TIGON KPIs Panel

Deliverable 2.4 (v01)
WP2. Boundary conditions and baseline for TIGON development

Responsible Partner

CIRCE

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Executive Summary

This document sets out the guidance for the use of KPIs by the TIGON project during the deployment and testing phases. During the execution of this task, a general list of KPIs was defined together with the leaders of the demos and the technology providers. Additionally, to provide more flexibility during the deployment stage, this list was divided into two large categories, corresponding to the main KPIs and the auxiliary KPIs. The first list covers the requirements indicated by the demo leaders, the second works as a complementary list that can be used on demand during later stages. To complement this, a contingency and monitoring plan is included, the former will allow KPIs to be modified or adjusted if necessary, and the latter provides general guidance on how to evaluate and coordinate efforts during the deployment phase.

The TIGON project has two defined demonstration sites (in Spain and France), initially, both will share the same KPIs but it is possible to adapt the final list to better fit the specific requirements defined later during WP6 and WP5 (Spanish and French deployment stages respectively). The complete list is shown in Table 1.

Table 0.1. KPI general list

Cat	KPI	ID
Main	Self-Consumption Rate	SCRt
	Energy Consumption	EC
	Peak load reduction	PLRed
	Average estimation of savings per stakeholder	AeS
	Generation Available Flexibility	GAF
	Reverse Power Flow	RPF
	CAIDI	CAIDI
	CO2 tonnes saved	CO2Sv
	Number of Grid Events	NGE
	SAIDI	SAIDI
	Line overload occurrence	LOO
	Grid investment deferral	GID
	Load curve valley filling	VF
	Voltage Unbalance Factor	VUF
Aux	Demand Flexibility Potential	DFP
	DR Delivery Deviation	DRDD
	Energy not supplied	END
	SAIFI	SAIFI
	Demand Available Flexibility	DAF
	Increased EV Hosting capacity	EVHC
	Number of Voltage Limits Violations	VLV
	Reduction in Energy Losses	REL
	Number of frequency out of range events	FOR
	RoCoF	RoCoF
	Flexibility actions taken	FAT
	NADIR	NADIR
	Reactive Energy Consumption	RE

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List of acronyms, figures and tables

Abreviations and acronyms

A	Current in Ampere
BaU	Business as Usual
DER	Distributed Energy Resources
EV	Electric Vehicles
KPI	Key Performance Indicator
M	Month
PV	Photovoltaic system
R&D	Research and Development
RES	Renewable Energy Sources
RMS	Root Mean Squared
TP	Technical Partner
UCS	Use Case supervisor
V	Voltage in Volts
WP	Work Package

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1. Objective of TIGON KPIs Panel

The main goal of TIGON is to enable a smooth deployment and integration of intelligent DC-based grid architectures within the current energy system, while providing ancillary services to the main network. To do so, TIGON proposes a four-level approach aiming at improving reliability, resilience performance, and cost efficiency of hybrid grids through the development of an innovative portfolio of power electronic solutions and software systems and tools focused on the efficient monitoring, control and management of DC grids. These solutions will be demonstrated in two main Demo-Sites located in France and Spain, while additional use cases will act as niche markets for analysing and further solidifying the replication of TIGON developments after the project's end.

This concept has been designed to assure the operation of DC grids in different modes (e.g. connected to the main grid or in isolated mode even in emergency situations) as well as the accommodation of high shares of renewable energy, while minimizing investments in infrastructures. This will enable a smooth integration of DC grids within the existing electricity grid based mainly on AC, thus boosting their deployment across the whole European electricity system.

The novelty of this approach relies on the integration of TIGON main physical and software developments, which are the key enablers for the smart and cost-effective operation of the whole DC-based hybrid grid. The starting point is the Solid-State Transformer (SST), which constitutes the link of the hybrid grid with the main AC grid. Compared to conventional transformers, the SST is a power electronics based apparatus that includes features such as voltage regulation, power flow management, load disturbance rejection or fault current limitation. Therefore, the optimization of the power flows will be performed already at the AC/DC interface, influencing as well the power flow from other conventional transformers and avoiding congestion issues, which implies a high degree of digitalization and improved smartness in the network.

The objective of this deliverable is to provide a comprehensive set of KPIs defined with the help of all partners involved (demo site leaders and developers), this list will be complemented by the use of a common template form containing all the information to perform the calculation, as well as the definition of the data source, the frequency of collection and the responsible parties.

In addition, solutions for monitoring and backup plans for KPI troubleshooting will be shown, based on procedures to be used during the demonstration stage.

2. KPI Definition

2.1. Selection methodology

The first set of KPIs was launched at the beginning of WP2, based on earlier projects that focused on deployment and integration of intelligent DC-based grid architectures within the current energy system (see references). Feedback from all the leaders of the demonstration sites on this first KPI list was collected and analyzed, and each leader proposed new KPIs considering their specific needs.

As a result of the first iteration, a second list of KPIs was sent, this time to all technology partners (software and hardware solutions), analogous to the initial list, all responses were collected and considered to improve all aspects to be monitored.

Finally, the last iteration was carried out to eliminate redundant and less relevant KPIs and the complete KPIs Panel list was defined (see Annex A.2). The outline of the process mentioned above is shown below.

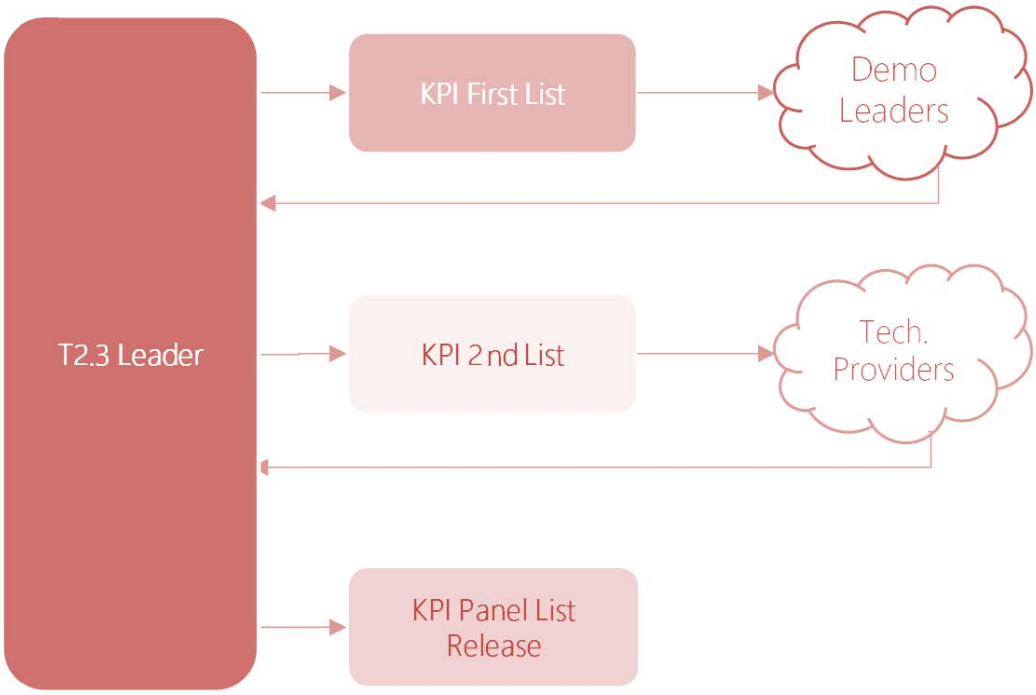

Figure 2.1. KPI Definition workflow

2.2. Categories and implementation

The TIGON project has two demonstration with several technologies to be tested, as result, there are a significant number of KPIs on the panel list, therefore, to provide an effective set of performance indicators for each demonstration the KPI Panel list was divided into categories.

These categories correspond to two classifications: core KPI and auxiliary KPI. The core KPI contains a minimum number of essential indicators (usually less than 10) that will be measured in the testing stage following the strategies defined in the monitoring plan proposed in this document. In addition, a list of auxiliary KPIs will be established for rapid deployment if demonstration needs arise or change during the demonstration campaign activities. The general classification scheme of the KPI groups is shown in the next figure.

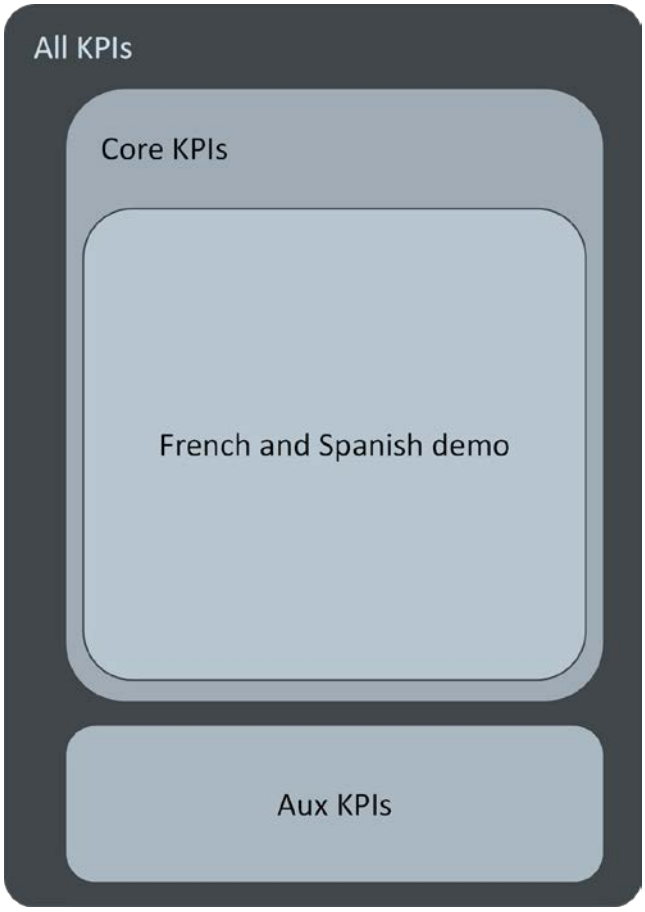

Figure 2.2. KPI Classification

3. KPI PANEL LIST

After following the procedure described in section 3.1, the KPI panel list is defined and contains both the core and auxiliary KPIs along with their names, IDs and a high-level description, as shown in Table 4.1. KPI panel List.

Table 4.1. KPI panel List

ID	KPI	Description	Unit
SCRt	Self-Consumption Rate	Amount of energy supplied by local RES and consumed on site/locally	percent
EC	Energy Consumption	Sum of electrical energy [kWh], measured over a given time period	[kWh]
PLRed	Peak load reduction	Reduction of the value of the maximum load on a given period (day, month, year).	%
AeS	Average estimation of savings per stakeholder	Total savings from avoided energy consumption or purchase (depending on stakeholder concerned) over the sum of that avoided energy	€/kWh
GAF	Generation Available Flexibility	The amount of generation that can be shifted temporally	[MW]
RPF	Reverse Power Flow	power/energy flown from distribution feeder/system upward due to excess of RES power generation	kWh/y
CAIDI	CAIDI	sum(duration all customer interruptions) / number of customer interruptions	min
CO2Sv	CO2 tonnes saved	Tonnes of carbon dioxide saved	%
NGE	Number of Grid Events	e.g. Tripping event, recloser operation. include a location ID and timestamp	integer
SAIDI	SAIDI	Is the average duration of all interruptions per utility customer during the period of analysis. Here, the total customer minutes of interruption are added together and divided by the total number of customers in the system.	min
LOO	Line overload occurrence	Number of line overloading events up to 15 minutes (OL_E [-]) within a year	Integer / [year]
GID	Grid investment deferral	Savings (avoided costs) by employing new proposed solutions vs traditional (e.g. line reinforcement)	[€]

ID	KPI	Description	Unit
VF	Load curve valley filling	Can be a result of improvements in Tariffs & Demand Response and Network Balance with Steering	[MW]
VUF	Voltage Unbalance Factor	Difference in the voltage of the three phases	percent
DFP	Demand Flexibility Potential	The amount of potential Demand Flexibility reflects the amount of energy consumption reduction participating Customers (i.e. End Users) could potentially accept and apply	kWh
DRDD	DR Delivery Deviation	The difference between the DR the Customer has committed to deliver and the DR that the Customer actually delivered	kWh
ENS	Energy not supplied	The amount of energy that normally would be delivered, but now is not because of a power outage in [MWh]	[MWh]
SAIFI	SAIFI	System average interruption frequency index during the period of analysis.	interruptions/customer.year
DAF	Demand Available Flexibility	The amount of load that can be shifted temporally. Needs specification dependent on the method used to provide an incentive (RTP, remote operation of customer assets or other options)	[MW]
EVHC	Increased EV Hosting capacity	The additional EV capacity that can be accommodated on the distribution network after the deployment of the project solution, compared to the EV capacity that can be accommodated on the distribution network without it.	[MW]
VLV	Number of Voltage Limits Violations	Number of times that voltage in a node exceeds (under or over) the tolerance limit (e.g. voltage dips/swells).	Integer / [time]
REL	Reduction in Energy Losses	Amount of electrical energy lost on grid's conductors, transformers, etc.	[kWh]
FOR	Number of frequency out of range events	calculates times that the average value of the fundamental frequency measured over periods of 10 s goes out of the stated ranges (FCE).	Integer / [time]
RoCoF	RoCoF	Rate of Change of Frequency	Hz/s
FAT	Flexibility actions taken	Number of flexibility actions taken to reduce demand, load control, network configuration, etc. (NaT [-]) in a period	integer/[time]
NADIR	nadir	minimum frequency reached after a contingency event	Hz
RE	Reactive Energy Consumption	Total reactive power in a period	[kVAr]/[time]

4. KPI DATASHEET

4.1. Common Format

A common data sheet format was developed for all KPIs. This data sheet defined the calculation process, the necessary data and those responsible for providing the information.

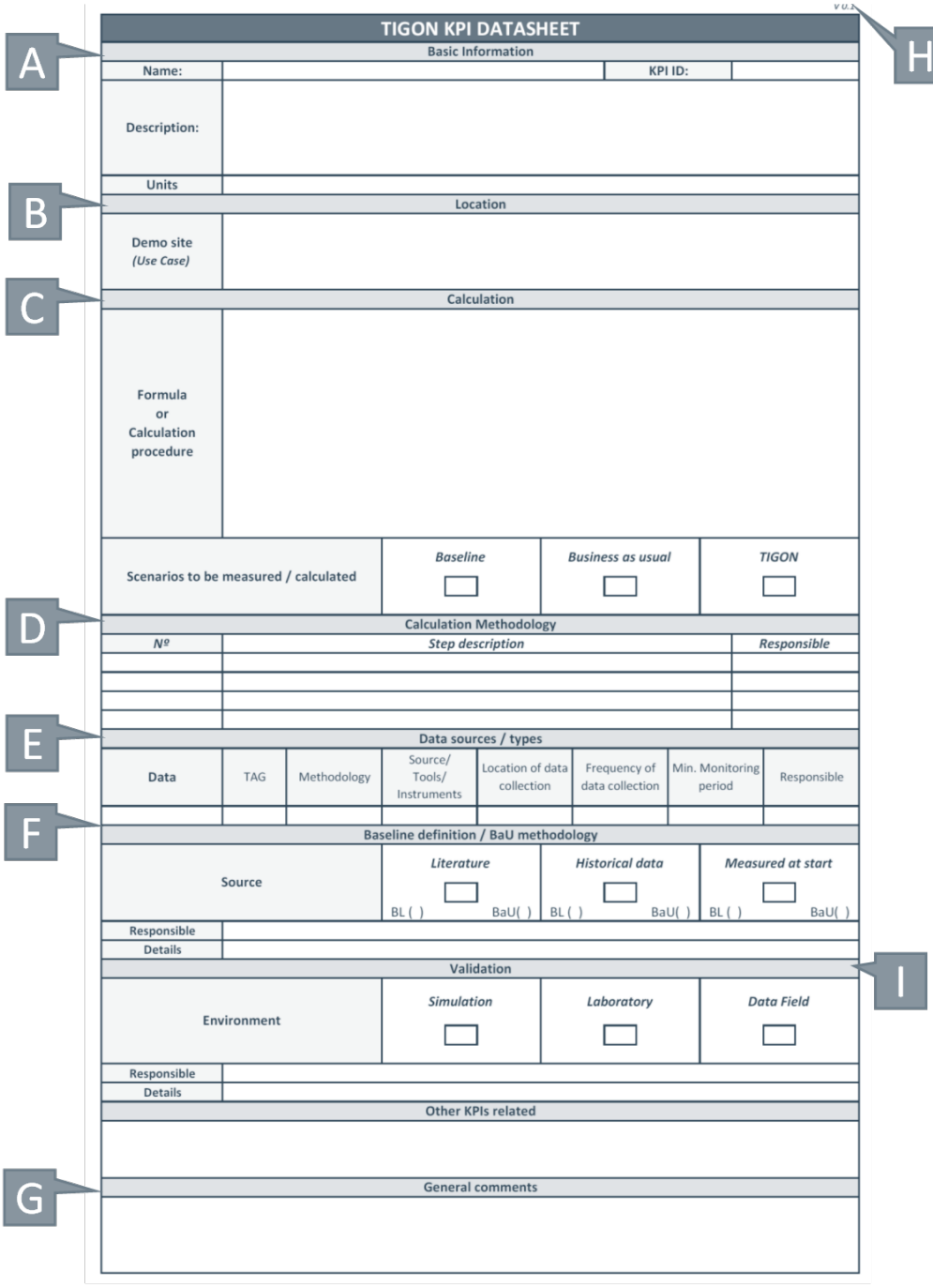

Figure 4.1. KPI Datasheet common format sections

4.2. Sections

The form includes all elements shown in Figure 3 and indicated as follow:

A. Basic information: where the short name (ID) and a brief description of the KPI will be indicated.
B. Location: Demo sites and use cases where the performance indicator can be applied will be indicated. (It may change according to the criteria set out in the demonstration stage)
C. Calculation: This section describes the KPI calculation process and indicates the scenarios to be calculated. At the beginning of the demonstration phase the baseline or business as usual will be calculated, and a final scenario based on the use of TIGON solutions will be calculated at the end of the demonstration phase.
D. Calculation methodology: The methodology indicates the steps to perform the KPI calculation, including the necessary input data, the intermediate processes, and the final value, as well as the engineering units.
E. Data sources/types: In this section the required data, its sources, and the way to obtain it, as well as the responsible for providing the data can be found. Information on the data collection period is also included.
F. Baseline: This section defines the method used to determine the baseline conditions of the KPI, either through historical data, simulations, reference to literature or others.
G. Comments: General section for comments and notes.
H. Versioning: Indicates the version of the data sheet.
I. Validation: indicates the environment in which data will be obtained to calculate/compare versus base values.

The blank form is shown in Annex A.1, the completed data sheets are in Annex A.2.

5. Monitoring plan

During the demonstration campaign, the effectiveness of the different solutions proposed will be evaluated through all the previously defined KPIs. At the beginning of the demonstration campaign, an internal workshop will be held to define the definitive actions and procedures to be used during all the deployment and testing stages. As a guide for the mentioned workshop, this document provides the main actions and schedules considering the solution development periods as well as the internal milestones in WP5 and WP6. At least once KPIs will be measured at the beginning and end of the demonstration phase by the use cases supervisors and demo-sites coordinators to assess the impacts achieved using TIGON technologies and services at the two demonstration sites.

The proposed monitoring plan consists of the following steps:

1. Internal workshop to discuss and define the common plan for demonstration and monitoring common protocols for demonstration activities, including reporting and data collection procedures. The key performance indicators defined in Task 2.4 (contained in this document) will be measured at the beginning and end of the demonstration phase by use case monitors and demonstration site coordinators to assess the effects achieved through the use of TIGON technologies and services at the two demonstration sites.

2. Calculation of the baseline and/or BaU: This will allow to define the status of the demos before the implementation of the solutions proposed in the TIGON project, as indicated in the corresponding datasheet.

3. First evaluation of the KPI list: It is recommended to perform the calculation of all core indicators contained in the final KPI list. The objective is to determine the feasibility to perform the calculation without problems and make a first performance evaluation. If any drawbacks are detected in the calculation procedure, the problem-solving scheme shown below in section six of this document should be followed.

4. Evaluation of the KPI in the medium term: at the discretion of the plan defined in the workshop, a follow-up analysis of the progress of the KPIs can be carried out. A review schedule can be followed every four months or in any other period defined in the WP5 and WP6 workshops.

5. General evaluation of the KPIs (end of test): Calculate all indicators at the end of the test phase, this value will be used as input for task T5.4 and T6.4 to compare the progress made after the implementation of the TIGON project solutions.

6. Deliverable D6.6 (first draft): Following the main presentation scheme indicated in the proposal document, the first draft of the KPI assessment should be made at the end of M47.

7. Submission of deliverable D5.4 and D6.4.

An outline of the proposed monitoring plan is shown in the diagram below (Figure 5.1), with all steps and milestones considered as references that could be modified during the main workshop held at the beginning of WP5 and WP6.

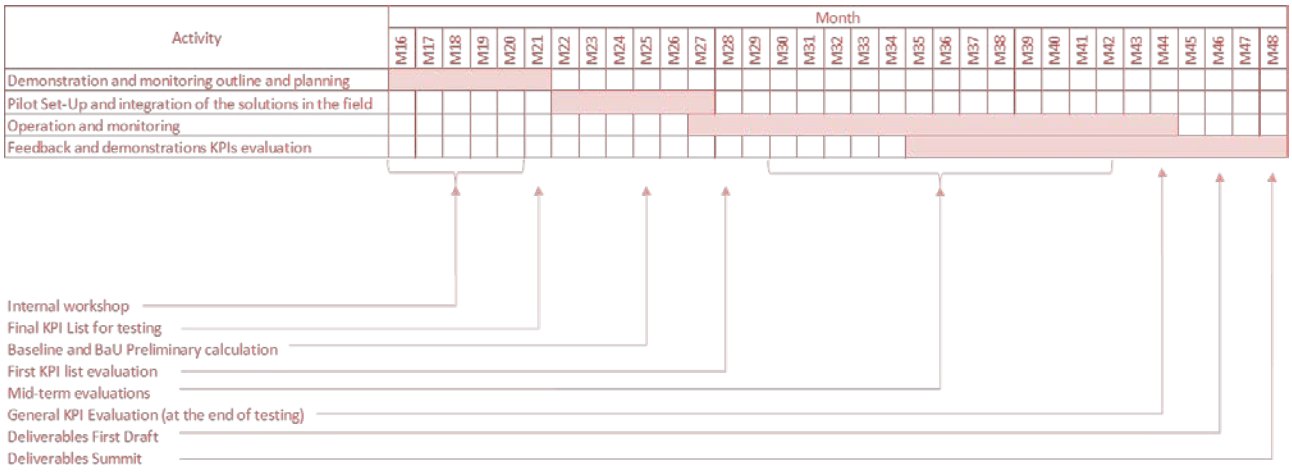

Figure 5.1. Monitoring plan: main scheme

6. Contingency plan

Due to the nature of the project, problems could arise in the calculation or application of the original list of key performance indicators. To address this situation, three alternatives are proposed depending on the level of difficulty encountered.

6.1. Auxiliary KPIs

Initially, only the base KPI will be calculated, but to address the need for a new performance indicator, there is the possibility to include an existing auxiliary KPI to the master list if required. The demonstration leader or solution provider can address this scenario during any stage of the deployment and test period by sending the request to the WP5 and WP6 leaders, pre-checking the availability of all inputs and the calculation procedure of the new KPI.

6.2. KPI Datasheet modification

Modification of an existing KPI (basic or auxiliary) is possible, this request comes from a demonstration coordinator or a use case supervisor. If the modification only affects the involved demonstration (the KPI is not used in another demonstration) the data sheet of the modified KPI can be updated to the final list (by increasing the version number), in case the KPI to be modified is also applied in another demonstration, the modified version is issued and it is indicated that it only affects to a particular demonstration the version number is changed and the suffix ES or FR is used according to the country concerned. For example, the modification of a datasheet with original version 0.2 for the Spanish demo gives as new version the 0.3ES, this code must be indicated in the section "G" of the datasheet.

The modification of the datasheet must be carried out by the applicant of the change, in which case she/he will check the availability of all data and the calculation process.

6.3. New KPI procedure

There is an option to create a new KPI, this option will be limited to only the supervisor of the use case, who must present the new KPI, the calculation method and required data (datasheet filled) to the leader of the demo for approval. After that it is included in the main list indicating in the comments section that it is a new KPI attachment.

It should be noted that creating a new KPI may require the assistance of work packages 3 or 4 depending on the type of KPI, the application should be requested before these packages are finalized (see monitoring plan in section 6), the general process for solving KPI calculation problems is shown in the next figure.

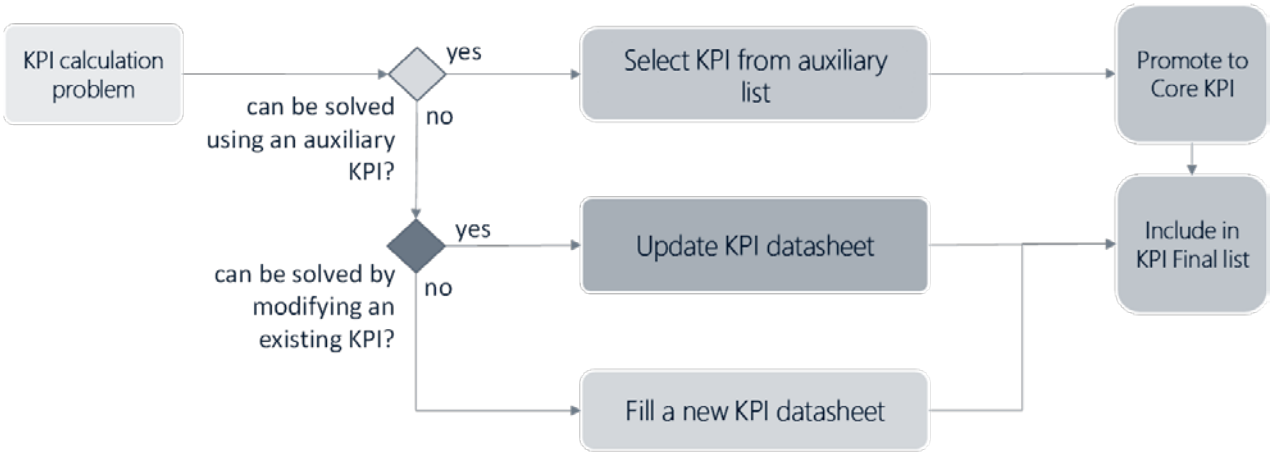

Figure 6.1. KPI troubleshooting procedure.

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IDE4L - IDEAL GRID FOR ALL - Deliverable D7.1: KPI Definition

Dionysios Pramangioulis et al. - A Methodology for Determination and Definition of Key Performance Indicators for Smart Grids Development in Island Energy Systems - Energies 2019

UPGRID – Report about KPI analysis and methods of comparison.

inteGRIDy - integrated Smart GRID Cross-Functional Solutions for Optimized Synergetic Energy Distribution, Utilization & Storage Technologies - inteGRIDy Global Evaluation Metrics and KPIs.

John Van Gorp - Using Key Performance Indicators (KPIs) to Manage Power System Reliability - Schneider Electric

Annex I: KPI Datasheet template

V 0.1

TIGON KPI DATASHEET

Basic Information			
Name:		**KPI ID:**	
Description:			
Units			

Location	
Demo site ***(Use Case)***	

Calculation	
Formula or Calculation procedure	

Scenarios to be measured / calculated	***Baseline*** ☐	***Business as usual*** ☐	***TIGON*** ☐

Calculation Methodology		
Nº	***Step description***	***Responsible***

Data sources / types							
Data	TAG	Methodology	Source/ Tools/ Instruments	Location of data collection	Frequency of data collection	Min. Monitoring period	Responsible

Baseline definition / BaU methodology			
Source	***Literature*** ☐ BL ( ) BaU( )	***Historical data*** ☐ BL ( ) BaU( )	***Measured at start*** ☐ BL ( ) BaU( )
Responsible			
Details			

Validation			
Environment	***Simulation*** ☐	***Laboratory*** ☐	***Data Field*** ☐
Responsible			
Details			

Other KPIs related

General comments

Annex II: KPI Datasheets (filled)

V 0.1

TIGON KPI DATASHEET

Basic Information			
Name:	Self-Consumption Rate (SCRt)	**KPI ID:**	SCRt
Description:	Is the ratio of consumed renewable energy over the sun of all renewable electricity generated on site.		
Units	[-]		

Location	
Demo site ***(Use Case)***	TBD in WP5 and WP6

Calculation

Formula or Calculation procedure

$$\mathrm{SCRt} = \frac{E_{C\_RE}}{E_{G\_RE\_tot}}$$

$$E_{C\_RE} = E_{G\_RE}\ ;\ E_{C\_tot} \geq E_{G\_RE}$$

$$E_{C\_RE} = E_{C\_tot}\ ;\ E_{C\_tot} < E_{G\_RE}$$

Where:
Ec_re: Is the on-site renewable electricity consumption [kWh]
Eg_re_tot: Total energy produced by RES locally
Ec_tot: Total electricity consumption locally [kWh]

Scenarios to be measured / calculated	***Baseline*** ☐	***Business as usual*** ☐	***TIGON*** ☐

Calculation Methodology

Nº	***Step description***	***Responsible***
SCRt_01	Define the electrical boundary of the demo site to perform the energy flow	TBD
SCRt_02	Obtain amount of generated energy locally (within the bounds)	TBD
SCRt_03	Obtain amount of consumed energy locally (within the bounds)	TBD
SCRt_04	Perform calculation of Ec_re	TBD
SCRt_05	Perform calculation of SCRt	TBD

Data sources / types

Data	TAG	Methodology	Source/ Tools/ Instruments	Location of data collection	Frequency of data collection	Min. Monitoring period	Responsible
Total energy	E_res	meters units	IEDs / Others	DSO registers	hourly	one year	TBD
Total energy	E_con	meters units	IEDs / Others	DSO registers	hourly	one year	TBD

Baseline definition / BaU methodology

Source	***Literature*** ☐ BL ( ) BaU( )	***Historical data*** ☐ BL ( ) BaU( )	***Measured at start*** ☐ BL ( ) BaU( )
Responsible			
Details			

Validation

Environment	***Simulation*** ☐	***Laboratory*** ☐	***Data Field*** ☐
Responsible			
Details			

Other KPIs related

General comments

V 0.1

TIGON KPI DATASHEET

Basic Information			
Name:	Energy Consumption	**KPI ID:**	EC
Description:	Total energy consumed in a period of time		
Units	[MWh]		

Location	
Demo site ***(Use Case)***	TBD in WP5 and WP6

Calculation

Formula or Calculation procedure

$$EC = \sum Ep_n$$

Where:
EC: Total Energy [MWh]
Eqn: Energy consumed in period n [MWh]

Scenarios to be measured / calculated	***Baseline*** ☐	***Business as usual*** ☐	***TIGON*** ☐

Calculation Methodology

Nº	***Step description***	***Responsible***
EC_01	Obtain energy consumption in all nodes involved	TBD
EC_02	Perform calculation of total energy according to the minimum monitoring period	TBD

Data sources / types

Data	TAG	Methodology	Source/ Tools/ Instruments	Location of data collection	Frequency of data collection	Min. Monitoring period	Responsible
Energy	Ep	Power meters	IEDs / Others	DSO power	monthly	one year	TBD

Baseline definition / BaU methodology

Source	***Literature*** ☐ BL ( ) BaU( )	***Historical data*** ☐ BL ( ) BaU( )	***Measured at start*** ☐ BL ( ) BaU( )
Responsible			
Details			

Validation

Environment	***Simulation*** ☐	***Laboratory*** ☐	***Data Field*** ☐
Responsible			
Details			

Other KPIs related

General comments

TIGON KPI DATASHEET

Basic Information			
Name:	Peak Load Reduction	**KPI ID:**	PLRed
Description:	This KPI shows the reduction in the maximum electricity demand. The KPI is actually the difference between the two peaks, the power peak with respect to the baseline and the power peak with respect to the Demand Response event with the TIGON solutions.		
Units	[%]		

Location	
Demo site ***(Use Case)***	TBD in WP5 and WP6

Calculation

Formula or Calculation procedure

$$\text{PLRed} = 100 \cdot \left(1 - \frac{PP_{R\&D}}{PP_{BL}}\right)$$

Where:
PP_BL: Peak load, evaluated during a Baseline scenario in a period [W]
PP_R&D: Peak load, evaluated using the TIGON solutions in a period [W]

Scenarios to be measured / calculated	***Baseline*** ☐	***Business as usual*** ☐	***TIGON*** ☐

Calculation Methodology

Nº	***Step description***	***Responsible***
PLRed_01	Define the electrical boundary of the demo site	TBD
PLRed_02	Obtain historical data of active power within the zone defined previously	TBD
PLRed_03	Obtain new data of active power within the zone defined previously after using the	TBD
PLRed_04	Perform calculation of PLRed	TBD

Data sources / types

Data	TAG	Methodology	Source/ Tools/ Instruments	Location of data collection	Frequency of data collection	Min. Monitoring period	Responsible
Active power	P	meters units	IEDs / Others	DSO power	daily	one year	TBD

Baseline definition / BaU methodology

Source	***Literature*** ☐ BL ( ) BaU( )	***Historical data*** ☐ BL ( ) BaU( )	***Measured at start*** ☐ BL ( ) BaU( )
Responsible			
Details			

Validation

Environment	***Simulation*** ☐	***Laboratory*** ☐	***Data Field*** ☐
Responsible			
Details			

Other KPIs related

General comments

V 0.1

TIGON KPI DATASHEET

Basic Information			
Name:	Average estimation of savings per stakeholder	**KPI ID:**	AeS
Description:	Total savings from avoided energy consumption or purchase (depending on stakeholder concerned) over the sum of that avoided energy.		
Units	[€]		

Location	
Demo site ***(Use Case)***	TBD in WP5 and WP6

Calculation

Formula or Calculation procedure	$\mathrm{AeS} = \frac{\sum S_n}{n}$ $\quad\quad \%\mathrm{AeS} = 100\,\frac{AeS\_fg}{AeS\_BaU}$ (*) Where: AeS: Average estimation of savings [€] S_n: Savings in cathegory n [€] n: Total number of categories for savings [-] AeS_fg: Average estimations savings in TIGON scenario [€] AeS_Bau: Average estimations savings in BaU scenario [€] (*) Complementary formula

Scenarios to be measured / calculated	***Baseline*** ☐	***Business as usual*** ☐	***TIGON*** ☐

Calculation Methodology

Nº	***Step description***	***Responsible***
AeS_01	Determine all categories to be included in savings	TBD
AeS_02	Define a BaU scenario for each category in AeS_01	TBD
AeS_03	Define a TIGON scenario for each category in AeS_01	TBD
AeS_04	Perform calculation for BaU and TIGON scenarios (savings)	TBD
AeS_05	Define a TIGON scenario for each category in AeS_01	TBD

Data sources / types

Data	TAG	Methodology	Source/ Tools/ Instruments	Location of data collection	Frequency of data collection	Min. Monitoring period	Responsible

Baseline definition / BaU methodology

Source	***Literature*** ☐ BL ( ) BaU( )	***Historical data*** ☐ BL ( ) BaU( )	***Measured at start*** ☐ BL ( ) BaU( )
Responsible			
Details			

Validation

Environment	***Simulation*** ☐	***Laboratory*** ☐	***Data Field*** ☐
Responsible			
Details			

Other KPIs related

General comments

V 0.1

TIGON KPI DATASHEET

Basic Information			
Name:	Generation Available Flexibility	**KPI ID:**	GAF
Description:	The amount of generation that can be shifted temporally		
Units	[MW]		

Location	
Demo site ***(Use Case)***	TBD in WP5 and WP6

Calculation

Formula or Calculation procedure

$$GAF = \sum Gf_n$$

Where:
GAF: [MW]
Gf_n: Amount of generation that can be shifted in node n [MW]

Scenarios to be measured / calculated	***Baseline***	***Business as usual***	***TIGON***
	☐	☐	☐

Calculation Methodology

Nº	***Step description***	***Responsible***
GAF_01	Power grid assets characteristics (lines, transformers, generatos, etc.) #GD	TBD
GAF_02	Modeling power grid for LPF using #GD	TBD
GAF_03	Determine generation available to be shifted in a baseline scenario in node (Gf_n)	TBD
GAF_04	Determine generation available to be shifted in a TIGON scenario in node (Gf_n)	TBD

Data sources / types

Data	TAG	Methodology	Source/ Tools/ Instruments	Location of data collection	Frequency of data collection	Min. Monitoring period	Responsible
Grid data	#GD	Power grid	DSO registers	DSO registers	once	-	TBD

Baseline definition / BaU methodology

Source	***Literature***	***Historical data***	***Measured at start***
	☐ BL ( ) BaU( )	☐ BL ( ) BaU( )	☐ BL ( ) BaU( )
Responsible			
Details			

Validation

Environment	***Simulation***	***Laboratory***	***Data Field***
	☐	☐	☐
Responsible			
Details			

Other KPIs related

General comments

V 0.1

TIGON KPI DATASHEET

Basic Information			
Name:	Reverse Power Flow	**KPI ID:**	RPF
Description:	Power/energy flow from distribution feeder/system upward due to excess of RES power generation		
Units	[kWh/year]		

Location	
Demo site *(Use Case)*	TBD in WP5 and WP6

Calculation

Formula or Calculation procedure	$RPF = \frac{\sum R_{POW}}{year}$ *Where:* RPF: Total reverse power flow [kWh/year] R_pow: reverse power energy [kWh]

Scenarios to be measured / calculated	***Baseline*** ☐	***Business as usual*** ☐	***TIGON*** ☐

Calculation Methodology

Nº	***Step description***	***Responsible***
RPF_01	Modeling of power grid, including inertial components of generation and load	TBD
RPF_02	Define scenarios to evaluate (different load and generations schemes)	TBD
RPF_03	Perform calculation of Load flow for the baseline scenarios / nodes	TBD
RPF_04	Determine R_pow for the baseline scenarios / nodes	TBD
RPF_05	Perform calculation of Load flow for the TIGON scenarios / nodes	TBD
RPF_06	Determine R_pow for the TIGON scenarios / nodes	TBD

Data sources / types

Data	TAG	Methodology	Source/ Tools/ Instruments	Location of data collection	Frequency of data collection	Min. Monitoring period	Responsible
Power grid data	PG_dat	data collection	DSO DB /	DSO DB /	once	--	TBD
Reverse power	R_pow	Simulated	LPF simulator	LPF software	once	--	TBD

Baseline definition / BaU methodology

Source	***Literature*** ☐ BL ( ) BaU( )	***Historical data*** ☐ BL ( ) BaU( )	***Measured at start*** ☐ BL ( ) BaU( )
Responsible			
Details			

Validation

Environment	***Simulation*** ☐	***Laboratory*** ☐	***Data Field*** ☐
Responsible			
Details			

Other KPIs related

General comments

V 0.1

TIGON KPI DATASHEET

Basic Information			
Name:	Customer Average Interruption Duration Index	**KPI ID:**	CAIDI
Description:	The Customer Average Interruption Duration Index (CAIDI) represents the average time required to restore service.		
Units	[minutes]		

Location	
Demo site ***(Use Case)***	TBD in WP5 and WP6

Calculation

Formula or Calculation procedure

$$CAIDI = \frac{\sum r_i N_i}{\sum N_i} = \frac{SAIDI}{SAIFI} \qquad r_i = SI_{st} - SI_{en}$$

Where:
ri : Restoration time for each interruption event [minutes]
Ni : Number of interrupted customers for each sustained interruption event during the reporting period [integer]

Scenarios to be measured / calculated	***Baseline*** ☐	***Business as usual*** ☐	***TIGON*** ☐

Calculation Methodology

Nº	***Step description***	***Responsible***
CAIDI_01	Detect number and duration of interruptions	TBD
CAIDI_02	Detect or estimate the number of affected customers	TBD
CAIDI_03	Calculate CAIDI in TIGON scenario	TBD
CAIDI_04	Compare to baseline scenario	TBD

Data sources / types

Data	TAG	Methodology	Source/ Tools/ Instruments	Location of data collection	Frequency of data collection	Min. Monitoring period	Responsible
Service interruption	SI_st	Sequence of	Various	DSO, SCADA	once at the	one year	TBD
Restoration	SI_en	Sequence of	Various	DSO, SCADA	once at the	one year	TBD
Number of	Ni	Adding the	Various	DSO,	once at the	one year	TBD

Baseline definition / BaU methodology

Source	***Literature*** ☐ BL ( ) BaU( )	***Historical data*** ☐ BL ( ) BaU( )	***Measured at start*** ☐ BL ( ) BaU( )
Responsible			
Details			

Validation

Environment	***Simulation*** ☐	***Laboratory*** ☐	***Data Field*** ☐
Responsible			
Details			

Other KPIs related

General comments

V 0.1

TIGON KPI DATASHEET

Basic Information			
Name:	CO2 tonnes saved	**KPI ID:**	CO2Sv
Description:	Amount of CO2 reduction due to substitution of fossil power generation by additional RES units inside the distribution network under analysis (Using TIGON solution)		
Units	[%]		

Location	
Demo site ***(Use Case)***	TBD in WP5 and WP6

Calculation

Formula or Calculation procedure	$$CO2Sv = 100 \cdot \left(\frac{CO2_{FG} - CO2_{BL}}{CO2_{BL}} \right)$$ Where: CO2Sv: Reduction in CO2 emissions [%] CO2_FG: Total CO2 emissions under TIGON scenario[kg]* CO2_BL: Total CO2 emissions under Baseline scenario[kg] *Calculate emissions according to available data in each demo site using (A),(B), (C) or (D)

Scenarios to be measured / calculated	***Baseline***	***Business as usual***	***TIGON***
	☐	☐	☐

Calculation Methodology

Nº	***Step description***	***Responsible***
CO2Sv_01	Result from demand shifting (A)	TBD
CO2Sv_02	Equivalent coefficient of CO2 emissions (B)	TBD
CO2Sv_03	Result from the reduction of technical losses (C)	TBD
CO2Sv_04	Result from the incorporation of RES due increase of hosting capacity (D)	TBD

Data sources / types

Data	TAG	Methodology	Source/ Tools/ Instruments	Location of data collection	Frequency of data collection	Min. Monitoring period	Responsible
Reduction of CO2	CO2Sv_01	Calculation	KPI calculation		TBD	TBD	TBD
Equivalent	CO2Sv_02	Public Values	Public Values	Public Values	TBD	TBD	TBD
Reduction of CO2	CO2Sv_03	Calculation of	KPI calculation		TBD	TBD	TBD
Reduction of CO2	CO2Sv_04	Calculation of	KPI calculation		TBD	TBD	TBD

Baseline definition / BaU methodology

Source	***Literature***	***Historical data***	***Measured at start***
	☐ BL ( ) BaU( )	☐ BL ( ) BaU( )	☐ BL ( ) BaU( )
Responsible			
Details			

Validation

Environment	***Simulation***	***Laboratory***	***Data Field***
	☐	☐	☐
Responsible			
Details			

Other KPIs related

General comments

V 0.1

TIGON KPI DATASHEET

Basic Information			
Name:	Number of grid events	**KPI ID:**	NGE
Description:	Number of events that change the network, as lines aperture, tripping of protection in substations, OLTC operation.		
Units	[-]		

Location	
Demo site ***(Use Case)***	TBD in WP5 and WP6

Calculation

Formula or Calculation procedure

$$NGE = \sum GE_n$$

Where:
NGE: Total number of grid events [-]
GE_n: Grid event number n [-]

Scenarios to be measured / calculated	***Baseline*** ☐	***Business as usual*** ☐	***TIGON*** ☐

Calculation Methodology

Nº	***Step description***	***Responsible***
NGE_01	Obtain event registers from DB, SCADA, SoE	TBD

Data sources / types

Data	TAG	Methodology	Source/ Tools/ Instruments	Location of data collection	Frequency of data collection	Min. Monitoring period	Responsible
Registered event	NGE_01	IED extraction	IEDs / Others	DSO SCADA DB	monthly	one year	TBD

Baseline definition / BaU methodology

Source	***Literature*** ☐ BL ( ) BaU( )	***Historical data*** ☐ BL ( ) BaU( )	***Measured at start*** ☐ BL ( ) BaU( )
Responsible			
Details			

Validation

Environment	***Simulation*** ☐	***Laboratory*** ☐	***Data Field*** ☐
Responsible			
Details			

Other KPIs related

General comments

V 0.1

TIGON KPI DATASHEET

Basic Information			
Name:	System Average interruption Duration Index	**KPI ID:**	SAIDI
Description:	Is the average duration of all interruptions per utility customer during the period of analysis. Here, the total customer minutes of interruption are added together and divided by the total number of customers in the system.		
Units	[min]		

Location	
Demo site ***(Use Case)***	TBD in WP5 and WP6

Calculation

Formula or Calculation procedure

$$SAIDI = \frac{\sum r_i N_i}{N_T} \qquad r_i = SI_{st} - SI_{en}$$

Where:
ri : Restoration time for each interruption event [minutes]
NT : Total number of customers served for the area [integer]
Ni : Number of interrupted customers for each sustained interruption event during the reporting period [integer]

Scenarios to be measured / calculated	***Baseline***	***Business as usual***	***TIGON***
	☐	☐	☐

Calculation Methodology

Nº	***Step description***	***Responsible***
SAIDI_01	Detect number and duration of interruptions	TBD
SAIDI_02	Detect or estimate the number of affected customers	TBD
SAIDI_03	Calculate SAIDI in TIGON scenario	TBD
SAIDI_04	Compare to baseline scenario	TBD

Data sources / types

Data	TAG	Methodology	Source/ Tools/ Instruments	Location of data collection	Frequency of data collection	Min. Monitoring period	Responsible
Service interruption	SI_st	Sequence of	Various	DSO, SCADA	once at the	one year	TBD
Restoration	SI_en	Sequence of	Various	DSO, SCADA	once at the	one year	TBD
Number of	Ni	Adding the	Various	DSO,	once at the	one year	TBD

Baseline definition / BaU methodology

Source	***Literature***	***Historical data***	***Measured at start***
	☐ BL ( ) BaU( )	☐ BL ( ) BaU( )	☐ BL ( ) BaU( )
Responsible			
Details			

Validation

Environment	***Simulation***	***Laboratory***	***Data Field***
	☐	☐	☐
Responsible			
Details			

Other KPIs related

General comments

V 0.1

TIGON KPI DATASHEET

Basic Information			
Name:	Line overload occurence	**KPI ID:**	LOO
Description:	Number of line overloading events up to 15 minutes within a year		
Units	[integer]		

Location	
Demo site ***(Use Case)***	TBD in WP5 and WP6

Calculation

Formula or Calculation procedure

$$LOO = \sum LOE_n$$

Where:
LOO: Total lines overload events in a period [-]
LOE_n: event of line overload n [-]

Scenarios to be measured / calculated	***Baseline***	***Business as usual***	***TIGON***
	☐	☐	☐

Calculation Methodology

Nº	***Step description***	***Responsible***
LOO_01	Define lines to be monitored	TBD
LOO_02	Obtain lines characteristics (type of conductor, suport geometry, geographical	TBD
LOO_03	Perform calculation of thermal limits for each line to define nominal current	TBD
LOO_04	Obtain currents values for each section of line to be monitored	TBD
LOO_05	Determine number of overloads line events	TBD

Data sources / types

Data	TAG	Methodology	Source/ Tools/ Instruments	Location of data collection	Frequency of data collection	Min. Monitoring period	Responsible
Line	e_for	Power meters	IEDs / Others	DSO SoE	daily	one year	TBD

Baseline definition / BaU methodology

Source	***Literature***	***Historical data***	***Measured at start***
	☐ BL ( ) BaU( )	☐ BL ( ) BaU( )	☐ BL ( ) BaU( )
Responsible			
Details			

Validation

Environment	***Simulation***	***Laboratory***	***Data Field***
	☐	☐	☐
Responsible			
Details			

Other KPIs related

General comments

V 0.1

TIGON KPI DATASHEET

Basic Information			
Name:	Grid investment deferral	**KPI ID:**	GID
Description:	Savings (avoided costs) by employing new proposed solutions vs traditional (e.g. line reinforcement)		
Units	[€]		

Location	
Demo site ***(Use Case)***	TBD in WP5 and WP6

Calculation

Formula or Calculation procedure

$$GID = \sum Sc_n$$

Where:
GID: Total grid investment deferral [€]
Sc_n: Amount of investment deferral by node/cathegory/element "n" in the grid [€]

Scenarios to be measured / calculated	***Baseline*** ☐	***Business as usual*** ☐	***TIGON*** ☐

Calculation Methodology

Nº	***Step description***	***Responsible***
GID_01	Get all demo site asset characteristics	TBD
GID_02	Model the power grid to perform OPF simulations	TBD
GID_03	Perform an OPF for a BaU scenario to identify possible reinforcements	TBD
GID_04	Perform an OPF for a TIGON to discard reinforcements estimated in GID_03	TBD
GID_05	Determine investments required by GID_04 and GID_03 to define SCn	TBD

Data sources / types

Data	TAG	Methodology	Source/ Tools/ Instruments	Location of data collection	Frequency of data collection	Min. Monitoring period	Responsible
Demo assets characteristics	GID_01	Nominal values / specifications	Datasheets / Registers	DSO DB	once	--	TBD

Baseline definition / BaU methodology

Source	***Literature*** ☐ BL ( ) BaU( )	***Historical data*** ☐ BL ( ) BaU( )	***Measured at start*** ☐ BL ( ) BaU( )
Responsible			
Details			

Validation

Environment	***Simulation*** ☐	***Laboratory*** ☐	***Data Field*** ☐
Responsible			
Details			

Other KPIs related

General comments

V 0.1

TIGON KPI DATASHEET

Basic Information			
Name:	Load curve valley filling	**KPI ID:**	VF
Description:	It is defined as the ability to shift load to valley hours, by means of the direct control of assets or by tariff strategy.		
Units	[%]		

Location	
Demo site ***(Use Case)***	TBD in WP5 and WP6

Calculation	
Formula or Calculation procedure	$$VF = 100 \cdot \left\lvert \frac{V_{BL} - V_{FG}}{V_{BL}} \right\rvert$$ Where: VF: Load valley filling [%] V_BL: Total demand in valley with baseline scenario [MW] V_FG: Total demand in valley with TIGON scenario [MW]

Scenarios to be measured / calculated	***Baseline*** ☐	***Business as usual*** ☐	***TIGON*** ☐

Calculation Methodology		
Nº	***Step description***	***Responsible***
VF_01*	Obtain load curve from demo site #LC (by node) for baseline a TIGON scenarios	TBD
VF_02	Perform calculation of minimun of demand (valley) for baseline a TIGON scenarios V_BS and V_FG	TBD
VF_03	Perform calculation of VF	TBD

Data sources / types

Data	TAG	Methodology	Source/ Tools/ Instruments	Location of data collection	Frequency of data collection	Min. Monitoring period	Responsible
Demand	#LC	Power meters	IEDs / Others	DSO power	TBD	TBD	TBD

Baseline definition / BaU methodology

Source	***Literature*** ☐ BL ( ) BaU( )	***Historical data*** ☐ BL ( ) BaU( )	***Measured at start*** ☐ BL ( ) BaU( )
Responsible			
Details			

Validation

Environment	***Simulation*** ☐	***Laboratory*** ☐	***Data Field*** ☐
Responsible			
Details			

Other KPIs related

General comments

V 0.1

TIGON KPI DATASHEET

Basic Information

Name:	Voltage Unbalance Factor	KPI ID:	VUF
Description:	Voltage unbalance is defined as the ratio of the negative sequence voltage component to the positive sequence voltage component		
Units	[%]		

Location

Demo site *(Use Case)*	TBD in WP5 and WP6

Calculation

Formula or Calculation procedure

$$VUF = 100 \cdot \left(\frac{V_{Neg}}{V_{Pos}}\right)$$

$$V_{Neg} = \frac{V_{ab} + a^2 V_{bc} + a V_{ca}}{3}$$

$$V_{Pos} = \frac{V_{ab} + a V_{bc} + a^2 V_{ca}}{3}$$

$$a = 1(120°)$$

Where:
VUF: voltage unbalance factor in sample k
V_neg: Negative sequence voltage component [V]
V_pos: Positive sequence voltage component [V]
Vab,Vbc,Vca: Line to line voltage magnitude [V]

Scenarios to be measured / calculated	*Baseline* ☐	*Business as usual* ☐	*TIGON* ☐

Calculation Methodology

Nº	*Step description*	*Responsible*
VUF_01	Obtain voltage samples in nodes to be monitored	TBD
VUF_02	Calculate positive and negative component for each node / sample	TBD
VUF_03	Calculate VUF for each node / sample	TBD
VUF_04	Calculate average VUF for voltage node in min. monitoring period	TBD

Data sources / types

Data	TAG	Methodology	Source/ Tools/ Instruments	Location of data collection	Frequency of data collection	Min. Monitoring period	Responsible
Voltage fasor	Vabc	Power meters	IEDs / Others	DSO power	TBD	one month	TBD

Baseline definition / BaU methodology

Source	*Literature* ☐ BL ( ) BaU( )	*Historical data* ☐ BL ( ) BaU( )	*Measured at start* ☐ BL ( ) BaU( )

Responsible	
Details	

Validation

Environment	*Simulation* ☐	*Laboratory* ☐	*Data Field* ☐

Responsible	
Details	

Other KPIs related

General comments

V 0.1

TIGON KPI DATASHEET

Basic Information			
Name:	Demand Flexibility Potential	**KPI ID:**	DFP
Description:	The amount of potential Demand Flexibility reflects the amount of energy consumption reduction participating Customers (i.e. End Users) could potentially accept and apply		
Units	[MW]		

Location	
Demo site ***(Use Case)***	TBD in WP5 and WP6

Calculation

Formula or Calculation procedure

$$DAP = \sum Df_n$$

Where:
DFP: Demand available for flexibility [MW]
Df_n: Amount of load that can be shifted in node n [MW]

Scenarios to be measured / calculated	***Baseline*** ☐	***Business as usual*** ☐	***TIGON*** ☐

Calculation Methodology

Nº	***Step description***	***Responsible***
GAF_01	Power grid assets characteristics (lines, transformers, generatos, etc.) #GD	TBD
GAF_02	Modeling power grid for LPF using #GD	TBD
GAF_03	Determine potencial load available to be shifted in a baseline scenario in node	TBD

Data sources / types

Data	TAG	Methodology	Source/ Tools/ Instruments	Location of data collection	Frequency of data collection	Min. Monitoring period	Responsible
Grid data	#GD	Power grid	DSO registers	DSO registers	once	-	TBD

Baseline definition / BaU methodology

Source	***Literature*** ☐ BL ( ) BaU( )	***Historical data*** ☐ BL ( ) BaU( )	***Measured at start*** ☐ BL ( ) BaU( )
Responsible			
Details			

Validation

Environment	***Simulation*** ☐	***Laboratory*** ☐	***Data Field*** ☐
Responsible			
Details			

Other KPIs related

General comments

V 0.1

TIGON KPI DATASHEET

Basic Information			
Name:	DR Delivery Deviation	**KPI ID:**	DRDD
Description:	The difference between the DR requested to be delivered by the Customer and the DR that the Customer actually delivered		
Units	[kWh]		

Location	
Demo site ***(Use Case)***	TBD in WP5 and WP6

Calculation	
Formula or Calculation procedure	$\mathrm{DRDD}_i = ADFD_i - DFR_i$ Where: $ADFD_t$: Actual Demand Flexibility Delivered by the Customer [kWh] in demand flexibility event at time t DFR_t: Demand Flexibility Requested to be delivered by the Customer [kWh] in demand flexibility event at time t The calculation of $ADFD_t$ and DFR_t can be carried out using the following process: The following times series are assumed to be available for the calculation (per asset / customer premise): $\hat{P}_t$: The forecasted baseline power (blue line), which is the forecast of the load given no activation is requested $\hat{P}_t^{min}$: The forecasted minimum power (orange line) that can be applied for providing downwards flexibility (reduced load) $\hat{P}_t^{max}$: The forecasted maximum power (yellow line) that can be applied for providing upwards flexibility (increased load) These time series represent the flexibility which was "promised" for a specific time period and afterwards in the evaluation period they are the reference power which the actual measured power must be compared against, in order to measure how much flexibility was actually delivered by Customers. The requested flexibility should be between the limits of the promised flexibility. None, all or part of it should be available for delivery (when requested). Let's assume that a_t=[0,1] is the signal that represents the requested flexibility (ranging from 0 indicating no activation to 1 indicating full activation). In what follows, we consider the case that the signal refers to decreased consumption (i.e. request to provide downwards flexibility). A similar approach should be followed for requests to provide upwards flexibility (i.e. increased consumption). The requested load reduction (downwards flexibility) (i.e. the DFR_t) is: $P_t^{(down,req)}=a_t\cdot(\hat{P}_t-\hat{P}_t^{min})$, while the delivered downwards flexibility at time t (i.e. the $ADFD_t$) is: $P_t^{(down,del)}=a_t\cdot(\hat{P}_t-\max(P_t,\hat{P}_t^{min}))$ From the above equations, it is evident that: If $P_t>\hat{P}_t^{min}$, the promised but not delivered flexibility at time t is equal to $a_t\cdot(P_t-\hat{P}_t^{min})$ If $P_t=\hat{P}_t^{min}$, the flexibility requested is equal to the one delivered at time t If $P_t<\hat{P}_t^{min}$, the flexibility delivered is greater than the one requested at time t. The additional flexibility delivered is equal to $a_t\cdot(\hat{P}_t^{min}-P_t)$.

Scenarios to be measured / calculated	***Baseline*** ☐	***Business as usual*** ☐	***TIGON*** ☐

Calculation Methodology		
Nº	***Step description***	***Responsible***
DRDD_01	Calculate the Demand Response requested as the difference between the	TBD
DRDD_02	Calculate the actual delivered Demand Response using the relevant formula	TBD
DRDD_03	The difference between DRDD_01 and DRDD_02 gives the DR Delivery Deviation	TBD

Data sources / types

Data	TAG	Methodology	Source/ Tools/ Instruments	Location of data collection	Frequency of data collection	Min. Monitoring period	Responsible
Forecasted	#FBP	Historical data	Local meter	Customer	Every minute	Day	TBD
Forecasted	#FMIP	Thermal	Sensors	Participating	Every minute	Day	TBD
Forecasted	#FMAP	Thermal	Sensors	Participating	Every minute	Day	TBD
Actual power	#APC	Measurement	Local meter	Customer	Every minute	Day	TBD

Baseline definition / BaU methodology			
Source	***Literature*** ☐ BL ( ) BaU( )	***Historical data*** ☐ BL ( ) BaU( )	***Measured at start*** ☐ BL ( ) BaU( )
Responsible			
Details			

Validation			
Environment	***Simulation*** ☐	***Laboratory*** ☐	***Data Field*** ☐
Responsible			
Details			

Other KPIs related

General comments

V 0.1

TIGON KPI DATASHEET

Basic Information			
Name:	Energy not supplied	**KPI ID:**	ENS
Description:	The amount of energy that normally would be delivered, but now is not because of an outage		
Units	[MWh]		

Location	
Demo site ***(Use Case)***	TBD in WP5 and WP6

Calculation	
Formula or Calculation procedure	$$ENS = \sum (P_i \times D_i)$$ *Where:* *Pi: Power interrupted for interruption "i" [MW]* *Di: Duration of interruption "i" [H]*

Scenarios to be measured / calculated	***Baseline*** ☐	***Business as usual*** ☐	***TIGON*** ☐

Calculation Methodology

Nº	***Step description***	***Responsible***
ENS_01	Detect number and duration of interruptions	TBD
ENS_02	Determine or estimate the number of MW interrupted	TBD
ENS_03	Perform calculation of ENS	TBD
ENS_04	Compare to baseline scenario	TBD

Data sources / types

Data	TAG	Methodology	Source/ Tools/ Instruments	Location of data collection	Frequency of data collection	Min. Monitoring period	Responsible
Service	SI_st	Sequence of	Various	DSO, SCADA	monthly	one year	TBD
Restoration	SI_en	Sequence of	Various	DSO, SCADA	monthly	one year	TBD
Power interrupted	Pi	Define power	GIS / IED /	DSO, SCADA	monthly	one year	TBD

Baseline definition / BaU methodology

Source	***Literature*** ☐ BL ( ) BaU( )	***Historical data*** ☐ BL ( ) BaU( )	***Measured at start*** ☐ BL ( ) BaU( )
Responsible			
Details			

Validation

Environment	***Simulation*** ☐	***Laboratory*** ☐	***Data Field*** ☐
Responsible			
Details			

Other KPIs related

General comments

V 0.1

TIGON KPI DATASHEET

Basic Information			
Name:	System Average Interruption Frequency Index	**KPI ID:**	SAIFI
Description:	The System Average Interruption Frequency Index (SAIFI) indicates how often the average customer experiences a sustained interruption over a predefined period of time.		
Units	[%]		

Location	
Demo site ***(Use Case)***	TBD in WP5 and WP6

Calculation	
Formula or Calculation procedure	$SAIFI = \frac{\sum N_i}{\sum N_T}$ *Where:* *Ni* : Number of interrupted customers for each sustained interruption event during the reporting period [integer] NT: Total number of customers served for the area [integer]

Scenarios to be measured / calculated	***Baseline*** ☐	***Business as usual*** ☐	***TIGON*** ☐

Calculation Methodology		
Nº	***Step description***	***Responsible***
SAIFI_01	Detect or estimate the number of affected customers	TBD
SAIFI_02	Calculate SAIFI on TIGON scenario	TBD
SAIFI_03	Compare to baseline scenario	TBD

Data sources / types

Data	TAG	Methodology	Source/ Tools/ Instruments	Location of data collection	Frequency of data collection	Min. Monitoring period	Responsible
Service interruption event timestamp	SI_st	Sequence of events logging	Various	DSO, SCADA DB or SoE	once at the end of the monitoring period	one year	TBD
Restoration command timestamp	SI_en	Sequence of events logging	Various	DSO, SCADA DB or SoE	once at the end of the monitoring period	one year	TBD
Number of interrupted customers	Ni	Adding the number of customers in the affected areas	Various	DSO, Costumers DB	once at the end of the monitoring period	one year	TBD

Baseline definition / BaU methodology			
Source	***Literature*** ☐ BL ( ) BaU( )	***Historical data*** ☐ BL ( ) BaU( )	***Measured at start*** ☐ BL ( ) BaU( )
Responsible			
Details			

Validation			
Environment	***Simulation*** ☐	***Laboratory*** ☐	***Data Field*** ☐
Responsible			
Details			

Other KPIs related

General comments

V 0.1

TIGON KPI DATASHEET

Basic Information			
Name:	Demand Available Flexibility	**KPI ID:**	GAF
Description:	The amount of load that can be shifted temporally. Needs specification dependent on the method used to provide an incentive (RTP, remote operation of customer assets or other options)		
Units	[MW]		

Location	
Demo site ***(Use Case)***	TBD in WP5 and WP6

Calculation	
Formula or Calculation procedure	$$DAF = \sum Df_n$$ *Where:* DAF: Demand Available for Flexibility [MW] Df_n: Amount of load that can be shifted in node n [MW]

Scenarios to be measured / calculated	***Baseline*** ☐	***Business as usual*** ☐	***TIGON*** ☐

Calculation Methodology		
Nº	***Step description***	***Responsible***
GAF_01	Power grid assets characteristics (lines, transformers, generatos, etc.) #GD	TBD
GAF_02	Modeling power grid for LPF using #GD	TBD
GAF_03	Determine load available to be shifted in a baseline scenario in node (Gf_n)	TBD
GAF_04	Determine load available to be shifted in a TIGON scenario in node (Gf_n)	TBD

Data sources / types

Data	TAG	Methodology	Source/ Tools/ Instruments	Location of data collection	Frequency of data collection	Min. Monitoring period	Responsible
Grid data	#GD	Power grid	DSO registers	DSO registers	once	-	TBD

Baseline definition / BaU methodology

Source	***Literature*** ☐ BL ( ) BaU( )	***Historical data*** ☐ BL ( ) BaU( )	***Measured at start*** ☐ BL ( ) BaU( )
Responsible			
Details			

Validation

Environment	***Simulation*** ☐	***Laboratory*** ☐	***Data Field*** ☐
Responsible			
Details			

Other KPIs related

General comments

V 0.1

TIGON KPI DATASHEET

Basic Information			
Name:	Increased EV Hosting capacity	**KPI ID:**	EVHC
Description:	The additional EV capacity that can be accommodated on the distribution network after the deployment of the TIGON solution, compared to the EV capacity that can be accommodated on the distribution network without it.		
Units	[%]		

Location	
Demo site ***(Use Case)***	TBD in WP5 and WP6

Calculation

Formula or Calculation procedure	$$EVHC = 100 \cdot \left(\frac{HC_{FG} - HC_{BL}}{HC_{BL}} \right)$$ *Where:* *EVHC: Is the enhanced hosting capacity of EV when TIGON solutions are applied [%]* *HC_FG: Is the additional hosting capacity of EV when TIGON solutions are applied with respect to currently connected generation [MW]* *HC_BL: Is the hosting capacity of EV in baseline scenario with respect to currently connected generation [MW]*

Scenarios to be measured / calculated	***Baseline*** ☐	***Business as usual*** ☐	***TIGON*** ☐

Calculation Methodology

Nº	***Step description***	***Responsible***
EVHC_01	Get all demo site asset characteristics	TBD
EVHC_02	Model the power grid to perform OPF simulations	TBD
EVHC_03	Perform an OPF for a baseline scenario to obtain the capacity of the grid	TBD
EVHC_04	Perform an OPF for a TIGON scenario to obtain the capacity of the grid	TBD
EVHC_05	Perform calculation of EVHC	TBD

Data sources / types

Data	TAG	Methodology	Source/ Tools/ Instruments	Location of data collection	Frequency of data collection	Min. Monitoring period	Responsible
Demo assets characteristics	EVHC_01	Nominal values / specifications	Datasheets / Registers	DSO DB	ones	--	TBD
Hosting capacity	HC_FG/ HC_BL	OPF Simulation	OPF Simulator	DB	--	--	TBD

Baseline definition / BaU methodology

Source	***Literature*** ☐ BL ( ) BaU( )	***Historical data*** ☐ BL ( ) BaU( )	***Measured at start*** ☐ BL ( ) BaU( )
Responsible			
Details			

Validation

Environment	***Simulation*** ☐	***Laboratory*** ☐	***Data Field*** ☐
Responsible			
Details			

Other KPIs related

General comments

V 0.1

TIGON KPI DATASHEET

Basic Information			
Name:	Number of Voltage Limits Violations	**KPI ID:**	VLV
Description:	Number of times than voltage in a node exceeds (under or over) the tolerance limit (usually 5%) for more than 2 seconds in a period of time.		
Units	[integer]/[time]		

Location	
Demo site ***(Use Case)***	TBD in WP5 and WP6

Calculation

Formula or Calculation procedure

$$VLV = \sum e_{vlv}$$

Where:
VLV: Total number of voltage limits violations in a period [-]
e_vlv: event of voltage limit violation [-]

Scenarios to be measured / calculated	***Baseline*** ☐	***Business as usual*** ☐	***TIGON*** ☐

Calculation Methodology

Nº	***Step description***	***Responsible***
VLV_01	Obtain all voltage limits violations from the baseline scenario	TBD
VLV_02	Calculate VLV to the baseline scenario	TBD
VLV_03	Obtain all voltage limits violations from the FLEXIFRID (R&D) scenario	TBD
VLV_04	Calculate VLV for the TIGON scenario (simulated or field data)	TBD
VLV_05	Compare to baseline scenario	TBD

Data sources / types

Data	TAG	Methodology	Source/ Tools/ Instruments	Location of data collection	Frequency of data collection	Min. Monitoring period	Responsible
Voltage limit violation event	VLVe	Power meters units lecture	IEDs / Others	DSO SoE register	daily	one year	TBD

Baseline definition / BaU methodology

Source	***Literature*** ☐ BL ( ) BaU( )	***Historical data*** ☐ BL ( ) BaU( )	***Measured at start*** ☐ BL ( ) BaU( )
Responsible			
Details			

Validation

Environment	***Simulation*** ☐	***Laboratory*** ☐	***Data Field*** ☐
Responsible			
Details			

Other KPIs related

General comments

V 0.1

TIGON KPI DATASHEET

Basic Information			
Name:	Reduction in Energy Losses	**KPI ID:**	REL
Description:	Amount of electrical energy lost on grid's conductors, transformers, etc.		
Units	[%]		

Location	
Demo site ***(Use Case)***	TBD in WP5 and WP6

Calculation

Formula or Calculation procedure	$$REL = 100 \cdot \left(\frac{\sum EL_{BL} - \sum EL_{FG}}{\sum EL_{BL}} \right)$$ Where: REL: Total reduction in energy losses [%] EL_FG: Total energy losses under TIGON scenario[MW] EL_BL: Total energy losses under BaU scenario[MW]

Scenarios to be measured / calculated	***Baseline*** ☐	***Business as usual*** ☐	***TIGON*** ☐

Calculation Methodology

Nº	***Step description***	***Responsible***
REL_01	Demo site network data #ND (lines characteristics, datasheets, nameplates, databases, etc.)	TBD
REL_02	Modeling demo site network with data supplied in REL_01	TBD
REL_03	Perform calculation of LPF to estimate energy losses in a baseline and aTIGON scenarios to obtain REL	TBD

Data sources / types

Data	TAG	Methodology	Source/ Tools/ Instruments	Location of data collection	Frequency of data collection	Min. Monitoring period	Responsible
Network data for modeling	#ND	characteristics of devices for modeling	datashhets, DB, nameplates	DSO registers	once	-	TBD

Baseline definition / BaU methodology

Source	***Literature*** ☐ BL ( ) BaU( )	***Historical data*** ☐ BL ( ) BaU( )	***Measured at start*** ☐ BL ( ) BaU( )
Responsible			
Details			

Validation

Environment	***Simulation*** ☐	***Laboratory*** ☐	***Data Field*** ☐
Responsible			
Details			

Other KPIs related

General comments

V 0.1

TIGON KPI DATASHEET

Basic Information			
Name:	Number of frequency out of range events	**KPI ID:**	FOR
Description:	Calculates times that the average value of the fundamental frequency measured over periods of 10 s goes out of the stated ranges (FCE).		
Units	[integer]		

Location	
Demo site ***(Use Case)***	TBD in WP5 and WP6

Calculation

Formula or Calculation procedure

$$FOR = \sum e_{for}$$

Where:
FOR: Total number of frequency out of range events in a period [-]
e_for: event of voltage limit violation [-]

Scenarios to be measured / calculated	***Baseline*** ☐	***Business as usual*** ☐	***TIGON*** ☐

Calculation Methodology

Nº	*Step description*	*Responsible*
FOR_01	Obtain all frequency out of range event from the baseline scenario	TBD
FOR_02	Calculate FOR to the baseline scenario	TBD
FOR_03	Obtain all frequency out of range event from the FLEXIFRID (R&D) scenario	TBD
FOR_04	Calculate FOR for the TIGON scenario	TBD
FOR_05	Compare to baseline scenario	TBD

Data sources / types

Data	TAG	Methodology	Source/ Tools/ Instruments	Location of data collection	Frequency of data collection	Min. Monitoring period	Responsible
Frequency out range event	e_for	Power meters units lecture	IEDs / Others	DSO SoE register	daily	one year	TBD

Baseline definition / BaU methodology

Source	***Literature*** ☐ BL ( ) BaU( )	***Historical data*** ☐ BL ( ) BaU( )	***Measured at start*** ☐ BL ( ) BaU( )
Responsible			
Details			

Validation

Environment	***Simulation*** ☐	***Laboratory*** ☐	***Data Field*** ☐
Responsible			
Details			

Other KPIs related

General comments

V 0.1

TIGON KPI DATASHEET

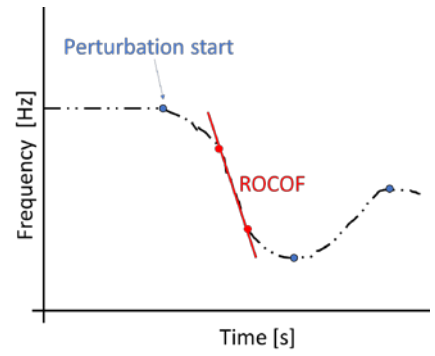
Basic Information			
Name:	Rate of Change of Frequency	**KPI ID:**	ROCOF
Description:	Corresponds with the frequency gradient after an active power imbalance.		
Units	[Hz/s]		

Location	
Demo site ***(Use Case)***	TBD in WP5 and WP6

Calculation

Formula or Calculation procedure

$$ROCOF(t) = \left(\frac{df(t)}{dt}\right)$$



Where:
ROCOF: Gradient of frequency [Hz/s]
f(t): Frequency function in a event of inertial/load/generation variation [Hz]

Scenarios to be measured / calculated	***Baseline*** ☐	***Business as usual*** ☐	***TIGON*** ☐

Calculation Methodology

Nº	***Step description***	***Responsible***
ROCOF_01	Modeling of power grid, including inertial components of generation and load	TBD
ROCOF_02	Define scenarios to evaluate (different inertia, load and generations schemes)	TBD
ROCOF_03	Perform calculation of ROCOF for the baseline scenarios / nodes	TBD
ROCOF_04	Perform calculation of ROCOF for the TIGON scenarios / nodes	TBD

Data sources / types

Data	TAG	Methodology	Source/ Tools/ Instruments	Location of data collection	Frequency of data collection	Min. Monitoring period	Responsible
Network data	ROCOF_01	Modeling power grid	DSO DB / Registers	DSO DB / Registers	once	-	TBD
Frequency function	ROCOF_03 / 04	Simulation	Simulated COMTRADE, Oscillography register	DSC	once	-	TBD

Baseline definition / BaU methodology

Source	***Literature*** ☐ BL ( ) BaU( )	***Historical data*** ☐ BL ( ) BaU( )	***Measured at start*** ☐ BL ( ) BaU( )
Responsible			
Details			

Validation

Environment	***Simulation*** ☐	***Laboratory*** ☐	***Data Field*** ☐
Responsible			
Details			

Other KPIs related

General comments

V 0.1

TIGON KPI DATASHEET

Basic Information			
Name:	Flexibility actions taken	**KPI ID:**	FAT
Description:	Number of flexibility actions taken to reduce demand, load control, network configuration, etc. in a period		
Units	[integer]		

Location	
Demo site ***(Use Case)***	TBD in WP5 and WP6

Calculation

Formula or Calculation procedure

$$FAT = \sum FA_n$$

Where:
FAT: Number of flexibility actions taken [-]
FA_n: An event in the grid that involves a change in generation or demand behavior [-]

Scenarios to be measured / calculated	***Baseline*** ☐	***Business as usual*** ☐	***TIGON*** ☐

Calculation Methodology

Nº	***Step description***	***Responsible***
FAT_01	Determine characteristics of a flexibility action	TBD
FAT_02	Obtain all flexibility actions taken in the grid	TBD
FAT_03	Perform data calculation of total flexibility actions taken	TBD

Data sources / types

Data	TAG	Methodology	Source/ Tools/ Instruments	Location of data collection	Frequency of data collection	Min. Monitoring period	Responsible
flexibility actions taken	FAT_02	determine number of flexibility actions	IEDs / Simulations	DSO power registers / Simulation	hourly	one month	TBD

Baseline definition / BaU methodology

Source	***Literature*** ☐ BL ( ) BaU( )	***Historical data*** ☐ BL ( ) BaU( )	***Measured at start*** ☐ BL ( ) BaU( )
Responsible			
Details			

Validation

Environment	***Simulation*** ☐	***Laboratory*** ☐	***Data Field*** ☐
Responsible			
Details			

Other KPIs related

General comments

V 0.1

TIGON KPI DATASHEET

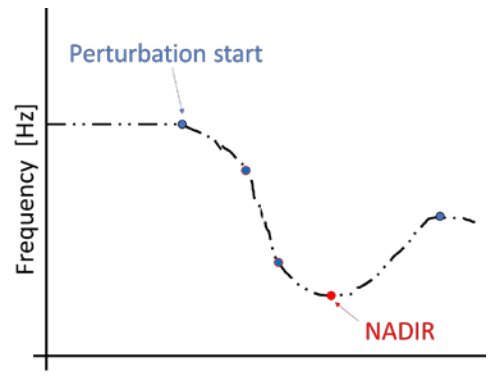
Basic Information			
Name:	Minimum frequency reached after a contingency event	**KPI ID:**	NADIR
Description:	Minimum frequency reached after a contingency event (by node)		
Units	[Hz]		

Location	
Demo site ***(Use Case)***	TBD in WP5 and WP6

Calculation

Formula or Calculation procedure

$$NADIR = min(f(t)_n)$$



Where:
NADIR: [Hz]
f(t)_n: Frequency function in a event of inertial/load/generation variation in node n [Hz]

Scenarios to be measured / calculated	***Baseline***	***Business as usual***	***TIGON***
	☐	☐	☐

Calculation Methodology

Nº	***Step description***	***Responsible***
NADIR_01	Modeling of power grid, including inertial components of generation and load	TBD
NADIR_02	Define scenarios to evaluate (different inertia, load and generations schemes)	TBD
NADIR_03	Perform calculation of NADIR for the baseline scenarios / nodes	TBD
NADIR_04	Perform calculation of NADIR for the TIGON scenarios / nodes	TBD

Data sources / types

Data	TAG	Methodology	Source/ Tools/ Instruments	Location of data collection	Frequency of data collection	Min. Monitoring period	Responsible
Network data	NADIR_01	Modeling power grid	DSO DB / Registers	DSO DB / Registers	once	-	TBD
Frequency function	NADIR_03 / 04	Simulation	Simulated COMTRADE, Oscillographyc register	DSC	once	-	TBD

Baseline definition / BaU methodology

Source	***Literature***	***Historical data***	***Measured at start***
	☐ BL ( ) BaU( )	☐ BL ( ) BaU( )	☐ BL ( ) BaU( )
Responsible			
Details			

Validation

Environment	***Simulation***	***Laboratory***	***Data Field***
	☐	☐	☐
Responsible			
Details			

Other KPIs related

General comments

V 0.1

TIGON KPI DATASHEET

Basic Information			
Name:	Reactive Energy Consumption	**KPI ID:**	RE
Description:	Total reactive energy consumed in a period of time		
Units	[MVARh]		

Location	
Demo site *(Use Case)*	TBD in WP5 and WP6

Calculation

Formula or Calculation procedure	$RE = \sum Eq_n$ *Where:* *RE: Total Reactive Energy [MVARh]* *Eqn: Reactive energy consumed in period n [MVARh]*

Scenarios to be measured / calculated	***Baseline*** ☐	***Business as usual*** ☐	***TIGON*** ☐

Calculation Methodology

Nº	***Step description***	***Responsible***
RE_01	Obtain reactive energy consumption in all nodes involved	TBD
RE_02	Perform calculation of total reactive energy according to the minimum monitoring period	TBD

Data sources / types

Data	TAG	Methodology	Source/ Tools/ Instruments	Location of data collection	Frequency of data collection	Min. Monitoring period	Responsible
Reactive energy	Eq	Power meters units lecture	IEDs / Others	DSO power registers	monthly	one year	TBD

Baseline definition / BaU methodology

Source	***Literature*** ☐ BL ( ) BaU( )	***Historical data*** ☐ BL ( ) BaU( )	***Measured at start*** ☐ BL ( ) BaU( )
Responsible			
Details			

Validation

Environment	***Simulation*** ☐	***Laboratory*** ☐	***Data Field*** ☐
Responsible			
Details			

Other KPIs related

General comments