prosumers to produce energy avoiding unwanted disconnections from the main grid (e.g. if the voltage levels exceed predefined thresholds). In addition, fast connection procedures (possible in the case of an adequate hosting capacity of the grid) and the opportunity to sell services on the market through an aggregator are other factors affecting the prosumers' activities.	The reduction of the energy bill is the factor mainly driving the Consumers' choices (consequently, in this case, there is a strong relationship between technical and economic KPIs). Therefore, for this stakeholders' category, the most significant KPIs are those aiming at evaluating energy consumption or peak load. Commercial consumers have usually in addition particular requirements on quality of service.	With reference to the technical domain, Market Operators are interested in increasing the amount of load and generation available in a given area to perform the dispatching and demand response strategies required. This is a function of the actual penetration of DER and RES power plants in distribution networks. Moreover, a better exploitation of MO's assets devoted to improving the regulating capabilities of Virtual Power Plant (e.g. energy storage systems) would reduce the required investment costs and increase the MO's incomes.	Policy Bodies are interested in monitoring the contribution of the projects (pilots) to the smart grid functions, which are directly related to Smart Grid policy objectives. These are among others: The Security and quality of supply, the connectivity and access to all categories of network users, the capacity of transmission and distribution grids to connect and bring electricity from and to users and others.

Economic domain	The aforementioned concerns of the DSOs in the technical domain are also having an economic aspect, as any potential inefficiencies in the quality of supply to the grid's customers, may cause significant charges from the side of the regulation authorities.	In contrast with the consumer, for whom energy is simply a good to be expended in pursuit of personal goals, the prosumer engages with energy as a meaningful part of his daily life and practices. As incentives for shifts in energy behaviour are commonly framed in financial (lower bills) terms, metrics should reflect these incentives.	The main expectation of the residential consumers is a direct economic benefit either in the form of cost reduction or in terms of at hand compensation, depending on the DR schema category they participate. Commercial consumers reap significant benefits from improved reliability. Many of the loads at their facilities are electronics based and require a higher level of power quality than ever before. And even short, momentary outages can create havoc. Losses in production and productivity and the impact on worker safety are major.	Profit-maximizing aggregators compete to sell DR services to the utility operator and provide compensation to consumers, in order to modify their preferable consumption pattern. In this respect, they will make use of economic indicators to identify operational needs, market opportunities or critical situations and deploy appropriate DSM strategies. From the perspective of utilities and because many countries let consumers move from one utility to another, consumers typically choose the least expensive one. When utility generation costs increase, companies still have to follow contract agreements and sell at present rates, which decreases their profits. Hence real-time views for revenue protection, unexpected EV and solar loads identification are some of the metrics that would make sense for utilities in such case.	From the perspective of policy makers, economic domain indicators should reflect the efficiency and quality of service achieved in electricity supply and grid operation. Measures of interest indicatively include: Demand side participation in electricity markets and in energy efficiency measures, societal CBA, which goes beyond the costs and the benefits incurred by the project promoter, as well as the monetary value of reduced CO2 emissions, whereas the KPI analysis might just refer to the amount of CO2 reduction expressed in tons.

Environmental domain	DSOs are highly interested in knowing about the effect new smart technologies will have on environment when applied and replace conventional systems, since their electrical grid, under supervision, influences a lot the cities and citizens' quality of life. This aspect is as well connected with business care pillars.	Prosumers are highly interested in knowing more about the sustainability of business operations. Reporting on environmental matters provides a good indication of what measures an organisation should be taking into consideration to reduce risks and develop opportunities, which can flourish their business turnover. In some counties, green certificates have been established for this purpose.	Commercial end-users and aggregators are directly connected; especially more on the business level compared to residential ones. In that respect both residential and commercial end-users are highly interested in knowing more about the environmental impact of any incentive. Environmental parameters are linked and to a certain extent reflect the, demographical, physical and contextual characteristics such as types of premises and profile of users, weather conditions, national/local characteristics, idiosyncrasies and legislation etc.	When aggregators are expected to apply schemes contributing in making grid distribution smarter and more efficient (e.g. DR programs by LSEs or third-party energy aggregators) environmental KPIs related to demand become relevant as these factors determine the quality of response from the customers, especially when and if feed-in-tariffs business models promoting the use of green energy are foreseen. Such metrics are useful in DR design and evaluation to determine the type of incentives to provide and the type of customers to recruit in order to achieve a certain amount of demand reduction.	Policy makers are interested in and would like to monitor in a quantified manner the levels of sustainability (including the reduction of greenhouse emissions and the environmental impact of electricity grid infrastructure) the smart grid projects under consideration are achieving.

Social domain	Social approaches give DSOs the opportunity to attract new customers and improve their services. Through their services to increase the satisfaction of end-users and to improve their energy attitudes.	The prosumers engage with energy as a meaningful part of their daily life. Thus, the Social KPIs measure the degree of active users' satisfaction from DR services.	Business and Residential consumers can be implicitly motivated to change their energy behaviour through different social approach techniques since there is direct monetary benefit. It further allows them to understand and feel comfortable with the energy infrastructures at home (RES, batteries, smart-meters, etc.) and improve their energy attitude.	Social approaches give Market Operators the opportunity to attract new customers and improve their services. Through their services to increase the satisfaction of end-users and to improve their energy attitudes.	

By defining the different layers and viewpoints that consist of the inteGRIDy Performance Assessment Framework, we proceed with the presentation of the holistic inteGRIDy Performance Framework.

3.5 Pilot Oriented inteGRIDy Performance Evaluation

The figure below illustrates the high level inteGRIDy Performance Assessment Framework with the different view-points as presented above. The overall framework is defined as pilot oriented to address the specifics of each pilot site.

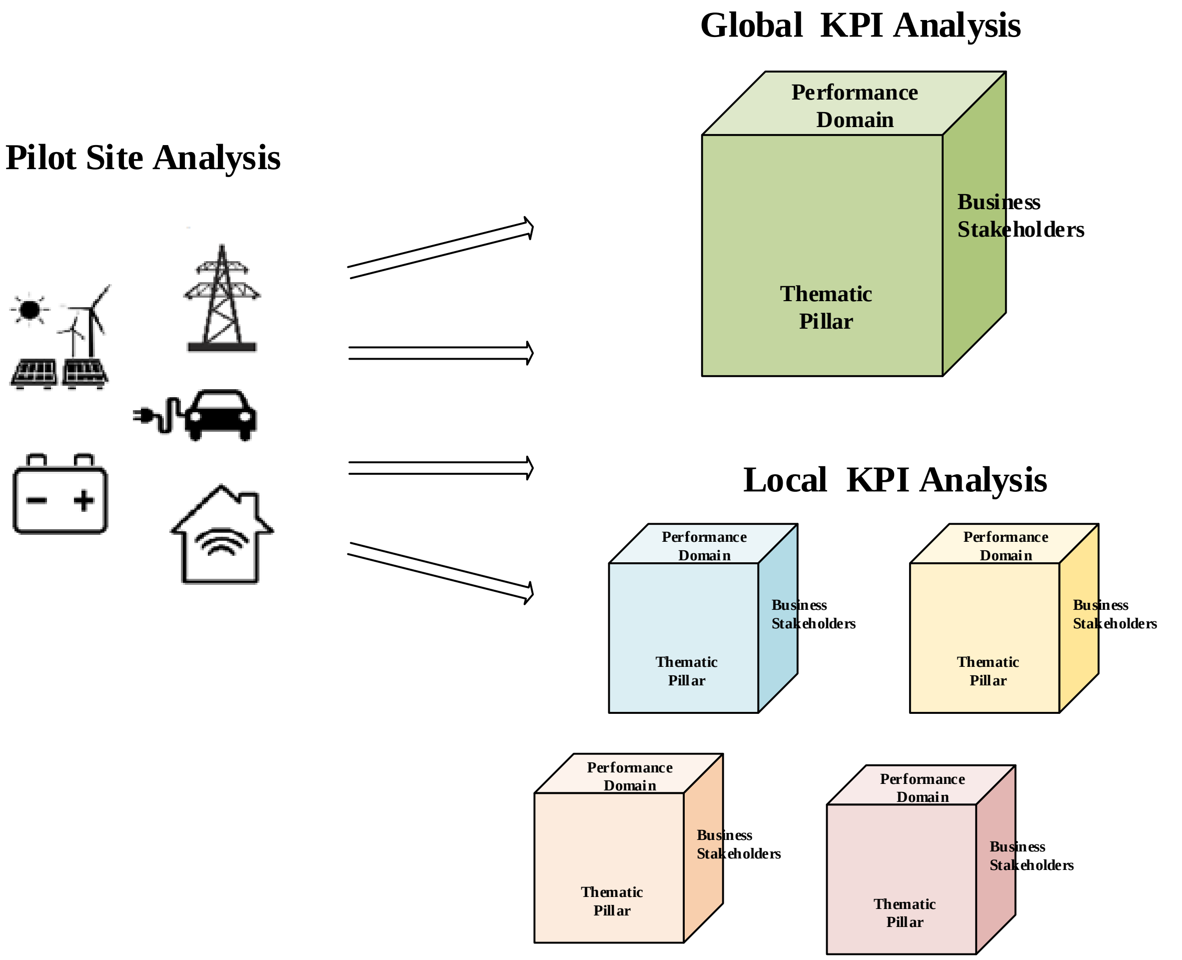

Figure 3. inteGRIDy Performance Assessment Framework

From the analysis above and the definition of the different viewpoints (thematic pillars, performance domains, business stakeholders) that consist of the inteGRIDy Performance Assessment framework, it is clear that we need to examine the characteristics of each pilot site to identify the KPIs that fit to each case scenario. Therefore, we provide the pilot analysis as the initial step towards the formulating the inteGRIDy performance assessment definition.

In order to proceed with the pilot specific analysis, a summary of the business objectives (for the 10 pilot sites of the project) as defined in T.1.3. “Pilot Surveying Project Report, Use-Case & Business Scenarios” is presented in the following Table.

Table 3. Summary of use cases per pilot

Pilot Site		Business Objective				Stakeholder		
Pilot ID	**Pilot Name**	**Demand Response**	**Smartening Grid**	**Energy Storage**	**Electric Vehicles**	**DSO**	**Customers**	**Retailer/ ESCO**
Pilot 1	Isle of Wight	++	++	+	(+)	+	+	-
Pilot 2	Terni	+	++	++	+	+	(+)	-
Pilot 3	San Severino	+	++	+	-	+	+	-
Pilot 4	Barcelona	++	-	+	-	-	+	+
Pilot 5	St Jean	++	-	+	-	+	+	-
Pilot 6	Nicosia	++	+	(+)	-	+	+	-
Pilot 7	Lisboa	+	-	-	++	-	+	+
Pilot 8	Xanthi	+	-	++	(+)	+	(+)	-
Pilot 9	Ploiesti	++	+	-	-	+	+	-
Pilot 10	Thessaloniki	++	-	+	-	-	+	+

++ *Strong interest and involvement*
+ *Moderate interest and involvement*
(+) *Light interest*
- *No interest*

Table 3, above, enables the selection of KPIs that fit the specific business objectives as examined in the project.

3.6 inteGRIDy Performance Assessment Framework

The different layers that consist of the inteGRIDy Performance Assessment framework have been defined above. A dynamic and modular approach towards KPIs taxonomy has been adopted, by semantically enhancing the identified KP indicators with the business and technical objectives examined in the project.

The next step of the work is to drill in and specify the list of specific KPIs and metrics that consist of the inteGRIDy Performance framework. Prior to this, a clear definition of what is Key Performance Indicator within the context of inteGRIDy project is provided.

3.6.1 inteGRIDy KPIs and Metrics

According to BABOK [BAB15], the purpose of metrics and key performance indicators is to measure the performance of solutions, solution components and other matters of interest to stakeholders. Metrics are used to measure different aspects of business activity at a specific point in time. KPIs, however, embody strategic objectives and measure performance against a specific target. These targets are defined in strategic, planning or budget sessions and have a range of performance. Therefore, KPIs are the detailed specifications that are used to track business objectives.

Selecting the right set of KPIs is a complex task and requires special effort and clear understanding of the business and technical objectives. Therefore, what matters is to measure relevant things that will help answer the most important questions. KPIs need to have the information to what the organisations/managers wants to know as specified in the next figure.

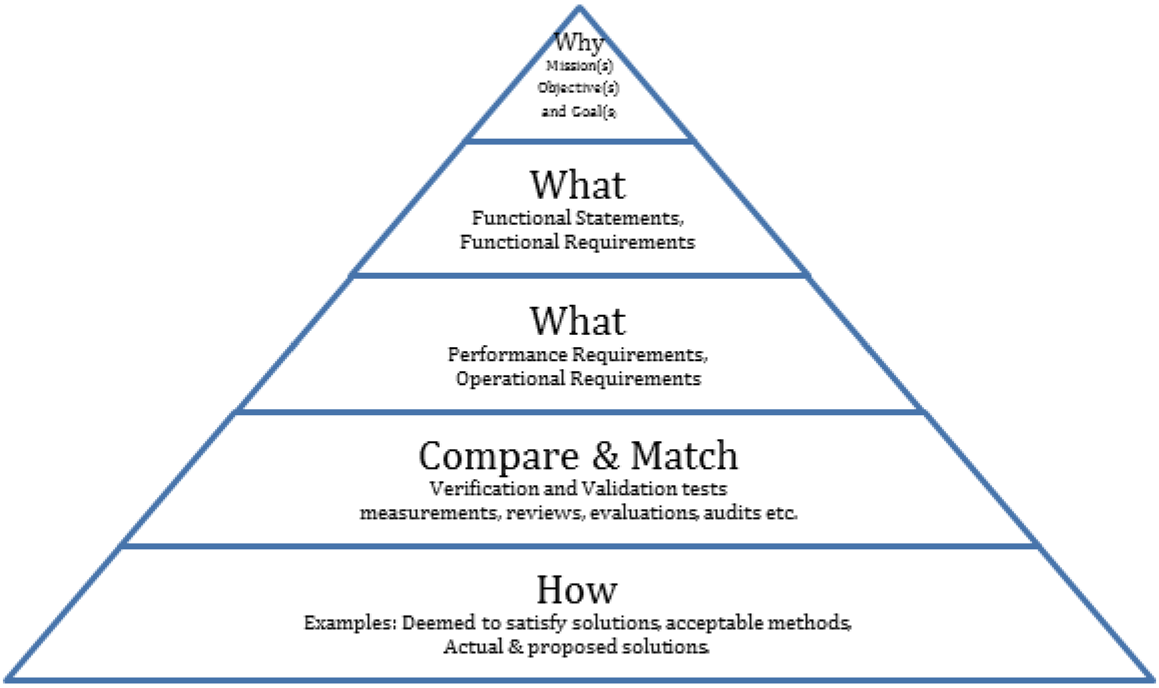

Figure 4. KPIs to measure the performance

Performance Indicators should be based on concrete and self-explained metrics. KPIs should be SMART (Specific, Measurable, Attainable, Relevant and Time-bound), and have the following characteristics:

- simple and understandable
- objective orientated
- measurable
- relevant to what you are trying to measure
- non-financial
- significant and positive impact (affecting all other performance measures in a positive way)
- frequently measured
- acted on by management team
- understood by all staff, and tie responsibility to the individual or team

The Standard of the European Committee for standardization CEN - EN 15341 describes the following methodology for selecting and use of KPIs [CEN06]:

1. Defining objective of the process: Identify what to do in order to improve global performance.
2. Selecting the relevant indicators, that can measure the parameters identified in 1.
3. Defining and collecting the necessary basic data
4. Calculating the KPIs

A good KPI should be constantly monitored and should indicate what actions need to take place. They should be detailed enough and on a basic level, and not being a result of many activities (as for instance return on capital). Furthermore, KPIs should be monitored in the lowest possible granularity, as for instance the smart meters do measure consumption rates per second.

By setting the overall contextual framework and the guidelines towards KPIs selection in InteGRIDy project, we proceed with the definition of the list of KPIs in the following section. The overall analysis is not provided as a steer representation of KPIs, rather it takes into account the different methodological layer specified as part of the InteGRIDy performance framework.

4 inteGRIDy Key Performance Indicators

Once defined the performance evaluation methodology and framework in previous sections, this section proceeds with the identification of the inteGRIDy Key Performance Indicators. As highlighted in previous section, the overall analysis is pilot oriented (from local level analysis to global KPI identification) and thus, an early KPI analysis and selection is provided per pilot site of the project. The overall analysis follows the steps:

- Brief presentation of pilot use cases and business objectives
- Selection of KPIs that fit to pilot use cases and business objectives
- Aggregation of list of KPIs to define the holistic InteGRIDy Key Performance Indicators framework.

4.1 Pilot Specific KPI analysis

The definition of pilot specific KPIs takes into account the list of use cases, business stakeholders and domains of interest as examined in the project. These use cases (highlighted in blue) have been defined in inteGRIDy D1.3 document, and a quick reference table can be found at Table 3 and Annex I: inteGRIDy use cases per pilot site. Related KPI IDs (as described in Table 4, Table 5, Table 6, Table 7, Table 8 and Table 9) are also referred on the text also highlighted in blue.

4.1.1 The Isle of Wight Pilot site

By taking into account the list of use cases we highlight the services for DSOs as the main stakeholder in the UK pilot site (Isle of Wight):

- Demand Response (IOW_UC01): Building optimization to maximize efficiency and demand flexibility contribution to DSO triggered Demand Response Services
- Smartening the distribution grid (IOW_UC02): Design of a smart grid architecture for the distribution network to minimize energy import/export with respect to network power flow and voltage constraints
- Energy Storage System (IOW_UC03): to set of multiple heat pumps, thermal storage, PV generation and possible electrical storage into an energy system with a single 'entry point' to the distribution network towards better providing grid balancing services
- Smart Integration of grid users from Transport (IOW_UC04): With an increasing need to integrate EV in order to promote zero carbon emission, to deploy Virtue EV technology to mitigate demand and promote zero carbon energy usage.

The main focus is to provide services for the DSO by fully exploiting the different technologies defined in the project: Demand Response, Battery Storage and partial integration of electric vehicles at the local network and thus the following indicators should be considered:

Regarding Demand Response, the metrics should include energy consumption in a given time period (T.01) (T.03), peak as a ratio to average consumption (T.02) and RES generation ratio (T.12) (T.13). The model can be completed with demand flexibility (T.04) (T.05) (T.06) (T.07), demand request (T.08) (T.09) and peak load reduction ratios (T.10). Altogether these metrics and their products can shape a complete impression of the energy consumption equilibrium at the Isle of Wight and this can be the baseline for the estimation of any aspect of performance in DR.

The smart grid performance measurement requires input related with the quality of service, such as the recording of energy losses (T.17) (T.18), voltage variations (T.19), power quality (T.20) (T.21) (T.22) (T.23), fault awareness and response (T.25).

In the economic domain, various aspects of the cost of energy (EC.01) (EC.02) (EC.03) (EC.04) (EC.05) would be appropriate for inclusion in the performance context, while CO_2 production level (EN.01) (EN.02) (EN.03) is a representative measure for the environmental domain. The number of people changing their behaviour (S.01) (S.05) and the degree of satisfaction from DR services (S.06) are measures appropriate for the environmental and social performance domains.

4.1.2 Terni Pilot Site

Similar approach is considered for the Terni pilot site with the local DSO as the main stakeholder for the innovative services developed in the project. More specifically:

- Demand Response strategies towards maximizing savings and economic benefits in normal operation by **optimizing flexibility management** towards reducing energy losses from the grid (ASM_UC01).
- Smartening the distribution grid towards ensuring **power quality improvement** in degraded operation by optimizing flexibility management of microgrid resources (ASM_UC02)
- Energy storage technology integrated within the context **of self-consumption** and improving that way the reliability of MV network (ASM_UC03)
- Smart Integration of grid users from Transport by performing a preliminary estimation of the **EV charging points impact** on the network will be performed by simulation models (ASM_UC04)

Special interest is the incorporation of local storage and CHP in a coordinated management framework to support optimal grid management scenarios for the local DSO.

Towards this direction, the proposed metrics include the energy consumption in a given time period (T.01) (T.03), the energy consumption peak as a ratio to average consumption (T.02), the RES generation ratio (T.12) (T.13), the demand flexibility and the peak load reduction ratios (T.04) (T.05) (T.06) (T.07), all included in the DR pillar.

For the smart grid performance measurement, input related with the quality of service, such as the recording of energy losses (T.17) (T.18), voltage variations (T.19) and power quality (T.20) (T.21) (T.22) (T.23).

In relationship with EVs and CHP metrics including the penetration level (T.28) (T.32) and the demand flexibility should be considered, while for battery storage, the proposed metrics include the State of Charge (SOC) (T.35) (T.36) (T.37) and battery demand flexibility (T.38) (T.39).

4.1.3 San Severino Pilot Site

By taking into account the list of use cases for the pilot site we highlight the core services:

- **Demand Response** strategies through energy storage to be controlled in real life while passive users to be properly informed about their energy behavior. The objective is to evaluate the effectiveness of resources aggregation in order to provide grid services (ASS_UC01).
- Smartening the Distribution Grid as the DSO identifies **optimal topology of the grid** in order to host dispersed generation, to minimize losses and to maximize grid resilience (providing a better quality of supply to the final users) (ASS_UC02)

- **Energy Storage** as a very promising resource due to the capability for a fast and accurate energy flow regulation (contribution to frequency control, voltage control, etc.). Similarly, in the final user perspective, energy Storage could be an effective resource in order to better shape the load profile (energy arbitrage, peak shaving) and to better exploit local generation (increase self-consumption) (ASS_UC03).

Once again, we highlight the role of the local DSO to evaluate different strategies, mainly focusing on optimal energy storage management (and local consumers) in Demand Response strateiges.Taking into account the list of diverse use cases examined in the pilot site, we are selecting the KPIs for performance assessment analysis.

First, in the field of DR we suggest energy consumption (T.01) (T.03) and the energy consumption peak as a ratio to average consumption (T.02), together with various metrics on Demand Flexibility (T.04) (T.05) (T.06) (T.07) and demand request (T.08) (T.09), given that these metrics can offer a good insight to the performance achieved by the proposed DR mechanism.

For the smart grid performance measurement, input related with the quality of service, such as the recording of energy losses (T.17) (T.18), voltage variations (T.19) and power quality (T.20) (T.21) (T.22) (T.23).

For battery storage, the proposed metrics include different indicators related with the State of Charge (SOC) (T.35) (T.36) (T.37) and battery demand flexibility (T.38) (T.39).

4.1.4 Barcelona Pilot Site

In Barcelona site, we highlight the role of ESCO (acting on behalf of Demand Side Aggregator) as the main business stakeholder. By taking into account the list of use cases for the pilot site we have:

- Thermal and Electric Synergies by modulating **temperatures set point for heat pumps** and dehumidifiers to allow for better device management **based on energy prices** (i.e. gas and electricity) (BCN1).
- Photovoltaics and **Electric Storage Optimization** towards promoting peak shaving, load **shifting and maximizing self-consumption** by also taking into account **energy prices** (BCN2)
- **Uninterruptible power supply** in case of a grid outage to a specific client. In this case, it will feed critical demand at building level to ensure the smooth operation of the building in grid intense conditions (BCN3)

This pilot site differentiates from the previous ones as the main focus is on the evaluation of ESCO services for final consumers (Virtual Thermal Storag and electric storage optimization under different grid and market conditions.)

The proposed metrics include energy consumption in a given time period (T.01) (T.03), peak as a ratio to average consumption (T.02), RES generation ratio (T.12) (T.13), demand flexibility (T.04) (T.05) (T.06) (T.07) and peak load reduction ratios (T.10). Furthermore, energy import / export into a neighbourhood (T.14) (T.15) or the energy mismatch ratio (T.16) are metrics within the same category of DR, providing a useful impression of the performance achieved within the specific domain (neighbourhood or virtual network).

For battery storage, the proposed metrics include different indicators related with the State of Charge (SOC) (T.35) (T.36) (T.37) and battery demand flexibility (T.38) (T.39).

In the economic domain, the cost of energy in a given time unit and under different perspectives, such as the retailer's cost of energy or the estimated reduction of the consumption's cost (EC.01) (EC.02) (EC.03) (EC.04) (EC.06) (EC.07) may offer a complete view of performance. CO_2 production level is a representative measure for the environmental domain (EN.01) (EN.02) (EN.03).

4.1.5 St Jean Pilot Site

Addressing the role of the local DSO acting also as a DR aggregator, the main focus in the French pilot site in St Jean is to set in place a Demand Side Energy Behaviour Profiling Mechanism that will allow for the assessment and evaluation of explicit (automated) DR strategies fully preserving end users' preferences and needs. Three use cases are examined in the pilot site at St Jean

- Demand Response: Explicit Demand Response Schemas in residential and commercial premises are going to be tested by incorporating occupants' comfort boundaries in the decision-making process, towards establishing a **demand side management framework** fully preserving end users' needs and preferences (INN_UC01).
- Energy Storage: Using thermal models (previously generated) in combination with other data sources, the thermal properties and the heating dynamics of the building will be inferred. The resulting profiles are used for the demonstration of innovative **power-to-heat solutions** resulting **VES in buildings** through optimized HVAC and water heaters control. This is a use case examined in FR pilot site to evaluate the impact of energy storage as an inherent component of future grids (INN_UC02).

The local DSO is operating as a DR Aggregator to evaluate the impact of automated demand response strategies (demand shedding and shifting by incorporating the Virtual Thermal storage concept) with the participation of end customers.

Energy consumption (T.01) (T.03) is central for the performance evaluation of the proposed DR mechanism at pilot nr 5, as it reflects the occupants' consumption patterns' compliance with the DR program. RES Generation ratio (T.12) (T.13) is also important, as it indicates the amount of energy imported into a neighbourhood or a virtual network, while VES usage level (T.40) (T.41) is heavily contributing in Demand Flexibility and eventually to the overall performance of the DR.

In the economic domain, various aspects of the cost of energy would be appropriate for inclusion in the performance context (EC.01) (EC.02) (EC.03) (EC.04) (EC.06) (EC.07), while CO_2 production level is a representative measure for the environmental domain (EN.01) (EN.02) (EN.03).

4.1.6 Nicosia Pilot Site

Two different use cases will be examined in the project. The first one concerns the university local microgrid and the interconnection with the local grid, while the second one has to do with prosumers and their active participation in Demand Response schemas:.

- Smartening the Distribution Grid: as the campus will use all the available tools (monitor and supervision of microgrid, demand response tool, smart management of stored energy) in order to schedule the energy flow within the microgrid with maximized efficiency. Furthermore, the microgrid will communicate with the DSO being able to trade its flexibility. The goal is to increase the effectiveness of the energy within the campus and provide ancillary services to the DSO (UCY_UC01).
- Demand Response: The prosumers are equipped with smart meters for measuring the energy production from PV and consumption. The smart meters are connected with the DSO, which shall trade flexibility offers with the prosumers (new pricing scheme towards adopting a more grid-friendly demand curve) (UCY_UC02)

Towards this direction, the diverse list of KPIs inline with the pilot site specific objectives is presented:

Energy consumption (T.01) (T.03), Peak to average (T.02) and Demand Flexibility ratios (T.04) (T.05) (T.06) (T.07) are global indicators which are covering DR performance, along with the “local” RES Generation, RES Generation ratio (T.12) (T.13) and Self Consumption Rate (T.03).

For battery storage, the proposed metrics include different indicators related with the State of Charge (SOC) (T.35) (T.36) (T.37) and battery demand flexibility (T.38) (T.39).

As with all previous pilots, in the economic domain, various aspects of the cost of energy would be appropriate for inclusion in the performance context (EC.01) (EC.02) (EC.03) (EC.04) (EC.06) (EC.07), while CO_2 production level is a representative measure for the environmental domain (EN.01) (EN.02) (EN.03).

4.1.7 Lisboa Pilot Site

These is the list of use cases to be examined in the PT pilot site:

- For the first use case, a study of DR shift potential in the building will be developed using the predicted charge profile to be applied in the building electric consumption profile. This will be linked with the smart meters in the building to assess the positive effect in the charging system devices. The demand response shift capacity allows the actual energy use to be allocated to user beneficiary daily periods taking into account the local generation and the maximization of self-consumption (LIS_UC01).
- The second case study will access the technical potential of an ice bank as energy storage system to provide the required DR shift according to a virtual tariff flexibility. This potential will be optimized through investment in equipment to regulate the ice banks thermal energy heat transfer capacity in order to fit its transfer power with DR needs (LIS_UC02).
- The third case study will address the potential to adapt the EV charging cycles to dynamic tariffs, replacing the already used fixed-tariff system (LIS_UC03).

The overall analysis is market oriented, towards the delivery of better services to customer by taking into account variation on energy prices. The list of KPIs selected for the evaluation analysis in this pilot site is presented.

Energy consumption (T.01) (T.03), Peak to average (T.02) and Demand Flexibility ratios (T.04) (T.05) (T.06) (T.07) are global indicators which are covering DR performance, along with the “local” RES Generation, RES Generation ratio (T.12) (T.13) and Self Consumption Rate (T.03).

For energy storage, VES Demand Flexibility is the proposed metric (T.40) (T.41).

In the economic domain, various aspects of the cost of energy would be appropriate for inclusion in the performance context (EC.01) (EC.02) (EC.03) (EC.04), while CO_2 production level is a representative measure for the environmental domain (EN.01) (EN.02) (EN.03) (EN.04) (EN.05). Then for implicit DR, which it the case for the pilot of Lisboa, the following social metrics are proposed: the number of people changing their behaviour (S.01), the degree of user satisfaction from DR services (S.02) and the penetration of dynamic energy tariffs in tertiary buildings (S.03).

4.1.8 Xanthi Pilot Site

Xanthi Pilot deals with the case of isolated small scale smart grid networks with local energy storage optimization with RES to be the main source of power. Therefore, the list of use cases for demonstration are presented:

- For Smartening the Distribution Grid: The Automated Grid Supervision System analyses and takes decisions for optimum energy distribution at the grid level to minimize usage of back-up sources (diesel generator) and to maximize utilization of available RES (SUN_UC01).
- In terms of Energy Storage Technologies, the goal is to protect the lifetime and operational capacity of the local storage systems by providing a virtual storage system that can be used upon request and availability at the grid level (SUN_UC02).
- Integration of grid users from transport to charge batteries utilizing energy from RES and to derive charging profiles upon request and towards evaluation of the EV charging effect at the storage systems (SUN_UC03).

This is a special pilot site (local microgrid) with special interest on the evaluation of battery storage in different business cases (local grid stability, maximum local RES exploitation etc…). The evaluation of use cases is energy storage oriented and towards this direction, the proposed indicators include: Energy consumption (T.01) (T.03), Peak to average (T.02), peak load reduction (T.10) and Demand Flexibility ratios (T.04) (T.05) (T.06) (T.07) as global indicators and RES Generation, RES Generation ratio (T.12) (T.13) and Self Consumption Rate (T.03) as local indicators.

Voltage variations (T.19), number of grid events (T.20), SAIFI (T.21), SAIDI (T.22) and average frequency deviation (T.26) are indicators in the pillar of 'Smartening the Distribution Grid'.

Regarding the Electric Vehicles, we propose EV penetration level (T.28) and EV peak demand (T.29).

In the economic domain, various aspects of the cost of energy should be included in the performance context (EC.01) (EC.02) (EC.03) (EC.04) (EC.06) (EC.07), while CO_2 production level is a representative measure for the environmental domain (EN.01) (EN.02) (EN.03).

4.1.9 Ploiesti Pilot Site

The proposed use cases satisfy the high-level objective of the Pilot, towards comparing the results of the implementation of a DR automated solution with the results of the existing AMR (Automated Meter Reading) solution.

- Towards promoting DR at building level, the goal is to Monitor and Control by determining the tendencies and prognosis of the consumption considering the implementation of different pricing strategies (DR_PL 01)
- On the other hand, auto DR strategies will be examined through monitoring and control at residential level, considering also the availability of DR infrastructure offering services to DSOs (DR_PL 02)
- The same technology will be considered towards promoting self-consumption and peak saving schemas (consumer focused DR strategies). System alerts / notifications concerning the optimization of own consumption / costs will be considered. (DR_PL 03)

The overall performance assessment analysis in the Romanian pilot site will focus on DR penetration through active participation of customers in Demand Response scenarios. The list of KPIs selected for pilot site is presented:

The proposed indicators in the DR pillar include: Energy consumption (T.01) (T.03), Peak to average (T.02), and Self Consumption Rate (T.03), as well as Demand Flexibility ratios (T.04) (T.05) (T.06) (T.07) as global indicators.

Energy Losses (T.17) and Energy Losses Ratio (T.18) are covering the 'Smartening of the Distribution Grid' pillar.

In the economic domain, various aspects of the cost of energy would be appropriate for inclusion in the performance context (EC.01) (EC.02) (EC.03) (EC.04) (EC.05) (EC.06) (EC.07), while CO_2 production level is a representative measure for the environmental domain (EN.01) (EN.02) (EN.03).

4.1.10 Thessaloniki Pilot Site

Addressing the role of retailer in Thessaloniki Pilot site, the list of use cases for pilot site is presented:

- The main purpose is to develop efficient, practical and reliable optimization DR mechanisms for residential customers towards minimizing their electricity payment or maximizing their welfare in order to achieve a generally uniform electricity load profile with reduced peak power (TH_UC01).
- The main purpose is to develop efficient, practical and reliable optimization DR mechanisms for residential and commercial customers by incorporating storage systems. Another purpose in this use case is to achieve maximum monetary savings and self-consumption as an impact of optimal battery system exploitation (TH_UC02).
- In addition to the last case scenario, the incorporation of demand side controllability offers high potential of flexibility to achieve peak shaving, load shifting, self-consumption as well as to increase the financial savings of the building (TH_UC03).

In this case scenario, a local retailer is actively participating in project activities to evaluate the impact of different demand response strategies (manual or automated evaluating also the impact of local storage installation). By taking into account the list of use cases (consumer oriented services), we specify the list of KPIs to be considered for the evaluation analysis.

Energy consumption (T.01) (T.03), Peak to average (T.02) and Demand Flexibility ratios (T.04) (T.05) (T.06) (T.07) are global indicators which are covering DR performance.

For battery storage, the proposed metrics include different indicators related with the State of Charge (SOC) (T.35) (T.36) (T.37) and battery demand flexibility (T.38) (T.39).

As with all previous pilots, in the economic domain, various aspects of the cost of energy would be appropriate for inclusion in the performance context (EC.01) (EC.02) (EC.03) (EC.04) (EC.05), while CO_2 production level is a representative measure for the environmental domain (EN.01) (EN.02) (EN.03).

Furthermore, for DR, which it the case for the pilot of Thessaloniki, we propose the following social metrics: the number of people changing their behaviour (S.01), the degree of user satisfaction from DR services (S.02) and the penetration of dynamic energy tariffs in tertiary buildings (S.03).

An overview (summary) of the KPIs selected for the 10 (ten) pilots of inteGRIDy can be found in Annex II: inteGRIDy KPIs per pilot and domain. Furthermore, by taking into account the definition of the use cases identified per pilot in deliverable D1.3 *Pilot Sites Surveys Use-Case Requirements & Business Scenarios* (see Annex I: inteGRIDy use cases per pilot site), the alignment of KPIs per use case and thematic pillar is provided (**Error! Reference source not found.**).

Following pilot site analysis and preliminary KPIs selection, we proceed with the representation of KPIs, considering the different viewpoints, defined earlier in **Error! Reference source not found.**. As an anchor point of the inteGRIDy evaluation framework we define the allocation of indicators to Global KPIs and Local KPIs.

4.2 inteGRIDy Global Indicators

In this section (taking into account the preselection of KPIs) we proceed with the definition of Global KPIs of inteGRIDy, further grouped at the different performance domains (technical, economic, environmental and social). The list of Global KPIs should be common to the different use cases, without specific reference to the inteGRIDy pilots (The idea is to show the flexibility of the proposed approach and its adaptability to different pilot sites). In this section, the KPIs are defined and described, while their calculation formulas are also provided.

4.2.1 Technical Performance KPIs

In the next pages, the list of technical KPIs are described

Table 4. List of Global KPIs - Technical Domain

ID	Name	Description	Calculation	Units
Technical Domain				
T.01	Energy Consumption (Monthly, Daily….)	Total energy consumption is the sum of electrical energy, over a given time period T	*Sum of electricity measures*	kWh / time period
T.02	Peak to Average Ratio (PAR)	The peak-to-average demand ratio is a measure how much higher annual peak demand is compared to annual average. A high ratio can result from a spike in the peak demand levels, or from average demand flattening or declining. A higher ratio can affect everything from electricity prices to energy availability.	$PAR = \frac{Peak\ Energy\ Consumption}{Average\ Energy\ Consumption}$	percent
T.03	Self-Consumption Rate	Share of DER in the energy mixture	$\frac{RES\ Generation}{Energy\ Consumption}$	percent
T.04	Energy Consumption Reduction (Demand Flexibility)	This KPI defines the actual amount of the provided load reduction	*Baseline Energy Consumption - Actual Energy consumption*	kWh / time period
T.05	Demand Flexibility Ratio	Demand Flexibility ratio defines the ratio of Demand Flexibility to Total Energy Consumption	$\frac{Demand\ Flexibility}{Baseline\ Energy\ Consumption}$	decimal
T.06	Demand Flexibility Request	The amount of the requested Demand Flexibility	*Baseline Energy Consumption - Requested Energy Consumption*	kWh / time period
T.07	Demand Flexibility Baseline (Potential)	The amount of potential Demand Flexibility reflects the amount of energy consumption reduction the End User could potentially accept and apply	*Baseline Energy Consumption - Potential Energy Consumption*	kWh / time period
T.08	Demand Request Participation	The ratio of the End User's actual participation to Demand Flexibility over the requested Demand Flexibility	$\frac{Demamd\ Flexibility}{Demand\ Flexibility\ Request}$	decimal

T.09	Demand Request Enrolment	The ratio of the requested participation to Demand Response campaigns over the Demand Flexibility Potential	$\frac{Demand\ Request}{Demand\ Flexibility\ Baseline}$	decimal
T.10	Peak load reduction	Reduction of the value of the maximum load on a given period (day, month, year).	*Peak load before the project - Peak load after the project*	kW

4.2.2 Economic Performance KPIs

The indicators cover the full range of requirements and particularities of the inteGRIDy pilots. Thus, a perspective that should be examined as part of the economic performance domain is the impact, mainly in terms of cost for the different operational scenarios in the pilots. Several scenarios will be examined as part of the inteGRIDy evaluation framework:

- Cost efficient operation. The main objective of this scenario is the extraction of the optimal strategy, taking into account the cost of energy. Thus, a list of price related KPIs has to be defined.
- Sustainable operation. This scenario is examined as a balancing mechanism between cost and comfort parameters.
- Demand Response operation: The Demand Requests are examined either due to Grid related abnormal situations or to Aggregator's operational decisions. On the other hand, the Aggregator's decision approach is mainly driven by energy markets operation and thus a detailed analysis is provided.

The list of Performance Indicators is presented, as part of the specific performance domain. The goal of the approach proposed is to help a market players to appraise portfolios of contracts from the point of view of the economic performance-which measures the potentiality of gains and the potentiality of losses-taking into account the multidimensional aspect of risk, the vagueness and nuances of the decision maker's preferences, and the different kinds of uncertainties.

Hence from economic perspective, a list of cost related performance indicators will be defined. The estimation of the related KPIs is based on:

- Energy prices: Energy market operation and wholesale market prices
- Retail prices: Prices of energy retailers
- Price rewards: The monetary reward for the provision of DR services (D.S.O. → Aggregator, Aggregator →Demand Side Customers)

Table 5. List of Global KPIs - Economic Domain

ID	Name	Description	Calculation	Units
Economic Domain				
EC.01	Retailer Cost of Energy (Monthly, Daily...)	This KPI defines the energy consumption cost in the reference time period	*Energy Consumption * Retailer Tariff*	monetary unit
EC.02	Average Cost of Energy Consumption	This KPI defines the average cost of energy consumption	$\frac{Cost\ of\ Energy\ Consumption}{Total\ Energy\ Consumption}$	monetary unit/KWh
EC.03	Cost of Energy reward (based on contractual Agreement)	This KPI defines the reward paid from the Aggregator to the facility managers for the provision of DR services based on the contractual agreement	*Demand Flexibility * Price Reward*	monetary unit
EC.04	Average Cost of Energy Reward	This KPI defines the average value of the reward paid from the Aggregator to the facility managers for the provision of DR services to the energy flexibility offered	$\frac{Cost\ of\ Energy\ reward}{Demand\ Flexibility}$	monetary unit/KWh

4.2.3 Environmental & Social Performance KPIs

As the last pillar of the inteGRIDy performance framework we define the environmental and social KPIs, domains not covered from the technical and business KPIs presented above.

This approach covers the aspects related to the environmental conditions in buildings but also takes into account the operational preferences on specific business conditions. A third dimension is introduced in the proposed framework for a holistic performance evaluation analysis. The list of environmental and social KPIs (here only environmental) that are part of the Global KPI framework are presented in the following table.

Table 6. List of Global KPIs - Environnemental & Social Domain

ID	Name	Description	Calculation	Units
Environmental Domain				
EN.01	CO_2 emissions	CO_2 direct emissions is the amount of the direct emissions (in kg) for the consumption of a specific (electrical) energy amount over a given period of time T.	*Energy Consumption * CO_2 emissions ratio*	kg
EN.02	CO_2 emissions Reduction	Reduction (%) in direct (operational) CO_2 emissions reflecting the energy consumption reduction achieved in the context of a pilot.	*Energy Consumption Reduction * CO_2 emissions ratio*	percent

In total, we have defined 16 KPIs the consist of the global KPIs framework of the project.The technical KPIs are mostly focusing on energy consumption, demand flexibility and request, and peak load reduction.

The economic domain is mainly reflecting the cost of energy and the environmental domain the CO_2 emissions. It is clear that this concrete set of KPIs is defined as the KPI performance skeleton (framework) that may be further replicated to other pilot sites.

4.3 inteGRIDy Local Indicators

Following the definition of the Global KPIs, we proceed with the presentation of Local Indicators. These KPIs are 'pilot specific', and offer meaningful, quantified insights to the operational performance of different technologies and components, demonstrated at the different pilots. The KPIs are again grouped under the three performance domains (technical, economic, environmental & social) further associated to the 4 thematic pillars examined in the project (Demand Response, Smartening the distribution grid, Energy storage, Smart integration of grid users from transport).

4.3.1 Technical Performance KPIs

In the technical domain, pilot specific KPIs include among other metrics: RES Generation, self-consumption and energy equilibrium in the DR field, Energy losses, voltage variations and grid events registration in the field "smartening the distribution grid", as well as representative metrics related with Electric Vehicles, Energy Storage and Combined Heat and Power applications.

Reviewed the use cases for each pilot (see Annex I: inteGRIDy use cases per pilot site and for more information D.1.3. "Pilot Surveying Project Report, Use-Case & Business Scenarios") we note that:

- All pilots are dealing with Demand Response Strategies, but specificities are applied to each pilot site.
- Pilots 1 (Isle of Wight), 2 (Terni), 3 (San Severino), 6 (Nicosia) and 9 (Ploiesti) have use cases under the pillar 'Smartening the Distribution Grid'
- Pilots 7 (Lisboa) and 9 (Ploiesti) are not dealing with energy storage
- Only pilots 1 (Isle of Wight), 2 (Terni), and 7 (Lisboa) include use cases related with Electric Vehicles

Based on the above, annexes II and III present the matching of the local KPIs which are following, per pilot and use case respectively.

Table 7. List of Local KPIs - Technical Domain

ID	Name	Description	Calculation	units
Demand Response				
T.11	Reactive Energy Consumption	Total reactive energy consumption is the sum of electrical energy, over a given time period T	*Sum (kVArh)*	kVArh/time period
T.12	RES Generation	The amount of energy produced by RES in a given time period	*RES Generation*	kWh / time period
T.13	RES Generation Ratio	The amount of energy produced by RES in a given time period over the nominal generation capacity of RES	$\frac{RES\ Generation}{Nominal\ RES}$	decimal
T.14	Energy Import	amount of energy imported into a neighbourhood or a virtual network	$\frac{Imported\ Energy}{Energy\ Consumption}$	percent
T.15	Energy Export	amount of energy exported from a neighbourhood or a virtual network	$\frac{Exported\ Energy}{Energy\ Consumption}$	percent
T.16	Energy Mismatch Ratio	The ration of the maximum exported energy over the maximum of the imported energy on a given time period	$\frac{Maximum\ Exported\ Energy}{Maximum\ Imported\ Energy}$	decimal
Smartening the distribution grid				
T.17	Energy Losses	Amount of electrical energy lost on grid's conductors, transformers, etc.	*Energy losses over the network * time*	kWh
T.18	Energy Losses Ratio	The energy losses ratio is a performance indicator reflecting the reliability of the transmission and distribution network.	$Energy\ Losses\ Ratio = \frac{Transmission\ Losses + Distribution\ Losses}{Output}$	percent

ID	Name	Description	Calculation	units
T.19	Voltage variations	Difference between the actual voltage supplied to MV/LV users and the nominal value	$\frac{(Actual\ voltage\ measured - Rated\ voltage)}{Rated\ Voltage}$	percent
T.20	Number of Grid Events	An event is an occurrence that changes the state of something. In power distribution, it could be that current stopped flowing, a relay opened or that a device battery reached a critical level of discharge. Events have both temporal and spatial characteristics, (they happen at a time and place). Data about events splits into three types: operational, non-operational, and event messages.	*Sum of registered Grid Events*	Number of events (integer)
T.21	SAIFI	System average interruption frequency index	*Average of interruptions number*	interruptions per customer
T.22	SAIDI	System average interruption duration	*Average of interruption duration*	time
T.23	Power quality (power factor)	Number and duration of voltage dips involving a given user or group of users.	*Voltage dips depth (residual voltage) and duration according to standard IEC50160*	Depth: % of rated voltage; duration: ms
T.24	THD/ harmonics distortions	Degree of distortion influencing efficiency	*Measured value vs normalized value*	percent
T.25	Reduction in time required for fault awareness, localization and isolation	Reduction of time between the occurrence of a fault and its identification, localization and isolation carried out through the network's automation and protection system of the grid and manual procedures of the DSO.	*Time required for the fault identification, localization and isolation before the project - Time required after the project*	hours, minutes, seconds

ID	Name	Description	Calculation	units
T.26	Average frequency Deviation	The Average Frequency Deviation is an indicator reflecting the imbalance between power generation and demand in the power system operation, as such imbalances might be threatening the stability and reliability of power systems.	$AFD_{average} = \frac{1}{N}\sum_{n=1}^{N} F_D(n)$ $N = \frac{M_w}{T_s}$ *where, F_D = the instantaneous frequency deviation* *M_w = is the measurement window size in sec* *and T_s = the sampling time*	Hz
T.27	Reaction time for providing primary control reserve	The time reaction of generation or demand towards providing primary control reserve services	Average T_react (when DR primary DR event)	Sec
Electric Vehicles				
T.28	EV Penetration Level	The percentage of EVs registered in a specific country over the total number of registered vehicles	$\frac{Number\ of\ EVs\ registered}{Total\ number\ of\ EVs\ registered}$	percent
T.29	EV Peak Demand	The peak electricity demand for the charging of EVs	*The highest demand of electricity for the charging of EVs only*	kW
T.30	EV demand flexibility baseline	The amount of potential Demand Flexibility reflects the amount of energy consumption reduction the EV End User could potentially accept and apply.	*Baseline Energy Consumption dedicated to EVs charging - Potential Energy Consumption dedicated to EVs charging*	kWh / timeperiod
T.31	EV demand flexibility	The KPI defines the actual amount of the achieved load reduction for the charging of EVs	*Baseline Energy Consumption dedicated to EVs charging - Actual Energy consumption dedicated to EVs*	kWh / time period

ID	Name	Description	Calculation	units
			charging	
Co-Generation (CHP) Analysis				
T.32	CHP Penetration Level	CHP penetration level is represented by the share of CHP installed power over the installed power in a system or country	$CHP\ Penetration = \frac{Installed\ Power\ of\ Total\ CHP\ units}{Installed\ Power}$	percent
Battery Storage Analysis				
T.35	State of Charge (SOC)	SOC is defined as the remaining capacity of a battery and it is affected by its operating conditions such as load current and temperature.	$SOC = \frac{Remaining\ Capacity}{Rated\ Capacity}$	percent
T.36	Depth of Discharge (DOD)	DOD is used to indicate the percentage of the total battery capacity that has been discharged. For deep-cycle batteries, they can be discharged to 80% or higher of DOD.	*DOD = 1 - SOC*	percent
T.37	Average SOC	If a battery spends a significant amount of time at a high state of charge (SOC), it will degrade faster than if it is left and maintained at a mid-level state of charge. Some batteries are more sensitive to this than others, but generally it is known that the higher the average SoC over the battery life, the faster it will degrade. Similarly, if a battery is kept at very low average SOC, it will also degrade quickly.	$SOC_{average} = \frac{1}{N}\sum_{i=1}^{N} SOC_i$	percent
T.38	Battery Demand Flexibility Baseline	The amount of potential Demand Flexibility reflects the amount of energy consumption reduction the Batteries End User could potentially accept and apply.	*Baseline Energy Consumption dedicated to Batteries charging - Potential Energy Consumption dedicated to Batteries charging*	kWh / timeperiod

ID	Name	Description	Calculation	units
T.39	Battery Demand Flexibility	The KPI defines the actual amount of the achieved load reduction for the charging of Batteries	*Baseline Energy Consumption dedicated to Batteries charging - Actual Energy consumption dedicated to Batteries charging*	kWh / time period
T.40	VES Demand Flexibility Baseline	The amount of potential Demand Flexibility reflects the amount of energy consumption reduction the Batteries End User could potentially accept and apply.	*Baseline Energy Consumption dedicated to Batteries charging - Potential Energy Consumption dedicated to Batteries charging*	kWh / time period
T.41	VES Demand Flexibility	The KPI defines the actual amount of the achieved load reduction for the charging of VES	*Baseline Energy Consumption dedicated to VES charging - Actual Energy consumption dedicated to VES charging*	kWh / time period

4.3.2 Economic Performance KPIs

The following local KPIs, in the economic domain are mostly applicable on those pilots which are testing DR and smart grid use cases, namely pilots 1 (Isle of Wight, 2 (Terni), 3 (San Severino), 5 (St Jean), 6 (Nicosia) and 9 (Ploiesti).

Table 8. List of Local KPIs - Economic Domain

Id	Name	Description	Calculation	units
EC.05	Demand Price Elasticity (Self Elasticity)	This KPI defines the reduction of the demand flexibility as a reference to the total cost of energy consumption.	$\frac{(\frac{Demand\ Flexibility}{Baseline\ Energy\ Consumption})}{(\frac{Cost\ of\ Energy\ savings}{Baseline\ Cost\ of\ Energy})}$	KWh/m.u.
EC.06	Average Estimation of Cost savings	This KPI defines the per KWh Energy Savings of the stakeholders, during the control operation	$\frac{Cost\ estimation\ of\ Energy\ Savings}{Demand\ Flexibility}$	monetary unit/KWh
EC.07	Cost of ancillary services	peak shaving	*energy savings * tariff*	monetary unit

4.3.3 Environmental & Social Performance KPIs

Table 9. List of Local KPIs - Environnemental & Social Domain

ID	Name	Description	Calculation	units
Environmental Domain				
EN.03	Thermal Comfort	This Indicator defines the Thermal User Preferences as examined within the inteGRIDy pilots. A scale of [0..1] is considered. The holistic value is defined per occupant and groups of occupants.	*Model based estimation: User Thermal Profiling model* *Thermal Comfort Value = f(PMV)* *Where f is the model based function as described in the introduction.*	scale of [0..1] integer
EN.04	Visual Comfort	This Indicator defines the Visual User Preferences as examined within the inteGRIDy pilots. A scale of [0..1] is considered. The holistic value is defined per occupant and groups of occupants (Facility Manager Perspective)	*Model based estimation: User Visual Profiling model* *Visual Comfort Value = f (luminance)* *Where f is the model based function as described in the introduction.*	scale of [0..1] integer
EN.05	Operative Temperature	Operative temperature (t_o), also known as Dry resultant temperature, or Resultant temperature, is defined as a uniform temperature of an imaginary black enclosure in which an occupant would exchange the same amount of heat by radiation plus convection as in the actual nonuniform environment.	$t_o = \frac{(hrtmr + hcta)}{h_r + hc}$ *where, h_c = convective heat transfer coefficient* *h_r = linear radiative heat transfer coefficient* *t_a = air temperature* *t_{mr} = mean radiant temperature*	degrees Celsius

ID	Name	Description	Calculation	units
EN.06	Thermal Comfort Deviation	This KPI defines the percentage differentiation of the individual preferences from commonly accepted standards	*f^{-1} [f PMV = 0.5]* *This formula is presented in a high-level view in order to define the PMV value (standardized format) that refers to the average thermal preferences of the individual examined*	percent
		Social Domain		
		Explicit Demand Response		
S.01	Number of people changing their behaviour	The goal is to make a motivational connection between individual energy use and its impact on the environment in order to motivate people to change their behaviour and conserve resources. Smart-meters comprises methods for displaying information of real-time energy use and can be used to facilitate energy efficiency.	*Number of people adopted inteGRIDy solution given a specific time frame*	Number of people/ time frame
S.02	Number of times social app is accessed	Maximizing target user awareness regarding the inteGRIDy solution through social media presence. A huge number of visitors in inteGRIDy's networks such as Facebook, Twitter, LinkedIn, Google and YouTube.	*Application analytics, such as: Youtube-channel statistics, Facebook-likes/rates, google analytics*	Number of hits /time frame
S.03	Demand response campaign penetration in buildings	The degree of DR campaign penetration in buildings of any type.	*Based on analytics: users interacting with the app vs/ users enrolled in the project.*	percent

ID	Name	Description	Calculation	units
S.04	Degree of user satisfaction from DR services	Customer satisfaction is defined as "the number of customers, or percentage of total customers, whose reported experience with a firm, its services exceeds specified satisfaction goals.	*Questionnaire for data collection on users' satisfaction. Likert Scale: Strongly Disagree, Disagree, neither agree or disagree, Agree, Strongly Angry*	categorical scale
		Implicit Demand Response		
S.05	Number of people changing their behaviour	The goal is to make a motivational connection between individual energy use and its impact on the environment in order to motivate people to change their behaviour and conserve resources. Smart-meters comprises methods for displaying information of real-time energy use and can be used to facilitate energy efficiency.	*Number of people adopted inteGRIDy solution given a specific time frame*	Number of people/ time frame
S.06	Degree of user satisfaction from DR services	Customer satisfaction is defined as "the number of customers, or percentage of total customers, whose reported experience with a firm, its services exceeds specified satisfaction goals.	*Questionnaire for data collection on users' satisfaction. Likert Scale: Strongly Disagree, Disagree, neither agree or disagree, Agree, Strongly Angry*	categorical scale
S.07	Penetration of dynamic energy tariffs in tertiary buildings	The level of DR schemes adoption as it is reflected by the active involvement of users in tertiary buildings (namely offices, shops, hospitals etc.)	$\frac{Users\ interacting\ to\ dynamic\ prices}{Users\ enrolled\ but\ not\ interacting}$	percent

We presented above the list of KPIs that consist of the local (pilot specific) KPI framework and together with Global KPIs set the hybrid KPI framework of the project. The local (pilot specific) KPIs definition is very important as it set the specificities of the KPI framework to the specific (pilot site) business objectives, scenarios etc.

In total 59 KPIs are identified and presented in the deliverable, from which 16 set the Global KPI framework and 43 set the Local (pilot-specific) KPIs framework. The KPIs are grouped according to the different thematic pillars and performance domains of inteGRIDy Performance Assessment Framework, which has been presented in paragraph 3.5 Pilot Oriented inteGRIDy Performance Evaluation . In addition, a high-level taxonomy of KPIs to the inteGRIDy business stakeholders is provided in Annex IV.

The selection and hierarchical analysis of KPIs is offering to the inteGRIDy, a common knowledge-base for the performance evaluation of the 10 pilot sites where the novel architectures and use cases are about to be tested. The selection of KPIs is based on the definition of inteGRIDy project foundations in WP1 (business objectives, pilot sites and use cases), screening the landscape for the design and development of inteGRIDy platform.

5 Data Collection Framework

Defining the KPI's is easy – collecting the data is difficult! We have to make sure that the KPIs take account of the data available at the different pilot sites or other sources. The KPI's are calculated raw data collected in the field and thus the main input parameters are defined which should be always and directly available during the calibration as well as during the simulation procedure.

The aim of the inteGRIDy performance framework is to present a holistic approach for the estimation of indicators based **on a priori estimations** and a **posteriori measurement values**. This separation of work mandates for the adoption of a hybrid method for the calculation of the inteGRIDy Performance Indicators.

In **Measurement based performance assessment**, it is of utmost importance to know the history of the system examined based on real data. The more detailed the information is (i.e. divided into different end-users and time intervals), the more useful it will be during the management programme.

In **Model based performance assessment**, the mathematical models of the building and the grid systems play an important role in identifying energy saving potentials as they are principally able to deliver reference values for the "normal" behaviour of the building as well as the system parameters for the optimal performance. Therefore, they can be used for the analysis of grid/aggregator level conditions and for the optimization procedure.

A mixture of measured based and model based KPIs is selected in the project. Measured based KPIs will be calculated by taking into account the measured data as presented in the next section. Model based KPIs calculation is based on measured and modelled data (by taking into account configuration parameters as also presented in the following sections).

5.1 Measured Data types and Collection methodology

5.1.1 Measured Data Types

In this section, the different data types required towards KPIs calculation are presented. The data types have been identified considering their relevance with the pilot use cases and the identification of key performance indicators.. They are divided in the following categories: generation, distribution, electricity storage, thermal storage, electric vehicles and demand side analysis considering the different thematic pillars defined in the project.

The proposed data types in this section represent a "superset" of options the pilot stakeholders have for gathering data. Some of these data types may be not directly relevant to the KPIs presented above, but they may be able to feed additional KPIs that the stakeholders will choose to monitor at a later stage of the project. Hence, in case their systems support it, the stakeholders involved in the pilots are encouraged to collect and store the most of these datatypes and at the lowest possible granularity (i.e. the most frequent of intervals).

5.1.1.1 Generation Data Type

In order to meet industry standards, generated electricity needs to fulfil certain conditions before being injected to the grid. Power is the electrical energy transferred per unit time. **Active Power** (P) measured in W (Watts), **reactive power** (Q) measured in VAr (Volt-Ampere reactive) and **apparent power** (S) measured in VA (Volt-Ampere) are the metrics considered for KPI calculation. **Energy Generation** (kWh, kJ) is the aggretate information per generation unit while **voltage** and **current** are also defined as metrics of interest for each unit. The latest are mainly examined towards power quality evaluation.

Harmonics occur in **voltage** and **current** due to non-linear loads. When the load is linear, it draws a sinusoidal current at the same frequency as the voltage, but when it is non-linear, the current waveform becomes more complex. Using Fourier analysis, this waveform can be decomposed into simpler sinusoidal waves, a fundamental and the harmonics. The frequencies of the harmonics are going to be multiples of the fundamental frequency (normally the grid frequency). Problems caused by harmonics may be excessive heating of components, misfiring drives and power quality problems.

THD (Total Harmonic Distortion) is an index to quantify the distortion of the waveform. To be able to calculate it, it is necessary to measure the RMS value of the first five or six harmonics. In order to reach the fifth harmonic accurately, the sample rate in a 50 Hz grid is going to be around 2500 Hz (ten samples per period on the fifth harmonic). It is important to know how much distortion is being injected to the grid, in the majority of cases, regulations are going to determine the limit.

It is important to highlight that when it comes to power quality measurements, the sampling frequency of voltage and current is going to be very high, in order to detect transients, harmonics or instability and to be able to control them. However, when the objective is just monitoring, frequencies can be much lower.

Power **factor** is another metric available from generation sites, as is the ratio of active power flowing to the load respect to the apparent power at the circuit. The detailed analysis for the generation side technologies examined in the project is provided.

<u>Solar photovoltaic energy</u>

Photovoltaic energy is going to be one of the main renewable energy sources under consideration for this project.

PV panels are the technology that transforms light into electricity. In a PV installation the **power output, voltage and current** are going to be measured to support the validation activities of the project.

In addition to DER measurements, access on outdoors environmental conditions is required to better model and evaluate RES operation. **Ambient temperature** and **irradiance** are among the metrics to be considered during the evaluation phase.

<u>Combined Heat and Power (CHP)</u>

This technology is also powered by fuel, nonetheless, apart from generating electricity, it also generates heat. Therefore, **generated heat** is going to be one data type, as well as **generated power and consumed fuel**.

<u>Local generation and power quality</u>

Harmonics occur in **voltage** and **current** due to non-linear loads. When the load is linear, it draws a sinusoidal current at the same frequency as the voltage, but when it is non-linear, the current waveform becomes more complex. Using Fourier analysis, this waveform can be decomposed into simpler sinusoidal waves, a fundamental and the harmonics. The frequencies of the harmonics are going to be multiples of the fundamental frequency (normally the grid frequency). Problems caused by harmonics may be excessive heating of components, misfiring drives and power quality problems.

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It is important to highlight that when it comes to power quality measurements, the sampling frequency of voltage and current is going to be very high, in the range of MHz, in order to detect transients, harmonics or instability and to be able to control them. However, when the objective is just monitoring, frequencies can be much lower.

5.1.1.2 Distribution Network Operation Data Types

After injecting the power to the grid, the distribution lines are responsible for bringing the energy to the consumers. **Power generation** and **power consumption** should always be almost the same, it is with imbalances that problems occur in the grid. Again, in this category the measuring **frequency** for control purposes should be in the range of MHz to detect faults, but it can be lower for monitoring purposes. We have to point out that that

When it comes to distribution lines, **voltage** and **current** need to be measured so that stability is maintained through the grid.

In substations, transformers change voltages to higher transmission voltages or lower distribution voltages. Another element are capacitor banks, they are used to counteract reactive power demanded by inductive devices, but also to filter harmonics. Therefore, power quality is fairly important in substations because electricity is close to the end consumers who need a power quality that their devices will support. So, **reactive power** and **THD** are very important data types as well as the **SOC** of the capacitors.

5.1.1.3 Electricity Storage Systems Data Types

Electricity storage is a core aspect examined in the project, either in terms of battery storage or in terms of thermal storage or EV storage. Towards this direction the list of measured data types to support KPI calculation is presented.

Electrical Batteries

When working with batteries, **voltage** and **current** are the most important measurements that need to be taken. Especially voltage, since there are some critical factors, such as overvoltage and undervoltage that can damage the cell irreversibly. Voltage measurement is also necessary to maintain a voltage balance in battery packs.

In addition, **battery temperature** should also be measured, as it can be an indicator of malfunctioning or can warn that conditions may be challenging for the battery to handle.

There are some important parameters that are calculated starting from the voltage and current:

Instantaneous cell capacity (Q measured in Ah) indicates how much electric charge the battery can deliver at the defined voltage. It is worth mentioning that the nominal cell capacity will decrease as the battery ages.

State of Charge (SOC measured in %) is the amount of energy left in the battery, this is a short-term indicator of the state of the battery. One of the most common ways of measuring it (in Li-ion batteries) is by measuring voltage. This measurement does not require a high sample rate, but enough to detect the final decline of voltage when battery is almost discharged, because if undervoltage occurs, the battery will be damaged.

State of Health (SOH measured in %) represents the long-term capability of the battery and it is based on a comparison between current capacity and capacity when the battery was new. It can also be measured by performed cycles and cycle life.

Thermal energy storage

Thermal storage is considered as an alternative to batteries storage used to store excess heat or cold for later use. There are two types of thermal storage systems examined in the project.

Heating and cooling storage

Ice thermal storage is normally used for air conditioning, it enables to shift electricity consumption from peak hours, as it avoids using electricity for cooling purposes, thus reducing cost and reducing the load on the grid. With this technology, the **inlet** and **outlet flows** and **temperatures** must be measured. Apart from the liquid`s temperature, the **tank temperature** is also important.

Heat Storage allows storing excess thermal energy in tanks or pools to use it when demanded. Similarly to ice storage, the **inlet and outlet flows** and **temperatures** have to be collected and also the **tank's temperature**. Another important data type is going to be the **available thermal energy** in the tanks.

Virtual Energy Storage

Virtual thermal storage consists in using elements that are not typically used for storage such as swimming pools or buildings in order to store excess heat. Instead of having a tank to store the heat, the temperature of the pool may be increased so that afterwards the additional temperature difference can be used for heating when demanded. The data types to consider are the same as in the previously mentioned thermal storage strategies **inlet** and **outlet flows** and **temperatures,** but also the **room temperature**, **outdoor temperature**, **relative humidity** and **stored energy**. In thermal cases, the monitoring of data types can be done with intervals of minutes, since the dynamics are slower than the electrical ones.

<u>Electric vehicles</u>

In the Smart Grid, electric vehicles can act as batteries, therefore, all the data types described in the battery part are applicable. Nevertheless, there are some data types worth highlighting. On the one hand, there are the **power** and **energy consumption.** On the other hand, there is the **state of charge** of the battery, however, it should be translated to a more relatable term for vehicles, **kilometres of autonomy left** for instance. Another important data type would be determining whether the **vehicle is at the charging station** to define the possibility of charge or discharge.

5.1.1.4 Demand Side

As an anchor point of the inteGRIDy we highlight the role of demand, acting as an active market player through the participation in innovative business models.

<u>Electric demand</u>

When it comes to the electrical demand, there are two main data types to measure. Firstly, the power demand, which is important since the customer has a contracted power limit that should not be exceeded. On the more variable part, there is energy consumption, which is going to cover the consumed electricity.

<u>Cooling and heating demand</u>

In some pilot sites, we highlight the potential of controllability to specific device types, namely HVAC and lighting. Towards this direction, **indoor (temperature, humidity** and **luminance)** and **outdoor environmental conditions** should be provided to ensure KPIs calculation. In this case, the collection frequencies are not that determinant, so they can vary from second to minute's level.

In the following table, the data types are shown with their respective collection sampling.

Table 10. Data types and collection frequency

Category	Sub-Category	Data Type	Acromym	Unit	Frequency

Category	Sub-Category	Data Type	Acromym	Unit	Frequency
GENERATION	POWER & QUALITY (These data types apply to every subcategory in generation)	Voltage	V_{RMS}	V	15 min
		Current	I_{RMS}	A	15 min
		Frequency	F	Hz	15 min
		Phase angle	θ	Degrees, radians	15 min
		Active power	P	W	15 min
		Reactive power	Q	VAr	15 min
		Apparent power	S	VA	15 min
		Energy	E	Wh	15 min
		Power factor	p.f.		15 min
		Total harmonic distortion	THD	%	15 min
	RES Generation	Weather Conditions (Irradiance, temperature etc.	-	-	15 min
	Local CHP	Consumed fuel		l	15 min
		Heat output	Q	W	15 min
DISTRIBUTION Grid	POWER & QUALITY	Voltage	V_{RMS}	V	1 min
		Current	I_{RMS}	A	1 min
		Frequency	F	Hz	1 min
		Phase angle	θ	Degrees, radians	15 min
		Active power	P	W	15 min
		Reactive power	Q	VAr	15 min
		Apparent power	S	VA	15 min
		Energy	E	Wh	15 min
		Power factor	p.f.		15 min
		Total harmonic distortion	THD	%	1 min
STORAGE	BATTERIES	Active power	P	W	15 min
		Reactive power	Q	VAr	15 min
		Voltage	V	V	30 s
		Current	I	A	30 s
		Capacity	Q	Ah	1 min

Category	Sub-Category	Data Type	Acromym	Unit	Frequency
		State of charge	SOC	%	1 min
		State of health	SOH	%,cycles	Every cycle
		Temperature	T_{batt}	°C	15 min
		Current	I	A	15 min
	ICE STORAGE HEAT STORAGE VIRTUAL STORAGE	Inlet flow	Q_{in}	m^3/s	15 min
		Outlet flow	Q_{out}	m^3/s	15 min
		Inlet temperature	T_{in}	°C	15 min
		Outlet temperature	T_{out}	°C	15 min
		Tank temperature	T_{tank}	°C	15 min
		Indoor Temperature	T	°C	Case Specific
		Relative Humidity	RH	%	15 min
		Power	P	W	15 min
		Energy	E	Wh	15 min
ELECTRIC VEHICLE		Active power	P	W	15 min
		Reactive power	Q	VAr	15 min
		Voltage	V	V	30 s
		Current	I	A	30 s
		Capacity	Q	Ah	1 min
		State of charge	SOC	%	1 min
		State of health	SOH	%,cycles	Every cycle
		Remaining autonomy		km	Every km
		Vehicle at charging station		Yes or no	Whenever there is a state change
DEMAND	ELECTRIC DEMAND	Voltage	V	V	15 min
		Current	I	A	15 min
		Active power	P	W	15 min
		Reactive power	Q	VAr	15 min
		Apparent power	S	VA	15 min

Category	Sub-Category	Data Type	Acromym	Unit	Frequency
		Energy	E	Wh	15 min
	Controllable Loads	Indoor Temperature	T	°C	Case Specific
		Relative Humidity	RH	%	Case Specific
		Luminance	Lux	lux	Case Specific
		Indoor Temperature	T	°C	Case Specific

By defining the data types required for KPI calculation, we proceed with the definition of data collection process in the next section.

5.1.2 Data Collection Methodology

Data collection of various variables from the different pilot sites is required in order to feed the inteGRIDy model. For the majority of cases, the data that is being collected can be described as interval data that consists of a value and a measurement timestamp. For example - the power level in kW at 14:25 on June 5th and we will therefore limit the discussion in this chapter to this type of data. Depending on the type of data, data source and available technologies different collection methods are possible. However, as will be further described in section 5.3, it is important to organize and store the data in standard formats that will enable sharing and easy accessibility to all the consortium members. The following collection methods can be identified:

Collection of data from BMS and BAS (Building Management and Automation Systems): Such systems are common in large organizations and are also central in the implementation of specific inteGRIDy pilot sites (such as pilot nr 1 at Isle of White). By integrating with these systems, we get access to the huge number of metrics gathered from building environment

Collection of data from utility bills: Historical and highly delayed data is provided by utility bills. This data is, of course, interval data for very long intervals (months). However, collecting this historical data can provide good benchmarks for initial calibration. This data is provided in different formats by different utilities and in most cases, needs to be manually collected and organized in files.

Collection of data from existing smart meters: Some sites may already have meters or data loggers installed that are already connected or provisioned to connect and send data to the network via a dedicated network interface. These meters can be easily connected and configured to send data files into a pre-defined web address that can then be accessed online by users or automatic web services. In some cases, such meters cannot be accessed directly, but need to be accessed via a web service that is included as part of the solution. In such case, data can be accessed online manually from a website and exporting the data, or using some type of API. Some of the more advanced utilities have also deployed smart meters at the utility input, and are enabling user access to the meter data. Some installed meters have local connectivity options (such as Modbus) that may require an additional interface device to enable network connectivity.

Collection of data from Battery Management Systems and EV charging platforms: Towards gathering data about battery and EV operation, interfaces with the management platform will be performed. By integrating with these systems, we get access to the number of metrics gathered from the modules.

Collection of data from existing web services: Online data, both real time and historical can be collected from online services via web-service API. One of the more common examples is environmental data such as temperature that is often needed for energy efficiency or demand calculations. Services such as http://www.wunderground.com, can provide easy access to such data either manually via a website, or automatically via connecting software using a web service API.

Smart sensors: In cases where data is required and is not available via all the above collection methods, or where more granular data is needed (such as device level energy data), highly granular data can be obtained by installing smart wireless sensors. Such sensors are easy to deploy with minimal effort and cost, and with very little interference to the operation of the facility. This is a very strong tool to obtain immediate, massive amounts of granular online data in real time for existing buildings. Such sensors are typically supported by cloud based technologies that can provide easy access to the data as well as analytic tools.

Considering the **distribution network operation**, data will be acquired/collected on substation level through integration with SCADA systems available in premises. The data types collected from the DSO tools are presented:

Table 11. List of metrics captured from SCADA

Data Type	Acronym	Unit	Frequency
Voltage	V_{RMS}	V	1 min
Current	I_{RMS}	A	1 min
Frequency	F	Hz	1 min
Phase angle	θ	Degrees, radians	15 min
Active power	P	W	15 min
Reactive power	Q	VAr	15 min
Apparent power	S	VA	15 min
Energy	E	Wh	15 min
Power factor	p.f.		15 min
Total harmonic distortion	THD	%	1 min

This is an indicative list of metrics defined for the Romanian Pilot site. An update of this list will be available once we have the final pilot survey in the rest of DSO oriented pilot sites.

Considering the **generation sites**, data will be acquired/collected on device level through integration with the local management and control systems available in premises. The data types collected from the gateway (power, energy generation, voltage etc…) will be available in the platform. In lack of dedicated monitoring equipment installed on site, smart metering data should be available at the generation sites to measure the metrics defined in previous section.

5.2 Model Data Types

Apart from the raw measurements associated with the real-time operation of the inteGRIDy platform, a list of static data is defined as parameters for the calculation of inteGRIDy Key Performance Indicators. These data consist of the **configuration parameters** and **normalization factors** that will enable the model based KPIs calculation. These values are of high importance and their actual use within our calculations is:

- Reflecting factors that can be considered constant throughout the overall inteGRIDy approach without introducing bias to our evaluation results.
- Representative values, selected taking into account the conditions/parameters of the EU market or the pilot countries.
- Factors to allow us normalize KPI values so as to support further comparative analysis.
- Factors and configuration parameter associated with different business models and contractual agreements; of high interest within the inteGRIDy framework.

A high level categorization of the inteGRIDy main configuration factors is presented in the following tabular representation:

Table 12. List of inteGRIDy configuration parameters

Factor	Unit	Description
CO_2 Rate	$kgCO_2$/KWh	An annual CO_2 output emission rate to convert kilowatt-hours into units of carbon dioxide emissions.
Retailer Energy Price	m.u./KWh	The per hour cost of energy as derived from the contractual operation of the energy supplier policies.
Market-Based Energy Price	m.u./KWh	The per time-period cost of energy as derived from the operation of different types of energy markets [ancillary services markets, intraday markets]
Price Reward	m.u./KWh	Static Value based on contractual agreement for DR participation
Space Area	m^2	A Static BIM related aspect, providing the total surface metrics for buildings → normalization factor
Nominal Capacity	KW	This static value represents the nominal value for a demand side installation
RES Capacity	KW	This static value represents the nominal value of installed Renewable Energy Sources Units
Max SoC	%	Nominal maximum SoC for batteries and EVs (typical value: 100%)
Contractual Demand Flexibility	KWh	Static parameter based on contractual agreement
Nominal Voltage Value	V	The nominal voltage value for the distribution grid examined
Nominal Frequency Value	f	The nominal Frequency value for the energy grid examined. For E.U. grids f=50Hz
Nominal Thermal Losses Value	A	The nominal value of thermal losses on the distribution grid

The configuration data values are extracted from the audit process at pilot infrastructures of the inteGRIDy project. In some cases (e.g. retailer or market prices), dynamically updated values will be considered and thus interfaces with external service providers (e.g. ENTSOE, energy markets, etc…) will be defined.

In summary, the inteGRIDy performance framework represents a holistic approach for the estimation of indicators based on a priori estimations and a posteriori measurement values. This separation of work mandates for the adoption of both Measurement based and Model based metrics and therefore, both types of KPIs have been selected for the performance evaluation of the project. The KPIs will be fed with raw data originated from a variety of devices, systems or web sources, coupled with or validated against technical references, where appropriate, for calibration and / or testing purposes. The data types of the metrics to be used, have been identified considering their relevance with the pilot use cases and they are grouped in the following general categories: generation, distribution, electricity storage, thermal storage, electric vehicles and demand side analysis.

6 Conclusions

inteGRIDy aims to integrate cutting-edge technologies, solutions and mechanisms in a scalable Cross-Functional Platform (CMP) of replicable solutions to connect existing energy networks with diverse stakeholders. Enhanced observation of both generation and consumption will facilitate the optimal and dynamic operation of the grid, fostering the grid stability and the coordination of distributed energy resources. VPPs and innovative collaborative storage schemes will be enabled within a continuously increased share of renewable energy.

Performance measures will be used to measure the success of the energy management strategies developed in inteGRIDy pilots and to create corrective and preventative action processes. These indicators will receive inputs, for instance, from smart meters and wireless sensors, demand and energy limiters, energy devices as well as the energy control system.

The Key Performance Indicators (KPIs) relevant for the inteGRIDy are identified and developed following existing best practices and requirements set at the pilot level. The process will assess the benefits of the experimental architecture and quantify its performance. Some of the performance indicators are general (global), and some are pilot-specific (local) for the pilots in the project. Both the pilot-specific and global performance indicators will be used for the comparative assessment of results among the pilots and in relation to baseline conditions.

The metrics and KPIs are grouped in three performance domains: technical, economic, environmental and social, as well as with respect to the dimensions of the project:

- the 4 thematic pillars investigated in the experimentation (Demand Response, Smartening the distribution grid, Energy storage, Smart integration of grid users from transport);
- the 10 pilot sites in which the novel solutions are tested and the relevant use case scenarios.

Finally, the data collection methodology has been presented, as regards both the general concept and the pilot-specific strategies.

The initial selection of KPIs takes into account the list of business stakeholders (D1.2), business scenarios and use cases (D1.3) to be examined at the different demonstration sites of the project. The analysis defines a global framework for the inteGRIDy evaluation and impact assessment, screening the landscape for the definition of Indicators & Benefit categories for CBA/CEA in WP3 and further the pilot specific evaluation framework definition in WP8. Therefore, this document is considered as a living document towards the design, development and further evaluation of the inteGRIDy framework during the project period.

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Annex I: inteGRIDy use cases per pilot site

Table 13. List of inteGRIDy Project Use Cases

Pilot 1 (Isle of Wight, UK)	IOW_UC01	Building optimisation to maximise efficiency and demand flexibility, minimise costs and reduce environmental impact across the enterprise.
	IOW_UC02	Smartening the distribution grid
	IOW_UC03	Energy Storage System
	IOW_UC04	Transport Smart Integration of Virtue EV charging systems
Pilot 2 (Terni, IT)	ASM_UC01	Maximizing savings and economic benefits in normal operation by optimizing flexibility management
	ASM_UC02	Power quality improvement in degraded operation by optimizing flexibility management of microgrid resources
	ASM_UC03	Energy storage technology
	ASM_UC04	Microgrid flexibility exploited for eventual EV recharging stations
Pilot 3 (San Severino Marche, IT)	ASS_UC01	Demand Response
	ASS_UC02	Smartening the Distribution Grid
	ASS_UC03	Energy Storage
Pilot 4 (Barcelona, ES)	BCN1	Thermal and electrical synergies
	BCN2	Photovoltaics and Electric Storage Optimization
	BCN3	Uninterruptible Power Supply
Pilot 5 (St-Jean, FR)	INN_UC01	Explicit Demand Response in residential and commercial premises
	INN_UC02	Demand Flexibility Analysis and forecasting
	INN_UC03	VES in Buildings through optimized HVAC and water heaters control.
Pilot 6 (Nicosia, CY)	UCY_UC01	University campus microgrid test case –Smartening distribution grid
	UCY_UC02	Prosumers Use Case- Demand Response Scenario
Pilot 7 (Lisboa, PT)	LIS_UC01	Demand Response
	LIS_UC02	Energy Storage in Ice Tanks
	LIS_UC03	EV charging managing system integrating dynamic tariffs
Pilot 8 (Xanthi, GR)	SUN_UC01	Monitoring, supervision and optimization based decision making for Smart Distribution Grid
	SUN_UC02	Flexible local and virtual central storage management strategies

	SUN_UC03	Supervisory EV charging and optimum profiling
Pilot 9 (Ploiesti, RO)	DR_PL 01	Implementing HES 1 (Head End System 1) – DSO perspective
	DR_PL 02	Implementing HES 2 (Head End System 2) – DSO perspective
	DR_PL 03	Implementing HES 2 (Head End System 2) – Consumer perspective
Pilot 10 (Thessaloniki, GR)	TH_UC01	Demand Response in residential buildings with smart meters
	TH_UC02	Demand Response in residential buildings with BESS
	TH_UC03	Demand Response in Commercial Building with BESS

Annex II: inteGRIDy KPIs per pilot and domain

Table 14. List of Pilot Specific KPIs

	KPI Name	Pilot 1 (Isle of Wight, UK)	Pilot 2 (Terni, IT)	Pilot 3 (San Severino Marche, IT)	Pilot 4 (Barcelona, ES)	Pilot 5 (St-Jean, FR)	Pilot 6 (Nicosia, CY)	Pilot 7 (Lisboa, PT)	Pilot 8 (Xanthi, GR)	Pilot 9 (Ploiesti, RO)	Pilot 10 (Thessaloniki, GR)
	Demand Response										
Technical Domain	Energy Consumption (Monthly, Daily...)	X	X	X	X	X	X	X	X	X	X
	Reactive Energy Consumption	X	X	X		X			X	X	
	Peak to Average	X	X	X	X	X	X	X	X	X	X
	RES Generation	X	X		X	X	X	X	X		
	RES Generation Ratio	X	X		X	X	X	X	X		
	Self-Consumption Rate	X	X	X	X	X	X	X	X	X	
	Energy Import				X	X			X		
	Energy Export				X	X					
	Energy Mismatch Ratio				X	X					
	Energy Consumption Reduction (Demand Flexibility)	X	X	X	X	X	X	X	X	X	X
	Demand Flexibility Ratio	X	X	X	X	X	X	X	X	X	X
	Demand Flexibility Request	X	X	X	X	X	X	X	X	X	X
	Demand Flexibility Baseline (Potential)	X	X	X	X	X	X	X	X	X	X
	Demand Request Participation	X	X	X	X	X	X	X	X	X	X
	Demand Request Enrolment	X	X	X	X	X	X	X	X	X	X
	Peak load reduction	X	X	X	X	X	X	X	X	X	X

KPI Name	Pilot 1 (Isle of Wight, UK)	Pilot 2 (Terni, IT)	Pilot 3 (San Severino Marche, IT)	Pilot 4 (Barcelona, ES)	Pilot 5 (St-Jean, FR)	Pilot 6 (Nicosia, CY)	Pilot 7 (Lisboa, PT)	Pilot 8 (Xanthi, GR)	Pilot 9 (Ploiesti, RO)	Pilot 10 (Thessaloniki, GR)
Smartening the Distribution Grid										
Energy Losses	X	X	X						X	
Energy Losses Ratio	X	X	X						X	
Voltage variations	X	X	X					X		
Number of Grid Events	X	X	X					X		
SAIFI	X	X	X	X				X		
SAIDI	X	X	X	X				X		
Power quality (power factor)	X	X	X							
Reduction in time required for fault awareness, localization and isolation	X		X							
Average frequency Deviation	X	X	X					X		
Reaction time improvement for providing primary control reserve	X		X							
Electric Vehicles										
EV Penetration Level	X	X					X	X		
EV Peak Demand	X	X					X	X		
EV demand flexibility baseline	X	X					X			
EV demand flexibility	X	X					X			
CHP										
CHP Penetration Level		X								
Battery Storage										
State of Charge (SOC)		X	X	X		X		X		X
Depth of Discharge (DOD)		X	X	X		X		X		X
Average SOC		X	X	X		X		X		X

	KPI Name	Pilot 1 (Isle of Wight, UK)	Pilot 2 (Terni, IT)	Pilot 3 (San Severino Marche, IT)	Pilot 4 (Barcelona, ES)	Pilot 5 (St-Jean, FR)	Pilot 6 (Nicosia, CY)	Pilot 7 (Lisboa, PT)	Pilot 8 (Xanthi, GR)	Pilot 9 (Ploiesti, RO)	Pilot 10 (Thessaloniki, GR)
	Battery Demand Flexibility Baseline		X	X	X		X		X		X
	Battery Demand Flexibility		X	X	X		X		X		X
	VES Demand Flexibility Baseline	X				X		X			
	VES Demand Flexibility	X				X		X			

	KPI Name	Pilot 1 (Isle of Wight, UK)	Pilot 2 (Terni, IT)	Pilot 3 (San Severino Marche, IT)	Pilot 4 (Barcelona, ES)	Pilot 5 (St-Jean, FR)	Pilot 6 (Nicosia, CY)	Pilot 7 (Lisboa, PT)	Pilot 8 (Xanthi, GR)	Pilot 9 (Ploiesti, RO)	Pilot 10 (Thessaloniki, GR)
Economic Domain	Retailer Cost of Energy (Monthly, Daily...)	X	X	X	X	X	X	X	X	X	X
	Average Cost of Energy Consumption	X	X	X	X	X	X	X	X	X	X
	Cost of Energy reward (based on contractual Agreement)	X	X	X	X	X	X	X	X	X	X
	Average Cost of Energy Reward	X	X	X	X	X	X	X	X	X	X
	Demand Price Elasticity (Self Elasticity)									X	X
	Average Estimation of Cost savings	X	X	X		X	X			X	
	Cost of ancillary services	X	X	X		X	X			X	
Environmental Domain	CO_2 emissions	X	X	X	X	X	X	X	X	X	X
	CO_2 emissions Reduction	X	X	X	X	X	X	X	X	X	X
	CO_2 emissions Ratio	X	X	X	X	X	X	X	X	X	X
	Thermal Comfort					X		X			X
	Visual Comfort					X					
	Operative Temperature	X			X			X			X
	Thermal Comfort Deviation					X					
	EXPLICIT DR										
	Number of people changing their behaviour	X		X		X	X			X	X
	Number of times social app is accessed			X			X				X
	Demand response campaign penetration in buildings			X			X				X
	Degree of user satisfaction from DR services	X		X		X	X			X	X
	IMPLICIT DR										
Social Domain	Number of people changing their behaviour							X		X	X
	Degree of user satisfaction from DR services							X		X	X
	Penetration of dynamic energy tariffs in tertiary buildings							X		X	X

Annex III: inteGRIDy KPIs per use case and Domain

Table 15. List of Use Case Specific KPIs

	KPI Name	IOW_UC01	IOW_UC02	IOW_UC03	IOW_UC04	ASM_UC01	ASM_UC02	ASM_UC03	ASM_UC04	ASS_UC01	ASS_UC02	ASS_UC03	BCN1	BCN2	BCN3	INN_UC01	INN_UC02	INN_UC03	UCY_UC01	UCY_UC02	LIS_UC01	LIS_UC02	LIS_UC03	SUN_UC01	SUN_UC02	SUN_UC03	DR_PL 01	DR_PL 02	DR_PL 03	TH_UC01	TH_UC02	TH_UC03
	Demand Response																															
Technical Domain	Energy Consumption (Monthly, Daily...)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Technical Domain	Reactive Energy Consumption	X				X				X						X										X	X	X	X			
Technical Domain	Peak to Average	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Technical Domain	RES Generation	X				X							X			X				X	X					X						
Technical Domain	RES Generation Ratio	X				X							X			X			X	X	X					X						
Technical Domain	Self-Consumption	X				X				X			X			X			X	X	X					X	X	X	X			

KPI Name	IOW_UC01	IOW_UC02	IOW_UC03	IOW_UC04	ASM_UC01	ASM_UC02	ASM_UC03	ASM_UC04	ASS_UC01	ASS_UC02	ASS_UC03	BCN1	BCN2	BCN3	INN_UC01	INN_UC02	INN_UC03	UCY_UC01	UCY_UC02	LIS_UC01	LIS_UC02	LIS_UC03	SUN_UC01	SUN_UC02	SUN_UC03	DR_PL 01	DR_PL 02	DR_PL 03	TH_UC01	TH_UC02	TH_UC03
Rate																															
Energy Import												X			X										X						
Energy Export												X			X																
Energy Mismatch Ratio												X			X																
Energy Consumption Reduction (Demand Flexibility)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Demand Flexibility Ratio	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Demand Flexibility Request	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Demand	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

	KPI Name	IOW_UC01	IOW_UC02	IOW_UC03	IOW_UC04	ASM_UC01	ASM_UC02	ASM_UC03	ASM_UC04	ASS_UC01	ASS_UC02	ASS_UC03	BCN1	BCN2	BCN3	INN_UC01	INN_UC02	INN_UC03	UCY_UC01	UCY_UC02	LIS_UC01	LIS_UC02	LIS_UC03	SUN_UC01	SUN_UC02	SUN_UC03	DR_PL 01	DR_PL 02	DR_PL 03	TH_UC01	TH_UC02	TH_UC03
	Flexibility Baseline (Potential)																															
	Demand Request Participation	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Demand Request Enrolment	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Peak load reduction	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Smartening the Distribution Grid																															
	Energy Losses		X				X				X																X	X				
	Energy Losses Ratio		X				X				X																X	X				
	Voltage variati		X				X				X													X								

	KPI Name	IOW_UC01	IOW_UC02	IOW_UC03	IOW_UC04	ASM_UC01	ASM_UC02	ASM_UC03	ASM_UC04	ASS_UC01	ASS_UC02	ASS_UC03	BCN1	BCN2	BCN3	INN_UC01	INN_UC02	INN_UC03	UCY_UC01	UCY_UC02	LIS_UC01	LIS_UC02	LIS_UC03	SUN_UC01	SUN_UC02	SUN_UC03	DR_PL 01	DR_PL 02	DR_PL 03	TH_UC01	TH_UC02	TH_UC03
	ons																															
	Number of Grid Events		X				X				X													X								
	SAIFI		X				X				X				X									X								
	SAIDI		X				X				X				X									X								
	Power quality (power factor)		X				X				X							X														
	Reduction in time required for fault awareness, localization and isolation		X								X							X														
	Average frequency Deviation		X				X				X							X						X								

	KPI Name	IOW_UC01	IOW_UC02	IOW_UC03	IOW_UC04	ASM_UC01	ASM_UC02	ASM_UC03	ASM_UC04	ASS_UC01	ASS_UC02	ASS_UC03	BCN1	BCN2	BCN3	INN_UC01	INN_UC02	INN_UC03	UCY_UC01	UCY_UC02	LIS_UC01	LIS_UC02	LIS_UC03	SUN_UC01	SUN_UC02	SUN_UC03	DR_PL 01	DR_PL 02	DR_PL 03	TH_UC01	TH_UC02	TH_UC03
	Reaction time improvement for providing primary control reserve		X								X							X														
	Electric Vehicles																															
	EV Penetration Level				X				X														X			X						
	EV Peak Demand				X				X														X			X						
	EV demand flexibility baseline				X				X														X									
	EV demand flexibility				X				X														X									

KPI Name	IOW_UC01	IOW_UC02	IOW_UC03	IOW_UC04	ASM_UC01	ASM_UC02	ASM_UC03	ASM_UC04	ASS_UC01	ASS_UC02	ASS_UC03	BCN1	BCN2	BCN3	INN_UC01	INN_UC02	INN_UC03	UCY_UC01	UCY_UC02	LIS_UC01	LIS_UC02	LIS_UC03	SUN_UC01	SUN_UC02	SUN_UC03	DR_PL 01	DR_PL 02	DR_PL 03	TH_UC01	TH_UC02	TH_UC03
CHP																															
CHP Penetration Level					X																										
Battery Storage																															
State of Charge (SOC)					X		X				X		X					X						X					X	X	X
Depth of Discharge (DOD)					X		X				X		X					X						X					X	X	X
Average SOC					X		X				X		X					X						X					X	X	X
Battery Demand Flexibility Baseline					X		X				X		X					X						X					X	X	X
Battery Demand Flexibility					X		X				X		X					X						X					X	X	X
VES			X														X				X										

	KPI Name	IOW_UC01	IOW_UC02	IOW_UC03	IOW_UC04	ASM_UC01	ASM_UC02	ASM_UC03	ASM_UC04	ASS_UC01	ASS_UC02	ASS_UC03	BCN1	BCN2	BCN3	INN_UC01	INN_UC02	INN_UC03	UCY_UC01	UCY_UC02	LIS_UC01	LIS_UC02	LIS_UC03	SUN_UC01	SUN_UC02	SUN_UC03	DR_PL 01	DR_PL 02	DR_PL 03	TH_UC01	TH_UC02	TH_UC03
	Demand Flexibility Baseline																															
	VES Demand Flexibility			X														X				X										
Economic Domain	Retailer Cost of Energy (Monthly, Daily...)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Average Cost of Energy Consumption	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Cost of Energy reward (based on contractual Agree	X		X	X	X		X	X	X		X	X	X		X		X		X	X	X	X		X	X	X	X	X	X	X	X

	KPI Name	IOW_UC01	IOW_UC02	IOW_UC03	IOW_UC04	ASM_UC01	ASM_UC02	ASM_UC03	ASM_UC04	ASS_UC01	ASS_UC02	ASS_UC03	BCN1	BCN2	BCN3	INN_UC01	INN_UC02	INN_UC03	UCY_UC01	UCY_UC02	LIS_UC01	LIS_UC02	LIS_UC03	SUN_UC01	SUN_UC02	SUN_UC03	DR_PL 01	DR_PL 02	DR_PL 03	TH_UC01	TH_UC02	TH_UC03
	ment)																															
	Average Cost of Energy Reward	X		X	X	X		X	X	X		X	X	X		X		X		X	X	X	X		X	X	X	X	X	X	X	X
	Demand Price Elasticity (Self Elasticity)																										X	X	X	X	X	X
	Average Estimation of Cost savings	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X				X	X	X	X	X	X			
	Cost of ancillary services		X				X				X				X		X		X					X			X	X	X			

	KPI Name	IOW_UC01	IOW_UC02	IOW_UC03	IOW_UC04	ASM_UC01	ASM_UC02	ASM_UC03	ASM_UC04	ASS_UC01	ASS_UC02	ASS_UC03	BCN1	BCN2	BCN3	INN_UC01	INN_UC02	INN_UC03	UCY_UC01	UCY_UC02	LIS_UC01	LIS_UC02	LIS_UC03	SUN_UC01	SUN_UC02	SUN_UC03	DR_PL 01	DR_PL 02	DR_PL 03	TH_UC01	TH_UC02	TH_UC03
	Demand Response																															
Environmental Domain	CO2 emissions	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Environmental Domain	CO2 emissions Reduction	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Environmental Domain	CO2 emissions Ratio	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Environmental Domain	Thermal Comfort															X	X	X			X	X	X							X	X	X
Environmental Domain	Visual Comfort															X	X	X														
Environmental Domain	Operative Temperature	X											X								X	X	X							X	X	X
Environmental Domain	Thermal Comfort Deviation															X	X	X														
	EXPLICIT DR																															
Environmental Domain	Number of people changing their behaviour	X								X						X				X							X	X	X	X	X	X
Environmental Domain	Number of times social app is accessed									X										X										X	X	X
Environmental Domain	Demand response campaign penetration in buildings									X										X										X	X	X
Environmental Domain	Degree of user satisfaction from DR services	X								X						X				X							X	X	X	X	X	X
	IMPLICIT DR																															
Social Domain	Number of people changing their behaviour																				X						X	X	X	X	X	X
Social Domain	Degree of user satisfaction from DR services																				X						X	X	X	X	X	X
Social Domain	Penetration of dynamic rgy tariffs in tertiary buildings																				X						X	X	X	X	X	X

Annex IV: inteGRIDy KPIs and Stakeholders' perspective

The following table summarises the relevant KPIs for each stakeholder group, in association with the analysis made in paragraph 3.3

List of GLOBAL KPIs

Table 16. List of Global KPIs per Business Stakeholder

	KPI Name	DSO	End Users	MO	Policies Bodies and Governance
Technical Domain					
T.01	Energy Consumption (Monthly, Daily...)	✓	✓	✓	✓
T.02	Peak to Average	✓		✓	
T.03	Self-Consumption Rate	✓	✓	✓	✓
T.04	Energy Consumption Reduction (Demand Flexibility)	✓	✓	✓	✓
T.05	Demand Flexibility Ratio			✓	
T.06	Demand Flexibility Request			✓	
T.07	Demand Flexibility Baseline (Potential)			✓	
T.08	Demand Request Participation			✓	✓
T.09	Demand Request Enrolment			✓	
T.10	Peak load reduction	✓	✓	✓	✓
Economic Domain					
EC.01	Retailer Cost of Energy (Monthly, Daily...)		✓	✓	
EC.02	Average Cost of Energy Consumption		✓	✓	
EC.03	Cost of Energy reward (based on contractual Agreement)		✓	✓	
EC.04	Average Cost of Energy Reward		✓	✓	
Environmental Domain					
EN.01	CO2 emissions	✓	✓	✓	✓
EN.02	CO2 emissions Reduction	✓	✓	✓	✓

List of LOCAL KPIs

Table 17. List of Local KPIs per Business Stakeholder

	KPI Name	DSO	End Users	MO	Policies Bodies and Governance
Technical Domain					
Demand Response					
T.11	Reactive Energy Consumption	✓	✓		

	KPI Name	DSO	End Users	MO	Policies Bodies and Governance
T.12	RES Generation	✓		✓	✓
T.13	RES Generation Ratio	✓		✓	
T.14	Energy Import	✓	✓		
T.15	Energy Export	✓	✓		
T.16	Energy Mismatch Ratio	✓	✓		✓
Smartening the Distribution Grid					
T.17	Energy Losses	✓			
T.18	Energy Losses Ratio	✓			
T.19	Voltage variations	✓			
T.20	Number of Grid Events	✓	✓		✓
T.21	SAIFI	✓	✓		
T.22	SAIDI	✓	✓		
T.23	Power quality (power factor)		✓		✓
T.24	THD/ harmonics distortions	✓	✓	✓	
T.25	Reduction in time required for fault awareness, localization and isolation	✓			
T.26	Average frequency Deviation	✓			
T.27	Reaction time improvement for providing primary control reserve	✓			
Electric Vehicles					
T.28	EV Penetration Level	✓		✓	✓
T.29	EV Peak Demand	✓		✓	✓
T.30	EV demand flexibility baseline			✓	
T.31	EV demand flexibility			✓	
CHP					
T.32	CHP Penetration Level	✓		✓	✓
Battery Storage					
T.35	State of Charge (SOC)		✓	✓	
T.36	Depth of Discharge (DOD)		✓	✓	
T.37	Average SOC		✓	✓	
T.38	Battery Demand Flexibility Baseline		✓	✓	
T.39	Battery Demand Flexibility		✓	✓	
T.40	VES Demand Flexibility Baseline		✓	✓	
T.41	VES Demand Flexibility		✓	✓	
Economic Domain					

	KPI Name	DSO	End Users	MO	Policies Bodies and Governance
EC.05	Demand Price Elasticity (Self Elasticity)		✓	✓	
EC.06	Average Estimation of Cost savings		✓	✓	
EC.07	Cost of ancillary services	✓			
Environmental Domain					
EN.03	Thermal Comfort		✓	✓	
EN.04	Visual Comfort		✓	✓	
EN.05	Operative Temperature		✓	✓	
EN.06	Thermal Comfort Deviation		✓	✓	
Social Domain					
Explicit DR					
S.01	Number of people changing their behaviour	✓	✓	✓	✓
S.02	Number of times social app is accessed			✓	
S.03	Demand response campaign penetration in buildings			✓	
S.04	Degree of user satisfaction from DR services		✓	✓	
Implicit DR					
S.05	Number of people changing their behaviour	✓	✓	✓	✓
S.06	Degree of user satisfaction from DR services		✓	✓	
S.07	Penetration of dynamic energy tariffs in tertiary buildings			✓	

Annex V: inteGRIDy nomenclature and common terminology

This annex contains the first approach to a common terminology to be adopted throughout all project activities and documentation. The glossary will be continuously updated during the project lifetime.

Table 18. inteGRIDy nomenclature and common terminology

Term	Category	Definition	Resource
Advanced Metering	Smart Grids & meters	Technology which enables an automated bi-directional communication between the energy meter and the utility. The communication is not limited to meter data alone but also includes information about consumption, tariffs, alerts and complementary services. (LandisGyr)	(LandisGyr)
Aggregator	Energy Efficiency	A legal entity that aggregates the load or generation of various demand and/or generation/production units. Aggregation can be a function that can be met by existing market actors, or can be carried out by a separate actor. A demand service provider that combines multiple short-duration consumer loads for sale or auction in organised energy markets. (Energy Efficiency Directive)	(European Commission - Smart Grids Task Force)
AMI	Smart Grids & meters	Automated or advanced metering infrastructure, utility infrastructure with two-way communications for metering and associated systems allowing delivery of a wide variety of services and applications to the utility and customer. (Smart Grid Today)	(Smart Grid Today)
Anaerobic Digestion	Climate Change & Emissions	A biochemical process in which bacteria break down biodegradable organic material, such as manure, in an oxygen-free environment. Temperature, moisture, nutrient content and pH, can be controlled through the use of an airtight chamber (digester). The break-down of the organic material results in biogas, a mixture of methane (CH4), carbon dioxide (CO2) and trace amounts of other gases. (EPA)	(EPA)
Ancillary services	Networks	All services procured by the transmission or distribution system operator from system users to enable them to maintain the integrity and stability of the transmission and distribution system as well as power quality (to be able to provide system services – see definition). They include i.e. frequency control, voltage control, blackstart capability, grid loss compensation (EURELECTRIC report ‘Ancillary services’, 2004)	(EURELECTRIC)
Annual Load Factor	Networks	The ratio of the actual energy output of a Generating Unit, CCGT Module or Power Station (as the case may be) to the maximum possible energy output of that Generating Unit, CCGT Module or Power Station (as the case may be) over a year. It is often expressed in percentage terms (National Grid)	(National Grid)

Term	Category	Definition	Resource
API	Smart Grids & meters	Application programming interface -- a piece of software that lets applications interact with the functions of an operating system or other piece of software. (Smart Grid Today)	(Smart Grid Today)
Apparent Power	Networks	Apparent Power is the product of voltage (in volts) and current (in amperes). It consists of a real component (Active Power) and an imaginary component (Reactive Power), usually expressed in kilovolt-amperes (kVA) or megavolt-amperes (MVA). (ENTSO-E UCTE Operational Handbook)	(ENTSO-E UCTE Operational Handbook)
Arbitrage	Markets	The simultaneous purchase and sale of similar commodities in different markets to take advantage of price discrepancy without taking a risk. (Point Carbon)	(Point Carbon)
Area Control Error (ACE)	Networks	Area Control Error is the instantaneous difference between the actual and the reference value (measured total power value and scheduled control program) for the power interchange of a control area (unintentional deviation), taking into account the effect of the frequency bias for that control area according to the network power frequency characteristic of that control area and the overall frequency deviation. (ENTSO-E UCTE Operational Handbook)	(ENTSO-E UCTE Operational Handbook)
Aromatic	Climate Change & Emissions	A type of hydrocarbon, such as benzene or toluene. Some aromatics are toxic. (EPA)	(EPA)
Auction	Markets	Procedure for making transactions after a period of time during which the orders entered by exchange members in the order book are accumulated but not executed. The price determination algorithm aims at optimising the total welfare, i.e. the seller surplus, the buyer surplus and the congestion rent (if applicable). (EPEX SPOT)	(EPEX SPOT)
Automated Meter Reading	Smart Grids & meters	Automated Meter Reading (AMR) collects utility meter data via radio or other networking technology. AMR is a form of Advanced Metering that uses communication devices to communicate data from the meter to the utility or to a meter data management provider. AMR may be used to transmit simple energy usage data from the meter or to transmit more complex measures of energy recorded in the meter. Moreover, it can feature advanced functionality such as outage detection or remote programming of meters by an authorised party. (LandisGyr)	(LandisGyr)
Availability	Networks	Availability is a measure of time during which a generating unit, transmission line, ancillary service or another facility is capable of providing service, whether or not it actually is in service. Typically, this measure is expressed as a percentage available for the period under consideration. (ENTSO-E UCTE Operational Handbook)	(ENTSO-E UCTE Operational Handbook)

Term	Category	Definition	Resource
Available transfer capability (ATC)	Networks	"A measure of the transfer capability remaining in the physical transmission network for further commercial activity over and above already committed uses. ATC is defined as the total transfer capability, less the transmission reliability margin, less the sum of existing transmission commitments (which includes retail customer service) and the capacity benefit margin." (Energy Risk Glossary) Available transfer capacity is a measure of the transfer capability remaining in the physical transmission network for further commercial activity over and above already committed uses. Available transmission capacity is the part of NTC that remains available after each phase of the allocation procedure for further commercial activity. ATC is defined by the following equation: ATC = NTC- AAC (ENTSO-E UCTE Operational Handbook)	(ENTSO-E UCTE Operational Handbook)
Balance Responsible Party (BRP)	Markets	A party that has a contract proving financial security and identifying balance responsibility with the imbalance settlement responsible of the market balance area entitling the party to operate in the market. This is the only role allowing a party to buy or sell energy on a wholesale level	(ENTSO-E The Harmonized Electricity Market Role Model)
Balance Service Provider (BSP)	Markets	A market participant providing balancing services to one or several TSOs within one or several control area(s). (ACER FG Balancing)	(ACER FG Balancing)
Balancing	Markets	All actions and processes through which TSOs ensure that total electricity withdrawals are equalled by total injections in a continuous way, in order to maintain the system frequency within a predefined stability range. (ACER FG Balancing)	(ACER FG Balancing)
Balancing Energy	Markets	Energy (MWh) activated by TSOs to maintain the balance between injections and withdrawals. (ACER FG Balancing)	(ACER FG Balancing)
Balancing Services	Markets	A service provided to a transmission system operator from a Balance Responsible Party	(European Commission - Smart Grids Task Force)
Best Available Technique (BAT)	Climate Change & Emissions	The most effective and advanced stage in the development of activities and their methods of operation which indicates the practical suitability of particular techniques for providing the basis for emission limit values and other permit conditions designed to prevent and, where that is not practicable, to reduce emissions and the impact on the environment as a whole. (Industrial Emissions Directive)	(Industrial Emissions Directive)
Bidding zone	Markets	The largest geographical area within which market participants are able to exchange energy without capacity allocation. (ACER FG Balancing)	(ACER FG Balancing)
Billing cycle	Smart	Period of days in which a utility or supplier totals customer energy use and produces the customer bill.	(LandisGyr)

Term	Category	Definition	Resource
	Grids & meters	(LandisGyr)	
Book	Markets	The total portfolio of a trader. (Point Carbon)	(Point Carbon)
Broker	Markets	A company or individual that executes physical or financial products in a market place. In commodity markets a broker normally does not take price of volume risk and hence does not normally take positions. A broker may however sometimes function as a portfolio manager – trading behalf of a commercial entity. (Point Carbon)	(Point Carbon)
Buyer Surplus	Markets	Difference between the submitted price and the market price, multiplied by the quantity actually purchased. (EPEX SPOT)	(EPEX SPOT)
Buying hedge	Markets	Buyer futures contracts to protect against a possible price increase of cash commodities that will be purchased in the future. At the time, the cash commodities are bought, the open futures position is closed by selling an equal number and type of futures contracts as those that were initially purchased. (Point Carbon)	(Point Carbon)
CAD	Smart Grids & meters	Current Average Demand (LandisGyr).	(LandisGyr)
CAIDI	Smart Grids & meters	Customer Average Interruption Duration Index, a measure of electric utility reliability. (Smart Grid Today)	(Smart Grid Today)
Call option	Markets	An option that gives the buyer the right, but not the obligation, to purchase (go “long") the underlying futures contract at the strike price on or before the expiration date. (Point Carbon)	(Point Carbon)
Cap	Climate Change & Emissions	An enforceable limit on total emissions for the facilities covered under the cap-and-trade program. The cap is set for each compliance period of the program by the state and emissions are reduced as the cap declines over time. (EPA)	(EPA)
CAPEX	Smart Grids & meters	Capital expense or expenditure. (Smart Grid Today)	(Smart Grid Today)
Carrying charge (cost	Markets	For physical commodities such as grains and metals, the cost of storage space, insurance, and finance charges incurred by holding a physical commodity. (Point Carbon)	(Point Carbon)

Term	Category	Definition	Resource
of carry)			
Carryover	Markets	Commodities not consumed during the marketing year and remaining in storage at the end of a period. These stocks are "carried over" into the next marketing year. (Point Carbon)	(Point Carbon)
Cash commodity/ physical commodity	Markets	An actual physical commodity someone is buying or selling, e.g., Co2e, power, soybeans, corn, gold, silver, Treasury bonds, etc. Also referred to as actuals. (Point Carbon)	(Point Carbon)
Cash settlement	Markets	Transactions generally involving index-based futures contracts that are settled in cash based on the actual value of the index on the last trading day, in contrast to those that specify the delivery of a commodity or financial instrument. (Point Carbon)	(Point Carbon)
Cash/physical contract	Markets	A sales agreement for either immediate or future delivery of the actual product. (Point Carbon)	(Point Carbon)
Catalyst	Climate Change & Emissions	A substance that can increase or decrease the rate of a chemical reaction between the other chemical species without being consumed in the process. (EPA)	(EPA)
CENELEC	Smart Grids & meters	European Committee for Electro-technical Standardization.	
Central West Europe (CWE)	Markets	Region encompassing the power spot markets of France, Germany, Belgium, Netherlands and Luxembourg, which are coupled since 9 November 2010. (EPEX SPOT)	(EPEX SPOT)
Charting	Markets	The use of charts to analyse market behaviour and anticipate future price movements. Those who use charting as a trading method plot such factors as high, low, and settlement prices; average price movements; volume; and open interest. (Point Carbon)	(Point Carbon)
CIM	Smart Grids & meters	Common Information Model, a standard developed by the electric power industry which aims to allow application software to exchange information about the configuration and status of an electrical network. (LandisGyr)	(LandisGyr)
Class	Smart Grids &	Usually used in the metering context to specify a meter's accuracy. IEC defines classes as 0.2%, 0.5%, 1.0% and 2.0% max. measurement deviation; the new MID (Metering instrument directive) specifies	(LandisGyr)

Term	Category	Definition	Resource
	meters	classes A, B, C. Class C represents the highest accuracy. The term is sometimes also used for environmental, mechanical and electromagnetic conditions. (LandisGyr)	
Closing price	Markets	The last price paid for a commodity on any trading day. Also referred to as settle price. (Point Carbon)	(Point Carbon)
Code of Conduct	Markets	The Code of Conduct sets forth the rules of conduct and market behaviour which must be respected at all times by the Exchange Members. (EPEX SPOT)	(EPEX SPOT)
Combustion	Climate Change & Emissions	Any oxidation of fuels, regardless of the way in which the heat, electrical or mechanical energy produced by this process is used, and any other directly associated activities, including waste gas scrubbing. (ETS Directive)	(First ETS Directive)
Commission fee	Markets	A fee charged by a broker for executing a transaction. Also referred to as brokerage fee. (Point Carbon)	(Point Carbon)
Commodity	Markets	An article of commerce or a product that can be used for commerce. The types of commodities include oil, oil products, power, gas, agricultural products, metals, petroleum, foreign currencies, and financial instruments and index. (Point Carbon)	(Point Carbon)
Congestion	Networks	In the context of regulation EC 714/2009, congestion is a situation in which an interconnection linking national transmission networks cannot accommodate all physical flows resulting from international trade requested by market participants, because of a lack of capacity of the interconnectors and/or the national transmission systems concerned.	
Congestion management	Networks	Set of actions that the network operator performs to avoid or relieve a deviation of the electrical parameters from the limits that define the secure operation. This term includes congestion management and voltage control.	(European Commission - Smart Grids Task Force)
Contango	Markets	A condition in which distant delivery prices for futures exceed spot prices, often due to the costs of storing and insuring the underlying commodity. The opposite of backwardation. (Point Carbon)	(Point Carbon)
Contingency	Networks	Contingency means the identified and possible or already occurred fault within the TSO's control area, including not only the transmission but also the distribution network on lower voltage levels. (ENTSO-E Operational Security NC)	(ENTSO-E Operational Security NC)
Contract Month	Markets	A specific month in which delivery may take place under the terms of a futures contract. (Point Carbon)	(Point Carbon)
Cross-border (Transmissio	Markets	A capacity to transfer the energy from one congestion management bidding zone to another one. (ACER FG Balancing)	(ACER FG Balancing)

Term	Category	Definition	Resource
n) Capacity			
Cross-border balancing	Markets	Exchanges of balancing energy and/or reserves between control areas and/or between bidding zones. (ACER FG Balancing)	(ACER FG Balancing)
CT	Smart Grids & meters	Current transformer. An alternating current device which reduces actual current flow through meter with a fixed ratio. (LandisGyr)	(LandisGyr)
CT Ratio	Smart Grids & meters	The relationship of a current transformers' primary to secondary rating. This ratio defines the multiplication factor that has to be applied to the meter output in order to obtain the actual metered amount. (LandisGyr)	(LandisGyr)
Curtailment	Networks	Curtailment means a reduction in the scheduled capacity or energy delivery. (ENTSO-E UCTE Operational Handbook)	(ENTSO-E UCTE Operational Handbook)
Curtailment	Markets	Imbalance of purchase and sale leading to extreme prices on the Auction Segment. (EPEX SPOT)	(EPEX SPOT)
DA	Smart Grids & meters	Distribution automation, a general term referring to a class of technology that lets electric utilities monitor and remotely control their power distribution networks with two-way computer networking and computerized data handling. (Smart Grid Today)	(Smart Grid Today)
Day-Ahead	Markets	Market timeframes where commercial transactions are executed one day ahead of the day of delivery of traded products. (ACER FG Balancing)	(ACER FG Balancing)
Demand Reduction	Markets	The voluntary or involuntary reduction in electricity demand by end –consumers.	(European Commission - Smart Grids Task Force)
Demand Response	Markets	Changes in electric usage by end-use consumers from their normal load patterns in response to changes in electricity prices and/or incentive payments designed to adjust electricity usage, or in response to the acceptance of the consumer's bid, including through aggregation. (ACER FG Balancing)	(ACER FG Balancing)
Demand Response	Smart Grids & meters	Demand response, on the contrary, implies a 'bottom up' approach: customers become active in managing their consumption in order to achieve efficiency gains and thus reap monetary/economic benefits. Demand response can be defined as "the changes in electric usage by end-use customers from their normal consumption patterns in response to changes in the price of electricity over time. Further, demand response can also be defined as the incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardised. Demand response includes all	(EURELECTRIC)

Term	Category	Definition	Resource
		intentional modifications to consumption patterns of electricity of end-use customers that are intended to alter the timing, level of instantaneous demand, or the total electricity consumption." Demand response aims to reduce electricity consumption in times of high energy cost or network constraints by allowing customers to respond to price or quantity signals. Customers' demand response can either be: • Manual: they see prices, for example on a display, and decide to shift their consumption; or • Automated: their consumption is shifted automatically through technical signals and based on an agreement established with the supplier. For instance, customers could agree to shift part of their consumption to times when prices are at a certain level. (EURELECTRIC report views on Demand-Side Participation)	
Demand-side management (DSM) / Load Management	Smart Grids & meters	The planning, implementation, and monitoring of activities designed to encourage consumers to modify patterns of energy usage, including the timing and level of electricity demand. Demand side management includes demand response and demand reduction	(European Commission - Smart Grids Task Force)
Dispersed Generation	Smart Grids & meters	Power generation connected to the electricity distribution network. Today DG is seldom centrally planned or dispatched, but that will change, because the increasing penetration of DG will make is necessary to increasingly use DG as controllable resources for the power system and for the electricity market. (European Smart metering alliance)	(European Smart metering alliance)
Distributed Energy Resource,	Smart Grids & meters	A controllable energy resource connected to the electricity distribution network. Thus controllable loads, DG and electricity storage are DER. (European Smart metering alliance)	(European Smart metering alliance)
Distributed Generation	Smart Grids & meters	Distributed generation' means generation plants connected to the distribution system; Gas production refers to natural gas wells, Biomethane or Power-to-Gas plants connected to the distribution system	(Bloomenergy)
Distribution System Operator (DSO)	Smart Grids & meters	DSO manages and operates a distribution network for energy (electricity, gas, heat) or water. DSO has operators, control rooms and various ICT systems for distribution management and automation. In the competitive electricity market the distribution of electricity is usually a natural monopoly controlled by the regulating authorities. (European Smart metering alliance)	(European Smart metering alliance)
Disturbance	Networks	Disturbance is an unplanned event that produces an abnormal system condition. (ENTSO-E UCTE Operational Handbook)	(ENTSO-E UCTE Operational Handbook)
Electric System	Networks	Electric System Losses are total electric energy losses in the electric system. The losses consist of transmission, transformation, and distribution losses between supply sources and delivery points. Electric energy is lost primarily due to heating of transmission and distribution elements. (ENTSO-E UCTE	(ENTSO-E UCTE Operational Handbook)

Term	Category	Definition	Resource
Losses		Operational Handbook)	
Electric Vehicle	Climate Change & Emissions	An electric vehicle (EV), also referred to as an electric drive vehicle, is a vehicle which uses one or more electric motors for propulsion. Depending on the type of vehicle, motion may be provided by wheels or propellers driven by rotary motors, or in the case of tracked vehicles, by linear motors.	ElectricVehiclesNews.com
Electrical Energy	Networks	Electrical Energy is a measure of the generation or use of electric power by a device integrated over a period of time; it is expressed in kilowatt-hours (kWh), megawatt-hours (MWh), or gigawatt-hours (GWh).(ENTSO-E UCTE Operational Handbook)	(ENTSO-E UCTE Operational Handbook)
Energy distributor	Energy Efficiency	A natural or legal person, including a distribution system operator, responsible for transporting energy with a view to its delivery to final customers or to distribution stations that sell energy to final customers. (Energy Efficiency Directive)	(Energy Efficiency Directive)
Energy Efficiency	Energy Efficiency	The ratio of output of performance, service, goods or energy, to input of energy (Energy Efficiency Directive)	(Energy Efficiency Directive)
Energy efficiency improvement	Energy Efficiency	An increase in energy efficiency as a result of technological, behavioural and/or economic changes. (Energy efficiency directive)	(Energy Efficiency Directive)
Energy management system	Energy Efficiency	A set of interrelated or interacting elements of a plan which sets an energy efficiency objective and a strategy to achieve that objective. (Energy Efficiency Directive)	(Energy Efficiency Directive)
Energy performance contracting	Energy Efficiency	A contractual arrangement between the beneficiary and the provider of an energy efficiency improvement measure, verified and monitored during the whole term of the contract, where investments (work, supply or service) in that measure are paid for in relation to a contractually agreed level of energy efficiency improvement or other agreed energy performance criterion, such as financial savings. (Energy Efficiency Directive)	(Energy Efficiency Directive)
Energy performance of a building	Energy Efficiency	The calculated or measured amount of energy needed to meet the energy demand associated with a typical use of the building, which includes, inter alia, energy used for heating, cooling, ventilation, hot water and lighting (Directive 2010/31/EC)	(Directive 2009/125/EC)
Energy recovery	Energy Efficiency	The use of combustible waste as a means to generate energy through direct incineration with or without other waste but with recovery of the heat. (Directive 2005/32/EC)	(Directive 2005/32/EC)

Term	Category	Definition	Resource
Energy savings	Energy Efficiency	An amount of saved energy determined by measuring and/or estimating consumption before and after implementation of one or more energy efficiency improvement measures, whilst ensuring normalisation for external conditions that affect energy consumption (Energy Efficiency Directive)	(Energy Efficiency Directive)
Energy Service	Energy Efficiency	The physical benefit, utility or good derived from a combination of energy with energy-efficient technology or with action, which may include the operations, maintenance and control necessary to deliver the service, which is delivered on the basis of a contract and in normal circumstances has proven to result in verifiable and measurable or estimable energy efficiency improvement or primary energy savings. (Energy Efficiency Directive)	(Energy Efficiency Directive)
Energy Service Provider	Energy Efficiency	A natural or legal person who delivers energy services or other energy efficiency improvement measures in a final customer's facility or premises. (Energy Efficiency Directive)	(Energy Efficiency Directive)
Energy Storage	Climate Change & Emissions	Energy storage in the electricity system would be defined as the act of deferring an amount of the energy that was generated to the moment of use, either as final energy or converted into another energy carrier	(European Commission)
Energy-using product (EuP)	Energy Efficiency	A product which, once placed on the market and/or put into service, is dependent on energy input (electricity, fossil fuels and renewable energy sources) to work as intended, or a product for the generation, transfer and measurement of such energy, including parts dependent on energy input and intended to be incorporated into an EuP covered by this Directive which are placed on the market and/or put into service as individual parts for end-users and of which the environmental performance can be assessed independently. (Directive 2005/32/EC)	(Directive 2005/32/EC)
Environmental performance (of an EuP)	Energy Efficiency	The results of the manufacturer's management of the environmental aspects of the EuP, as reflected in its technical documentation file. (Directive 2005/32/EC)	(Directive 2005/32/EC)
ESCO	Markets	Energy Services Company (ESCO): A company offering electricity, specialized or customized energy services by providing advice and products to customers.	https://www.constellation.com
ETSI	Smart Grids & meters	European Telecommunications Standards Institute, a key standards body. (Smart Grid Today)	(Smart Grid Today)
Explicit	Smart	Explicit Demand Response is the type of DR referred to in Article 15. In this program, demand competes	(SEDC)

Term	Category	Definition	Resource
Demand Response	Grids & meters	directly with supply in the wholesale, balancing and ancillary services markets through the services of aggregators or single large consumers. This is achieved through the control of aggregated changes in load traded in electricity markets, providing a comparable resource to generation, and receiving comparable prices.	
Flexibility	Smart Grids & meters	On an individual level, flexibility is the modification of generation injection and/or consumption patterns in reaction to an external signal (price signal or activation) in order to provide a service within the energy system. The parameters used to characterize flexibility in electricity include: the amount of power modulation, the duration, the rate of change, the response time, the location etc."	(European Commission)
Gateway	Smart Grids & meters	A network management device usually within a home or business that distributes throughout the premises the variety of available broadband services such as internet, voice and video.	
Hedging	Markets	The practice of offsetting the price risk inherent in any cash market position by taking an equal but opposite position in the futures market. Hedgers use the futures markets to protect their business from adverse price changes. (Point Carbon)	(Point Carbon)
Imbalance Settlement	Markets	A financial settlement mechanism aiming at charging or paying BRPs for their imbalances. (ACER FG Balancing)	(ACER FG Balancing)
Imbalance Settlement Period	Markets	Time unit used for computing BRPs' imbalances. (ACER FG Balancing)	(ACER FG Balancing)
Imbalances	Markets	Deviations between generation, consumption and commercial transactions (in all timeframes – commercial transactions include sales and purchases on organised markets or between BRPs) of a BRP within a given imbalance settlement period. (ACER FG Balancing)	(ACER FG Balancing)
Implicit Demand Response	Smart Grids & meters	Implicit Demand Response (sometimes called "price-based") refers to consumers choosing to be exposed to time-varying electricity prices or time-varying network tariffs (or both) that partly reflect the value or cost of electricity and/or transportation in different time periods and react to those price differences depending on their own possibilities (no commitment). These prices are always part of their supply contract. Implicit DR does not therefore allow a consumer to participate alongside generation in a market.	(SEDC)
Individual action	Energy Efficiency	An action that leads to verifiable, and measurable or estimable, energy efficiency improvements and is undertaken as a result of a policy measure. (Energy Efficiency Directive)	(Energy Efficiency Directive)

Term	Category	Definition	Resource
Injection	Markets	Power produced or declared to the TSO and included as a positive figure in the calculation of the Balance Responsible Imbalance. (EPEX SPOT)	(EPEX SPOT)
Interconnected system	Networks	An Interconnected System is a system consisting of two or more individual electric systems that normally operate in synchronism and are physically connected via tie-lines see also: synchronous area (ENTSO-E UCTE Operational Handbook)	(ENTSO-E UCTE Operational Handbook)
Interconnection Capacity	Markets	Cross-border electric energy transfer capacity on the interconnections. (EPEX SPOT)	(EPEX SPOT)
International standard	Energy Efficiency	A standard adopted by the International Standardisation organisation and made available to the public. (Energy Efficiency Directive)	(Energy Efficiency Directive)
Intraday	Markets	Market timeframe beginning after the day-ahead gate closure time and ending at the intraday gate closure time, where commercial transactions are executed prior to the delivery of traded products. (ACER FG Balancing)	(ACER FG Balancing)
Intraday Margin	Markets	Additional margin which has to be deposited in the course of an exchange trading day in highly volatile market situations. (EPEX SPOT)	(EPEX SPOT)
Intraday Market	Markets	Part of the spot market where the commodity is tradable up to 45 minutes before physical fulfilment. (EPEX SPOT)	(EPEX SPOT)
Island	Networks	An island represents a portion of a power system or of several power systems that is electrically separated from the main interconnected system (separation resulting e.g. from the disconnection / failure of transmission system elements) (ENTSO-E UCTE Operational Handbook)	(ENTSO-E UCTE Operational Handbook)
Load	Networks	1. The load is the value at a given moment of the electrical power supplied or absorbed at any point of a system as determined by an instantaneous measurement or by the integration of power during a given period of time. Load can refer to a consumer, an appliance, a group of consumers or appliances or a network (UNIPEDE 1991) 2. Load means an end-use device or customer that receives power from the electric system. Load should not be confused with demand, which is the measure of power that a load receives or requires. Load is often wrongly used as a synonym for demand (ENTSO-E UCTE Operational Handbook). 3. The demand on an energy producing system; the energy consumption or requirement of a piece or group of equipment. Usually expressed in terms of amperes or watts in reference to electricity. (US DoE Solar Glossary)	(US DoE Solar Glossary)
Load control	Smart Grids &	Activities performed by the utility that can interrupt load at the time of peak by interrupting power supply on	(LandisGyr)

Term	Category	Definition	Resource
	meters	consumer premises. Load control is usually applied to residential consumers. (LandisGyr)	
Load management	Smart Grids & meters	Utility activities designed to influence the timing and amount of electricity that customers may use.	
Load profile	Smart Grids & meters	"The estimated variation of electrical/gas load versus time. A load profile will vary according to customer type e.g. residential, commercial and industrial and/or temperatures and/or week-days. Load profiles are used to convert the monthly/yearly metered consumption data into estimates of daily/hourly or quarter hourly consumption.	(European Commission - Smart Grids Task Force)
Load profiling	Smart Grids & meters	In a deregulated energy market, the public utility commission may require utilities to perform load profile reads on a certain number of customers in each customer class. This load profiling data is needed to determine rates and usage for other customers in the same customer class. (LandisGyr)	(LandisGyr)
Load shedding	Networks	The disconnection of load from the synchronous electric system, usually performed automatically, to control the system frequency in emergency situations. (ENTSO-E UCTE Operational Handbook)	(ENTSO-E UCTE Operational Handbook)
Load shedding	Smart Grids & meters	The process of deliberately removing (either manually or automatically) preselected customer demand from a power system in response to an abnormal condition to maintain the integrity of the system and minimise overall customer outages. (LandisGyr)	(LandisGyr)
Load shifting	Smart Grids & meters	Demand-side management programs designed to encourage consumers to move their use of electricity from on-peak times to off-peak times. (LandisGyr)	(LandisGyr)
Low	Markets	The lowest price of the day for a particular futures contract. (Point Carbon)	(Point Carbon)
Low Carbon Technologies	Climate Change & Emissions	Low-carbon technology, reducing the use of fossil fuels, energy conservation, developing new energy, alternative energy and improving the current situations of global warming are fundamental ways to solve above problems	(Lin, Z.H. (2011) Low Carbon Technology and Its Application. Nature Magazine, No. 2, 74.)
LV	Smart Grids & meters	Low Voltage, an electrical engineering term that broadly identifies safety considerations of an electricity supply system based on the voltage used. It is often defined as 50-1000 V AC and is the voltage used in the final distribution to users. (LandisGyr)	(LandisGyr)

Term	Category	Definition	Resource
Market Area	Markets	An area comprising one or several Delivery Areas. (EPEX SPOT)	(EPEX SPOT)
Market Clearing Price	Markets	The market clearing price corresponds to the intersection between the aggregated supply and demand curve. (EPEX SPOT)	(EPEX SPOT)
Market Coupling	Markets	Market coupling allows the matching of power exchanges orders and the implicit allocation of the available cross-border capacities received from the Transmission System Operators (TSOs). (EPEX SPOT)	(EPEX SPOT)
MDMS	Smart Grids & meters	Gridstream Metering Data Management System is a standard-bases system designers to rigorously process and prepare data for a variety of utility programs and operations	(LandisGyr)
Metering	Networks	Metering describes the methods of applying devices that measure and register the amount and direction of electrical quantities with respect to time. (ENTSO-E UCTE Operational Handbook).	(ENTSO-E UCTE Operational Handbook)
Minimum price fluctuation	Markets	The smallest allowable increment of price movement for a contract. (Point Carbon)	(Point Carbon)
MV	Smart Grids & meters	Medium Voltage, an electrical engineering term that broadly identifies safety considerations of an electricity supply system based on the voltage used. It is often defined as 1-72 kV AC and is the voltage used in the local power lines. (LandisGyr)	(LandisGyr)
Net Metering Regime	Smart Grids & meters	Net metering allows customers of certain electric distribution companies to generate their own electricity in order to offset their electricity usage. Common examples of net metering installations include solar panels on a home or a wind turbine at a school. These installations are connected to a meter, which will measure the net quantity of electricity that the customer uses ("retail meter"). The retail meter spins forward when the customer uses electricity from the distribution company, and it spins backward when the customer generates excess electricity (thereby "exporting" electricity to the electric grid). A special retail meter (also called the "net meter") is required to allow for the "netting" of usage and generation, especially when there may be exporting of electricity.	(U.S. Executive Office of Energy and Environmental Affairs)
Offsets	Climate Change & Emissions	Offsets are tradable credits that represent greenhouse gas emissions reductions that are made in areas or sectors not covered by a cap-and-trade program. Under a greenhouse gas cap-and-trade program, covered entities could buy offset credits in lieu of buying allowances or reducing their greenhouse gas emissions on-site. One offset credit would be equal to one metric ton of greenhouse gas emissions. Offsets must meet rigorous criteria that demonstrate that the emissions reductions are real, permanent,	(EPA)

Term	Category	Definition	Resource
		verifiable, enforceable and quantifiable. (EPA)	
Operational security	Networks	The transmission system capability to retain a Normal State or to return to a Normal State as soon and as close as possible, and is characterized by thermal limits, voltage constraints, short-circuit current, frequency reference value and stability limit. (ENTSO-E Draft NC Operational Security)	(ENTSO-E Draft NC Operational Security)
Operational Security Limits	Networks	The acceptable operating boundaries: thermal, voltage, fault levels, frequency and stability limits. (ENTSO-E Draft NC Operational Security)	(ENTSO-E Draft NC Operational Security)
PLC	Smart Grids & meters	Power Line Communication (PLC) is a well-established communications technology that was initially used for telemetry purposes.	(LandisGyr)
Power System	Networks	The Power System comprises all generation, consumption and network installations interconnected through the network. (ENTSO-E UCTE Operational Handbook)	(ENTSO-E UCTE Operational Handbook)
Power to heat ratio	Energy Efficiency	The ratio between electricity from cogeneration and useful heat when operating in full cogeneration mode using operational data of the specific unit (Energy Efficiency Directive)	(Energy Efficiency Directive)
Primary Energy	Energy Efficiency	Energy in its original form that has not been subjected to any conversion or transformation process.	
Primary Energy Consumption	Energy Efficiency	Primary energy consumption means gross inland consumption, excluding non-energy uses. (Energy Efficiency Directive)	(Energy Efficiency Directive)
Primary Energy Factor (PEF)	Energy Efficiency	The relationship between the energy content of primary energy and secondary energy sources. It is calculated by dividing the energy content of primary energy with the energy content of secondary energy. The PEF is used to calculate primary energy consumption which is indirectly caused by the consumption of secondary energy.	
Real Time Metering	Smart Grids & meters	Metering that records consumer use in the same time frame as pricing changes in the market, typically hourly or more frequently. (LandisGyr)	(LandisGyr)
Real Time Pricing	Smart Grids & meters	The pricing of electricity based on the cost of the electricity available for use at the time the electricity is demanded by the customer. As distinguished from TOU pricing, RTP is usually applied to that power demand above a defined base usage for a given customer, and not to all power consumed by that customer. RTP may also encompass charges for transmission and distribution whereas market-based	(LandisGyr)

Term	Category	Definition	Resource
		rates cover only the energy (and possibly capacity) portion of an electric bill. (LandisGyr)	
Reliability	Networks	Reliability describes the degree of performance of the elements of the bulk electric system that results in electricity being delivered to customers within accepted standards and in the amount desired. Reliability on the transmission level may be measured by the frequency, duration, and magnitude (or the probability) of adverse effects on the electric supply / transport / generation. Electric system reliability can be addressed by considering two basic and functional aspects of the electric system: • Adequacy — The ability of the electric system to supply the aggregate electrical demand and energy requirements of the customers at all times, taking into account scheduled and reasonably expected unscheduled outages of system elements. • Security — the ability of the electric system to withstand sudden disturbances such as electric short circuits or unanticipated loss of system elements. (ENTSO-E UCTE Operational Handbook)	(ENTSO-E UCTE Operational Handbook)
Reliability (in Distribution networks)	Networks	DSOs are subject to technical performance requirements for quality of service including continuity of supply (commonly assessed by zonal indexes such as SAIDI and SAIFI or individual indexes like number and duration of interruptions) and power quality laid out in national law, standards and grid codes. They are also responsible for voltage quality in distribution networks (maintaining voltage fluctuations on the system within given limits). (EURELECTRIC report 'Ancillary services', 2004)	(EURELECTRIC)
Renewable energy obligation	Energy Efficiency	"Renewable energy obligation" means a national support scheme requiring energy producers to include a given proportion of energy from renewable sources in their production, requiring energy suppliers to include a given proportion of energy from renewable sources in their supply, or requiring energy consumers to include a given proportion of energy from renewable sources in their consumption. This includes schemes under which such requirements may be fulfilled by using green certificates. (2009/28/EC)	(2009/28/EC)
Replacement Reserves	Markets	Operating reserves used to restore the required level of operating reserves to be prepared for a further system imbalance. This category includes operating reserves with activation time from 15 minutes up to hours. (ACER FG Balancing)	(ACER FG Balancing)
Reservation of cross-border transmission capacity	Markets	A portion of available cross-border capacity which is reserved for cross-border exchange of balancing reserves and thus is not accessible to market participants for cross-border energy trade. (ACER FG Balancing)	(ACER FG Balancing)
Reserves (Balancing)	Markets	Power capacities (MW) available for TSOs to balance the system in real time. These capacities can be contracted by the TSO with an associated payment for their availability and/or be made available without	(ACER FG Balancing)

Term	Category	Definition	Resource
		payment. Technically, reserves can be either automatically or manually activated. (ACER FG Balancing)	
SAIDI (System Average Interruption Duration Index)	Smart Grids & meters	A system index of average duration of interruption in the power supply indicated in minutes per customer.	(Live-Line Operation and Maintenance of Power Distribution Networks)
SAIFI (System Average Interruption Frequency Index)	Smart Grids & meters	A system index of average frequency of interruptions in power supply	(Live-Line Operation and Maintenance of Power Distribution Networks)
Self-consumption Regime	Markets	Passive consumers become active 'prosumers' (i.e. producers and consumers of renewable energy)	(Delivering a New Deal for Energy Consumers)
Self-Regulation of Load	Networks	The Self-Regulation of Load is defined as the sensitivity of consumers' demand to variations in the system frequency (a decrease of the system frequency results in a decrease of the load), generally expressed in % / Hz. (ENTSO-E UCTE Operational Handbook)	(ENTSO-E UCTE Operational Handbook)
Seller Surplus	Markets	Difference between the submitted price and the market price, multiplied by the quantity actually sold. (EPEX SPOT)	8 EPEX SPOT)
Settle	Markets	The last price paid for a commodity on any trading day. The exchange clearinghouse determines a firm's net gains or losses, margin requirements, and the next day's price limits, based on each futures and options contract settlement price. If there is a closing range of prices, the settlement price is determined by averaging those prices. Also referred to as settlement price or closing price. (Point Carbon)	(Point Carbon)
Smart grid	Smart Grids & meters	A smart grid is an electricity network that can intelligently integrate the behaviour and actions of all its users to ensure a sustainable, economic and secure electricity supply. As a tool that provides much-needed flexibility, smart grids offer potential benefits to the entire electricity value chain (generators, TSOs, DSOs, suppliers and consumers) and to society as a whole. Smart grids will enable DSOs to monitor the electricity flowing within their grids. On the basis of collected data, they will be able to adjust to changing conditions by automatically reconfiguring the network and/or by taking control of connected demand and	(EURELECTRIC)

Term	Category	Definition	Resource
		distributed generation. While smart grids equip DSOs with new tools to keep the system highly reliable and affordable, they will also create new opportunities for customers and service providers. (EURELECTRIC report 10 Steps to smart grids)	
Smart meter	Smart Grids & meters	A smart meter is an essential device that integrates data collection and communication within smart grids. Thus, many smart grid functionalities cannot be deployed without smart metering. Supplemented by in-home displays and portal solutions, smart meters contribute to higher customer awareness. Using open standards, smart meters will enable dynamic pricing, in turn incentivising customers' involvement. In doing so, they will catalyse the development of retail markets and enable enlarged business models like network operation and asset management. Later on, they will be integrated with home appliances and home automation networks. (EURELECTRIC report 10 Steps to smart grids)	(EURELECTRIC)
Spinning reserve	Networks	Increase or decrease in generation or reduction in consumption that can be provided at short notice, carried out by partially loaded generating units and interruptible customers. (EURELECTRIC report 'Ancillary services', 2004)	(EURELECTRIC)
Spot	Markets	Usually refers to a cash market price for a physical commodity that is available for immediate delivery. (Point Carbon)	(Point Carbon)
Spot market	Markets	A market in which commodities, such as grain, gold, crude oil, or RAM chips, are bought and sold for cash and delivered immediately. Also called cash market. (Point Carbon)	(Point Carbon)
Spot month	Markets	The futures contract month closest to expiration. Also referred to as nearby delivery month. (Point Carbon)	(Point Carbon)
Spread	Markets	The price range between best bid and best ask is called spread. (EPEX SPOT)	(EPEX SPOT)
Stability	Networks	Stability is the ability of an electric system to maintain a state of equilibrium during normal and abnormal system conditions or disturbances. • Small-Signal Stability — The ability of the electric system to withstand small changes or disturbances without the loss of synchronism among the synchronous machines in the system while having a sufficient damping of system oscillations (sufficient margin to the border of stability). • Transient Stability — The ability of an electric system to maintain synchronism between its parts when subjected to a disturbance of specified severity and to regain a state of equilibrium following that disturbance. (ENTSO-E UCTE Operational Handbook)	(ENTSO-E UCTE Operational Handbook)
Supervisory Control and Data Acquisition	Networks	Supervisory Control and Data Acquisition is a system of remote control and telemetry used to monitor and control the electric system. (ENTSO-E UCTE Operational Handbook)	(ENTSO-E UCTE Operational Handbook)

Term	Category	Definition	Resource
(SCADA)			
System Services	Networks	System services are services provided by network operators to users connected to the system in order to ensure required power quality and the stability of the distribution grid. See ancillary services above (EURELECTRIC report 'Ancillary services', 2004)	(EURELECTRIC)
System State	Networks	The operational state of the transmission system in relation to the Operational Security Limits. (ENTSO-E Draft NC Operational Security)	(ENTSO-E Draft NC Operational Security)
TOU	Smart Grids & meters	Time-of-Use tables facilitate load control and planning on the part of utilities. This involves dividing the day, month and year into tariff slots and with higher rates at peak load periods and low tariff rates at off-peak load periods. The TOU table can also be used for load control, signal generation, etc. (LandisGyr)	(LandisGyr)
Transmission	Networks	Transmission is the transport of electricity on the extra-high or high-voltage network (transmission system) for delivery to final customers or distributors. Operation of Transmission includes the tasks of system operation as well concerning the management of energy flows, reliability of the system and availability of all necessary system services / ancillary services. (ENTSO-E UCTE Operational Handbook)	(ENTSO-E UCTE Operational Handbook)
Transmission rate	Smart Grids & meters	The transmission rate, sometimes also called bit rate, represents the digital data quantity transmitted within a specific time. Unit: bit/s or bps. The term "baud rate" is often used for transmission rate, although it signifies the symbol changes per time unit at the interface (unit: baud = symbols/second). Depending on coding, a symbol can consist of several bits of a data stream. The transmission rate can, therefore, be several times higher than the baud rate. (LandisGyr)	(LandisGyr)
Transmission Reliability Margin (TRM)	Networks	The Transmission Reliability Margin is a security margin that copes with uncertainties on the computed TTC values arising from: • Unintentional deviations of physical flows during operation due to the physical functioning of secondary control • Emergency exchanges between TSOs to cope with unexpected unbalanced situations in real-time • Inaccuracies, e. g. in data collection and measurements (ENTSO-E UCTE Operational Handbook)	(ENTSO-E UCTE Operational Handbook)
Transmission System Operator (TSO)	Networks	a natural or legal person responsible for operating, ensuring the maintenance of and, if necessary, developing the transmission system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet reasonable demands for the transmission of electricity. (2009/75/EC)	(2009/28/EC)
Transmission System Operator	Smart Grids & meters	Natural or legal person responsible for operating, ensuring maintenance, of and, if necessary, developing the transmission system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet reasonable demands for the transmission of	(Directive 2009/72/EC)

Term	Category	Definition	Resource
(TSO)		electricity. (DIRECTIVE 2009/72/EC)	
Unbundling	Smart Grids & meters	Disaggregating the electric utility service into its basic components and offering each component separately for sale with separate rates for each component. For example, generation, transmission and distribution could be unbundled and offered as discrete services or metering and billing could be offered as discrete services. (LandisGyr)	(LandisGyr)
Volatility	Markets	Volatility is a measure of the price fluctuations in the course of one day. The additional margin parameter and the spread margin parameter can then be determined on the basis of volatility. (EPEX SPOT)	(EPEX SPOT)
Voltage control	Networks	A distribution system control managed by distribution system operators in order to maintain voltage in their networks within limits and to minimise the reactive power flows and consequently, technical losses and to maximise available active power flow	
Withdrawal	Markets	Power consumed or declared to the TSO and included as a negative figure in the calculation of the Balance Responsible Imbalance. (EPEX SPOT)	(EPEX SPOT)

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