DISCERN

Project DISCERN
KPI questionnaire
Data collection sheets for Input values

Version	2.0
Date	08.07.2014
Author	DNV GL

Sheets

Guidelines	Notes and descriptions on how to use the questionnaire
Overview	Compilation of the KPIs, used as delivery sheet
Project characteristic	Sheet for data input describing the demo site's major grid characteristics
Performance KPI	Sheet for data input per KPI
Cost KPI	Sheet for data input on cost for technical solution

Input cells are marked with light orange color

Matrix	Summary matrix for allocated KPIs per sub-functionality and leader/learner
Glossary	Explanation for applied abbreviations
Template	Template for KPI sheets for administrative purposes only, please do not change!

Contact details in case of questions

Name, company	*Email*	*Phone*
Lutz Itschert, DNV GL - Energy	Lutz.Itschert@dnvgl.com	+49 228 4469051
Katrin Spanka, DNV GL - Energy	Katrin.Spanka@dnvgl.com	+49 228 4469039

Guideline and Instructions for Performance KPI Questionnaire

Within EU Project DISCERN KPIs (Key Performance Indicators) are applied to measure and compare technical solutions for certain sub-functionalities.

This present **Questionnaire** collects all necessary input data per KPI and sub-functionality.
Each tap "*KPI x*" contains the description and calculation methodology including instructions for the necessary input for each KPI. One tab is provided for each KPI, but not all KPIs will be completed by each DSO. Please refer to the tap "*Matrix*" for further support.

Leaders are requested to provide the data **once** for the respective technical solution / Use Case. Leader will deliver KPIs based on measured values (measured or lagging KPIs). Leaders can optionally deliver KPIs on a monthly base if the demo site is ongoing and they like to keep track on improvements / development of the respective KPIs.

Learners are requested to provide the data **at least twice**. First time will be prior to the implementation and help to set the indicative target, considering the current situation (baseline - BAU) and the most possible R&I situation, e.g. what do you believe can be reached in your specific demo site by implementing the selected technical solution / Use Case. This will be called the target KPIs (or leading KPIs). After implementation of technical solution leaders are requested to monthly report the respective KPIs (monitored/lagging KPI). This will enhance the evaluation of the KPIs. In some cases this is not necessary, however, this will be indicated in section time base.

Exemplary table

KPI Name
Definition
Objective
Time base
KPI Input
HC BAU
HC R&I
Boundary conditions
KPI Output
Increased Hosting Capacity DER
Validity criteria
Grid level
Maximum load
Least thermal capacity

Structure of the performance KPI questionnaire

In the **header**, the respective KPI is named and numbered (on the right). Below you find the description and objective for each KPI, elaborating further the meaning and aim of the respective KPI. The time base states the respective time frame/frequency for which the KPI is requested to be provided to DNV GL. This can be either for a week (e.g. voltage quality), a month (e.g. customer complains) or for a year (e.g. SAIDI) or not applicable, e.g. calculation does incorporate certain set conditions but result does not depend on a point of time of calculation (e.g. hosting capacity). If the KPI is seen relevant for monthly time base, learners are requested to provide the progress of KPI for each month. This shall help to interpret the results in later work packages based on the development curve of the respective KPI.

The main part of the questionnaire is the part **KPI Input**, where all the required data shall be inserted by the respective leader / learner (light orange cells). A description and - if applicable - calculation rules are given per input value in order to allow for constant and comparable calculations of the respective KPI. Additionally boundary conditions are provided that have to be considered and/or fulfilled for each calculation.

The **KPI Output** part displays the value of the respective KPI based on the provided inputs above and the formula (automated excel based calculation).

At the end, leaders/learners are requested to state the main **validity criteria** under which the respective KPI is true for the respective time period, e.g. define those influencing factors that would potentially lead to significant variation of the provided KPI and/or help to understand the current value of the KPI (that might be higher or lower as expected).

Guideline and Instructions for Cost KPI Questionnaire

Within EU Project DISCERN KPIs (Key Performance Indicators) are applied to measure and compare technical solutions for certain sub-functionalities.

This present **Questionnaire** collects all necessary input data per KPI and sub-functionality.
The tap ***Cost KPI* collects the data and cost driver per KPI.**

Leaders are requested to provide the data once for the respective technical solution / Use Case. Leader will deliver KPIs based on measured values (measured or lagging KPIs).

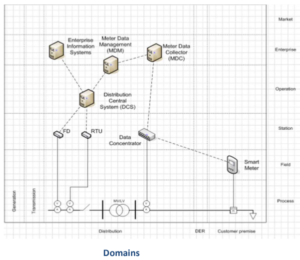
Learners are requested to provide the data at least twice. First time will be prior to the implementation and help to set the indicative target, e.g. what do you believe will cost the implementation of the technical solution right now? This will be called the target KPI (or leading KPI). After implementation of the technical solution leaders are requested to report the monitored KPI, e.g. what have been the actual cost to implement the technical solution. This will be called the monitored KPI (or lagging KPI).

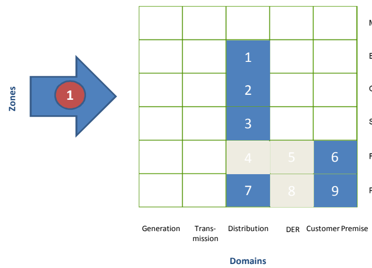
In order to make the costs of each technical solution more comparable, they are collected per array. The respective array is derived from the SGAM model, using the component layer. Please use the appropriate use case and the description of the component layer. Each KPI represents one specific array. The following process should be adopted to complete this area of the questionnaire.

1. Identify the respective array(s) by selecting the corresponding domain and zone.
2. Insert the total cost allocated to the respective array.
3. Estimate the portion per dimension (hardware - HW, software - SW, communication - C)
   Hint: The dimension should be in line with the actor type
4. Insert value of defined cost driver(s) per array.

Example

Use SGAM Component layer of respective use case as guideline to select the appropriate arrays.





Select the appropriate Zone-domain combination and insert the respective cost.

N°	Zone	Domain	Total investment cost [€]	HW [%]	SW [%]	C [%]	Cost Driver CAPEX Type	Cost Driver CAPEX Value	Cost Driver CAPEX Unit	Cos… Type
KPI 1	Enterprise	Distribution								
KPI 2	Operation	Distribution								
KPI 3	Station	Distribution								
KPI 4	Field	Distribution								
KPI 5	Field	DER								
KPI 6	Field	Customer								
KPI 7	Process	Distribution								
KPI 8	Process	DER								
KPI 9	Process	Customer								

The associated cost driver per array will be selected automatically according to the table below. Please insert the relevant value per each cost driver as requested in the table.

Zone	Domain	Combined (column hided)	Array Nr	Cost Driver 1 (short)	Cost Driver (long)	Cost Driver 1 (unit)	Cost Driver 2 (short)	Cost Driver 2 (long)	Cost Driver 2 (unit)
Enterprise	Distribution	EnterpriseDistribution	KPI 1	Metering points	Number of metering points [#] (including data concentrator, substation, DER, customer)	#	Data transfer	Average amount of data received per day	MB/day
Operation	Distribution	OperationDistribution	KPI 2	Intelligent metering points	Number of metering points equipped with ICT [#] (including data concentrator, substation, DER, customer)	#	Data transfer	Average amount of data received per day	MB/day
Station	Distribution	StationDistribution	KPI 3	Data concentrator	Number of data concentrators	#	Data transfer	Average amount of data received per day	MB/day
Field	Distribution	FieldDistribution	KPI 4	Intelligent substations	Number of substations equipped with ICT	#	-	-	-
Field	DER	FieldDER	KPI 5	Intelligent metering points DER	Number of DER metering points equipped with ICT	#	-	-	-
Field	Customer	FieldCustomer	KPI 6	Intelligent metering points customer	Number of customer metering points (load) equipped with ICT	#	-	-	-
Process	Distribution	ProcessDistribution	KPI 7	Intelligent substations	Number of substations equipped with ICT	#	-	-	-
Process	DER	ProcessDER	KPI 8	Intelligent metering points DER	Number of DER metering points equipped with ICT	#	-	-	-
Process	Customer	ProcessCustomer	KPI 9	Intelligent metering points customer	Number of customer metering points (load) equipped with ICT	#	-	-	-

4 4

Cost Driver 1 Type	Cost Driver 1 Value	Cost Driver 1 Unit	Cost Driver 2 Type	Cost Driver 2 Value	Cost Driver 2 Unit
Metering points	20.000	#	Data transfer	200	MB/day
Intelligent metering points	10.000	#	Data transfer	200	MB/day
Data concentrator	1.000	#	Data transfer	200	MB/day
Intelligent metering points customer	9.500	#	-		-
Intelligent 2nd substations	500	#	-		-
Intelligent metering points customer	9.500	#	-		-

Based on your input values excel calculates the appropriate cost KPIs per dimension (Hardware, Software, Comm.). These will be transferred automatically to KPI overview.

Cost KPI [€] HW	Cost KPI [€] SW	Cost KPI [€] C
0,33	0,13	0,20
1,07	2,67	1,60
10.000,00	0,00	0,00
160,00	20,00	20,00
3.200,00	800,00	0,00
180,00	10,00	10,00

KPI Overview

	Name	Email	Phone
Contact person	*[name surname]*	[xx@xx.com]	*[+49 xxx xxxxx]*
Company name			
Date of submission	*enter date of submission*		

Type of KPI		Type of KPI	
Reported month		Reported month	
Reported year		Reported year	

Performance KPI		Value
KPI 01	Increased Hosting Capacity (network capacity)	
KPI 03a	Improvement SAIDI (security of supply)	
KPI 03b	Improvement ASIDI (security of supply)	
KPI 05	Improvement voltage quality (monitoring)	
KPI 06	Reduction in time required for fault awareness, localization and isolation (service quality)	
KPI 07	Amount of load capacity participating in Demand Response (DR)	
KPI 08	Peak load reduction	
KPI 14	Percentage reduction in complaints of customers	
KPI 17a	Availability of intelligent network components	
KPI 17b	Success index in meter reading	
KPI 18a	Amount of technical losses identified (LV)	
KPI 18b	Potential for reduction in technical losses (LV)	
KPI 18c	Potential for reduction in technical losses_Balanced network (LV)	
KPI 19	Amount of non-technical losses identified	
KPI 21b	Percentage cost reduction in IT in comparison with conventional strategies for AMR data concentration & communication	
KPI 24	Reduced delays for new connections	
KPI 25	Number of sensors to achieve the (sub)functionality	
KPI 26	Percentage of consumers being metered automatically	
KPI 27a	Change in voltage variation on medium voltage level	
KPI 27b	Change in voltage variation on low voltage level	
KPI 28	Better support of network planning	-

Cost KPI		Value HW	Value SW	Value C
KPI 1	EnterpriseDistribution	#DIV/0!	#REF!	#REF!
KPI 2	OperationDistribution			
KPI 3	StationDistribution			
KPI 4	FieldDistribution			
KPI 5	FieldDER			
KPI 6	FieldCustomer			
KPI 7	ProcessDistribution			
KPI 8	ProcessDER			
KPI 9	ProcessCustomer			

To help the project identify the specific network attributes and conditions, please complete the following descriptive sections

General Information

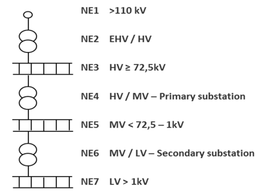
Company name	
Role	
Demo site	
Sub-functionality	
Period	

Grid Characteristic	Value	Unit	As of	Comment	Definition
Type of Grid		-			Rural ==> population density of less than 750 inhabitants per km²
Area of the demo site		km²			
N° od inhabitants		EW			
N° of customer LV		#			Equal to number of metering points
%-share with smart meter		%			
N° of customer MV		#			Equal to number of metering points
%-share with smart meter/remote meters		%			
Length of network					
MV - Cable		km			
MV - Overhead lines		km			
LV - Cable		km			Including home connection
LV - Overhead lines		km			Including home connection
N° of primary substations		#			
%-share of intelligent substations		%			An intelligent substation is a substation integrated in a communication network, which enable the substation to send or receive measurements and signals.
N° of transformers		#			
Installed transformer capacity (HV/MV)		MVA			Total capacity of all transformers
N° of feeders		#			Total number of feeders at primary substation level within demo side area
N° of secondary substations		#			
%-share of intelligent substations		%			An intelligent substation is a substation integrated in a communication network, which enable the substation to send or receive measurements and signals.
N° of transformers		#			
Installed transformer capacity (MV/LV)		MVA			Total capacity of all transformers
N° of feeders		#			Total number of feeders at secondary substation level within demo side area
MV network					
DER connected to the grid		MW			Peak installed DER generation capacity
Minimum load of the grid		MW			Basic load of the grid as of the provided year.
Maximum load of the grid		MW			Peak load of the gird as of the provided year.
LV network					
DER connected to the grid		MW			Peak installed DER generation capacity
Minimum load of the grid		MW			Basic load of the grid as of the provided year.
Maximum load of the grid		MW			Peak load of the gird as of the provided year.

Communication Network

Type of data communication in the field (of 100%)	0	%	100% = total number of connection to the communication network (includes substations, data concentrators, consumers, generators, etc.)
Power cable (for PLC/BPLC)		%	
Radio communication (for GPRS, GSM)		%	
Cable Communication - fiber optic/copper (for DSL, etc.)		%	

Picture 1: Definition of voltage levels



NE1	maximum voltage level (MHV)
NE2	transformer level between maximum and high voltage level
NE3	high voltage level (HV)
NE4	transformer level between high and medium voltage level
NE5	medium voltage level (MV)
NE6	transformer level between medium and low voltage level
NE7	low voltage level (LV)

Picture 2: Definition of grid assets

1 substation
2 busbar
3 feeder
4 line

KPI Name	Increased Hosting Capacity (network capacity)	Nr	01	
Definition	The DER hosting capacity represents the total capacity of DER that can be connected to the respective grid (no grid reinforcement) without endangering system stability and reducing system reliability [CEER2011]. DER refers to small and medium wind, PV modules or other distribution generation resources connected to distribution grids.			
Objective	It is expected that due to the implementation of ICT and the therefore enhanced monitoring and/or control capabilities hosting capacity to the distribution grid increases without adding additional cable or traditional network capacity.			
Time base	yearly			
KPI Input	**Explanation**	**Calculation instructions (rules)**	**Value**	**Unit**
HC BAU	Additional hosting capacity of DER in non-ICT scenario with respect to currently connected generation.	*According to EEGI guideline proposing calculation method with DMS based on 4 steps: 1. Set appropriate calculation conditions: - Set load condition to minimum load - Set distributed generation equal to installed capacity at a chosen point in time (e.g. years end) - Set busbar (of the lower voltage level) set point to rated voltage - Enable regulation algorithm with 0.9 as inductive power factor 2. Identify highest voltage node 3. Install a generator in the highest voltage node, with no generated active power and 0.9 inductive power factor 4. Increase generator power until reaching boundary conditions (voltage, current or temperature limits) The generator power associated with reaching boundary conditions equals the hosting capacity.*		kVA
HC R&I	Additional hosting capacity of DER when ICT solutions is applied with respect to currently connected generation.	*Same procedure as described above by using the same values for threshold limits, however, due to monitoring results improved values for the grid characteristics may be available and shall be used.*		kVA
Boundary conditions	· N-1 criterion (for MV) · Additional hosting capacity without harming security of supply i.e. not reaching the thermal, current or voltage limit of the grid section or cable. · System reliability BAU <= system reliability R&I (monitored e.g. by SAIDI, etc.)			
KPI Output	**Formula**		**Value**	**Unit**
Increased Hosting Capacity (network capacity)	$\Delta HC\,\% = \left(\frac{HC_{R\&I} - HC_{BAU}}{HC_{BAU}}\right) \times 100$	*Positive: Improvement Negative: Setback*		%
Validity criteria	**Explanation**		**Value**	**Unit**
Change_highest voltage node	This shall cover the case, that the highest voltage node - identified by the DMS - differs between BAU and R&I case. We believe this may occur frequently but does not harm the calculation method.	*If a different highest voltage node was identified between BAU and R&I, enter "yes". If equal, please enter "no".*		-
Installed DG capacity_BAU	The total amount of DG (peak) capacity connected to the grid (as of end of BAU stage).	*The determined hosting capacity depends on the defined DG capacity connected to the grid as well as the minimum load. It is assumed that the HC decreases (ceteris paribus) if the DG capacity connected to the grid increases, as well as the HC increases (ceteris paribus) if the minimum load increases.*		MW
Installed DG capacity_R&I	The total amount of DG (peak) capacity connected to the grid (as of end of evaluated period / R&I stage).			MW
Min load_BAU	Base load (as of end of BAU stage)			MW
Min load_R&I	Base load (as of end of evaluated period / R&I stage).			MW

KPI Name	Improvement SAIDI (security of supply)	Nr	03a	
Definition	SAIDI (System Average Interruption Duration Index) measures the average interruption duration for each customer in LV network until restoration of full supply.			
Objective	As an indicator of security of supply it is expected to decrease (ceteris paribus) due to implementation of ICT respectively not increase under severe conditions (e.g. increase of DER).			
Time base	yearly			
KPI Input	**Explanation**	**Calculation instructions (rules)**	**Value**	**Unit**
# end customer interruptions BAU	Sum of all end customer interruption duration within the observed period within BAU stage.	*∑ (interruption duration customer 1 + … + interruption duration customer n)*		min/a
# end customers BAU	Total number of end customers served in the observed network (average within the observed period) within BAU stage.	*- # end customer - Hereby are final consumer, which are interrupted again after a recent re-supply, to be counted twice (or more).*		-
# end customer interruptions R&I	Sum of all end customer interruption duration within the observed period R&I stage.	*∑ (interruption duration customer 1 + … + interruption duration customer n)*		min/a
# end customers R&I	Total number of end customers served in the observed network (average within the observed period) R&I stage.	*- # end customer - Hereby are final consumer, which are interrupted again after a recent re-supply, to be counted twice (or more).*		-
Boundary conditions	- Long interruptions > 3 min (acc. definition in CEER 4th Benchmarking Report and EN 50160, Voltage characteristics of electricity supplied by public distribution networks, CENELEC, Brussels, 2007) - Within the observed area of the demo site - Observed period should equal one year (12 month) - Calculation method according to DISQUAL / IEEE 1366			
KPI Output	**Formula**		**Value**	**Unit**
SAIDI BAU	$SAIDI = \frac{\#\ end\ customer\ interruptions}{\#\ end\ customer}$			min/a
SAIDI R&I				min/a
Improvement SAIDI (security of supply)	$\Delta\ SAIDI\ \% = (\frac{SAIDI_{Bau} - SAIDI_{R\&I}}{SAIDI_{Bau}}) \times 100$	*Positive: Setback Negative: Improvement*		%
Validity criteria	**Explanation**		**Value**	**Unit**
Installed DG capacity_BAU	The total amount of DG (peak) capacity connected to the grid (as of end of BAU stage).	*It is assumed that the value of SAIDI is partly depended on the connected DG level to the grid in such way that increases of SAIDI may be caused by an increase of DG capacity connected to the grid (ceteris paribus).*		MW
Installed DG capacity_R&I	The total amount of DG (peak) capacity connected to the grid (as of end of evaluated period / R&I stage).			MW

KPI Name	Improvement ASIDI (security of supply)	Nr	03b	
Definition	ASIDI (Average System Interruption Duration Index) measures the average interruption duration of total installed allocated apparent power in MV network until restoration of full supply.			
Objective	As an indicator of security of supply it is expected to decrease (ceteris paribus) due to implementation of ICT respectively not increase under severe conditions (e.g. increase of DER).			
Time base	not applicable			
KPI Input	**Explanation**	**Calculation instructions (rules)**	**Value**	**Unit**
# interruptions BAU	Sum of interruption duration of all allocated apparent power of grid transformers and customer transformers within the observed period and BAU stage.	*∑ (interruption duration 1 * installed apparent power 1 + … + interruption duration * installed apparent power n)*		minMVA/a
# power transformers BAU	Total of installed allocated apparent power of grid transformers and customer transformers (average within the observed period) within BAU stage.	*∑ total installed apparent power of all transformers (grid; customer)*		MVA
# interruptions R&I	Sum of interruption duration of all allocated apparent power of grid transformers and customer transformers within the observed period and R&I stage.	*∑ (interruption duration 1 * installed apparent power 1 + … + interruption duration * installed apparent power n)*		minMVA/a
# power transformers R&I	Total of installed allocated apparent power of grid transformers and customer transformers (average within the observed period) within R&I stage.	*∑ total installed apparent power of all transformers (grid; customer)*		MVA
Boundary conditions	- Long interruptions > 3 min (acc. definition in CEER 4th Benchmarking Report and EN 50160, Voltage characteristics of electricity supplied by public distribution networks, CENELEC, Brussels, 2007) - Within the observed area of the demo site - Observed period should equal one year (12 month) - Calculation method according to DISQUAL / IEEE 1366			
KPI Output	**Formula**		**Value**	**Unit**
ASIDI BAU	$ASIDI = \frac{\#\, interruptions}{\#\, power\ transformer}$			min/a
ASIDI R&I				min/a
Improvement ASIDI (security of supply)	$\Delta\, ASIDI\ \% = (\frac{ASIDI_{R\&I}\quad ASIDI_{BAU}}{ASIDI_{BAU}})$ x 100	*Positive: Setback* *Negative: Improvement*		%
Validity criteria	**Explanation**		**Value**	**Unit**
Installed DG capacity_BAU	The total amount of DG (peak) capacity connected to the grid (as of end of BAU stage).	*It is assumed that the value of SAIDI is partly depended on the connected DG level to the grid in such way that increases of SAIDI may be caused by an increase of DG capacity connected to the grid (ceteris paribus).*		MW
Installed DG capacity_R&I	The total amount of DG (peak) capacity connected to the grid (as of end of evaluated period / R&I stage).			MW
TIEPI	Time Interruption of Installed Power is a similar value to ASIDI used in Spain.	*By providing similar value based on calculation methodology known in Spain differences may be tracked with may support comparison of use cases in different areas.*		MW

Only for simulations

KPI Name	Improvement voltage quality (monitoring)	Nr	05	
Definition	Voltage quality refers to the attribute of voltage level not to under or overrun certain threshold values. It is assumed that there are voltage ligament injury in the grid area under evaluation. **Only slow changes in voltages are subject to this KPI.**			
Objective	The implementation of ICT and the therefore enhanced monitoring and control capabilities will lead to improved voltage profiles. In order to receive a full picture of the voltage quality the voltage profile is monitored through two values that are directly retrieved from power quality instrumentation or calculation: V_max and V_95% (according to EN 50160). The objective is that due to ICT the values between BAU and R&I decrease as well as the difference between V95% and Vmax will diminish.			
Time base	weekly			
KPI Input	**Explanation**	**Calculation instructions (rules)**	**Value**	**Unit**
V_95% BAU	The value for which 95% of all voltage profile measurements fall below within BAU scenario [V].			V
V_95% R&I	The value for which 95% of all voltage profile measurements fall below within R&I scenario [V].			V
V_max BAU	The maximum reached line voltage during defined monitoring period within BAU scenario [V].			V
V_max R&I	The maximum reached line voltage during defined monitoring period within R&I scenario [V].			V
Boundary conditions	- 10 or 15-minutes average values during a week (EN 50160), if possible, various weeks could be covered and an average of these weeks provided. - significant amount of sensors (at least 20; better 200) - nodes randomly selected or at strategic / critical nodes			
KPI Output	**Formula**		**Value**	**Unit**
Improvement voltage quality (monitoring)	$\Delta V_{95\%}\% = \left(\frac{V_{95\%_{BAU}} - V_{95\%_{R\&I}}}{V_{95\%_{BAU}}}\right) \text{X } 100$	*Positive: Improvement* *Negative: Setback*		%
Improvement voltage quality (monitoring)	$\Delta V_{\max}\% = \left(\frac{V_{\max_{BAU}} - V_{\max_{R\&I}}}{V_{\max_{BAU}}}\right) \text{X } 100$	*Positive: Improvement* *Negative: Setback*		%
Validity criteria	**Explanation**		**Value**	**Unit**
# of measurements	number of total measurements per period (e.g. measurements per 10min interval would equal 1,008 measured values per week)			#

KPI Name	Reduction in time required for fault awareness, localization and isolation (service quality)	Nr	06	
Definition	This parameter specifies how long it takes to clear any disorders with supply interruption to all affected customers on average of all of these disorders. The time measurement starts with the point of awareness (either customer call or system alarm), and ends with completed isolation of the damaged equipment / clearing of fault (either by report of success by electrician or system information), however, does not include restoration full supply of each customer (in contrary to SAIDI/ASIDI).			
Objective	Due to improved knowledge of area of disorder time required for fault awareness, localization and isolation can be reduced.			
Time base	yearly			
KPI Input	**Explanation**	**Calculation instructions (rules)**	**Value**	**Unit**
T fault_BAU	Average time required for fault awareness, localization and isolation in BAU scenario [min].	*- ∑(event 1+ ... + event n) / n*		min
T fault_R&I	Average time required for fault awareness, localization and isolation in R&I scenario [min].	*- ∑(event 1+ ... + event n) / n*		min
Boundary conditions	- Long interruptions > 3 min (acc. definition in CEER 4th Benchmarking Report and EN 50160, Voltage characteristics of electricity supplied by public distribution networks, CENELEC, Brussels, 2007)			
KPI Output	**Formula**		**Value**	**Unit**
Reduction in time required for fault awareness, localization and isolation (service quality)	$\Delta\, T_{fault}\,\% = \left(\frac{T_{fault\ BAU} - T_{fault\ R\&I}}{T_{fault\ BAU}}\right)$ X 100	*Positive: Improvement* *Negative: Setback*		%
Validity criteria	**Explanation**		**Value**	**Unit**
# events	Number of events within period of time.	*Helps to define the significance of the KPI and evaluate the change in numbers of faults (which could be an individual KPI itself.*		#
# events that required field attendance	Number of events that required to sent out field staff in order to isolate the fault.	*It might be that time was basically reduced due to the fact that faults could be solved centrally / decentrally by ICT.*		#
Average driving time within grid	Average driving time of field staff until reaching the location of fault. Includes all necessary drivings, from the starting point including the various stops in between in order to find the location of fault. Rough indication is acceptable.	*The time would decrease dramatically in case average driving time is high and some faults could be solved by ICT only.*		min

Only for simulations

KPI Name	Amount of load capacity participating in Demand Response (DR)	Nr	07	
Definition	Amount of flexible load / energy required to accommodate a certain level of DER integration without harming threshold limits like voltage or current. This KPI will be subject to simulations only, varying the level of DER integration accordingly. The analysis will be based on daily profiles. The results will provide insights to required positive (reduced load/energy) as well as negative (increase load/energy) demand response. The value is provided in MWh, in order to account not only for the total amount of load but also the required time the flexible load is required (sustain time). The flexible load curve may include a combination of various sources of flexibility such as water heaters, air conditioner, electric vehicles (EV), and any form of flexible storages (such as batteries, fly wheels, etc.). There will be no comparison to BAU as the main focus is on the relation between DER integration level and required demand response to accommodate that DER level in the grid. However, the amount of required demand response will be set in relation to the residual load in order to reflect load and generation level in the respective grid area.			
Objective	Flexible loads could be used as a way to control voltage and current levels, improving the power flow and avoiding congestion inside distribution grids. Smart Grids allow for including various parties to address today's grid challenges. It is assumed that with increasing DER level the need for flexibility in the grid increases as well. This KPI shall capture the amount of flexible loads / demand response required in order to leverage generation and demand in real time, improving power flow and avoiding congestions.			
Time base	not applicable			
KPI Input	**Explanation**	**Calculation instructions (rules)**	**Value**	**Unit**
DR+	Amount of positive energy required to accommodate the level of DER integration.	*For simulations there will a benchmark model applied. The level of DER integration will be varied in the limits of 0%-70% or max. A defined set of daily generation and flexible load curves will be used. The level of positive and negative energy is defined by the total energy required to keep the grid conditions within defined threshold limits.*		MWh
DR-	Amount of negative energy required to accommodate the level of DER integration.			MWh
Residual load+	Sum of positive residual load. The term residual load refers to the electricity network power (load) less a share of fluctuating feed-in of non-controllable power plants (such as wind or solar power). It represents the residual demand, which must be covered by controllable loads. The residual load is positive if load is higher than generation.	*Integral of positive difference of load and DER generation within a day in MWh.*		MWh
Residual load-	Sum of negative residual load. The term residual load refers to the electricity network power (load) less a share of fluctuating feed-in of non-controllable power plants (such as wind or solar power). It represents the residual demand, which must be covered by controllable loads. The residual load is negative if load is less than generation.	*Integral of negative difference of load and DER generation within a day in MWh.*		MWh
Boundary conditions	- Grid conditions within threshold limits according to EN50160.			
KPI Output	**Formula**		**Value**	**Unit**
Required amount of DR+	$\Delta\ DR+\% = \frac{DR+}{Residual\ load+}$ x 100			%
Required amount of DR-	$\Delta\ DR-\% = \frac{DR-}{Residual\ load-}$ x 100			%
Amount of load capacity participating in Demand Response (DR)	$\Delta\ DR\ \% = DR+\ \% + DR-\ \%$			%
Validity criteria	**Explanation**		**Value**	**Unit**
Level of DER integration level (R&I)	Total amount of DER to be connected and feed in to grid.	*It is assumed that the higher the level of DER integration the more demand response is required.*		MWh
$E_{customer}$	Total energy delivered and consumed by end customers.			MWh

Only for simulations

KPI Name	Peak load reduction	Nr	08	
Definition	Represents the peak load reduction in a certain period in the area under evaluation (average of each 60 minutes = interval) due to control actions of flexibility sources and is measured at the substation of the grid area where the use case is deployed. The peak load reduction is expressed by using the load factor. The load factor related the peak load to the average demand. In order to assess the impact by the use case per season, the peak load is provided per season. There will be up to four different daily profiles applied for load and generation, representing the four seasons (spring (01.03-30.05), summer (01.06-31.08), autumn (01.09-30.11), winter (1.12-29.02)). However, for the load factor the maximum value (for the overall period) is used. This KPI is subject to simulations only. According to the definition of simulations there will be variations (among others) to the level of flexible loads.			
Objective	Due to incentivizing load shifts by different market designs / ancillary services, peak load is expected to be reduced in relation to average load.			
Time base	yearly			

KPI Input	Explanation	Calculation instructions (rules)	Value	Unit
P_peak BAU_spring	Peak load during spring season for area under evaluation (Average load per 60 minutes (=interval)) in BAU scenario [MW].	*Physical maximum of demand (average hourly interval).*		MW
P_peak R&I_spring	Peak load during spring season for area under evaluation (Average load per 60 minutes (=interval)) in R&I scenario [MW].			MW
P_peak BAU_summer	Peak load during summer season for area under evaluation (Average load per 60 minutes (=interval)) in BAU scenario [MW].			MW
P_peak R&I_summer	Peak load during summer season for area under evaluation (Average load per 60 minutes (=interval)) in R&I scenario [MW].			MW
P_peak BAU_autumn	Peak load during autumn season for area under evaluation (Average load per 60 minutes (=interval)) in BAU scenario [MW].			MW
P_peak R&I_autumn	Peak load during autumn season for area under evaluation (Average load per 60 minutes (=interval)) in R&I scenario [MW].			MW
P_peak BAU_winter	Peak load during winter season for area under evaluation (Average load per 60 minutes (=interval)) in BAU scenario [MW].			MW
P_peak R&I_winter	Peak load during winter season for area under evaluation (Average load per 60 minutes (=interval)) in R&I scenario [MW].			MW
Average demand_BAU	Average demand for the evaluated period.	*Total sum of averaged load per hour divided by total number of intervals for the evaluated period.*		MW
Average demand_R&I	Average demand for the evaluated period.			MW

Boundary conditions	- No significant changes to generation/consumptions are assumed (newly connected to the grid), however, in case significant changes are expected, measurements should be performed before and after the change in order to evaluate the impact accordingly.			

KPI Output	Formula		Value	Unit
Peak load reduction	$\Delta\ P_{peak}\% = \left(\frac{Load\ factor_{BAU} - Load\ factor_{R\&I}}{Load\ factor_{BAU}}\right) \text{X } 100$ $\text{load factor} = \frac{P_{peak}}{average\ demand}$	*Positive: Improvement* *Negative: Setback*		%

Validity criteria	Explanation		Value	Unit
Level of flexible load (R&I)	Activated level of flexible load per season. This value should be equal for all seasons. It is assumed that only for R&I scenario flexible load can be applied.	*It is assumed that the higher the level of flexible load applied the higher the reduction on peak load.*		MWh

KPI Name	Percentage reduction in complaints of customers	Nr	14	
Definition	The reduction in complaints of customers will be measured by the reduction of customer calling the grid operator (related supplier) due to irregularities concerning the electricity supply (voltage quality, faults / interruptions, and similar complaints). By those means the customer complaints are connected to specific events.			
Objective	The new information from grid equipment (monitoring and automation) will lead to better system stability and hence allow a more efficient management of the distribution grid, providing better customer services and hence leading to less complaints due to disturbances caused by the grid / grid operator.			
Time base	monthly			
KPI Input	**Explanation**	**Calculation instructions (rules)**	**Value**	**Unit**
#_CC BAU	Total number of customer calls regarding irregularities in BAU scenario per period.			#
#_CC R&I	Total number of customer calls regarding irregularities in R&I scenario per period.			#
Boundary conditions	Irregularities include calls that address the following issues for unplanned events: - voltage quality - faults / interruptions - similar complaints The definition would include calls registered by grid operator and include complaints to the Supplier which are assumingly transferred to the DSO			
KPI Output	**Formula**		**Value**	**Unit**
Percentage reduction in complaints of customers	$\Delta\ \#\,CC\ \% = \left(\frac{\#CC_{BaU} - \#CC_{R\&I}}{\#CC_{BaU}}\right) \text{X } 100$	*Positive: Improvement* *Negative: Setback*		%
Validity criteria	**Explanation**		**Value**	**Unit**
Coverage of Smart Meters_BAU	It is assumed that due to the fact that Smart Meters are rather perceived as unwelcomed by customers complaints will increase.	$\text{coverage } \% = \frac{\sum metering\ points\ being\ metered\ automatically}{\sum metering\ points}\ x\ 100$		%
Coverage of Smart Meters_R&I	It is assumed that due to the fact that Smart Meters are rather perceived as unwelcomed by customers complaints will increase.	*Same procedure as BAU.*		%
# of events_BAU	Number of costumer complains assumingly correlates with number of events. The KPI may as well be reflecting the increase in events instead of impacts by the use case.	*Total number of unplanned events (per month) with duration > 3 minutes.*		#
# of events_R&I	Number of costumer complains assumingly correlates with number of events. The KPI may as well be reflecting the increase in events instead of impacts by the use case.	*Total number of unplanned events (per month) with duration > 3 minutes.*		#

KPI Name	Availability of intelligent network components	Nr	17a	
Definition	Measures reliability and efficiency of communication data transfer for network operation and control purposes and its impact on network performance. Negative network performance is expected every time sensors or actors do not provide the relevant data (do not response, send or act). **This only includes critical components, where late or no response of ICT equipment may potentially lead to system faults.** Assuming that there are no data BAU available at the beginning of the demo sites KPI reflects the % availability of the ICT components in the Smart Grid in the future to give an indication of the reliability of the ICT.			
Objective	Reliable and efficient communication is the indispensable backbone of Smart Grid utilization. Hence, the availability should be - in general - as close to 100% as possible.			
Time base	monthly			
KPI Input	**Explanation**	**Calculation instructions (rules)**	**Value**	**Unit**
actions_in time	Number of actions (sending/receiving signals, control activity) performed in time.	*Counts all measurements/activities that can be processed directly without corrective measurements.*		#
actions_total	Total number of triggered measurements and actions within the relevant period of time.	*Counts all measurements/actions that have been triggered. A measurements that failed in the first attempt but succeeds in the second is count twice (1x first attempt + 1x second attempt), and so forth.*		#
Boundary conditions	Not in time refers to prior defined threshold time (latency) that is not fulfilled by response time of respective component - required monitoring signal not received at all or not in time - required measurement value not received at all or not in time - required control activity not performed at all or not in time - relevant tariff information not delivered at all or not in time by decentralized components (either at customer side, DER or station)			
KPI Output	**Formula**		**Value**	**Unit**
Availability of intelligent network components	$Availability\ \% = \frac{\#\ action\ in\ time}{\#\ action\ \_total}$ X 100			%
Validity criteria			**Value**	**Unit**
Average number of actions/measurements per meter	This provides the average number of actions per day and meter, in order to evaluate the availability.	*More actions per meter and day may provide explanation for lower availability in one use case compared to another.*		#/day
Latency	Average allowed latency (timeframe which is valid for a transfer) per component, as this effects the calculation of the availability.	*If there are different latency valid for different devices please document accordingly by using multiple rows.*		min

KPI Name	Success index in meter reading	Nr	17b	
Definition	Measures communication data transfer reliability and efficiency for billing purposes and for customers supply connection/disconnection. This only includes **actions by smart meters at the customer site**, which are used for metering and billing intention and not for other purposes like network operations. In contrary to availability of information and communication technology (ICT) this does not lead to critical situations within grid operation. Therefore the technical requirements (e.g. response time) may be less strictly. This KPI is designed for Use Cases applying improved communication solutions. Within DISCERN this KPI is applied for the Use Case of applying virtual instead of conventional data concentrators. Hence, the BAU is regarded as conventional solution, using physical data concentrator and the respective communication design. R&I represents the improved solution using virtual data concentrators and the respective communication design.			
Objective	Reliable and efficient communication is the indispensable backbone of Smart Grid utilization. Hence, the success index should be as close to 100% as possible.			
Time base	monthly			
KPI Input	**Explanation**	**Calculation instructions (rules)**	**Value**	**Unit**
Communication_success_BAU	Total number of measurements and actions that are correct and successfully performed by the first data retrieval and can be used for the respective process.	*Counts all measurements/activities that can be processed directly without corrective measurements or other additional activities (e.g. afresh triggering).*		#
Communication_total_BAU	Total number of triggered measurements and actions within the relevant period of time.	*Counts all measurements/actions that have been triggered. A measurements that failed in the first attempt but succeeds in the second is count twice (1x first attempt + 1x second attempt), and so forth.*		#
Communication_success_R&I	Total number of measurements and actions that are correct and successfully performed by the first data retrieval and can be used for the respective process.	*Counts all measurements/activities that can be processed directly without corrective measurements or other additional activities (e.g. afresh triggering).*		#
Communication_total_R&I	Total number of triggered measurements and actions within the relevant period of time.	*Counts all measurements/actions that have been triggered. A measurements that failed in the first attempt but succeeds in the second is count twice (1x first attempt + 1x second attempt), and so forth.*		#
Boundary conditions	Successful means "the desired result is reached". - Measurement is received correctly by first data retrieval - Supply connection is activated/deactivated *"Not correct"* includes - Measurements that are triggered but not received in time (within threshold time/latency) - Measurements that are unreadable / invalid format - Measurements that are otherwise incorrect (implausible) Period of time should be equal between BAU and R&I.			
KPI Output	**Formula**		**Value**	**Unit**
Success index in meter reading	$\Delta\, Success\ index\ \% = Sucess\ index_{BAU} - Sucess\ index_{R\&I}$	*positive: setback* *negative: improvement*		%
	with $Sucess\ index\ \% = \frac{communication\_success}{communcation\_total}$			
Validity criteria	**Explanation**		**Value**	**Unit**
Average number of actions/measurements per meter	This provides the average number of actions per year and meter, in order to evaluate the availability.	*Please indicate the amount of measurements that are triggered per year and meter, assuming that the first trigger would be successful. In other words, how much measurements/actions are required per year to be retrieved per meter?*		#/year
Latency	Average allowed latency (timeframe which is valid for a transfer) per component, as this effects the calculation of the availability.	*If there are different latency valid for different devices please document accordingly by using multiple rows.*		min

KPI Name	Amount of technical losses identified (LV)	Nr	18a	
Definition	Technical losses are calculated based on actual network load situation (mainly unbalanced) and technical parameters of the network components by i.e. transformer, low voltage main distribution / switches and cables (lengths)			
Objective	The use of Smart Grid technologies can collaborate to identified and quantified in detail technical and non-technical energy losses. Afterwards measurements such as optimization of network operation and field actuations can be implemented to achieve the reduction of these losses. This KPI is aimed at providing an insight on the LV operation condition through the quantification of Technical losses in relation to the total energy delivered to consumers connected to Secondary Substations. In such a way, information about the relative weight of these losses can be calculated.			
Time base	yearly			
KPI Input	**Explanation**	**Calculation instructions (rules)**	**Value**	**Unit**
Lo_{tech} R&I	Technical losses in the R&I	*Total sum of losses based on values including technical parameters of components and cables (i.e. transformer, low voltage main distribution / switches, cables and their lengths, home connection).*		kWh
$E_{customer}$ R&I	Total energy delivered and consumed by end customers.	*Equals the amount of total energy measured leaving the SS.*		kWh
Boundary conditions	- secondary substations considered in the area under evaluation - evaluation performed during a defined period of time - cables characteristics and network configurations should be known			
KPI Output	**Formula**		**Value**	**Unit**
Amount of technical losses identified (LV)	$E_{tech\ loss}\% = \frac{Lo_{tech}\ R\&I}{E_{Customer} R\&I} \text{ X } 100$			%
Validity criteria	**Explanation**			**Unit**
Coverage of remote smart meters	Percentage of customers equipped with remote smart meters. A high coverage is desired as this improves the calculations.		0	%
Lo_{tech} BAU	Technical losses in BAU scenario (if available).	*Calculation/simulation of total sum of losses based on network load and technical parameters of components and cables (i.e. transformer, low voltage main distribution / switches, cables and their lengths, home connection).*		kWh

Only for simulations

KPI Name	Potential for reduction in technical losses (LV)	Nr	18b	
Definition	Technical losses cover all physically caused losses. The potential for reduction captures the possible decrease in technical losses due to certain measures, e.g. optimized operation of the network. **However, the actual execution of loss reductions is not intended within this KPI. The potential is identified primarily through simulations.**			
Objective	To reduce technical losses more detailed identification is basic precondition. Use of Smart Grid technology causes a reduction of technical losses due to the possibility of identification of sources of losses. Therefore it is aimed to get more detailed information on LV operation condition esp. load and load balancing using smart grid technology to monitor LV network at different points of the network. BAU values for energy losses are calculated based on measurements, actual load situation and technical parameters of the network components. If provided, values can be captured by KPI 18a, identified technical losses.			
Time base	yearly			
KPI Input	**Explanation**	**Calculation instructions (rules)**	**Value**	**Unit**
Lo tech $_{BAU}$	Technical losses in BAU scenario (actual network conditions).	Total sum of losses based on values including technical parameters of components and cables (i.e. transformer, low voltage main distribution / switches, cables and their lengths, home connection).		kWh
Lo tech $_{R\&I}$	Technical losses in R&I scenario by deploying various measures to reduce technical losses (e.g. balanced network conditions, peak reduction, etc.).	Simulation of total technical losses based on values including technical parameters of components and cables and phase related network load of the observed network including consumer, prosumer and DER.		kWh
Boundary conditions	- Same grid network conditions for BAU and R&I, including same injection and consumption, nominal voltage - Boundary conditions are ensured due to simulation			
KPI Output	**Formula**		**Value**	**Unit**
Potential for reduction in technical losses (LV)	$\Delta\, Lo_{tech}\,\% = \left(\frac{Lo_{tech}\,BAU - Lo_{tech}\,R\&I}{Lo_{tech}\,BAU}\right) X\ 100$	*Positive: Improvement* *Negative: Setback*		%
Validity criteria	**Explanation**		**Value**	**Unit**
E_customer $_{BAU/R\&I}$	Total energy consumed by end customer.	*Equals the amount of total energy measured.*		kWh
E_RES $_{BAU/R\&I}$	Total energy injected locally (low voltage level) by generation units.	*Equals the amount of total energy injected.*		kWh

KPI Name	Potential for reduction in technical losses_Balanced network (LV)		18c	
Definition	Information provided by LV supervisors and smart meters allows calculating technical losses. Simulating reduction of losses is possible thanks to the information provided by LV supervisor regarding unbalancing. The KPI can be calculated by a comparison of percentage reduction of technical losses. This KPI gives an idea of the theoretical limit/maximum value of losses that can be reduced.			
Objective	Quantifying the potential reduction of technical energy losses due to the optimized operation and rearranging of the network with ideal distribution of loads. When loads are unbalanced, technical losses are higher than in the case of perfectly balanced loads. With the information provided by LV supervisors, actual loads in every phase can be known, and technical losses can be simulated for both the current situation and the ideal situation with perfectly balanced loads. The actual reduction of losses is not intended within this KPI, but the potential is identified through simulations.			
Time base	not applicable			
KPI Input	**Explanation**	**Calculation instructions (rules)**	**Value**	**Unit**
Lo tech $_{Unbalanced}$	Technical losses in actual scenario (unbalanced) - equals BAU.	*Total actual technical losses in LV network components obtained from losses estimation algorithms (compare 18a)*		kWh
Lo tech $_{Balanced}$	Technical losses in ideal scenario under optimized conditions (load balancing) - equals R&I.	*Total simulated technical losses in LV network components obtained from simulation in the ideal scenario where loads are perfectly balanced among phases and feeders.*		kWh
Boundary conditions	- Only technical losses can be simulated. - Same grid network conditions for BAU and R&I, including same injection and consumption, nominal voltage - Boundary conditions are ensured due to simulation			
KPI Output	**Formula**		**Value**	**Unit**
Potential for reduction in technical losses_Balanced network (LV)	$\Delta\, Lo_{tech_{balance}}\,\% = \left(\frac{Lo_{tech}\,unbalance - Lo_{tech}balanced}{Lo_{tech}\,unbalanced}\right) x\ 100$	*Positive: Improvement* *Negative: Setback*		%
Validity criteria	**Explanation**		**Value**	**Unit**
E_customer $_{BAU/R\&I}$	Total energy consumed by end customer.	*Equals the amount of total energy measured.*		kWh
E_RES $_{BAU/R\&I}$	Total energy injected locally (low voltage level) by generation units.	*Equals the amount of total energy injected.*		kWh

KPI Name	Amount of non-technical losses identified	Nr	19	
Definition	Identifies the share of total non-technical (commercial) losses compared to total energy consumption (commercially sold). Losses outline electricity injected into a network that are not captured by meters and paid for by users. Specifically, non technical losses are originated by human actions and are mainly electricity theft, but also losses due to poor equipment maintenance, calculation errors and accounting mistakes.			
Objective	Non technical losses can just calculated as the difference between fed-in electricity and consumed electricity including the technical losses. Target is to minimize or ideally eliminate nontechnical losses by identifying them locally and through their origination. Therefore to reduce losses more detailed identification is basic precondition. It is aimed to get more detailed information on LV operation condition. Due to the installation of ICT including the monitoring of substations and lines and due to the roll out of smart meter it is expected that fraud and other sources of non technical losses are detected and therefor identification of source for technical losses is increased.			
Time base	yearly			
KPI Input	**Explanation**	**Calculation instructions (rules)**	**Value**	**Unit**
$Lo_{non\text{-}tech}$ R&I	Total amount of non technical losses in R&I case.	*Value for non-technical losses calculated by algorithms.*		kWh
$E_{customer}$ R&I	Total energy consumed by end customer.	*Equals the amount of total energy measured.*		kWh
Boundary conditions	- Only grid area under evaluation, metering of the injected power in low or medium voltage network - Defined period of time - Eradication of theft and therefor of the most non-technical losses is expected			
KPI Output	**Formula**		**Value**	**Unit**
Amount of non-technical losses identified	$E_{non-tech\ loss}\% = \left(\frac{Lo_{non-tech}\ R\&I}{E_{Customer}\ R\&I}\right) \times 100$			%
Validity criteria	**Explanation**		**Value**	**Unit**
Coverage of remote smart meters	Percentage of customers equipped with remote smart meters. A high coverage is desired as the improves the calculations.		0	%

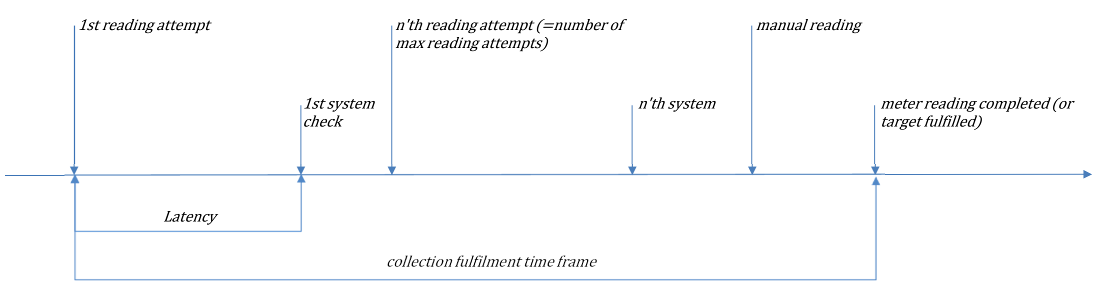
KPI Name	**Percentage cost reduction in IT in comparison with conventional strategies for AMR data concentration & communication**	**Nr**	**21b**	
Definition	Accounts for cost reductions due to virtual solutions in comparison to installations of real components, that however, deliver similar results.			
Objective	It consists in a comparison of data concentration and communication solutions. There is conventional equipment (e.g. PLC connected data concentrators) that will be installed in substations, but this solution becomes too expensive for some locations with scattered customers, where the cost per customer would be very high. Cheaper solutions (e.g. application of virtual concentrator) aim at reducing the cost per customer in areas with dispersed consumption without decreasing required functionalities.			
Time base	yearly			
KPI Input	**Explanation**	**Calculation instructions (rules)**	**Value**	**Unit**
IT_cost_BAU	These are the costs for data concentration & communication solutions for conventional AMR strategy (BAU), e.g. data collection and communication via physical data concentrators using PLC.	*Average cost for data concentration and communication using physical data concentrators. Cost including hardware, software and communication.*		€ / Meter
IT_cost_R&I	These are the costs for data concentration & communication for new solutions for AMR strategy (R&I), e.g. virtual data collection and communication via GPRS, or others.	*Average cost for data concentration and communication using virtual data concentrators. Cost including hardware, software and communication.*		€ / Meter
Number of Meters per Data Concentrator	Number of meters connected per data concentrator.	*This number should be correspond to the number of meters which was used to calculate the total cost (IT_Cost). This number should be equal for virtual as well as physical data concentrator in order to have comparable results.*		#/Data Concentrator
Boundary conditions	- Number of total meters connected to conventional or virtual data concentrator is equal between BAU and R&I case			
KPI Output	**Formula**		**Value**	**Unit**
Percentage cost reduction in IT in comparison with conventional strategies for AMR data concentration & communication	$\Delta\ IT_{cost}\% = (\frac{IT_{cost}\ R\&I - IT_{cost}\ BAU}{IT_{cost}\ BAU})$ X 100	*Positive: Setback* *Negative: Improvement*		%
Validity criteria	**Explanation**		**Value**	**Unit**
Max Number of meters_DC_R&I	Maximum number of meters connected per data concentrator (within the demo side).	*These information are needed in order to assess and evaluate the KPI for business case analysis.*		#/Data Concentrator
Min Number of meters_DC_R&I	Minimal number of meters connected per data concentrator (within the demo side).	*These information are needed in order to assess and evaluate the KPI for business case analysis.*		#/Data Concentrator
Max Number of meters_Virt_R&I	Maximum number of meters connected per virtual data concentrator (within the demo side).	*These information are needed in order to assess and evaluate the KPI for business case analysis.*		#/Data Concentrator
Min Number of meters_Virt_R&I	Minimal number of meters connected per virtual data concentrator (within the demo side).	*These information are needed in order to assess and evaluate the KPI for business case analysis.*		#/Data Concentrator

KPI Name	Reduced delays for new connections	Nr	24	
Definition	For planning and permission of new connections to the grid including DER there are calculations necessary regarding grid capacity to guarantee grid stability. These calculations are quite essential in general while there is no measured values of the grid conditions i.e. the load, or the peak load available.			
Objective	The time to calculate the actual and predictive grid condition shall be shortened when there are measured values available for the analyzed grid lines.			
Time base	monthly			
KPI Input	**Explanation**	**Calculation instructions (rules)**	**Value**	**Unit**
Quote_Time_BAU	The time taken to complete the planning requirements for a new connection request (BAU)	*∑ of the average number of days required to complete the connection planning*		Days
Quote_Time_R&I	The time taken to complete the planning requirements for a new connection request (R&I)	*∑ of the average number of days required to complete the connection planning*		Days
Boundary conditions	Process begin and end: - Process begin equals the arrival of the application at the network planning center - Process end equals the completion of the planning request, represented by sending the offer to the customer. Time related to DSO internal processes, customer influenced time starting receiving proposal for the new connection is not included.			
KPI Output	**Formula**		**Value**	**Unit**
Reduced delays for new connections	$\Delta\, Quote\ time\ \% = \left(\frac{Quote\ Time_{BAU} - Quote\ Time_{R\&I}}{Quote\ Time_{BAU}}\right) x\ 100$	*Positive: Improvement* *Negative: Setback*		%
Validity criteria	**Explanation**		**Value**	**Unit**
Number of planning	Number of planning processes included in determination of average time.			#

KPI Name	Number of sensors to achieve the (sub)functionality	Nr	25	
Definition	Minimal number of required sensors in a defined demo site to achieve all information to apply a defined functionality in grid operation. The number of sensors has to be representative with reference to the installed electrical equipment.			
Objective	Identification of the minimum level of sensors to monitor and control the distribution grid with respect to special defined functionalities.			
Time base	yearly			
KPI Input	**Explanation**	**Calculation instructions (rules)**	**Value**	**Unit**
Total number of sensors - R&I	Count of all remote sensor devices deployed on the demo site network	*∑ of ALL sensor devices deployed on the demo site network (R&I situation)*		#
Total number of secondary substations	Count all secondary substations within the demo site network	*∑ of ALL substations within the demo site network (R&I situation)*		#
Boundary conditions	- Devices that have been deployed on the demo site network only - Number of secondary substations should equal the number available from Project Characteristics			
KPI Output	**Formula**		**Value**	**Unit**
Number of sensors to achieve the (sub)functionality	$Sensor\ density = \frac{total\ number\ of\ sensors}{total\ number\ of\ secondary\ substations}$	*Targets to be set by DSO depending on local conditions. Requires feedback by leaders / learners*		#/SS
Validity criteria	**Explanation**		**Value**	**Unit**
Sensors SS-level	Number of sensors required on secondary substation level.	*Total number of sensors deployed at secondary substation level (for the relevant grid grid area) divided by total number of secondary substations.*		#
Sensors feeder-level	Number of sensors required at feeder level per secondary substation.	*Total number of sensors deployed at feeders (for the relevant grid grid area) divided by total number of secondary substations.*		#
Sensors end customer-level	Number of sensors required at customer level per secondary substation area.	*Total number of sensors deployed at end customers (for the relevant grid grid area) divided by total number of secondary substations.*		#

KPI Name	Percentage of consumers being metered automatically	Nr	26	
Definition	Quota of consumers with smart meters (SM) (i.e. meters that allow for remote reading of measurements (kWh, etc.)), that were read automatically, i.e. not requiring manual readings on-site / field work in order to provide the required measurement or function. Whereas smart meter is defined as installed and remote read meters that are connected to the communication network and able to be remotely accessed and read. This may also include meters at larger customer sites, able to registering load response measurement. Manual reading becomes necessary if certain time limits are exceeded without successful communication between meter and collection system, due to malfunction of hardware, software or communication. This KPI is limited to measurement readings, excluding alarms/signals as well as other functions like connecting or disconnecting.			
Objective	To evaluate the percentage of smart meters that need manual reading due to malfunction and to provide a quality criteria for the smart metering infrastructure.			
Time base	monthly			
KPI Input	**Explanation**	**Calculation instructions (rules)**	**Value**	**Unit**
#_SM_R&I	Number of smart meters that are connected to the communication network and able to be remotely accessed and read in the R&I scenario.	*Includes all smart meters installed in the field. Count number of meters, not meter points o.s.*		#
#_SM_automatically read_R&I	Total number of smart meters that provided the required measurement or function within the time limits and without on-site / manual assistance by field staff in the R&I scenario.	*Includes all smart meters connected to a remote meter reading system by ICT and read out successfully within defined time limit as input to further billing o.s. processes. Count number of meters, not meter points o.s.*		#
Boundary conditions	- Within the observed area of the demo site - At all voltage levels (LV; MV) but excludes transformer level (MV/LV)			
KPI Output	**Formula**		**Value**	**Unit**
Percentage of consumers being metered automatically	Quota % $= \frac{\sum Smart\ Meter\ automatically\ read\ R\&I}{\sum Smart\ meter\ R\&I}\ x\ 100$	*Targets to be set by DSOs. Eventually, feedback by leaders / learners is required.*		%
Validity criteria	**Explanation**		**Value**	**Unit**
#_SM_BAU	Number of smart meters that are connected to the communication network and able to be remotely accessed and read in the BAU scenario.	*In those cases where smart meters were about to be implemented by the Use Case, this value is zero. Otherwise, the value equals the total sum of smart meters in the evaluated area.*		#
#_SM_automatically read_BAU	Total number of smart meters that provided the required measurement or function within the time limits and without on-site / manual assistance by field staff in the BAU scenario.	*In those cases where automated readings were about to be implemented by the Use Case, this value is zero. Otherwise, the value equals the total sum of smart meters that were read automatically and in time.*		#
Latency	The longer the latency time the higher the KPI (ceteris paribus).	*Round-trip latency (e.g. collecting systems calls data concentrator to deliver registered data, data sent by data concentrator is received by collecting system)*		seconds
Number of max collecting attempts	The higher the number of maximum attempts the higher the KPI (ceteris paribus).	*The maximum attempts equals the number of collecting attempts before manual readings would be initiated.*		# per measurement
Collection fulfilment time frame	Time frame in which all meter readings (or a certain percentage of it / target) are available. The longer the time frame the higher the KPI (see picture below).	*This includes the meter readings collected by the collecting system as well as manually.*		days

Picture: Validity criteria - collection fulfilment time frame



KPI Name	Change in voltage variation on medium voltage level	Nr	27a	
Definition	Variation of voltage (voltage variation - VV) is the rated value of voltage between the maximum value and the minimum value in a certain period and a certain point in the grid. This KPI expresses the change in voltage variation due to active control within the network section.			
Objective	This KPI requires solutions that include active control of load within the network section, which has direct influence on the voltage level. It is expected that due to the implementation of control measures the voltage variation will be reduced.			
Time base	weekly			

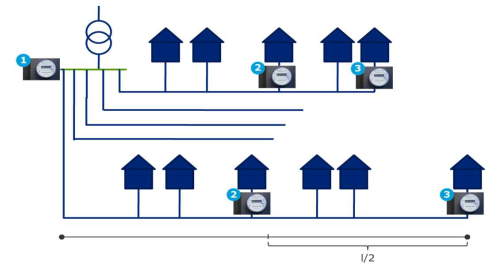
KPI Input	Explanation	Calculation instructions (rules)	Value	Unit
VV BAU	Variation of voltage in non-ICT scenario with respect to currently connected generation. If there was no voltage sensor available and thus no measurements in the BAU case, the VV BAU shall reflect the measured values without active control in the network section.	*The voltage is measured at the busbar of the primary substation belonging to the grid where the novel solution is applied. The maximum and minimum voltage values of the measuring period have to be identified. The value VV BAU equals the maximum voltage minus the minimum.*		kV
VV R&I	Variation of voltage when ICT solution is applied (i.e. active control) with respect to currently connected generation.	*Same procedure as described for the BAU case.*		kV
Boundary conditions	- Based on the execution of several trials the calculation should meet following conditions to ensure a valid BAU vs. R&I comparison: 1. The measuring period is one week to reflect the behavior of grid (generation, consumption) 2. The measuring cycle shall be 10 min, max. 15 minutes. 3. The weather conditions need to be comparable for BAU and R&I to ensure similar situations for the power generation (e.g. PV) and consumption (e.g. heating, cooling) 4. The measuring should be performed at least in 3 consecutive weeks to ensure consistency. - Without harming the thermal, current limit of the grid section or cable - Allowed voltage variation in accordance to EN50160 - No significant changes to generation/consumptions are assumed (newly connected to the grid), however, in case significant changes are expected, measurements should be performed before and after the change in order to evaluate the impact accordingly.			

KPI Output	Formula		Value	Unit
Change in voltage variation on medium voltage level	$\Delta VV\ \% = \frac{VV_{BAU} - VV_{R\&I}}{VV_{BAU}}$ x 100	*Positive: Improvement* *Negative: Setback*		%

Validity criteria	Explanation		Value	Unit
Connected DER capacity_BAU	It is assumed that due to a higher level of volatile DER capacity the VV tends to be higher.	*Sum of all connected volatile DER capacity Ppeak (PV, Wind) within the observed network section (connected to the low voltage lines below the selected primary substation) and period.*		MW
Connected load_BAU	It is assumed that due to increased consumers connected to the network section, the VV tends to be higher.	*Sum of all connected loads (max. connected load and customer) within the observed network section (connected to the low voltage lines below selected primary substation) and period.*		MW
Connected DER capacity_R&I	It is assumed that due to a higher level of volatile DER capacity the VV tends to be higher.	*Sum of all connected volatile DER capacity Ppeak (PV, Wind) within the observed network section (connected to the low voltage lines below the selected primary substation) and period.*		MW
Connected load_R&I	It is assumed that due to increased consumers connected to the network section, the VV tends to be higher.	*Sum of all connected loads (max. connected load and customer) within the observed network section (connected to the low voltage lines below selected primary substation) and period.*		MW

KPI Name	Change in voltage variation on low voltage level	Nr	27b	
Definition	Variation of voltage (voltage variation - VV) is the rated value of voltage between the maximum value and the minimum value in a certain period and a certain network section. This KPI defines the change of voltage variation, within the network section where the intelligent solution is applied, as arithmetic average of various measuring points within this network section. In order to gather a good picture of the change in voltage variation within the network section, the voltage should be measured at least at the busbar of the secondary substation (1) belonging to the grid where the novel solution is applied, as well as at two more points at each line (outgoing from the 2nd substation) - at the most farthest (from the substation) customer (3) and at the customer in the middle (2). The middle is defined as the closest customer to l/2, where l is the length of the corresponding line (see picture).			
Objective	This KPI requires solutions that include active control of load within the network section, which has direct influence on the voltage level. It is expected that due to the implementation of control measures the voltage variation will be reduced within the network section.			
Time base	weekly			
KPI Input	**Explanation**	**Calculation instructions (rules)**	**Value**	**Unit**
VV BAU (without control)_2nd substation	Variation of voltage in a non-ICT scenario with respect to currently connected generation. As there is in general no measurements of voltage on the low voltage level, the VV BAU shall reflect the measured values without active control in the network section.	*The maximum and minimum voltage values at the secondary substation within the measuring period have to be identified. The voltage variation (VV) equals the maximum voltage minus the minimum voltage.*		V
VV BAU (without control)_middle		*The maximum and minimum voltage values of each measuring point at the middle of each line have to be identified as well as the voltage variation, which equals the difference of maximum and minimum voltage for each measuring point. If there is more than one line, the value that has to be reported here, shall be the maximum voltage variation of all measuring points (middle).*		V
VV BAU (without control)_end		*Same procedure as described above, but for the measuring points at the end (or farthest away from measuring point 1) of each line.*		V
VV R&I (with control)_2nd substation	Variation of voltage when ICT solution is applied, i.e. active control, with respect to currently connected generation.	*Same procedure as described for the BAU case.*		V
VV R&I (with control)_middle		*Same procedure as described above, however, the measuring point with the highest VV is not necessarily equal with the measuring point under BAU, and can be placed at a different line.*		V
VV R&I (with control)_end		*Same procedure as described above, however, the measuring point with the highest VV is not necessarily equal with the measuring point under BAU, and can be placed at a different line.*		V
Boundary conditions	- Based on the execution of several trials the calculation should meet following conditions to ensure a valid BAU vs. R&I comparison: 1. The measuring period is one week to reflect the behavior of grid (generation, consumption) 2. The measuring cycle shall be 10 min, max. 15 minutes. 3. The weather conditions need to be comparable for BAU and R&I to ensure similar situations for the power generation (e.g. PV) and consumption (e.g. heating, cooling) 4. The measuring should be performed at least in 3 consecutive weeks to ensure consistency. - Without harming the thermal, current limit of the grid section or cable - Allowed voltage variation in accordance to EN50160 - No significant changes to generation/consumptions are assumed (newly connected to the grid), however, in case significant changes are expected, measurements should be performed before and after the change in order to evaluate the impact accordingly.			
KPI Output	**Formula**		**Value**	**Unit**
Change in voltage variation on low voltage level	$\Delta VV\ \% = \frac{\Delta\, VV\ (2nd\ substation)\ \% + \Delta\, VV\ (middle)\ \% + \Delta\, VV\ (end) \%}{3}$ whereas $\Delta VV(\ldots)\ \% = \frac{VV_{BAU} - VV_{R\&I}}{VV_{BAU}} \text{ x } 100$	*Positive: Improvement* *Negative: Setback*		%
Validity criteria	**Explanation**		**Value**	**Unit**
Connected DER capacity_BAU	It is assumed that due to a higher level of volatile DER capacity the VV tends to be higher.	*Sum of all connected volatile DER capacity Ppeak (PV, Wind) within the observed network section (connected to the low voltage lines below the selected secondary substation) and period.*		kW
Connected load_BAU	It is assumed that due to increased consumers connected to the network section, the VV tends to be higher.	*Sum of all connected loads (max. connected load and customer) within the observed network section (connected to the low voltage lines below selected secondary substation) and period.*		kW
Connected DER capacity_R&I	It is assumed that due to a higher level of volatile DER capacity the VV tends to be higher.	*Sum of all connected volatile DER capacity Ppeak (PV, Wind) within the observed network section (connected to the low voltage lines below the selected secondary substation) and period.*		kW
Connected load_R&I	It is assumed that due to increased consumers connected to the network section, the VV tends to be higher.	*Sum of all connected loads (max. connected load and customer) within the observed network section (connected to the low voltage lines below selected secondary substation) and period.*		kW
Change_max VV_middle	This shall cover the case, that the measuring point, where the maximum VV occurred differs between BAU and R&I case. We believe this may occur frequently but does not harm the calculation method.	*If the measuring point of the maximum VV is not equal (different lines) between BAU and R&I enter "yes", if equal enter "no".*		-
Change_max VV_end	This shall cover the case, that the measuring point, where the maximum VV occurred differs between BAU and R&I case. We believe this may occur frequently but does not harm the calculation method.	*If the measuring point of the maximum VV is not equal (different lines) between BAU and R&I enter "yes", if equal enter "no".*		-

Picture: Definition of measuring points



KPI Name	Better support of network planning	Nr	28	
Definition	Both enhanced monitoring and observability of network components in the low voltage levels and using the smart metering infrastructure provide the planning departments with detailed information of the grid and therefore provides the possibility of reducing planning time.			
Objective	It is expected that for instance on site visits and grid capacity calculations can be reduced because of available information from the monitoring.			
Time base	not applicable			
KPI Input	**Explanation**	**Calculation instructions (rules)**	**Value**	**Unit**
Planning time for building or reinforcement projects decreases.	It is not possible to give an exact definition of the inputs relating to this KPI. The KPI is qualitative rather than quantitative	To be evaluate by questionnaire and discussions (workshops).	-	-
Boundary conditions				
KPI Output	**Formula**		**Value**	**Unit**
Better support of network planning	Evaluation by questionnaire. To be observed within workshop in work package 8.	To be evaluate by questionnaire and discussions (workshops).	-	-
Validity criteria	**Explanation**		**Value**	**Unit**

Insert the data for the arrays relevant to your Use Case; leave the others blank

Marked as red if numbers do not cumulate to 100%

							Cost Driver CAPEX			Cost Driver Communication			Cost KPI [€]
N°	Zone	Domain	Total investment cost [€]	HW [%]	SW [%]	C [%]	Type	Value	Unit	Type	Value	Unit	CAPEX
KPI 1	Enterprise	Distribution											#DIV/0!
KPI 2	Operation	Distribution											#DIV/0!
KPI 3	Station	Distribution											#DIV/0!
KPI 4	Field	Distribution											#DIV/0!
KPI 5	Field	DER											#DIV/0!
KPI 6	Field	Customer											#DIV/0!
KPI 7	Process	Distribution											#DIV/0!
KPI 8	Process	DER											#DIV/0!
KPI 9	Process	Customer											#DIV/0!

DISCERN

KPI - Sub-functionality - Demo site - Role Matrix

This matrix shows the **assigned KPI per sub-functionality and** per **leader/learner**.
The sub-functionality is provided in column A, relevant KPIs in row 8 and 9.
Each leader/learner has a separate row per sub-functionality.

*Use Cases are identified with the following path: DISCERN_DSO_Role_Sub-functionalityID, with "DSO" being the abbreviation of the DSO that describes the Use Case (IBRD, VRD, UFD, RWE, SSEPD), "Role" being Leader or Learner, and "Sub-functionalityID" being the identifier of the corresponding sub-functionality, (e.g.: B6, B7bd, etc.). Simulation: KPIs provided by simulations apply slightly different identification: DSO is exchanged by the name of the simulation party (CIRCE, KTH), and role is exchanged by simulation.

	Increased Hosting Capacity (network capacity)	Improvement SAIDI (security of supply)	Improvement ASIDI (security of supply)	Improvement voltage quality (monitoring)	Reduction in time required for fault awareness, localization and isolation (service quality)	Amount of load capacity participating in Demand Response (DR)	Peak load reduction	Percentage reduction in complaints of customers	Availability of intelligent network components	Success index in meter reading	Amount of technical losses identified (LV)	Potential for reduction in technical losses (LV)	Potential for reduction in technical losses_Balanced network (LV)	Amount of non-technical losses identified	Percentage cost reduction in IT in comparison with conventional strategies for AMR data concentration & communication	Reduced delays for new connections	Number of sensors to achieve the (sub)functionality	Percentage of consumers being metered automatically	Change in voltage variation on medium voltage level	Change in voltage variation on low voltage level	Better support of network planning
Use Case ID* \ KPI ID	**01**	**03a**	**03b**	**05**	**06**	**07**	**08**	**14**	**17a**	**17b**	**18a**	**18b**	**18c**	**19**	**21b**	**24**	**25**	**26**	**27a**	**27b**	**28**
DISCERN_IBDR_Leader_B6			3b																		*28*
DISCERN_RWE_Leader_B6	1								17a										27a		
DISCERN_UFD_Leader_B6			3b		6																
DISCERN_VTF_Learner_B6		3a			6																
DISCERN_SSEPD_Listener_B6																					
DISCERN_CIRCE_Simulation_B6	1	3a	3b		6																
DISCERN_KTH_Simulation_B6									17a												
DISCERN_SSEPD_Leader_B7bd	1															24	25				
DISCERN_RWE_Leader_B7bd																	25			27b	
DISCERN_UFD_Leader_B7bd								14					18c								
DISCERN_IBDR_Learner_B7bd													18c								
DISCERN_KTH_Simulation_B7bd	1												18c				25				
DISCERN_VTF_Leader_B9a										17b								*26*			
DISCERN_UFD_Learner_B9a								14		17b					21b			26			
DISCERN_KTH_Simulation_B9a									17a	17b					21b						
DISCERN_IBDR_Leader_B9b											18a		18c	19							
DISCERN_UFD_Learner_B9b											18a		18c	19							
DISCERN_SSEPD_Listener_B9b																					
DISCERN_CIRCE_Simulation_B9b											18a		18c	19							
DISCERN_CIRCE_Simulation_C12b	1			5		7	8					18b									
DISCERN_KTH_Simulation_C12b																					
DISCERN_all DSO_Listeners_C12b																					
DISCERN_CIRCE_Simulation_C12c	1			5		7	8					18b									
DISCERN_KTH_Simulation_C12c																					

Index	Glossary	Explanation
BAU	Business as usual	situation before implementation of technical solution, equals conventional situation, e.g. current state of technology
R&I	Research & Innovation	situation after implementation of technical solution, equals pilot state of technology
DG	Distributed Generation	energy generation plants in LV and MV network, e.g. wind, PV, biomass
DER	Distributed Energy Resources	energy generation plants in LV and MV network, e.g. wind, PV, biomass
DR	Demand response	demand sources that offer flexibilities and are integrated within the public grid
HW	Hardware	refers to the hardware part of a system
SW	Software	refers to the software part of a system
C	Communication	refers to the communication part of a system
AMR	Automated Meter Reading	automatically collecting consumption, diagnostic, and status data from energy metering devices