IDE4L
ideal grid for all

Third External DISCERN Workshop

The role of KPIs in evaluating Smart Grid Projects: the IDE4L experience

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COOPERATION

Agenda

- The IDE4L Consortium
- Expected Outcomes
- Demonstration Approach
  - Use Cases (UCs) mapping
  - KPI Definition and Calculation Methodology

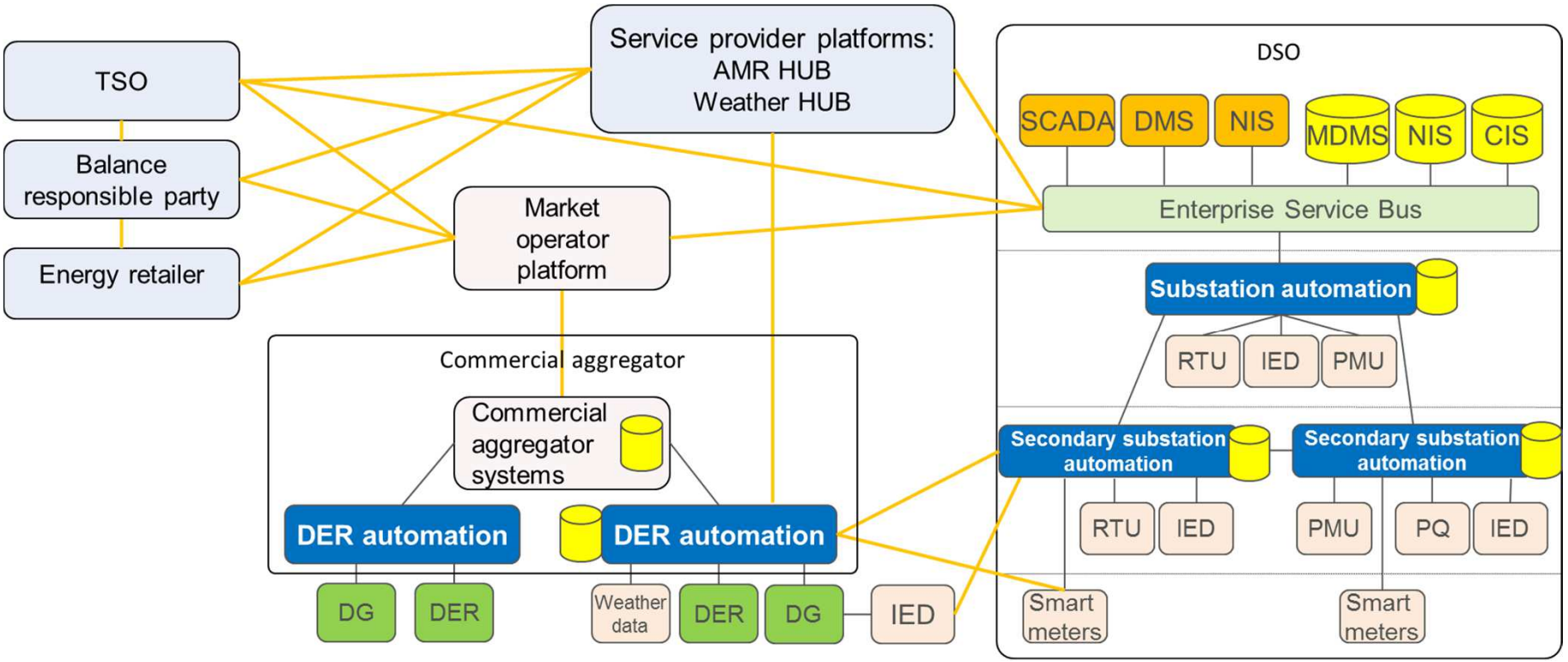
Basic facts

- Co-funded by European Commission
- Duration: 09/2013 - 08/2016
- Budget: 8 M€

IDE4L Consortium

- A2A Reti Elettriche SpA (Italy)
- Unión Fenosa Distribución (Spain)
- Østkraft Holding A/S (Denmark)
- Telvent (Spain)
- Danish Energy Association (Denmark)
- Tampere University of Technology (Finland)
- Technical University of Denmark (Denmark)
- RWTH Aachen University (Germany)
- University Carlos III de Madrid (Spain)
- Kungliga Tekniska Högskola (Sweden)
- Catalonia Institute for Energy Research (Spain)

IDE4L Automation Architecture



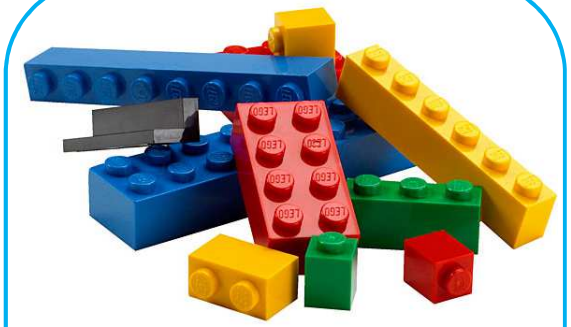
Expected outcomes (1/2)

- **Planning tools** to design active DN and to evaluate costs and benefits related to the concepts and technical solutions developed within the project
- **Advanced automation system** to extend monitoring and control functions within DNs
  - DG hosting capacity increase
  - Management of fast changing conditions and integration of large number of DERs
  - Standards, such as IEC 61850, to allow reusability and general applicability to other EU scenarios
  - Aggregation of information from small-scale DERs and flexibility services for DN management

Expected outcomes (2/2)

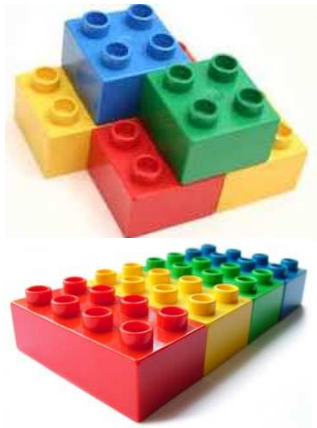
- **Automation infrastructure to enhance DN reliability**
  - Automatic fault location, isolation and supply restoration (FLISR) algorithm developed and demonstrated to improve the DN reliability
  - Design of a universal controller to enable flexible operations of microgrids, such as smooth transition from grid-connected mode to islanded operations mode while guaranteeing adequate quality of service

Demonstration working approach: three-steps testing



Building-blocks, e.g.:

1. Algorithms
2. TLV' devices
3. Third party devices
4. Third party software



Groups of building-blocks, e.g.:

1. State estimation algorithm within a PC connected to an RTU via a 61850 interface

Use cases, e.g.:

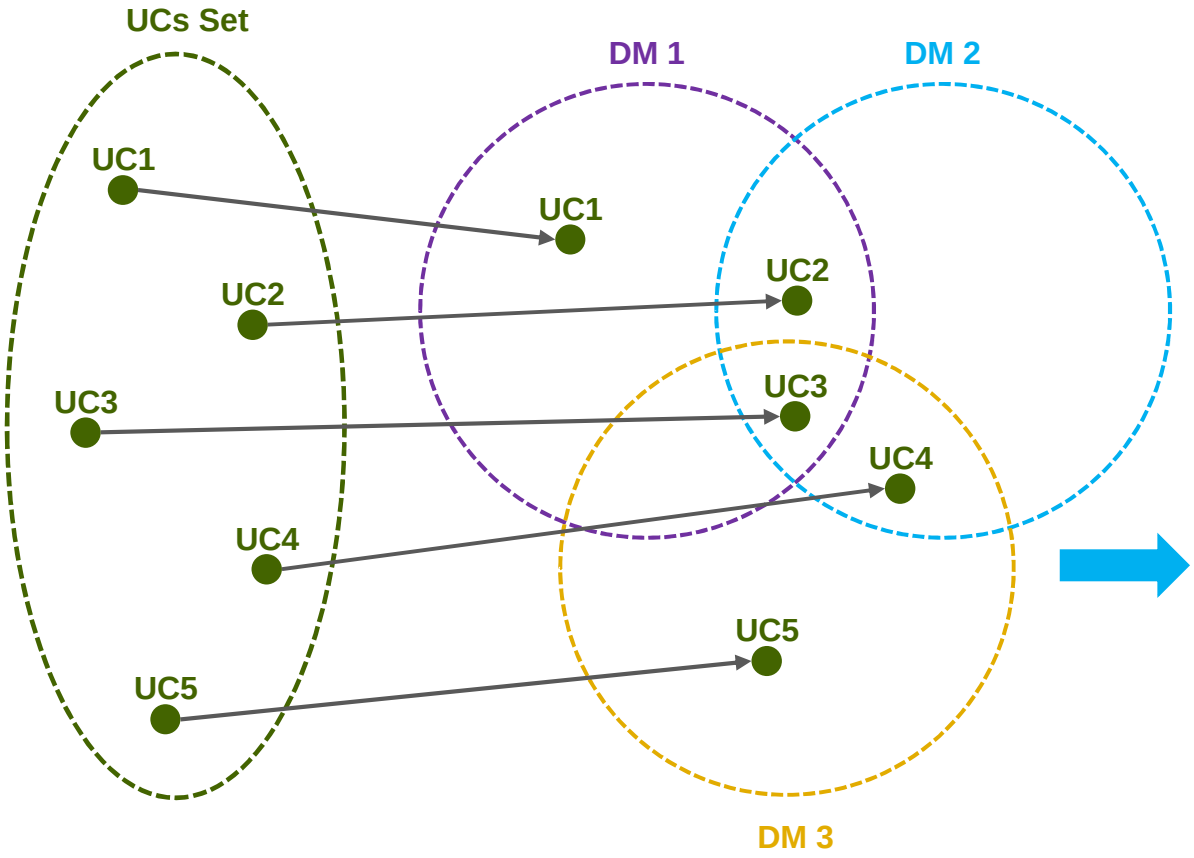
1. Monitoring of LV grid (PC + state estimation + RTU + Smart meters + interfaces)

1st Dev. lab **2nd Integration lab** **3rd Demo**

Demonstration working approach: Demo Sites

- Lab Demo Site
- Field Demo Site

Demonstration working approach: to validate the IDE4L architecture by applying and verifying a set of UCs through demonstrators



IDE4L Validation

	DM1	DM2	DM3	TOT
UC1	V			V
UC2	V	X		X
UC3	V	V	V	V
UC4		V	V	V
UC5			V	V

Demonstration working approach: to validate the IDE4L architecture by applying and verifying a set of UCs through demonstrators

V or X?

IDE4L Validation

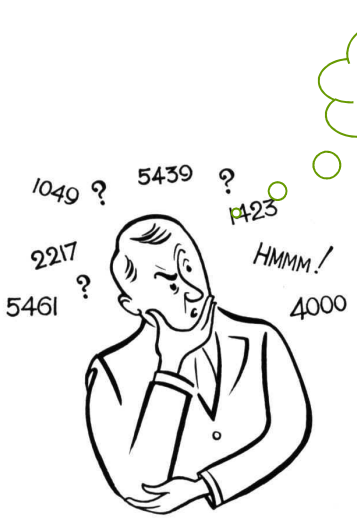
	DM1	DM2	DM3	TOT
UC1	V			V
UC2	V	X		X
UC3	V	V	V	V
UC4		V	V	V
UC5			V	V

Demonstration working approach: validate the IDE4L architecture by applying and verifying a set of UCs through demonstrators

How to say that a UC has been verified?

- What measures?
- Which evaluation procedure?
- Which kind of analysis?
- …

IDE4L Validation



	DM1	DM2	DM3	TOT
UC1	V			V
UC2	V	X		X
UC3	V	V	V	V
UC4		V	V	V
UC5			V	V

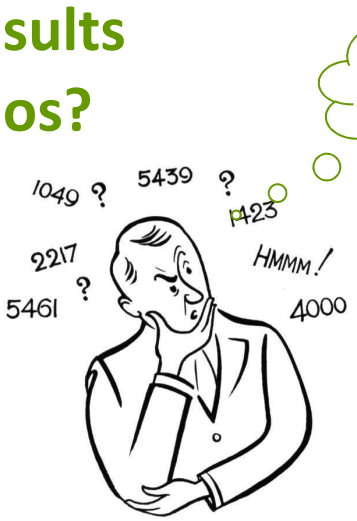
Demonstration working approach: validate the IDE4L architecture by applying and verifying a set of UCs through demonstrators

How to say that a UC has been verified?

- What measures?
- Which evaluation procedure?
- Which kind of analysis?
- …

How to compare results from different demos?

- Same measures?
- Same units?
- Same time scales?
- …

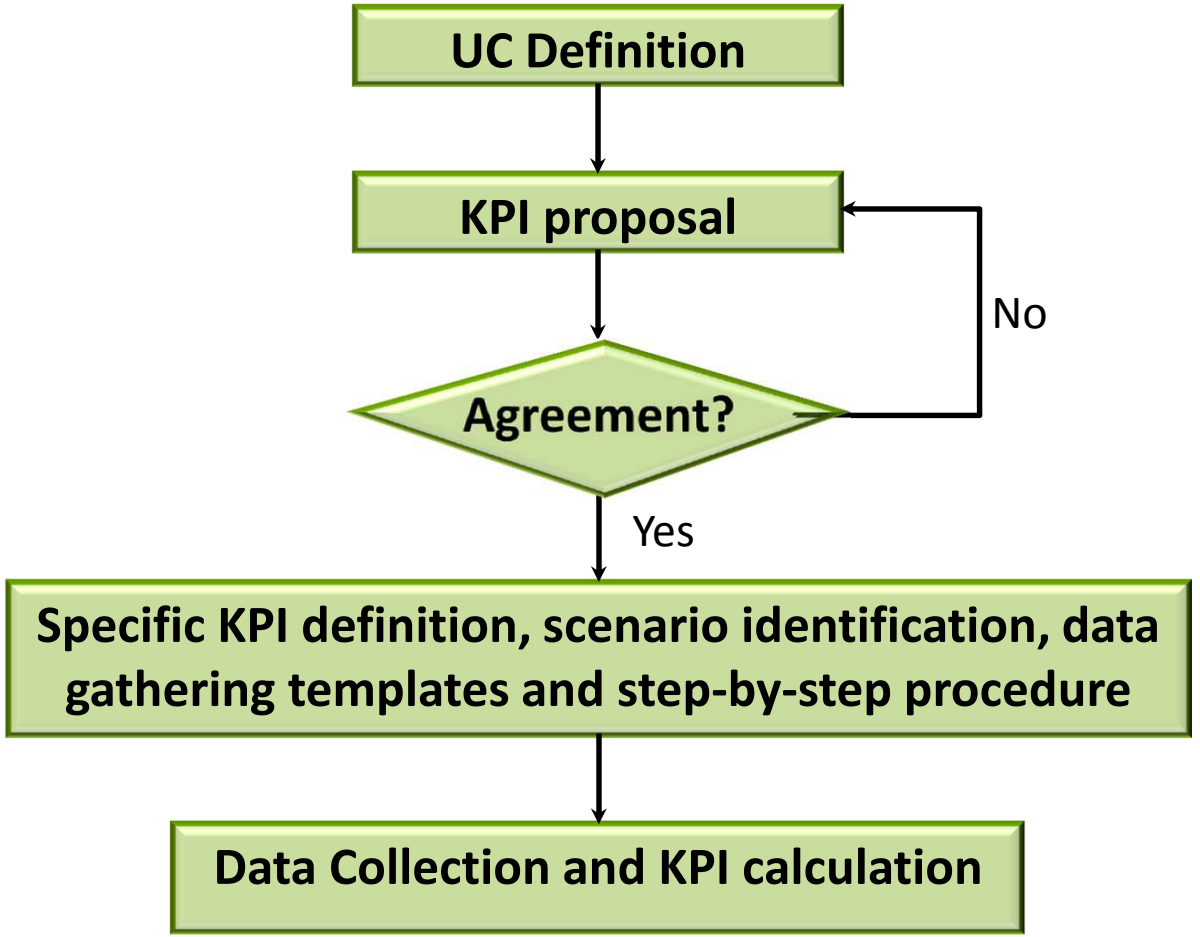


V or X?

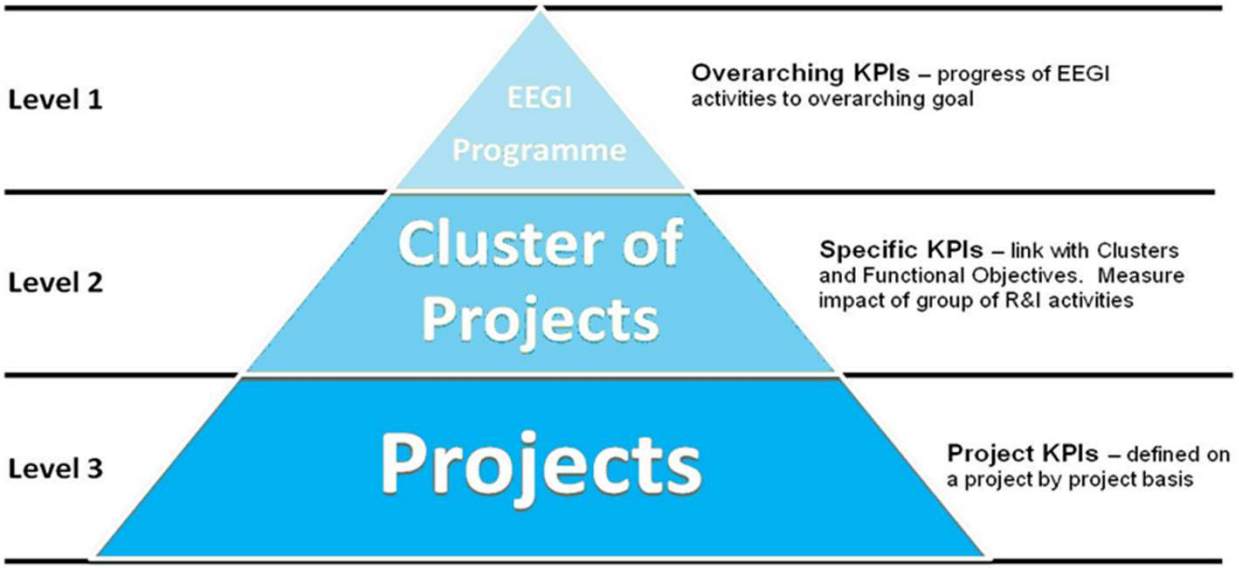
IDE4L Validation

	DM1	DM2	DM3	TOT
UC1	V			V
UC2	V	X		X
UC3	V	V	V	V
UC4		V	V	V
UC5			V	V

Demonstration working approach: KPIs definition and calculation methodology



Demonstration working approach: EEGI Framework reference



Level 1: "Overarching KPIs": set of indicators which trace clear progress brought by EEGI activities towards its overarching goal

Level 2: "Specific KPIs": set of indicators to quantify the expected impacts of a group of R&I activities in view of meeting the R&I roadmap overarching goal

Level 3: "Project KPIs": set of indicators proposed by each R&I project in view of detailing further the contribution of each R&I project to level 2 KPIs

Demonstration working approach: EEGI Framework reference

- **Level 1: "Overarching KPIs"**
  - A.1 Increased network capacity
  - A.2 Increased system flexibility

- **Level 2: "Specific KPIs"**
  - B.1 Increased RES & DER hosting capacity (DSO+TSO)
  - B.2 Reduced energy curtailment of RES and DER (DSO+TSO)
  - B.3 Power Quality and Quality of Supply (DSO+TSO)
  - B.4 Extended asset lifetime (DSO+TSO)
  - B.5 Increased flexibility from energy players (DSO+TSO)
  - B.6 Improved competitiveness of the electricity market (DSO+TSO)
  - B.7 Increased hosting capacity for Electric Vehicles and other new loads (DSO)

- **Level 3: "Project KPIs"**

Demonstration working approach: KPI templates

- **Measured KPIs**
- **Theoretical KPIs**

KPI template

- General and specific description of the magnitude to be measured
- Main objective
- Project sites where it is measured
- Connection with other KPIs and UCs
- Magnitude formula
- Formula of the KPI as a difference (improvement or worsening) between scenarios
- Step-by-step methodology
- Required data and collection frequency
- Definition of scenarios (Baseline, BaU, Smart Grid) where the magnitude must be measured

Demonstration working approach: General and Detailed KPI templates

BASIC KPI INFORMATION			
KPI Name		KPI ID	
Main Objective			
KPI Description			
Project sites to be calculated	Development laboratory ☐	Demonstration laboratory ☐	Field demonstrator ☐
KPI SCENARIOS			
Scenarios to be measured	BASELINE ☐	BUSINESS AS USUAL (BaU) ☐	SMART GRID ☐
GENERAL COMMENTS			

BASIC KPI INFORMATION			
KPI Name		KPI ID	
Main Objective			
KPI Description			
KPI Formula			
Unit of measurement			
Connection / Link with other relevant defined KPIs and Use Cases			
Project sites to be calculated	Development laboratory ☐	Demonstration laboratory ☐	Field demonstrator ☐

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	Step	Responsible

KPI SCENARIOS			
Scenarios to be measured	BASELINE ☐	BUSINESS AS USUAL (BaU) ☐	SMART GRID ☐

KPI DATA COLLECTION							
Data	Data ID	Methodology for data collection	Source/Tools /Instruments for Data collection	Location of Data collection	Frequency of data collection	Minimum monitoring period	Data collection responsible

KPI BASELINE			
Source of Baseline Condition	LITERATURE VALUES ☐	COMPANY HISTORICAL VALUES ☐	VALUES MEASURED AT START OF PROJECT ☐
Details of Baseline			
Responsible (Name, Company) for Baseline			

GENERAL COMMENTS

Demonstration working approach: KPI results template description

- **Based on demo measurements:** both operation conditions and the mechanism used to determine the KPI value are introduced under the template field *KPI Conditions Where Calculated* and *Evaluation*
- **Based on historical data:** if no demo measurements available due to Demo constraints but historical data available
- **Based on theoretical computations:** based on the use of technical data and mathematical equations

BASIC KPI INFORMATION			
KPI Name		KPI ID	
Main Objective			
KPI Description			
KPI Formula			
Unit of measurement			
Connection / Link with other relevant defined KPIs and Use Cases			
Project sites where calculated	Development laboratory ☐	Demonstration laboratory ☐	Field demonstrator ☐
KPI CONDITIONS WHERE CALCULATED			
KPI SCENARIOS			
Scenarios to be measured	BASELINE ☐	BUSINESS AS USUAL (BaU) ☐	SMART GRID ☐
KPI RESULT			
EVALUATION AND INTERPRETATION			

Demonstration working approach: KPI to EEGI mapping (1/5)

IDE4L KPIs	B.1	B.2	B.3.1	B.3.2	B.3.3	B.3.4	B.4	B.5.1	B.5.2	B.6.1	B.6.2	B.6.3	B.7	Note
Current Monitoring Data Volume														No direct match with EEGI KPIs. Monitoring system has not a direct impact on a Business Case but it is required because it enables other Use Cases. So that also the related KPIs can't be classified as index of improved performances in terms of direct business
Current Monitoring Granularity														
Powers Monitoring Data Volume														
Powers Monitoring Granularity														
Voltage Monitoring Data Volume														
Voltage Monitoring Granularity														
Real-time LV Network State Estimation	X				X								X	
Real-time MV Network State Estimation	X				X									
Voltage stability of the electricity system														No direct match EEGI L2 KPIs
TSO´s visibility of distribution network								X	X					
Evaluation of IEC 61850-90-5 library														No direct match EEGI L2 KPIs
Success index in meter reading														No direct match EGI L2 KPIs
LV load/generation forecaster	X												X	

Demonstration working approach: KPI to EEGI mapping (2/5)

IDE4L KPIs	B.1	B.2	B.3.1	B.3.2	B.3.3	B.3.4	B.4	B.5.1	B.5.2	B.6.1	B.6.2	B.6.3	B.7	Note
MV load/generation forecaster	X												X	
LV state forecaster	X				X								X	
MV state forecaster	X				X								X	
Network Description Update														No direct match with EEGI L2 KPIs. System update (needed to maximize other UCs performance) does not have a direct impact on the main business
Protection Configuration Update														
Control Centre Tertiary Power Control - Technical and Economic Parameters	X	X			X								X	
Control Center Tertiary Power Control - Operational Parameters	X	X			X								X	
Control Center Tertiary Power Control - Technical Safety Parameters	X	X			X								X	
LV Network Power Control - Technical and Economic Parameters	X	X			X								X	
LV Network Power Control - Operational Parameters	X	X			X								X	

Demonstration working approach: KPI to EEGI mapping (3/5)

IDE4L KPIs	B.1	B.2	B.3.1	B.3.2	B.3.3	B.3.4	B.4	B.5.1	B.5.2	B.6.1	B.6.2	B.6.3	B.7	Note
LV Network Power Control - Technical Safety Parameters	X	X			X								X	
MV Network Power Control - Technical and Economic Parameters	X	X			X								X	
MV Network Power Control - Operational Parameters	X	X			X								X	
MV Network Power Control - Technical Safety Parameters	X	X			X								X	
SAIDI			X			X								Do not follow the common definition of SAIDI but they provide a similar evaluation Time needed for FLI is related to averaged interruption time.
SAIFI				X	X									Do not follow the common SAIFI definition of but they provide a similar evaluation. Number of voltage line violations is related to averaged interruption frequency.

Demonstration working approach: KPI to EEGI mapping (4/5)

IDE4L KPIs	B.1	B.2	B.3.1	B.3.2	B.3.3	B.3.4	B.4	B.5.1	B.5.2	B.6.1	B.6.2	B.6.3	B.7	Note
Breaker energized operations							X							Reduction of breaker operations in fault condition extends asset lifetime
Interconnection Switch														No direct match EEGI L2 KPIs
Flicker mitigation MV/LV active grid					X									Flicker mitigation improves the fulfill of the nominal voltage requirements
Expansion Planning Scenario Evaluation	X		X	X	X	X	X	X	X				X	Expansion planning will consider the usage of FLISR and congestion management as an alternative solution to network investments and to postpone these investments.
Target network Planning														No direct match EEGI L2 KPIs
Reduction of technical network losses														No direct match EEGI L2 KPIs

Demonstration working approach: KPI to EEGI mapping (5/5)

IDE4L KPIs	B.1	B.2	B.3.1	B.3.2	B.3.3	B.3.4	B.4	B.5.1	B.5.2	B.6.1	B.6.2	B.6.3	B.7	Note
Percentage utilization of electricity network components														No direct match EEGI L2 KPIs
Reduction in CO2 emissions														No direct match EEGI L2 KPIs
RES curtailment		X												They look similar according to the definition. Detailed description of KPI is needed to evaluate the complete or partial equivalence
Demand Response								X						
Day Ahead Dynamic Tariff								X						

Demonstration working approach: KPI to UCs mapping example

UCs	KPIs
Control Center Network Power Control	Control Centre Tertiary Power Control Technical and Economic Parameters
	Control Center Tertiary Power Control - Operational Parameters
	Control Center Tertiary Power Control - Technical Safety Parameters
LV Network Power Control	LV Network Power Control - Technical and Economic Parameters
	LV Network Power Control - Operational Parameters
	LV Network Power Control - Technical Safety Parameters
MV Network Power Control	MV Network Power Control - Technical and Economic Parameters
	MV Network Power Control - Operational Parameters
	MV Network Power Control - Technical Safety Parameters
Decentralized FLISR	SAIDI
	SAIFI
	Breaker energyzed operations
	Interconnection Switch

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…and the validation is ongoing…

Thank you!

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Demonstration working approach: SAIDI KPI example (1/3)

BASIC KPI INFORMATION				
KPI Name	SAIDI		**KPI ID**	SAIDI
Main Objective	Estimate the average interruption duration			
KPI Description	This KPI will estimate the average interruption duration, which leads to disturbance for network users and maintenance costs. It can be calculated using the outage time for every track and the total number of users on it (or averaged number of users per track)			
KPI Formula	$$\frac{SAIDI_{BL} - SAIDI_{SG}}{SAIDI_{BL}}$$ SAIDI is measured according to Std. IEEE 1366-1998. $$SAIDI = \frac{\sum r_i N_i}{N_t}$$ r_i Restoration time for each interruption event; N_i Number of interrupted customers for each interruption event during reporting period; N_t Total number of customers served for the area being indexed; $$r_i = SI_{end} - SI_{start}$$ SI Service Interruption			
Unit of measurement	%			
Connection / Link with other relevant defined KPIs and Use Cases	Related to Decentralized FLISR UC.			
Project sites to be calculated	Development laboratory ☐	Demonstration laboratory ☐	Field demonstrator ☑	

Demonstration working approach: SAIDI KPI example (2/3)

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
SAIDI_01	Detect number and duration of interruptions	DSO
SAIDI_02	Detect or estimate the number of affected customers	DSO
SAIDI_03	Calculate SAIDI in smart grid scenario	DMS
SAIDI_04	Compare to baseline scenario	DMS

KPI SCENARIOS			
Scenarios to be measured	BASELINE ☑	BUSINESS AS USUAL (BaU) ☐	SMART GRID ☑

KPI DATA COLLECTION							
Data	**Data ID**	**Methodology for data collection**	**Source/Tools /Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Minimum monitoring period**	**Data collection responsible**
Service interruption event timestamp	SI_{start}	Sequence of events logging		RTUs managing switches and breakers	Once at the end of the monitoring period	Complete test phase. (Typically one year)	DSO
Restoration command timestamp	SI_{end}	Sequence of events logging		RTUs managing switches and breakers	Once at the end of the monitoring period	Complete test phase. (Typically one year)	DSO
Number of interrupted customers	N_i	Adding the number of customers in the affected areas		DMS	Once at the end of the monitoring period	Complete test phase. (Typically one year)	DMS

Demonstration working approach: SAIDI KPI example (3/3)

KPI BASELINE			
Source of Baseline Condition	LITERATURE VALUES ☐	COMPANY HISTORICAL VALUES ☑	VALUES MEASURED AT START OF PROJECT ☐
Details of Baseline	Previous SAIDI values in the same area.		
Responsible (Name, Company) for Baseline	DSOs		
GENERAL COMMENTS			
This KPI has been defined for UC "Decentralized FLISR"			