Summary of the innovative solution performances based on the measured KPIs during the demonstrations

Version 1.0

Deliverable D2.5

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Short Description

This deliverable provides an overview of the calculated KPIs' results and innovative solution performance.

Revision history

Version	Date	Modifications' nature	Author
V0.2	20/09/2019	Draft document	ČEZ Distribuce
V0.3	04/11/2019	Inputs WP5, WP6, WP7, WP8, WP9 included	WPLs
V0.4	10/11/2019	Completing chapter 5	ČEZ Distribuce
V0.5	25/11/2019	WP8 and WP9 additions	ČEZ Distribuce
V1.0	19/12/2019	Final document	ČEZ Distribuce

Accessibility

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Owner/Main responsible

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Work Package ID	WP2	**Task ID**	Task 2.5

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EXECUTIVE SUMMARY

As defined in the Description of Work, the scope of Task 2.5 is to write a final report that gives a summary of the innovative solution performances based on the measured project and economic KPIs during the demonstrations. Its evaluation and validation for demo projects is supposed to signal the deployment decision to be made based on the promising technical and economical results obtained during the demonstrations. Evaluation and validation of project and economic KPIs was done by particular demo projects.

D2.5 is based on D2.2, but in the second year of the project two additional economic KPIs were defined and added based on EC request. For the collection of the data inputs, the Clearing House Database was used and stored on the project cloud. D2.1 (Use case detailed definitions and specifications) was updated based on approved or occurred changes within demo projects and these changes are described in deliverables submitted by each demo project at the end of the InterFlex project.

This report provides the relevant information regarding the KPIs calculated by the different demonstrators, giving an overview of the calculation methods and baseline values. In addition to that, some considerations regarding the cross-comparison of the KPIs’ results are also presented.

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LIST OF FIGURES AND TABLES

1. INTRODUCTION

1.1. Scope of the document

The document is divided into 5 main chapters, as depicted below.

- Overview of common project KPIs
- Detailed description of two additional economic KPIs
- Calculations and results
- Cross comparison between demonstrators
- Conclusions and results of Task 2.5

The deliverable follows a logical path, starting from the KPIs definition and ending with a tentative of "cross comparison" of the "common" KPIs, defined at the beginning of the project in the deliverable D2.2. Between the definition and the "cross comparison", the KPIs' values calculated by each Demo are summarized and presented.

1.2. Notations, abbreviations and acronyms

The table below provides an overview of the notations, abbreviations and acronyms used in the document.

Table 1 List of acronyms

BAU	Business as usual
DER	Distributed Energy Resources
DSO	Distribution System Operator
ESCO	Energy Service Company
EC	European Commission
EC-GA	European Commission Grant Agreement
EU	European Union
EV	Electric Vehicle
GA	General Assembly
WP	General Work Package
KPI	Key Performance Indicator
PC	Project Coordinator
SC	Steering Committee
SG	Smart Grid
TC	Technical Committee
TD	Technical Director
WP	Work Package
WPL	Work Package Leader

2. OVERVIEW OF INTERFLEX PROJECT KPIS

The seven proposed common KPIs are detailed below. Five of them were already described in D2.2 and two additional (economic) KPIs were added during the course of the InterFlex project. Three indicators will monitor technical aspects of the DEMOs, while two other KPIs will be "softer" indicators, measuring social aspects of the different DEMOs. Additional two KPIs evaluate Economic impact of various Use cases.

2.1. KPI description summary list

Table 2 InterFlex project KPIs summary

Interflex Project KPI	KPI ID	KPI TYPE	KPI Description
Flexibility	WP2.2_KPI_1	Technical	Flexible power that can be used for balancing specific grid segment.
Hosting capacity	WP2.2_KPI_2		Percentage increase of network hosting capacity for DER.
Islanding	WP2.2_KPI_3		Capacity of the energy system to switch to islanding whilst keeping the power quality requirement.
Customer recruitment	WP2.2_KPI_4	Social	Measure whether demos are managing to recruit enough customer bases in order to attain demo objectives.
Active participation	WP2.2_KPI_5		Reflects how versatile the demos are in leveraging flexibility from different technologies.
Cost Savings	WP2.5_KPI_6	Economic	Cost savings after Smart Grid solution implemented either on DSO, customer or another stakeholder side.
Energy distributed thanks to Islanding	WP2.5_KPI_7		Failure in the interconnected distribution grid activates an Island mode and the energy in Island mode could be monetized and compared with BAU scenario or national penalties.

2.2. KPIs definition and formulas

See below further details of calculation formulas of the different KPIs.

Table 3 KPI formulas

Project KPI	KPI Definition and formula
Flexibility WP2.2_KPI_1	$$\text{Flexibility}_{\%} = \frac{\sum P_{Available\ flexibility}}{\sum P_{Total\ in\ area}} \times 100$$ $\text{Flexibility}_{\%}$: Percentage of flexible power used available in reporting period. $P_{Available\ flexibility}$: Power in MW of available flexibility in reporting period. $P_{Total\ in\ area}$: Maximum power consumed by the customers in the considered area
Hosting capacity WP2.2_KPI_2	$$\text{HC}_{\%} = \frac{\text{HC}_{\text{SG}} - \text{HC}_{\text{Baseline}}}{\text{HC}_{\text{Baseline}}} \times 100$$ HC_{SG}: Hosting Capacity for DER with Smart Grid solutions (kW). This hosting capacity should measure DER that can be connected to the grid after the Smart Grid solution is implemented. $\text{HC}_{\text{Baseline}}$: Hosting Capacity for DER in Baseline situation (kW). This hosting capacity should measure DER that can be connected to the grid before the Smart Grid solution is implemented.
Islanding WP2.2_KPI_3	$$\text{I}_{\text{capacity}} = \frac{\sum \text{D}_{\text{isl}}}{\sum \text{D}_{\text{req}}} \times 100$$ $\text{I}_{\text{capacity}}$: The capacity of demo's islanding to last as long as required. D_{isl}: The duration of a single islanding. D_{req}: The required duration of an islanding, after an intentional or unintentional disconnection from the grid.
Customer recruitment WP2.2_KPI_4	$$\text{CR}_{\%} = \frac{\text{CR}_{\text{successful}}}{\text{CR}_{\text{required}}} \times 100$$ $CR_{\%}$: Percentage of required customer base that use case was able to recruit. $CR_{successful}$: Number of customers (installed capacity, energy volume) actually recruited. $CR_{required}$: Number of customers (installed capacity, energy volume) needed to obtain enough flexibility in demo in order to verify use cases.

Active participation WP2.2_KPI_5	$$\text{Participation}_{\%} = \frac{N_{leverage\ technology}}{\mathrm{N}_{target\ technology}} \times 100$$ $\text{Participation}_{\%}$ — Percentage of technologies leveraged $N_{leverage\ technology}$ — number of different technologies leveraged in DEMO $\mathrm{N}_{target\ technology}$ — number of types of technologies initially targeted in DEMO
Cost Savings WP2.5_KPI_6	Version A: $$\Delta COST_{savings\,\%} = \frac{COST_{BAU} - COST_{SG}}{COST_{BAU}} \times 100$$ $\Delta\mathrm{COST}_{\mathrm{savings}\,\%}$ — Percentage in overall savings in UC (%) $\mathrm{COST}_{\mathrm{SG}}$ — Smart Grid solutions costs (EUR) $\mathrm{COST}_{\mathrm{BAU}}$ — Business as usual costs without Smart Grid solution improvements (EUR)
	Version B: $$Cost_{\ DSO} = \frac{\sum PCost_{BAU} - \sum Cost_{flex\ traded\ with\ DSO} - \sum Penalty_{flex\ traded\ with\ DSO}}{\sum PCost_{BAU}} \times 100$$ $Cost_{DSO}$ — KPI flexibility cost in relation with Business as usual means investment cost for grid reinforcement in a certain period. $\sum Cost_{flexibility\ traded\ with\ DSO}$ — Cost made as a payment to the aggregator for delivered flex. $\sum Penalty_{flexibility\ traded\ with\ DSO}$ — Payed penalty by aggregator for not delivered flex as agreed. $\sum PCost_{BAU}$ — Investment cost DSO for grid reinforcement.
Energy distributed thanks to Islanding WP2.5_KPI_7	$$EnergyIslanded_{EUR} = R \times \sum_{i=1}^{N} \int_{T_{start(i)}}^{T_{end}(i)} P_{LCi}(t) \times dt$$ *EnergyIslanded* — The energy distributed in islanding mode (in €) $P_{LC}(t)$ — The load curve of the islanded grid (in kW) $T_{start}(i)$ — The beginning of the islanding $T_{end}(i)$ — The end of the islanding N — The number of islanding trials R — The ratio €/MWh used in planning tools by the DSO

2.3. KPI relationship to each DEMO

The respective DEMOs that each KPI applies to are detailed in the table below:

Table 4 Mapping InterFlex Project KPIs applicable to each DEMO

Project KPI	Germany Avacon	Czech Rep. ČEZd	Netherlands Enexis	Sweden E.ON	France Enedis
Flexibility WP2.2_KPI_1	✓	✓	✓	✓	✓
Hosting capacity WP2.2_KPI_2	✓	✓		✓	
Islanding WP2.2_KPI_3				✓	✓
Customer recruitment WP2.2_KPI_4	✓			✓	✓
Active participation WP2.2_KPI_5	✓			✓	✓
Cost Savings WP2.5_KPI_6	✓	✓	✓	✓	
Energy distributed thanks to Islanding WP2.5_KPI_7				✓	✓

2.4. Relationship with InterFlex Use Cases

The table below summarizes the close relationship with the InterFlex Use Cases and the defined Project Key Performance Indicators.

Table 5 Matrix InterFlex Project KPI addressing Use Cases

Project KPI	DE			CZ				NL			SE					FR		
	UC1	UC2	UC3	UC1	UC2	UC3	UC4	UC1	UC2	UC3	UC1	UC2	UC3	UC4	UC5	UC1	UC2	UC3
Flexibility WP2.2_KPI_1		✓				✓	✓			✓	✓	✓	✓	✓	✓			✓
Hosting capacity WP2.2_KPI_2	✓			✓	✓		✓				✓	✓	✓	✓	✓			
Islanding WP2.2_KPI_3													✓	✓	✓	✓		
Customer recruitment WP2.2_KPI_4	✓	✓	✓								✓		✓	✓	✓			✓
Active participation WP2.2_KPI_5	✓	✓	✓								✓		✓	✓	✓			✓
Cost Savings WP2.5_KPI_6	✓		✓	✓	✓		✓			✓			✓	✓	✓			
Energy in Islanding WP2.5_KPI_7													✓	✓	✓	✓		

3. ECONOMIC KPIs

After Deliverable D2.2 was published, all Work Package leaders have agreed during Technical Committee no. 12 meeting in Aachen (January 2019), Germany, that economic KPIs should be added to better assess financial benefits of the InterFlex project's innovative solutions and to respond to the request of the Project officer (INEA). Two additional economic KPIs were defined and evaluated. This chapter describes economic indicators in the same way as the first five in D2.2 (please see D2.2 first).

3.1. Cost Savings

Table 6 KPI - Cost Savings: basic information, calculation methodology, data collection, and baseline

<table>
<tr><th colspan="6">BASIC KPI INFORMATION</th></tr>
<tr><td>KPI Name</td><td colspan="3">Cost Savings</td><td>KPI ID</td><td>WP2.5_KPI_6</td></tr>
<tr><td>Strategic Objective</td><td colspan="5">Cost savings after Smart Grid solution implemented either on DSO, customer or another stakeholder side.</td></tr>
<tr><td>DEMO where KPI applies</td><td>GERMANY
☑</td><td>CZECH REP
☑</td><td>NETHERLANDS
☑</td><td>SWEDEN
☑</td><td>FRANCE
☐</td></tr>
<tr><td>Owner</td><td colspan="5">Germany – Thorsten Gross (Avacon)
Czech Republic – Stanislav Hes (ČEZ Distribuce)
Netherlands - Marcel Willems (Enexis)
Sweden – Jörgen Rosvall (E.ON)</td></tr>
<tr><td>KPI Description</td><td colspan="5">Refers to any cost reduction achieved by the UC and is encountered on the side of DSO or customer or both. This KPI builds on various options and ways how to apply cost reductions on InterFlex UCs. BAU costs could be grid investments needed to provide sufficient hosting capacity to connect new RES or customer energy bill before any SG solution applied. Smart Grid costs could be costs of devices needed to flexibility market start to work etc.</td></tr>
<tr><td>KPI Formula (version A)</td><td colspan="5">$$\Delta COST_{savings\,\%} = \frac{COST_{BAU} - COST_{SG}}{COST_{BAU}} x100$$
$\Delta\mathrm{COST}_{\mathrm{savings}\,\%}$ = Percentage in overall savings in UC (%)
$\mathrm{COST}_{\mathrm{SG}}$ = Smart Grid solutions costs (EUR)
$\mathrm{COST}_{\mathrm{BAU}}$ = Business as usual costs without Smart Grid solution improvements (EUR)</td></tr>
</table>

KPI Formula (version B)	$$Cost_{DSO} = \frac{\sum PCost_{BAU} - \sum Cost_{flex\ traded\ with\ DSO} - \sum Penalty_{flex\ traded\ with\ DSO}}{\sum PCost_{BAU}} * 100$$ $Cost_{DSO}$ = KPI flexibility cost in relation with Business as usual means investment cost for grid reinforcement in a certain period. $\sum Cost_{flexibility\ traded\ with\ DSO}$ = Cost made as a payment to the aggregator for delivered flex. $\sum Penalty_{flexibility\ traded\ with\ DSO}$ = Payed penalty by aggregator for not delivered flex as agreed. $\sum PCost_{BAU}$ = Investment cost DSO for grid reinforcement.			
Unit of measurement	% of cost saved after SG solution implemented			
Expectations	Germany ---- Czech Republic – UC1 - 100%, UC2 – 100%, UC4 – 100% Netherlands – 10% Sweden ----			
Reporting Period	Germany - At the end of each use case demonstration Czech Republic - At the end of each use case demonstration Netherlands - At the end of each use case demonstration Sweden - At the end of each use case demonstration			
Relevant Standards	None			
Connection / Link with other relevant defined KPIs	Netherlands - KPI 7_3			
Reporting Audience and Access Rights	PUBLIC ☑	INTERFLEX PARTNERS ☑	DEMO PARTNERS ☑	OTHER (please specify) ☐
OTHER (please specify)				

KPI CALCULATION METHODOLOGY		
DEMO Germany		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
WP2.5_KPI_6_AVA_1	Determine baseline for UC1	Avacon
WP2.5_KPI_6_AVA_2	Determine baseline for U3	Avacon
WP2.5_KPI_6_AVA_3	Determine potential savings for UC1	Avacon
WP2.5_KPI_6_AVA_4	Determine potential savings for UC3	Avacon
WP2.5_KPI_6_AVA_5	Confirm feasibility in practical field test demonstration	Avacon
WP2.5_KPI_6_AVA_6	Calculate KPI(Savings)	Avacon

DEMO Czech Republic		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
WP2.5_KPI_6_CEZd_1	For each use case - evaluation of BAU grid reinforcement costs (thicker cables, higher transformer rated power etc.) in the UC area in order to connect requested power (generation) in the grid.	ČEZd
WP2.5_KPI_6_CEZd_2	Smart Grid solution cost evaluation from DSO perspective. If only part of the cost is considered to be compared with BAU solution, it will be described with the calculation and result.	ČEZd
WP2.5_KPI_6_CEZd_3	Calculation of KPI for all selected UCs. Cost data is stored in InterFlex clearing house and formula is applied. Result is published and commented in final deliverable.	ČEZd
DEMO Netherlands		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
WP2.5_KPI_6_Enex_1	Cost Flexibility traded with DSO is analysed from the central project database and use in KPI 7.3.	Enexis
WP2.5_KPI_6_Enex_2	Penalty Flexibility traded with DSO is analysed from the central project database.	Enexis
WP2.5_KPI_6_Enex_3	Cost BAU are internal cost within Enexis used for grid reinforcement calculations.	Enexis
DEMO Sweden		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
WP8_KPI_6_EON_1	The installation of an EV-charging pole at the church in Simris would require a grid reinforcement in form of a transformer upgrade (BAU). This in order to secure power transfer during the highest consumption peaks of the year in Simris. The insight is based on historical data and specifications from the supplier. The potential reinforcement costs on DSO-level was approximated to 30 000 Euro.	EON
WP8_KPI_6_EON_2	Alternatives to the traditional method were discussed. Active network management was chosen to replace the grid upgrade by regulating the EV-charger output during the highest peaks.	EON
WP8_KPI_6_EON_3	The active network management was developed and implemented, costs for DSO ended up at 5 000 Euro for the fully operational solution.	EON
WP8_KPI_6_EON_4	KPI is calculated using the stated formula were costs from BAU and SG are inputs.	EON

KPI DATA COLLECTION							
DEMO Germany							
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**
Annual remunerations for curtailments	UC 1_1	Annual reporting	Avacon internal reporting	Avacon	Annually	FY	Avacon
Annual costs for energy in DSO balancing circle	UC 3_1	Annual reporting	Avacon internal reporting	Avacon	Annually	FY	Avacon
Potential savings generated by UC1	UC 1_2	Simulation	MATLAB, Powerfactory simulations	Avacon	Per UC	-	Avacon
Potential savings generated by UC3	UC 3_2	Simulation	MATLAB, Excel / VBA simulations	Avacon	Per UC	-	Avacon
DEMO Czech Republic							
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**
Grid reinforcement cost (BAU)	COST BAU	Internal development project planning and standard	SAP PS tool for project CAPEX	ČEZd systems	Only once in the beginning of the project	N/A	ČEZd
Smart Grid solution cost (SG)	COST SG	Internal development project planning and standard	SAP PS tool for project CAPEX	ČEZd systems	Only once when final SG cost is known	N/A	ČEZd
DEMO Netherlands							
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**
Cost Flex	Cost Flex	USEF	GMS	Central project database	15 minutes	8 weeks	Enexis
Penalty flex	Penalty flex	USEF	GMS	Central project database	15 minutes	8 weeks	Enexis
Cost BAU	Cost BAU	Internal calculations	No specific	Internal documents	N/A	N/A	Enexis

DEMO Sweden							
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**
Grid reinforcement cost (BAU)	$COST_{BAU}$	Internal project planning and standard	Encorp, Iconics and DpPower?	EON systems	Once, during reinforcement planning	N/A	EON
Smart Grid solution cost (SG)	$COST_{SG}$	Internal development, project planning	Encorp, Iconics and DpPower?	EON systems	Once, after SG was operational	N/A	EON

KPI BASELINE			
DEMO Germany			
Source of Baseline Condition	LITERATURE VALUES ☐	COMPANY HISTORICAL VALUES ☑	VALUES MEASURED AT START OF PROJECT ☐
Details of Baseline	UC1: Total cost for remuneration of curtailments in 2017, 2018 UC3: Total costs for energy in DSO balancing circle before implementation. (This value is confidential, we will implicitly use it as reference value for BAU scenario)		
Responsible	Thorsten Gross, Avacon		
DEMO Czech Republic			
Source of Baseline Condition	LITERATURE VALUES ☑	COMPANY HISTORICAL VALUES ☑	VALUES MEASURED AT START OF PROJECT ☑
Details of Baseline	In this KPI Baseline means Business as Usual. It is calculated as cost/expenditure needed for increasing DER hosting capacity		
Responsible	Stanislav Hes, ČEZd		
DEMO Netherland			
Source of Baseline Condition	LITERATURE VALUES ☐	COMPANY HISTORICAL VALUES ☑	VALUES MEASURED AT START OF PROJECT ☑
Details of Baseline	Baseline is reinforcement of the grid when congestion problems occur. This can also be solved with traded Flexibility.		
Responsible	Marcel Willems, Enexis		

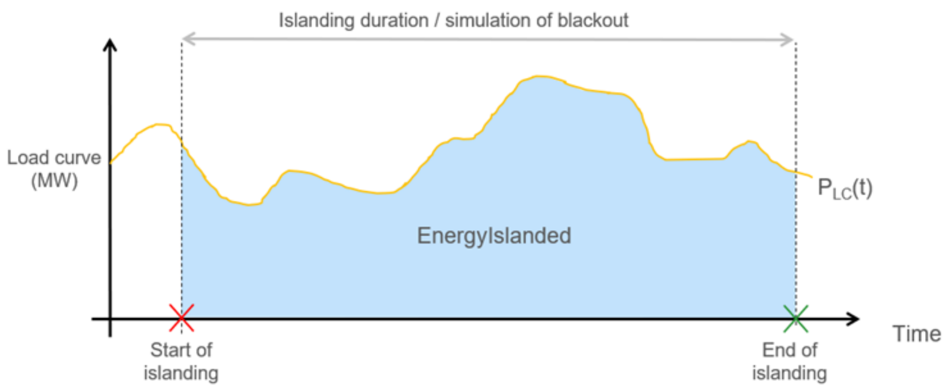
DEMO Sweden			
Source of Baseline Condition	LITERATURE VALUES ☐	COMPANY HISTORICAL VALUES ☑	VALUES MEASURED AT START OF PROJECT ☐
Details of Baseline	To ensure power availability for the residents is Simris would BAU result in a grid reinforcement with the cost of 50 000 EUR, this is considered as case baseline.		
Responsible	Jörgen Rosvall, EON		

GENERAL COMMENTS
DEMO Czech Republic - KPI Cost Savings will be evaluated for use cases WP6_1, WP6_2 and WP6_4. DEMO Netherlands - KPI Cost Savings will only be evaluated for use case WP7_3. DEMO 4b (EON) - KPI Cost Savings will be evaluated for use cases 3, 4 and 5. DEMO Germany – KPI Cost Savings are calculated on a theoretical basis and applied to the Avacon global baseline. Use case demonstrations confirmed feasibility of use case implementation in daily operations.

3.2. Energy distributed thanks to Islanding

Table 7 KPI - Energy distributed thanks to Islanding: basic information, calculation methodology, data collection, and baseline

BASIC KPI INFORMATION					
KPI Name	**Energy distributed thanks to Islanding**			**KPI ID**	WP2.5_KPI_7
Strategic Objective	Failure in the interconnected distribution grid activates an Island mode and the energy is distributed to customers without (or with very short) outage. The energy in Island mode could be monetized and compared with BAU scenario or national penalties.				
DEMO where KPI applies	GERMANY ☐	CZECH REP ☐	NETHERLANDS ☐	SWEDEN ☑	FRANCE ☑
Owner	Sweden – Jörgen Rosvall (E.ON) France – Thibaut Wagner (Enedis)				
KPI Description	This KPI applies to UCs where Island mode is activated in case of outage. It represents how much (in costs of interruption) could be saved from a DSO planning methods point of view when energy sources (or storage) inside Island mode supply customers without significant time of outage.				

KPI Formula	
	$EnergyIslanded_{EUR} = R \times \sum_{i=1}^{N} \int_{T_{start}(i)}^{T_{end}(i)} P_{LCi}(t) \times dt$
	
	EnergyIslanded = the energy distributed in islanding mode
	P_{LC} (t) = the load curve of the islanded grid
	T_{start} = the beginning of the islanding #i
	T_{end} = the end of the islanding #i
	N = the number of islanding trials
	R = the ratio €/MWh used in planning tools by the DSO *(in Enedis R = 9200 €/MWh if Energy < 30 MWh, EON uses the average electricity price in SE4 during the islanded periods; R = 47.5€/MWh)*				

Unit of measurement	EUR				

Expectations	Sweden – The focus is knowledge about microgrid, DSR influence P2P platform e.g. as the islanding is intentional and low electricity prices makes the solution economically unfeasible. France - ≥ € 30 000			
Reporting Period	Sweden - At the end of each use case demonstration France - At the end of Use Case #1 demonstration			
Relevant Standards	None			
Connection / Link with other relevant defined KPIs				
Reporting Audience and Access Rights	PUBLIC ☑	INTERFLEX PARTNERS ☑	DEMO PARTNERS ☑	OTHER (please specify) ☐
OTHER (please specify)				

KPI CALCULATION METHODOLOGY		
DEMO Sweden		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
WP8 _KPI_7_EON _1	The village of Simris is connected to the main power grid which supply the required power.	EON
WP8 _KPI_7_EON _2	Disconnection from the grid is by choice (to test islanding). Local generation assets supply the required power and intermittent production is stored using battery system. Thus, the power that normally would be supplied by the main power grid is now it is freed up due to islanding.	EON
WP8 _KPI_7_EON _3	The value of the redistributed energy is calculated by measuring the amount of energy, multiplied by the average electricity price in SE4 during the islanded periods.	EON
DEMO France		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
WP2.5_KPI_7_ENEDIS_1	For each islanding test, record and extract the power consumed by the local microgrid in order to assess the energy supplied.	SOCOMEC
WP2.5_KPI_7_ENEDIS_2	For each islanding test, extract the exact moment of islanding from ENEDIS' IT in order to calculate the exact energy saved.	ENEDIS
WP2.5_KPI_7_ENEDIS_3	The value of served energy is calculated by multiplying the sum of the energy[1] served (during each islanding tests) by the R criteria used in ENEDIS' planning tools.	ENEDIS

[1] Load curve multiplied by the step time of the measurements.

KPI DATA COLLECTION							
DEMO Sweden							
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**
Lode curve during islanding	P_{LC} (t)	Fiber, 3G, wi-fi	Encorp, Iconics, Loccioni	EON Systems	Minutes to milliseconds	Till decommission	EON
Ratio (€/MWh)	R	Fiber, 3G, wi-fi	Encorp, Iconics, Loccioni	EON Systems	Minutes to milliseconds	Till decommission	EON
DEMO France							
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**
Islanding start	T_{start}	Export of ENEDIS' IT at the regional control room	ENEDIS IT	Regional control room	After every test's sequences	N/A	ENEDIS
Islanding end	T_{end}	Export of ENEDIS' IT at the regional control room	ENEDIS IT	Regional control room	After every test's sequences	N/A	ENEDIS
Load curve of the islanded grid	P_{LC}	Export of SOCOMEC cloud	SOCOMEC cloud	Cloud	After every test's sequences	10 min	SOCOMEC

KPI BASELINE			
DEMO Sweden			
Source of Baseline Condition	LITERATURE VALUES ☑	COMPANY HISTORICAL VALUES ☐	VALUES MEASURED AT START OF PROJECT ☐
Details of Baseline			
Responsible	Jörgen Rosvall, E.ON		
DEMO France			
Source of Baseline Condition	LITERATURE VALUES ☐	COMPANY HISTORICAL VALUES ☑	VALUES MEASURED AT START OF PROJECT ☐
Details of Baseline	This KPI describes the maximum economic value of the microgrid. Note that this is an upper bound of the value of the islanding system and not the real value as there is no investment planned yet on these islands.		
Responsible	Thibaut Wagner, Enedis		

GENERAL COMMENTS
DEMO 4b (EON) - KPI Energy distributed thanks to Islanding will be evaluated for use cases 3, 4 and 5. The KPI formula is alternated for the Swedish demo 4b. DEMO France - KPI Energy distributed thanks to Islanding will be evaluated for use cases WP9_1.

4. KPI CALCULATION

This chapter provides an overview for each Demo individually, which includes the KPI calculation for the baseline and smart solution conditions. Each paragraph contains:

- First (blue) table is an explanation of calculations.
- Second (green) table contains the reported results.

For more detailed description of the calculation methodologies and all the results see the deliverables of the corresponding demonstrators.

4.1. WP5 (Germany)

Table 8 WP5 KPI calculation details

CALCULATION DETAILS			
KPI	Baseline	SG	Comment
Flexibility	0 (Without Smart Grid Hub there is no flexibility available for DSO)	+177,3 kW (PV) -72 kW (Heating)	Results show that >95% of 15-min intervals less than 5% of flexibility is available as bi-directional flexibility
Hosting Capacity	Annual curtailments without smart grid hub	Reduction in curtailments of up to 4%	Field tests demonstrated technical feasibility, potential confirmed with simulations
Customer recruitment	200 (Ambition)	360 (expressed interest)	60 could be integrated technically. Remaining customers could not be integrated due to lack of mobile network coverage, lack of space for meter equipment installation or incompatible controllable device.
Active Participation	5 (Ambition)	3	EV chargers and batteries could not be integrated
Cost Savings	0	Results of simulation	Assumption complete rollout of smart meters and integration of all compatible devices.

Table 9 WP5 KPI results

KPI RESULTS						
KPI	UC	Baseline value	SG Value	KPI Value	Expected	Comment
Flexibility	2	0	5% * (+177,3 // -72)	5%	>0	Total available flex is only considered what is connected to SGH, KPI reflects what can reliably be used as bi-directional flexibility in typical scenario
Hosting Capacity	1	-438 MWh/a	-420,5 MWh/a	4%	>0	Hosting capacity measured as reduction in annual curtailments

Customer recruitment	1 2 3	20 40 20	27 52 25	135% 130% 125%	100%	KPI only considers flawless installations
Active Participation	1 2 3	5 5 5	3 3 3	60% 60% 60%	100%	EV chargers and batteries could not be integrated
Cost Savings	1 3	43,800,000€ Confidential	42,480,000€ 1,177,755€	3% 1,177,755€	10%	Best case scenario max potential savings if applied across entire service area of Avacon

Note: Based on the German context and the focus on the amount of required curtailments of RES, the KPI for Hosting Capacity was adjusted by Avacon and thus energy in MWh was reported, instead of installed capacity in MW. It is the technical result based on the time series simulation that WP5 ran. This adjustment corresponds with regulatory framework set by German NRA.

4.2. WP6 (Czech Republic)

Table 10 WP6 KPI calculation details

CALCULATION DETAILS			
KPI	Baseline	SG	Comment
Flexibility	In case of UC3 Nominal charging power of EV charging station and in UC4 PV production peak determined as a sum of PV modules power.	Charging power (limited to 0% or 50%) of EV charging station in emergency situation (or during field test) or PV production peak after smart charging of home energy storage is implemented.	Solutions were proved in real demonstration.
Hosting Capacity	Number of DER which are possible to connect to the grid before smart solution implementation.	Number of DER connected physically to the grid after smart solution implementation or hosting capacity calculated with new rules for DER hosting capacity calculation.	Solutions were proved in real demonstration. Hosting capacity calculation respecting demonstrated solutions were done.
Cost Savings	Grid reinforcement cost (BAU) based on development project planning and standards.	Smart Grid solution cost (SG) based on smart grid project planning and standards.	Cost savings are calculated from CEZ Distribuce perspective (DSO).

Table 11 WP6 KPI results

KPI RESULTS						
KPI	UC	Baseline value	SG Value	KPI Value	Expected	Comment
Flexibility	UC3 UC4	90,3 kW 24,8 kW	55 kW 12,4 kW	60,91% 50,00%	40% 20%	Expectations are fulfilled for all demonstration areas.

Hosting Capacity	UC1_T UC1_D UC2_V UC2_K UC2_Z UC2_H UC2_N UC4_L	14,6 kW 38,4 kW 6630 kW 4761 kW 5760 kW 1915 kW 4892 kW 21,8 kW	25,7 kW 51,4 kW 8540 kW 6018 kW 7720 kW 3676 kW 7770 kW 29,1 kW	76,03% 33,85% 28,81% 26,40% 34,03% 91,96% 58,83% 33,49%	25% 25% 25% 25% 25% 25% 25% 5%	Expectations are fulfilled for all demonstration areas.
Cost Savings	UC1_T UC1_D UC2_V UC2_K UC2_Z UC2_H UC2_N UC4_L	34 615 EUR 41 538 EUR 1 020 600 EUR 210 600 EUR 232 200 EUR 1 020 000 EUR 613 600 EUR 51 923 EUR	0 EUR 0 EUR 0 EUR 0 EUR 0 EUR 0 EUR 0 EUR 0 EUR	100% 100% 100% 100% 100% 100% 100% 100%	100% 100% 100% 100% 100% 100% 100% 100%	Cost savings are calculated from CEZ Distribuce (DSO) perspective as described in WP6 CBA. Baseline values were calculated with average investment costs per kilometre. In case of LV grid 240AYKY cable costs 69 000 EUR/km, in MV grid 240AlFe line costs 54 000 EUR/km, in MV grid 240AXEKCY cable costs 104 000 EUR/km.

Note: If different suffix is added after use case abbreviation, it means different location (name of area) is in place. For example, “UC2_H” is for area “Hracholusky”. For more information please see WP6 deliverables.

4.3. WP7 (Netherlands)

Table 12 WP7 KPI calculation details

CALCULATION DETAILS			
KPI	Baseline	SG	Comment
Flexibility	Normal grid operation	Flex delivered by battery, PV panels on EV’s	Flex delivered by aggregator on a market model
Cost Savings	Reinforcement costs	Flex costs	Flex costs are depending on the availability of the assets in the specific area

Table 13 WP7 KPI results

KPI RESULTS						
KPI	UC	Baseline value	SG Value	KPI Value	Expected	Comment
Flexibility	3	1020 kW	448 kW	43%	>0	The flexibility is the average of the different assets. The battery can deliver the most flexibility, EV and PV is depending on the consumers and the sunny days.
Cost Savings	3	€ 25,25 a day	€ 20,41 a day	19%	10%	The cost saving is depending on the flex costs and the penalty costs. This is also depending on the flex availability in the LV network.

4.4. WP8 (Sweden)

Table 14 WP8 KPI calculation details

CALCULATION DETAILS			
KPI	Baseline	SG	Comment
Flexibility	No smart controllable district heating. No controllable power existed in the area before the project, seen from a DSO perspective (UC3-5).	Thanks to steerable assets, batteries and deals with local owners were flexibility introduced.	More flexibility than expected from distributed assets but also an additional main battery. UC2 can completely switch to district heating.
Hosting Capacity	Number of DER which are possible to connect to the grid before smart solution implementation.	Number of DER connected physically to the grid after smart solution implementation or hosting capacity calculated with new rules for DER hosting capacity calculation.	This has not been a main focus for UC 3-5 as the grid has capacity to spare.
Islanding	No baseline as no islanding would occur if BAU	Disconnected from the main power grid, every 5th week as starting-point	Frequency and durations of the islanding periods have varied throughout the project.
Customer recruitment	Without the project the customers connections to the grid would be non-smart.	Number of customers having steerable assets installed.	UCs have had a direct influence to improve the number of smart assets
Active Participation	Asset types and technologies that were relevant during starting phase	Asset types and technologies that were implemented	Seen from DSO perspective
Cost Savings	Grid reinforcement cost (BAU) based on development project planning and standards.	Smart Grid solution cost (SG) based on implementation an Active Network Management.	Based on direct costs from DSO perspective
Energy distributed thanks to Islanding	The baseline is considered as still connected to the grid, thus the cost of electricity during the islanded period.	Savings during islanding as the village is in self-consumption mode	The idea was not financial gains but the knowledge of micro grids.

Table 15 WP8 KPI results

KPI RESULTS						
KPI	UC	Baseline value	SG Value	KPI Value	Expected	Comment
Flexibility	UC1 UC2 UC3-5	8800 kW 65 kW 0 kW	7000 kW 65 kW 1250 kW	20.5% 100% 100%	10% 20% 5%	The flexibility could temporarily be limited by factors such as living comfort, outdoor climate.
Hosting Capacity	UC1 UC2 UC3-5	8800 kW 0 kW 900 kW	10560 kW 65 kW 970 kW	16.6 % 100 % 7.2%	10% 50% 5%	Main contributors are smart steering and storage solutions (UC3-5).

Islanding	UC3-5	0	81 hours	100 %	100 %	Varies every islanding period but getting new learnings are also prioritised.
Customer recruitment	UC1 UC3-5	1000 0	30 20	3 % 200 %	50% 100%	UC1: The customer recruitment is set to get most of the system, E.ONs plan for roll-out is set to 2023. In the InterFlex project only 10 buildings were planned so the KPI is a bit misleading. UC3-5: 10 households were expected to get steerable assets installed but the result was 20 (UC3-5).
Active Participation	UC1 UC3-5	0 0	2 5	100% 100 %	100% 80 %	All contemplated types of steerable assets were implemented.
Cost Savings	UC3-5	50 000 EUR	5 000 EUR	90%	50 %	Baseline is the approximated cost for grid upgrade.
Energy distributed thanks to Islanding	UC3-5	0	3 388 EUR	3 388 EUR	>0	Simris has intentional islanding period so normal electricity prices. R = 47.5 EUR/MWh

4.5. WP9 (France)

Table 16 WP9 KPI calculation details

CALCULATION DETAILS			
KPI	Baseline	SG	Comment
Flexibility	Sum of the maximum consumption of the primary substations included into the project on flexibility activation day	Maximum amount of flexibility available during the project	
Islanding	Sum of the expected duration of each islanding	Sum of effective duration of islanding	This KPI gives insights on ENEDIS' quality of supply with islanding
Customer recruitment	350 residential customers and 20 industrial customers	Number of customers recruited during the project	
Active Participation	Number of technologies leveraged in the project	Number of types of technologies installed during the project	
Energy distributed thanks to Islanding	/	Sum of the energy served during islanding multiplied by the planning R factor	This KPI does not give information about the price of the islanding service because it would require a probability term

Table 17 WP9 KPI results

KPI RESULTS						
KPI	UC	Baseline value	SG Value	KPI Value	Expected	Comment
Flexibility	3	47,484 kW	1,677 kW	3.53%	5%	Expectations are not fulfilled for this KPI. As described in previous deliverables, current situation makes recruitment for flexibility complicated (see D9.2 and D9.5 for more details).
Islanding	1	12.3h	26,6h	216%	100%	Expectations are fulfilled.
Customer recruitment	3	370	197	53.24%	80%	Expectations are not fulfilled for this KPI. As described in previous deliverables, current situation makes recruitment for flexibility complicated (see D9.2 and D9.5 for more details). *Note that this KPI is directly connected to the Flexibility KPI, thus, it is logical not to fulfil both if one is not at the expectations.*
Active Participation	3	4	4	100%	100%	Expectations are fulfilled.
Energy distributed thanks to Islanding	1	/	/	€35,896	€30,000	Expectations are fulfilled.

5. KPIs CROSS COMPARISON

As noted in the Introduction, two additional economic KPIs were added during the last year of the project, in most of the cases economic KPIs were conducted with simulated (not measured) data.

The table below shows a summary of results and calculated indicators. Values show the result of fulfilling the targeted value for all use cases, in particular demonstrator/Work Package. For example, if the target was to achieve hosting capacity of 50kW and the demonstrator result is 20kW, the value in this table is 40%. If the colour is in green, all figures are better than expected. If the colour is light grey, some figures are below expectation or missing. If the colour is dark grey, all use cases resulted in figures that were lower than expected.

Table 18 Project KPI results

KPI	Germany Avacon	Czech Rep. ČEZd	Netherlands Enexis	Sweden E.ON	France Enedis
Flexibility	Fulfilled	152% - 250%	Fulfilled	200% - 2000%	71%
Hosting Capacity	Fulfilled	105% - 670%	-	144% - 200%	-
Islanding	-	-	-	100%	216%
Customer recruitment	125% - 135%	-	-	6% - 200%	67%
Active Participation	60%	-	-	100% - 125%	100%
Cost Savings	30%	100%	190%	180%	-
Energy distributed thanks to Islanding	-	-	-	Fulfilled	120%

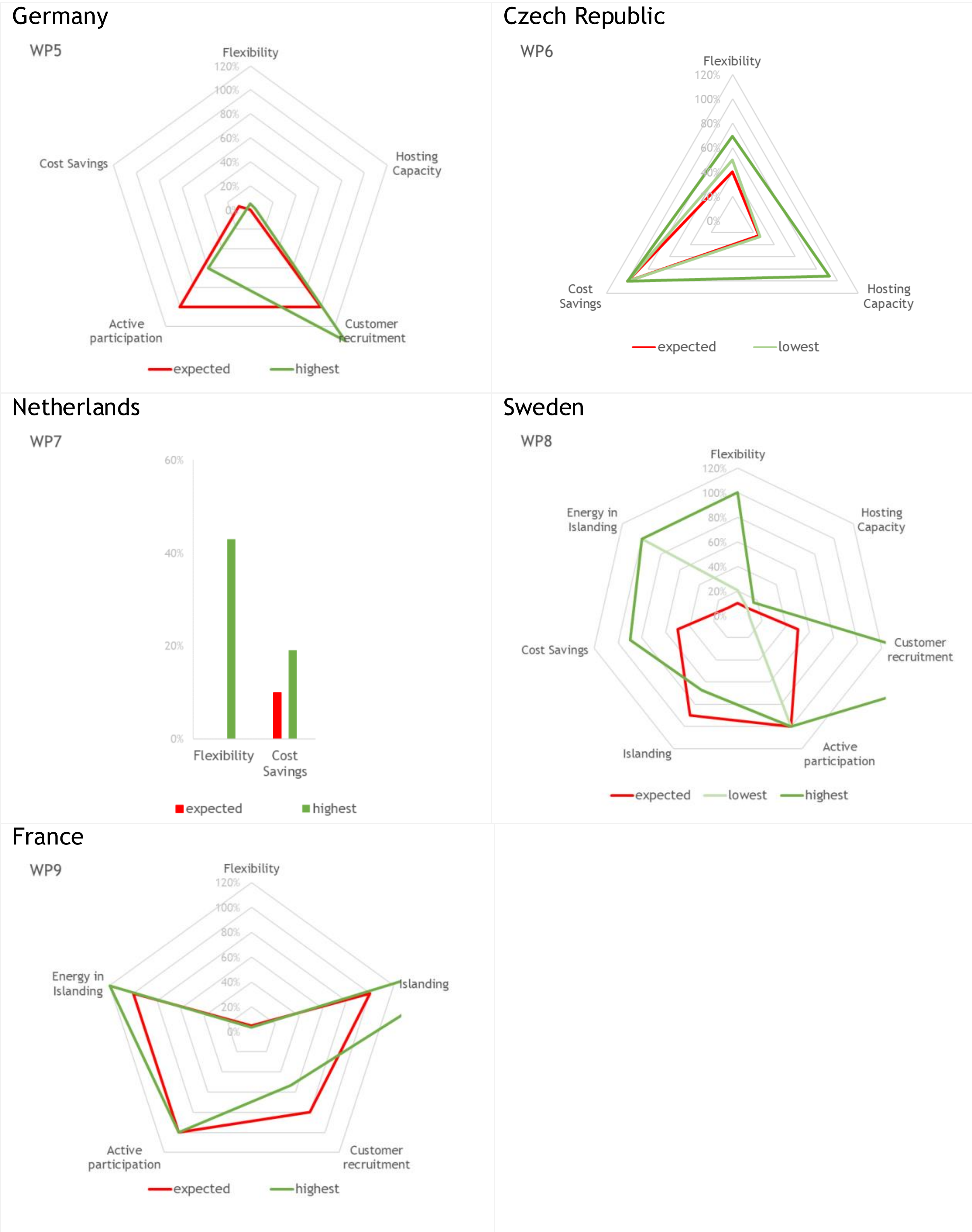


Figure 19 Radar charts of Project KPIs by Work Package

5.1. Flexibility

The KPI on Flexibility could be considered as primary goal and main indicator for the project. All the project demonstrators (with exception of WP9, which almost reach the expectation) fulfilled objectives assessed at the beginning of the InterFlex in 2017.

In some cases (WP8) the flexibility is even higher than expected thanks to additional assets installed during the project. A main feature of flexibility based on renewables or EVs is that EVs and PV depend on the consumers and the sunny days. In case of battery installation, the flexibility is wider but also limited by capacity of the battery.

5.2. Hosting capacity

Increasing the Hosting Capacity was the primary goal of WP6 and the results are quite beneficial. Values can vary between 20% - 90% depending on the voltage level, R/X parameter of conductors or primary or substitute topology on MV grid. This KPI has not been the main focus for WP9 UC 3-5 as the grid has capacity to spare, but still more than 7% increase was achieved.

Generally speaking, smart functions and new flexible and controllable technologies are increasing the traditionally computed hosting capacity or connectivity. This could be considered when a new methodology (or an update of formula) for connection is developed. For example, the change of power factor for DER (under-excited) within the hosting capacity calculation or the percentage of voltage change on LV before and after connection could be raised from common 2% to e.g. 4%.

5.3. Islanding

The purpose of this particular Islanding KPI was to prove the reliability of the transition and operating the grid when failure occurs. Because testing and evaluating period has limited time, simulated failure (or disconnection from the main grid) had to be carried out. In the case of Simris (WP8) this testing was conducted every 5th week.

In all cases, the duration for islanding operation covered the whole failure (or simulated) time, which is considered as success.

5.4. Customer recruitment

Fulfilling the Customer recruitment rate turned out to be quite problematic since in some cases it was not possible to engage more customers, simply because there were no further customers available who were willing to contribute to the project or because it was technically not possible.

As a recommendation for future innovation projects, it is recommended to include detailed customer potential surveys in the proposals, otherwise the recruitment goals may not be relevant, potentially impossible to reach or not sufficiently ambitious.

5.5. Active participation

Active participation KPI was set as a verification whether demos are leveraging all types of flexibility they initially declared. This KPI reflects how versatile the demos are in leveraging flexibility from different technologies. WP8 and WP9 fulfilled the expectations. In case of WP5, EV chargers and batteries could not be integrated, so two initially technologies were missing in the testing phase. This could (and probably will) be completed in next years, when the technology of SGH will pass the first implementation phase.

5.6. Cost Savings

Cost savings varies a lot mainly because of the technologies used in use-cases. In WP7 the formula was adjusted to the flex market and the cost saving is depending on the flex costs and the penalty costs. This is also depending on the flex availability in the LV network. In WP6, the smart solution cost is near nothing, so 100% savings are achieved in comparison with very costly traditional refurbishment of the grid. For WP8, the Smart Grid solution cost (SG) is based on implementation an Active Network Management, so it is only a fraction of the traditional reinforcement cost.

5.7. Energy distributed thanks to Islanding

Together with the Cost Savings KPI, this KPI for energy savings during islanding was added in the last year of the project. Swedish demo evaluated this KPI as fulfilled, because the idea was not financial gains but the knowledge of micro grids. In the case of the French demo, this KPI does not give information about the price of the islanding service because it would require a probability term. The defined expectations were fulfilled.

6. CONCLUSIONS

With final Task 2.5, the results based on Key Performance Indicators have been evaluated. All demonstrators provided results of original KPIs set in D2.2 at the beginning of the project in 2017 and also additional two economic KPIs added in the last year.

The project KPIs can represent useful parameters to evaluate how specific smart solutions can improve the network performances, but with relevant limitations. It is in fact of utmost importance not to consider the results in an absolute way, but they must be contextualised. The analysis of the demos’ KPIs has shown how the characteristics of the network, of the control solution and the solution’s main goal greatly influence the values of the KPIs. In addition, results depend on the KPI definition, relying often on a combination of measured and calculated data especially for more theoretical indicators such as energy distributed in islanding. The changes quantified by KPIs then may vary on the specific definition and calculation methods and on the baseline condition before the SG implementation. Results must be interpreted in the context of the specific considered network and control solutions.

The set of indicators defined in the project has helped to identify more clearly how different leverages, constraints and benefits are correlated and how it could be possible to improve the network performances as a whole, although talking about cross-comparison of different solutions using KPIs, according to the demos’ results, is very difficult.

7. REFERENCES

7.1. Project Documents

[GA] Grant Agreement (list of all demo KPIs)
[D2.2] Minimal set of use case KPIs
[D6.3] Demonstration activities results
[D8.5] E.ON Sweden DEMO - Lessons learnt from DSR demonstrations in use case #1
[D8.6] E.ON Sweden DEMO - Lessons learnt to draw business models in use case #2
[D8.7] E.ON Sweden DEMO - Raw demonstration results based on the KPI measurements
[D8.11] E.ON Sweden DEMO – Lessons learnt from islanding demonstrations in use case #3
[D9.2] Enedis French DEMO - Innovative solutions to be tested in the use cases with the customer recruitment and contractual procedures for the demonstrations
[D9.5] Enedis French DEMO - Simulation results on use case 3 for further extrapolation of the use case

7.2. External Documents

[1] Standard EN 50160 - Voltage Characteristics in Public Distribution Systems
[2] EN 50438:2013 - Requirements for micro-generating plants to be connected in parallel with public low-voltage distribution networks
[3] BDEW MS-Richtlinie - Technische Richtlinien für Erzeugungsanlagen am Mittelspannungsnetz
[4] VDE-4105 - Power generation systems connected to the low-voltage distribution network