Flexible energy systems Leveraging the Optimal integration of EVs deployment Wave

Grant Agreement Nº: 101056730

Deliverable 7.1

Validation Plan and Assessment Methodology & KPIs

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Website FLOW

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List of Acronyms

Acronym	Meaning
AC	Alternate Current
ADLM	Advanced Dynamic Load Management
API	Application Programming Interface
CBP	Crowd Balancing Platform
CCA	Conditional Connection Agreement
CPO	Charging Point Operator
DC	Direct Current
DSO	Distribution System Operator
DTU	Technical University of Denmark
EMS	Energy Management System
EV	Electric Vehicle
EVSE	Electric Vehicle Supply Equipment
FR	Flexibility Register
FSP	Flexibility Service Provider
IP	Innovation Pillar
KPI	Key Performance Indicators
LV	Low-Voltage
M	Month
MSP	Mobility Service Provider
MV	Medium-Voltage
PGUI	Graphical User Interface
RES	Renewable Energy Sources
SO	Specific Objective
SP	Service Provider
SPG	Service Provider Group
SPU	Service Provider Unit
TSO	Transmission System Operator
UVA	Virtually Aggregated Unit
UVAM	Virtually Aggregated Mixed Units
V1G	Smart charging
V2G	Vehicle-to-Grid
V2X	Vehicle-to-Everything
WP	Work Package

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Executive summary

Deliverable 7.1 documents the efforts done in task 7.1 - Validation Plan and Impact Assessment Methodology. The objective of task 7.1 is to ensure full assessment of the results from the three demonstrations sites in Rome - Italy, Menorca - Spain and Copenhagen - Denmark. This objective is reached through the development of a comprehensive validation plan, which includes:

1. Mapping and characterization of use cases in the different demonstration sites - section 3;
2. Definition of relevant KPIs to assess the impact and quality of the solution - section 4;
3. Definition of strategies to ensure validity of results - section 5.

The first part includes the mapping of the use cases, which is necessary for having a clear overview of the use cases in the FLOW project, before a more detailed description is provided. For the purposes of providing a summary of the use cases, each of the demonstrations is mapped in a condensed manner, indicating the services, products, and main definition of all use cases. The mapping is shown in Figure 1.

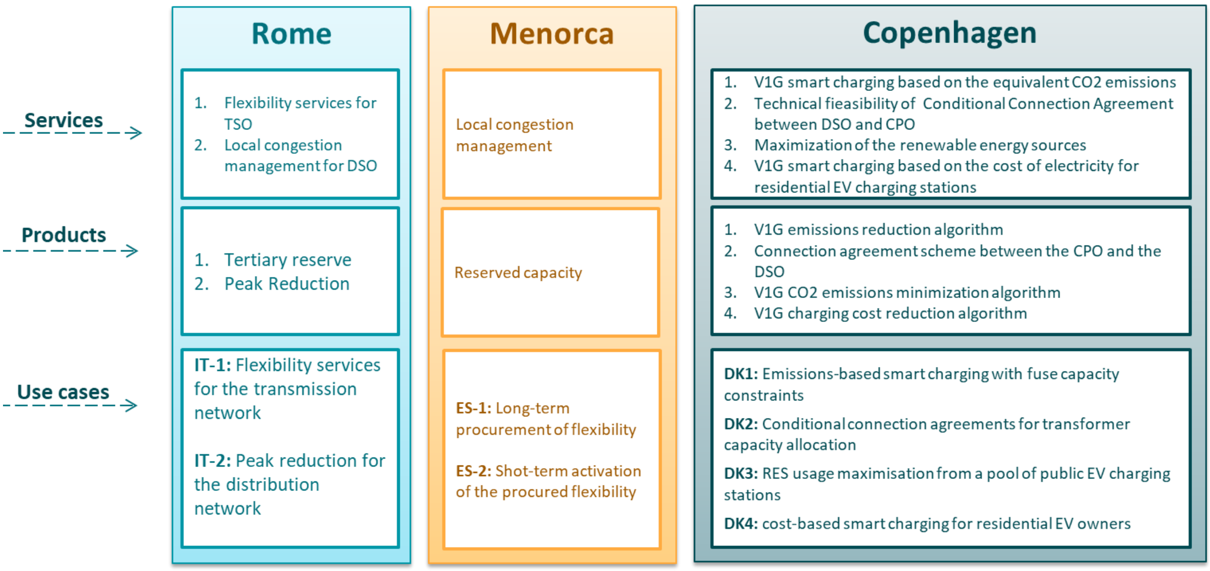

Figure 1 - Mapping of use cases per demonstration.

The second part involves a development of a list of KPIs that sets the foundation for the impact assessment of the different solutions that will be tested with the three demonstrations. The list is created so that it can evaluate the effects of the solutions on economical, technical, user-focused and environmental level. The summarized list of KPIs and their connection to each of the demonstrations is provided in Table 1.

Table 1 - Summary of the KPI list.

KPI ID	KPI Name	KPI Type	Impact	IT	ES	DK
KPI_1	CAPEX for solution implementation	Economic	Benefits to stakeholders	Yes	Yes	Yes
KPI_2	Overall OPEX	Economic	Benefits to stakeholders	Yes	Yes	Yes

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KPI ID	KPI Name	KPI Type	Impact	IT	ES	DK
KPI_3	OPEX for service procurement	Economic	Benefits to stakeholders	Yes	Yes	Yes
KPI_4	Average cost per service for the examined period	Economic	Benefits to stakeholders	Yes	Yes	Yes
KPI_5	Cost for availability	Economic	Benefits to stakeholders	Yes	Yes	TBD
KPI_6	Cost for provided energy	Economic	Benefits to stakeholders	Yes	Yes	TBD
KPI_7	EV users' economic benefits	Economic	Benefits to stakeholders	Yes	Yes	Yes
KPI_8	Estimation of the increment of active power flexibility for the network operators (TSO and DSO)	Technical	Impact on grid/Benefits to stakeholders	Yes	Yes	TBD
KPI_9	Potential offered flexibility from EVs	Technical	Impact on grid/Quality of solution	Yes	Yes	Yes
KPI_10	Increase in the amount of load capacity participating in demand response	Technical	Impact on grid	Yes	Yes	Yes
KPI_11	Volume of transactions	Technical	Effectiveness of platform integration and services	Yes	Yes	Yes
KPI_12	Number of transactions	Technical	Effectiveness of platform integration and services	Yes	Yes	Yes
KPI_13	Deviation between accepted and activated flexibility	Technical	Quality of solution/Effectiveness of platform integration and services	Yes	Yes	Yes
KPI_14	Increased grid connections of EVs	Technical	Impact on grid/Quality of solution	Yes	Yes	Yes
KPI_15	Peak load demand reduction/increase	Technical	Impact on grid	Yes	Yes	Yes
KPI_16	Total activation time of flexibility	Technical	Impact on grid/Quality of solution	Yes	Yes	Yes
KPI_17	Total computation time	Technical	Quality of solution /Effectiveness of platform integration and services	Yes	Yes	Yes
KPI_18	Power demand for overnight charging stations	Technical	Impact on grid	Yes	Yes	Yes

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KPI ID	KPI Name	KPI Type	Impact	IT	ES	DK
KPI_19	Power demand for daytime charging stations	Technical	Impact on grid	Yes	Yes	Yes
KPI_20	Total capacity of charging stations	Technical	Impact on grid/Quality of solution	Yes	Yes	Yes
KPI_21	Volume of aggregation from charging stations	Technical	Impact on grid/Quality of solution	Yes	Yes	Yes
KPI_22	Number of charging stations	Technical	Impact on grid/Quality of solution	Yes	Yes	Yes
KPI_23	EV users' recruitment	Users	End-user responsiveness	Yes	Yes	No
KPI_24	Active participation of users	Users	End-user responsiveness	Yes	Yes	Yes
KPI_25	Acceptance and satisfaction	Users	End-user responsiveness	Yes	Yes	Yes
KPI_26	Ration of number and duration of EV charging sessions with and without providing flexibility	Users	End-user responsiveness	Yes	Yes	Yes
KPI_27	CO2 emissions increase/decrease due to the provision of flexibility services	Environmental	Quality of solution	Yes	Yes	Yes

The third and final part of the task was to provide validation and impact assessment methodologies that can assure the validity of the results and help evaluate the results from all use cases.

The validation methodology consists of five actions distributed across the four stages of the demonstrations:

1. **Stage 1:** preliminary establishment of use cases.
2. **Stage 2:** detailed definition of each use case.
3. **Stage 3**: development and/or improvement of tools.
4. **Stage 4:** use cases execution.

The actions of the validation methodology are summarized in Figure 2 for each of the stages of the demonstrations.

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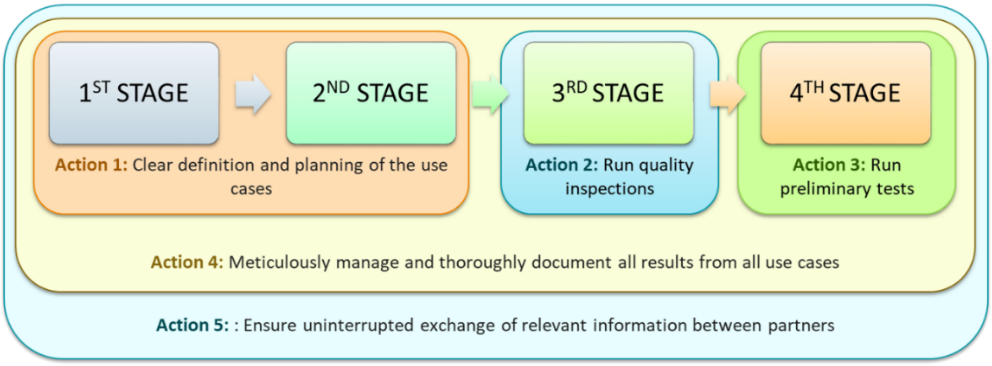

Figure 2 - Actions of the Validation Methodology.

The impact assessment methodology involves eight important steps that serve as a guide for the evaluation of the demonstration results. These steps are presented in Figure 3.

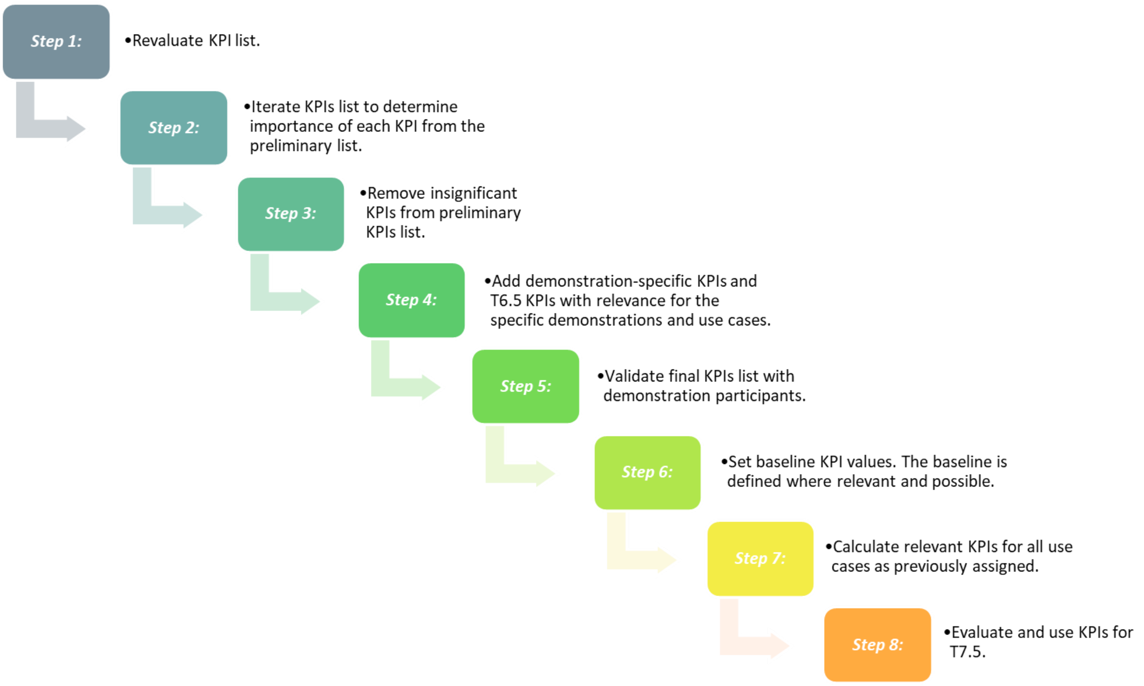

Figure 3 - Steps of the Impact Assessment Methodology.

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1 Introduction

This report serves to present the work done in task 7.1 - Validation Plan and Impact Assessment Methodology. The objective of task 7.1 is to ensure full coverage and correct assessment of the results from the three demonstrations sites in Rome - Italy, Menorca - Spain and Copenhagen - Denmark. This objective is reached with the provision a detailed validation plan, which includes:

1. Mapping and characterization of use cases in the different demonstration sites;
2. Definition of relevant KPIs to assess the quality of the solution in terms of: operative and technical realisation; benefits to different stakeholders, effectiveness of platform integration and services offered, impact on the transmission, low voltage and high voltage distribution networks, end-user responsiveness;
3. Definition of strategies to ensure validity of results.

Based on these actions, this task delivers this methodological report that is used as a reference for all validation activities.

The report starts with the definition of the use cases in the three demonstrations, namely Rome, Menorca and Copenhagen.

Next section, section 4, is dedicated to outline the process for the creation of a comprehensive list of KPIs that will be used as a base for assessing the impacts of the demonstrations. It presents the methodology used to define the KPIs and the structure of the KPIs information.

The final section of the report focuses on the two main methodologies: the validation methodology, and the impact assessment methodology. It underlines all actions and steps that need to be taken to ensure validity of the results and to meticulously evaluate their impact.

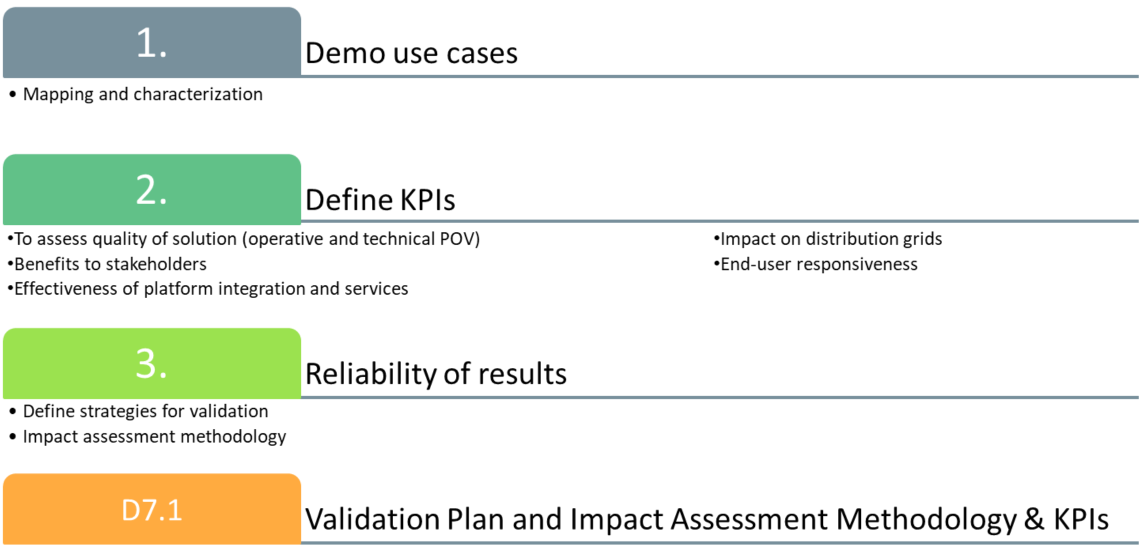

Figure 4 - Overview of task 7.1.

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2 Definition of use cases

This section provides an overview of the mapping and characterization of the use cases in the three demonstration sites in Rome, Menorca and Copenhagen. It first summarizes all use cases to provide a comprehensive description and continues with a more detailed description for each demonstration.

2.1 Mapping of use cases

Mapping of the uses cases is necessary to have a clear overview of the use cases in the FLOW project, before a more detailed description is provided. The aim is to summarize all use cases by presenting the services, products, and use case definitions of all demonstrations.

It is important to point out that the three demonstration sites have different characteristics that influence the use cases. The site in Menorca is an island and it is compelling for its seasonality issues and tourism, whereas in Rome the area is larger and significant in both infrastructure and number of vehicles, making the use case valuable for scalability and replicability. In Rome and Menorca, the focus is on the procurement of flexibility services from electric vehicles (EVs), to deal with network congestions and possibly grid balancing, through a coordinated orchestration of the different actors that are involved.

The site in Denmark involves a distribution of smaller sites (hubs, clusters of electric vehicle supply equipment (EVSEs)) located in the Greater Copenhagen area. The focus is to promote the harmonization of smart charging representing public, private, and semi-private charging.

There are two use cases identified for the Rome demonstration. The first one is to respond to the flexibility needs of the transmission network, and the second one to the flexibility needs of the distribution network.

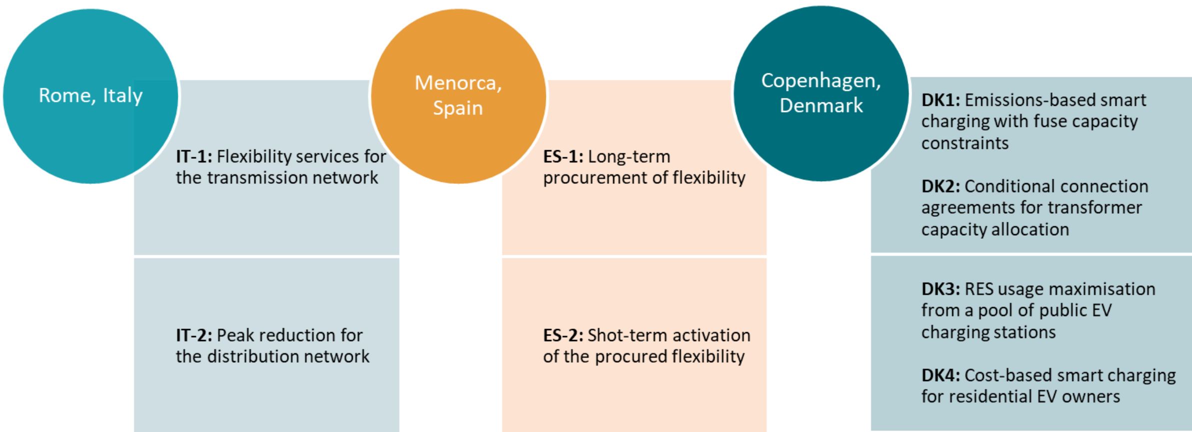

Figure 5 - Use cases abbreviations per demonstration.

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As part of the Menorca demonstration, two use cases are defined and presented in this document. The first use case is long-term procurement of flexibility to deal with local congestions in the distribution network, and the second one is short-term activation of the procured flexibility.

The Copenhagen demonstration has four use cases presented in this document. The first use case is dedicated to the reduction of charging emissions in parking lots, considering capacity constraints. The second treats the conditional connection agreements for transformer capacity allocation. The third is focused on renewable energy sources (RES) usage maximisation from a pool of public EV charging stations, and the fourth deals with cost-based smart charging for residential EV owners.

For ease of referencing the use cases in the next stages of the project, the abbreviations presented in Figure 5 are proposed.

Additionally, in order to have a better overview of all use cases, each of the demonstrations is mapped in a condensed manner, indicating the services, products, and main definition of all use cases. The mapping is shown in Figure 6. The details in the Rome demonstration that are not yet defined are omitted from the current version of the mapping.

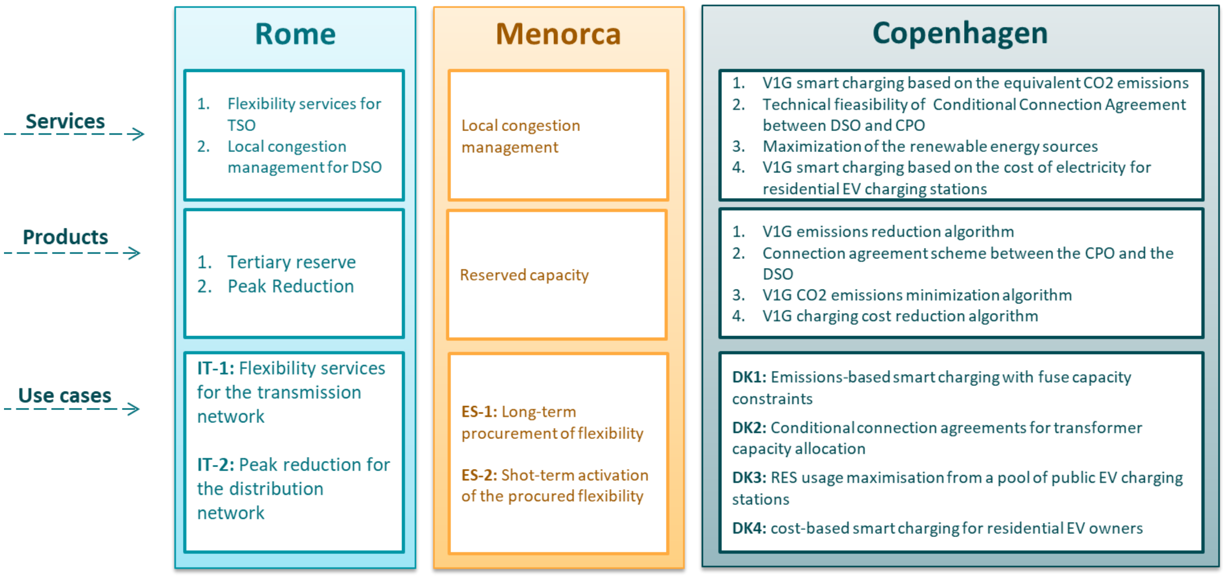

Figure 6 - Services, products and use cases of the three demonstrations.

2.2 Use cases per demonstration

This section is dedicated to the use cases for each of the demonstrations. It starts with the definition of the use cases in the Rome demonstration, then proceeds to the presentation of the use cases for the Menorca demonstration and finally provides the details of the use cases in the Copenhagen demonstration.

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2.2.1 Rome demonstration

2.2.1.1 General description

The Rome demonstration deploys a complete innovative solution enabling the massive smart charge/V2G services implementation, maximizing the benefits for all stakeholders, including TSO, DSO, CPOs, Mobility Service Provider (MSP), Aggregators, EV drivers, grid users, keeping at centre the customer smart charging experience and satisfaction.

The demo investigates how the electrical system and all involved stakeholders benefit from massive spread of EV charging. Supported by a comprehensive partnership including TSO, DSO, CPO, Aggregator, RTO and EV drivers, the demonstration deploys a comprehensive set of solutions for a range of services in a coordinated manner. These embrace a wide spread of interests (from grids issues up to EV customer's behaviours and needs), passing through smart-devices (BTM) and business of CPOs/MSPs/Aggregators.

Within the framework of WP7, specifically task 7.2., the need emerged for the demonstration in Rome to implement two use cases that could respond both to the flexibility needs of the distribution network and those of the transmission network.

Concerning the potential local ancillary services beneficial for the distribution system operator (DSO), the experimentation aims at testing a program of the Peak Reduction type; it will involve the public charging stations, thus responding to the distributor's need to act in real-time on the low voltage grid where congestion occurs.

Concerning the transmission network potential services, the aim is to technically validate the flexibility that EVs aggregates can actually provide to the grid, by assessing the EV aggregate performance in responding to (slow) frequency regulation-like services. It will assess the EV resource behaviour in terms of availability and participation as well as the effects that a variation/sensitivity on parameters and requirements along the flexibility value chain can have on actual flexibility volume availability and participation.

2.2.1.2 Services

The Rome demonstration will offer flexibility services through two use cases with an architecture that is compatible with EVs and networks' needs (TSO and DSO):

- TSO Use Case: A proxy of a tertiary reserve services, taking into account, as a reference, the existing programmes now working in Italy for the participation of aggregates of distributed resources to the Ancillary Services Market, such as the "UVAM" programme, that stands for Virtually Aggregated Mixed Units. In the demonstration, innovative requirements will be taken into account to assess how such changes can potentially benefit a wider participation.
- DSO Use Case: Peak Reduction for public charging stations to relief the distribution grid in "surgical" manner, integrating all the stakeholders along the value chain (DSO, CPO, MSP, driver).

In these use cases, the involved users and charging points consist of:

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- Private charging: No new installations are required; private charging (B2B and B2C) will participate in TSO use case; customer engagement mechanism is under definition.
- Public charging: No new installations are required; pilot charging stations are identified in areas of interest - DSO Use Case**.** It is still under discussion if it can be used for the TSO use case, as well. Customer engagement is passive, meaning that the customers are informed, but they do not take an active role in the process.

2.2.1.3 Products

This section describes the products for each use case in the Rome demonstration.

2.2.1.3.1 IT1: TSO use case

In the TSO use case, EV aggregates are asked to provide flexibility and their performance is assessed. Provision of such flexibility will follow, as a reference, a user journey which tries to be analogous to that needed for the real-market UVAM program in which aggregates of resources are asked to provide, among others, tertiary frequency reserve regulation. As the demo testing will be led off-market in a sandbox environment, and also due to some of the demo characteristics, some simplifications will be applied in the various phases of the user journey of the experimentation. On the other hand, this allows also the necessary elasticity to perform a wider variety of tests. On top of that this also allows to implement and test innovative features that could eventually support market access of EV aggregates.

In particular,

- Due to the demo scale, also an aggregate lower than 1MW of flexible power is considered ok for testing purposes. On the other hand, UVAM today foresees at least 1 MW flex power to be registered for participation, and this requirement is likely set to remain also for the future updates of regulation (new dispatching regulation will be active in Italy from 2025). Nonetheless, the demo will cover a geographical zone already coherent with aggregation perimeters defined in UVAM.
- For the case being, the aggregate will be only made of e-mobility technologies (only technology focus in FLOW) while it is possible already to aggregate mixed technologies (and it is usually preferred by BSPs).
- As far as the aggregation model is concerned, a Behind-the-Meter approach will be tested in the demo, allowing the direct aggregation of assets instead of just PODs (as it happens today). Also, the performance validation will be conducted focusing on the output provided by the single assets (but then also benchmarked with the response registered by PODs). Registration of behind the meter assets will leverage on the Crowd Balancing Platform functionalities.
- Bidding and activation will be conducted with simplified means, nonetheless in a manner that can resemble market timelines and test the response of the aggregate as if it was asked to respond to an activation order coming from the TSO. This will potentially allow also to play with gate closure times, activation times and see how the aggregate response varies.

As a reference, the current UVAM program in Italy can be found in the document "Regolamento MSD UVAM", available through the TSO's website [1].

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2.2.1.3.2 IT2: DSO use case

The DSO use case in Rome consists in providing a service to the DSO in case of energy peak request in some portions of the local distribution grid. The ratio behind this use case is to allow the installation of new charging stations also in sites that could have power limitation constraints in peak period thanks to this flexibility mechanism. In fact, during non-peak period the chargers can offer the nominal power while in peak period the DSO can request to the CPO (and through the CPOS also to the MSPs) to limit the available power.

In practise this use case is similar to a "non-firm connection agreement" between DSOs and CPOs.

2.2.1.4 Use cases sequence

This section shows the sequence of each of the use cases.

2.2.1.4.1 IT1: TSO use case

As explained before, the Italian UVAM program serves as a reference for the tests to be done in FLOW. In FLOW, a process flow analogous to that of the UVAM will be followed, adopting simplifications where needed, especially considering this serves as a sandbox experimentation.

Synthetically, the steps that make up the process can be stated as follows:

- STEP 1: Resource registration. Resource registration consists of the assets/POD registration and the creation of the aggregate including the single points. This process leverages on the use of the Crowd Balancing Platform. Due to the demo characteristics and to reduce burden on the BSP, qualification will be done "on the run", and not in advance, supported by technology information regarding the involved assets that the BSP might provide during registration.
- STEP 2: Bidding. It is proposed that during the bidding phase the BSP provides just a "flexibility availability" indication and the baseline for its aggregate with the possibility to update such availability during the offer till some hours before the provision of the service. Such an approach is judged as the most flexible and feasible taking into account the nature of EVs aggregate that will participate to the test and will allow to learn more about the resource availability, although in the future it is expected that they can provide their availability with timelines analogous to those of other resources. In fact, as the number of EVs that will participate is not sufficiently high, a variation in the behaviour of even a couple of EV owners can have an impact on the aggregate.
- STEP 3: Activation. Activation would be managed by the TSO sending activation orders in a simplified manner and possibly a live power measurement for the aggregate is sent back to the TSO (CBP functionalities being investigated for the purpose too).
- STEP 4: Verification. The process should include:
    i) on the one side the BSP sharing the single measurements from BTM assets, baselines and activations on the assets in the aggregate.
    ii) and on the other the DSO communicating POD data relative to the activated assets to the TSO.

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2.2.1.4.2 IT2: DSO use case

The DSO use case sequence is represented graphically in Figure 7.

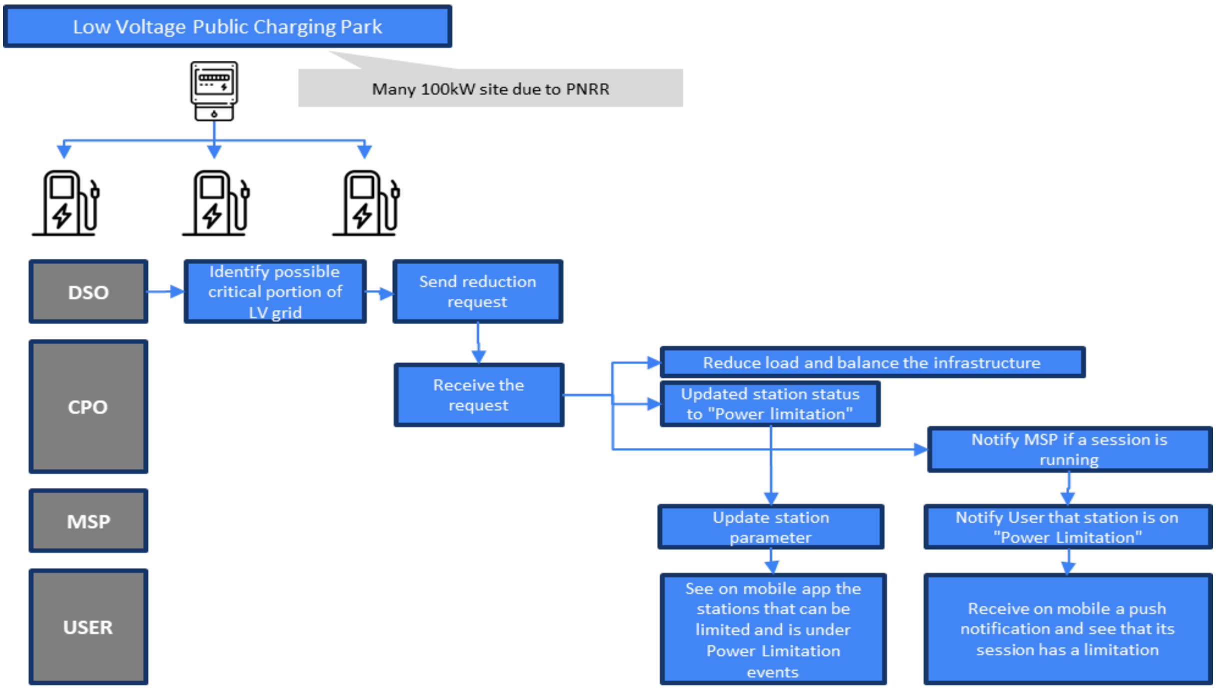

Figure 7 - Rome demonstration, DSO use case sequence, IT2.

The first step is the installation of PGUIs in the charging stations presented in the following table.

Table 2 - Rome demonstration, charging stations for the DSO use case, IT2.

ID	Power	CPO
2	140	AE (65) and EX (75)
2	150	EX (50;100)
2	200	AE (100;100)

2.2.2 Menorca demonstration

2.2.2.1 General description

The Menorca demonstration deploys and validates both unidirectional smart charge chargers and vehicle-to-grid (V2G) network on the island, which has high seasonality on energy demand, providing flexibility to the DSO and allowing the development of mechanisms to compensate the energy transaction across aggregators, charging point operator (CPO), mobility service providers (MSP), and EV drivers. The demo analyses how all the electrical systems and involved stakeholders benefit from the massive spread of EV charging networks by smoothing the demand peaks caused by seasonality due to tourism, guaranteeing supply in all demand scenarios over the distribution grid and analysing the benefits that are provided by smart charging (V1G)/vehicle-to-everything (V2X). The deployment of connected chargers' networks provides a simplified user experience for EV users, which can charge

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in several places across the island. FLOW demonstrates the value and reliability of these solutions that can be easily scalable throughout the island, and later replicated in other islands or larger bigger territories with similar challenges, thanks to the development of the flexibility markets by standardisation of protocols interfaces and products/service definition across Aggregators, DSO, CPO, MSP, and EV users. Cost benefit analysis will assess investment and operative costs of all involved actors, allowing the DSO to apply these solutions to reduce the traditional network investments.

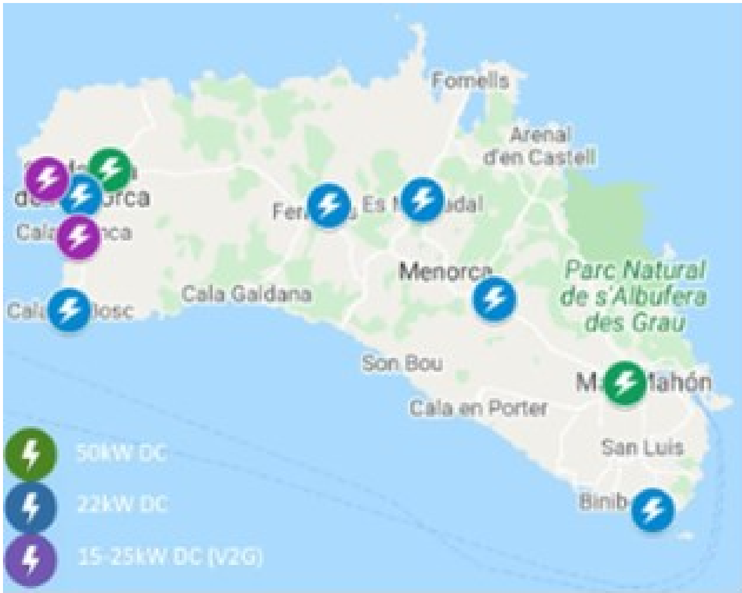

Figure 8 - FSP location in Menorca demo site.

This section presents a general overview of the components and platforms required for the development of the FLOW Menorca demonstration.

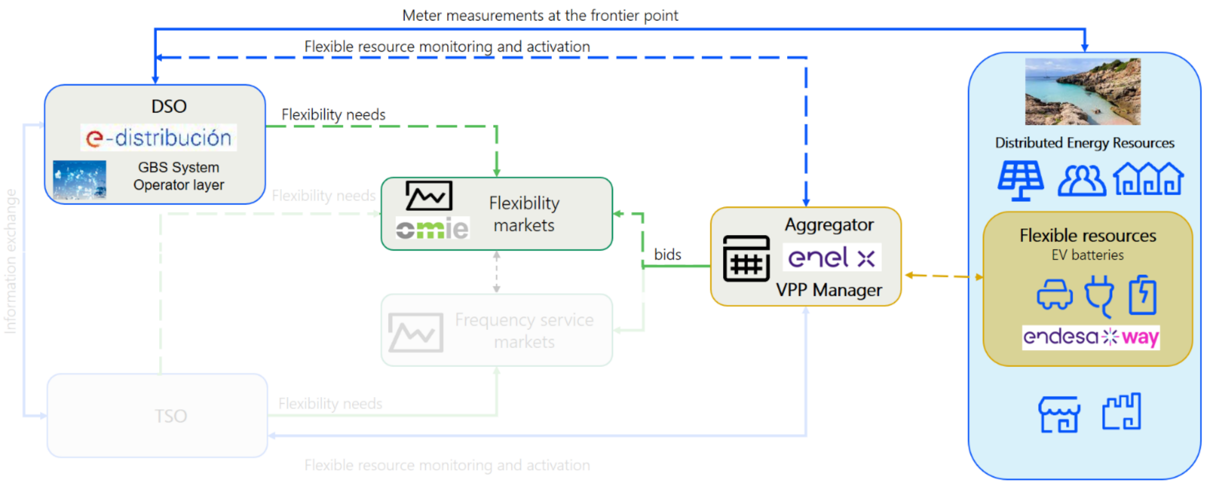

Figure 9 - General overview of actor and information exchange.

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The figure above presents a general overview of the actors, and the information exchange flows between them. The blue traces represent operational information flows, the green traces represent market information flows, and the yellow traces show the internal information exchange processes between the aggregator and his flexible resources. The dashed traces represent the flows to be developed in this project.

2.2.2.1.1 Charging points locations and characteristics

As established previously, in this demo, two types of chargers will be used: V1G and V2G. The first one being the typically used smart charging unit, in its simplest form, permitting electrical flow in one direction. The second one, V2G, are more advanced chargers that permit bidirectional power flow between the charging station and the grid.

The type and location of the V1G charging stations included in this demo are as follows.

Table 3 - V1G Charging Stations.

CP	Model	Tech	Power	CPs	Address	Serial Number
1	Urban T22	V1G	44 kW	2	Carrer de Bajolí 28 Maó, Menorca 07714 Spain	61838048530008
2	Urban T22	V1G	44 kW	2	Avinguda del Dr. Llansó, 54 Mercadal, Menorca 07740 Spain	61922022610015
3	Urban T22	V1G	44 kW	2	Av. VI Urbanizables Indústria, 5 Alaior, Menorca 07730 Spain	61922022610013
4	Urban T22	V1G	44 kW	2	Calle Poife, 0 S/N Ferreries, Menorca 07750 Spain	61922022610020
5	Urban T22	V1G	44 kW	2	C/Joan Estelrich Ciudadela, Menorca 07769 Spain	61922022610007
6	Urban T22	V1G	44 kW	2	Urbanizacion Biniancolla, C/ Equinocio Sant Lluis, Menorca 07710 Spain	61947051020024
7	Urban T22	V1G	44 kW	2	S/N, Carrer de Baix Fornells, Menorca 07748 Spain	61945049570010
8	Urban T22	V1G	44 kW	2	S/N, Carrer de Baix Fornells, Menorca 07748 España	61945049570018
9	Raption 50 Trio	V1G	150 kW	2	Mariners I Pescadors ,2 Parc.8, Sect. B-6 Menorca, Menorca 07760 Spain	61942049840005
10	Raption 50 Trio	V1G	150 kW	2	Carrer Mayor 4 Son Parc, Menorca 07740 Spain	62023018540003
11	Raption 50 Trio	V1G	150 kW	2	Carrer de s'Era Alta, 7 Mahón, Menorca 07714 Spain	61934038200014

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CP	Model	Tech	Power	CPs	Address	Serial Number
12	Waypole 1.1	V1G	44 kW	2	Avinguda de la Playa h2 Sol Parc, Menorca 07740 Spain	19XP22T3KK4AZ00853
13	Raption 50 Trio	V1G	150 kW	2	Poligono Industrial Poima, Carrer de Bajolí, 36 Mahon, Menorca 07714 Spain	61945052670003
14	Waypole 1.1	V1G	44 kW	2	Carrer Llevant, s/n Cala en Bosch, Menorca 07769 Spain	20XP22T3KK4AZ00142

Figure 10 - CP 2, Urban T22.

Figure 11 - CP 11, Raption 50 Trio.

Figure 12 - CP 14, Waypole 1.1.

V2G chargers shall be installed. V2G chargers can only be used by certain electric vehicles that are compatible with this technology. The three car models that will be in use on the Island of Menorca are the Hyundai Ioniq 5, the Smart #1 and the Renault 5e.

In addition, car rentals with an EV fleet will be included in the project to make use of the V1G charging points.

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2.2.2.2 Services

2.2.2.2.1 Local congestion management

This use case consists in attending the grid needs in the medium-voltage (MV) during the short-term grid operation requesting the activation of local flexibility services, previously procured and provided by the flexibility resources connected to DSO grids at the low-voltage (LV) level.

The solution in the use case focuses on managing congestion, and it will be taken care of by congestion management of local flexibility services procured by the DSO. The services provided in this project will be obtained from the charging of Electric vehicles.

The use case is sequenced into two different stages:

- **Long term:** where the service provider unit (SPU)/service provider group (SPG) SPU/SPG are purchased in a simulated market auction managed by a local market operator (LMO - OMIE). Since this project only has one service provider (SP), there will be two offers with different packages of SPU/SPG from the same SP that can solve the same grid issue.
- **Short term:** the SPU/SPG offer that has won the competition will be activated (2-5 days ahead).

The key actions that will be monitored in both time frames are:

- Procedure to be applied by each agent, including roles/functions.
- Effectiveness of the interactions between actors (DSO, LMO, SP, etc.).
- Time to carry out each action.
- Tools and information needed to complete each action.
- Functionalities of the different platforms.

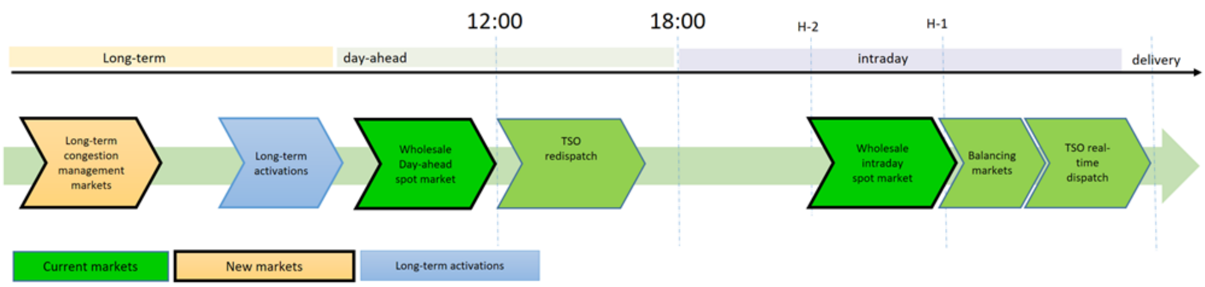

Figure 13 - Current markets and future flexibility markets timeline.

2.2.2.2.1.1 Objectives

Below, the main objectives of the use case:

1. To apply market procedures to obtain flexibility services attending DSO requirements.
2. Demonstrate that long term agreements are suitable amongst different available FSPs.

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3. Implement flexibility provision/usage through a market platform.
4. Use consumer's demand-response in efficient flexibility services.

2.2.2.3 Products

The flexibility provided by the flexibility service provider (FSP) can be used in different timeframes. In the timeline of the figure below, the current and future existing flexibility markets defined in the FLOW project and their activation are represented.

The product for the new flexibility market is defined in the following subsection.

2.2.2.3.1 Long term congestion management product

In the table below, the attributes of the long-term local congestion management product can be seen:

Table 4 - Attributes of local congestion management reserved product.

Attribute	Value
Service window	Selection of the required date and duration of the service o Start date: DD/MM/YYYY o Duration: TBD o Selection of days: M, T, W, T, F, S and S. o Opening time: 8:00 PM o Closing time: 10:00 PM
Availability	Selection of the capacity, the direction and the estimated hours of activation. o Capacity: TBD o Direction: Upwards (up for generation, down for consumption) o Estimated hours of activation: 120h
Activation window (in case of activation product):	Specific subperiod in an activation window when a particular FSP could be activated and thus it must be available. Multiple sets of activation windows can be defined. E.g.: o Day: DD/MM/YYYY o Hour: 19h o Duration: 2h o Capacity to modify: TBD o Direction: Upward
Local area	Selection of the trading area. Choice by postal code, connection point, lines… (to be determined). o Area: postal code
Activation Announcement	Time in advance that a DSO informs a FSP that its activation is confirmed.
Form of Remuneration	It establishes a form of payment to winning FSPs. Two different terms are defined: availability and activation (depending on the product). o Type of product: availability/activation o Availability/Activation cap price: X €/MW or X €/MWh

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2.2.2.4 Use cases sequence

In this section, the use case sequence is defined in detail. It is important to note that the integration among the different agents is at the process level, not among the systems.

All interactions between DSO and LMO in the Long-Term steps (see figure below), will be done manually. The proposed interactions for the short term (see figure below step 20) will be done via email, not using application programming interfaces (APIs).

2.2.2.4.1 ES1: Long-term use case

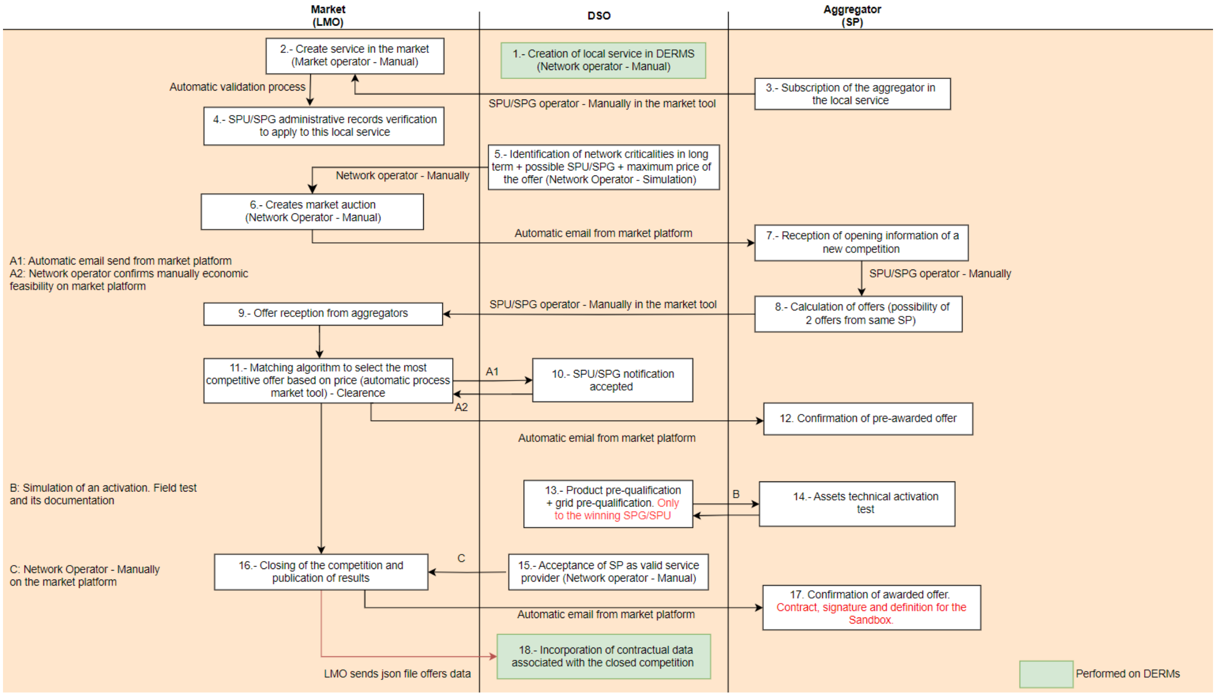

Figure 14 - Long-term BUC sequence, ES1.

- STEP 1. The DSO creates the local flexibility service (congestion management) with attributes in DERMS (DSO platform) manually to configure the parameters of the market product. To be done only once at the beginning of all the demo.
- STEP 2. The LMO also creates the local flexibility service (congestion management) with attributes in the OMIE platform manually. To be done only once at the beginning of all the demo.
- STEP 3. The SP registers to the local flexibility service and fulfil the form in the LMO platform (OMIE). At this point, the SP is entitled to participate in this market. To be done only once at the beginning of all the demo.
- STEP 4. Once the SP is registered in the LMO (OMIE) platform, there is an automatic process of verification and validation of the data provided by the SP that allows him to participate in future auctions for the local services.
- STEP 5. The DSO forecasts the potential grid criticalities and potential local services that can address those criticalities. Additionally in this stage the DSO sets the conditions (i.e., service

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attributes and maximum price) for SP to participate in the auction, which SPU/SPG can send a bid (can solve the congestion issue) and insert the information manually in the LMO platform.

- STEP 6. The LMO creates a market auction manually based on the information provided by the DSO and informs those SP already registered whose SPU/SPG can solve the congestion issues.
- STEP 7. The SP receives the communication that a new auction is open.
- STEP 8. The SP calculates his offers to participate in the auction. As mentioned above, as there is just one SP and in order to simulate the auction, two offers are submitted manually into the LMO platform.
- STEP 9. The LMO receives the offers made by the SP.
- STEP 10. The DSO receives the list of potential SP and validates each SP is feasible to provide the service, i.e. solve the specific congestion or voltage issue. Then informs to the LMO (OMIE).
- STEP 11. The LMO runs his clearance algorithm to select the most competitive offer, based on minimum price and merit order, and informs the DSO, by email, of the winner of the auction. If the SP is already prequalified by the DSO and the contract is already signed, the next step is publishing the results of the auction in the STEP 16.
- STEP 12. The SP confirms the acceptance of the offer that has been pre-accepted.
- STEP 13. In this stage, the DSO runs the pre-qualification (both product and grid) of the SPU/SPG that have been awarded. To be defined. Once this step is made, this should not be repeated in the future for these SPU/SPG.
- STEP 14. A simulation of a technical activation test of the SPG/SPU is carried out by the SP on request of DSO, if needed for the specific product. In this stage, the SP provides the structural information requested by the DSO to be able to accept the SP as a flexibility service provider. Once the technical activation test is performed, this is informed to the LMO platform and not repeated in the future.
- STEP 15. The DSO accepts the SP as a valid service provider when the information requested, and test are successfully passed the prequalification processes and is manually confirmed the final acceptance of the SP on the LMO market platform. This should be defined in detailed according to the final information exchange processes defined between LMO-DSO. For instance, sending the date under of the result of the activation of each SP.
- STEP 16. The LMO closes the competition, publishes the results of the auction, informs the SP by email (or other means).
- STEP 17. The SP receives the email confirmation of the results of the auction. At this stage the SP and DSO have all the information. The contract formalization between SP and DSO is out of scope of FLOW.
- STEP 18. Once the competition is closed, the LMO must provide the necessary fields to the DSO so that all information relevant to the new contracts (Flexibility Catalogue) can be manually uploaded into the DERMs platform. DERMs has a massive upload tool for this type of information, an example of the file formats required for this upload will be included in the attachments section. The document is sent by email. For this interaction between step 16 and 18, see the attached DERMS template (JSON files)

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2.2.2.4.2 ES2: Short-term use case

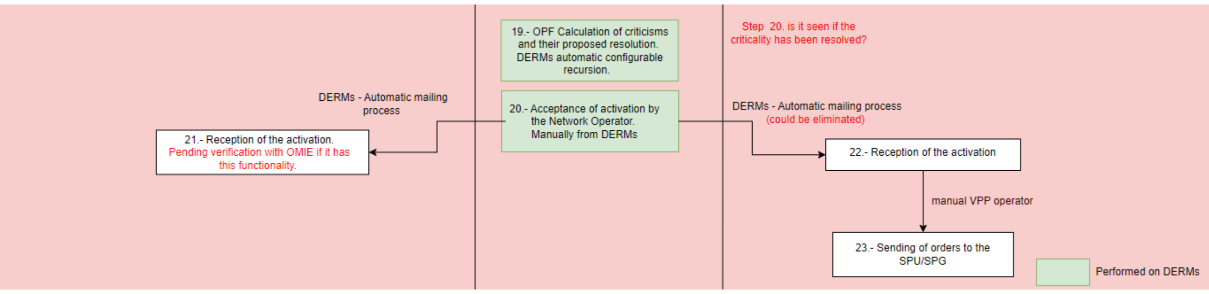

Figure 15 - Short-term BUC sequence, ES2.

- STEP 19. The DSO, 2 or 5 days ahead the potential criticality occurs, runs an OPF algorithm to calculate if the criticality can still occur with the standard conditions of the grid and how to solve it with the services that are already in place (competition winner or existing bilateral contracts).
- STEP 20. Once the DERMS calculations are done, the DSO accepts the resolution of the criticality by using the services already contracted. The DSO, in this case, informs the LMO and the SP, by mail, of the activation requested bid of the SPU/SPG considering the results from the STEP 16.
- STEP 21. The LMO receives the activation request by email.
- STEP 22. The SP also receives the activation notification request by email.
- STEP 23. An operator of the SP manually sends the signals to the SPU/SPG.

2.2.3 Copenhagen demonstration

2.2.3.1 General description

The Copenhagen demonstration consists of four use cases. The first use case is dedicated to the reduction of the charging emissions in parking lots, considering fuse capacity constraints. The second one treats the conditional connection agreements for transformer capacity allocation. The third one is focused on RES usage maximisation from a pool of public EV charging stations, and the fourth one deals with cost-based smart charging for residential EV owners.

The services, products and sequences are presented for each use case in the following sections.

2.2.3.2 Services

This section presents the services for each of the use cases in the Copenhagen demonstration.

2.2.3.2.1 DK1: Emissions-based smart charging with capacity constraints use case

The service which is going to be tested is V1G smart charging based on the equivalent CO2 emissions produced by the electricity system of Denmark. The case study is a public parking lot located in DTU's Lyngby Campus (DK) in front of building 325, featuring six EVLink (Schneider Electric) charging stations, with a nominal power of 22 kW per outlet, and two outlets per station.

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The economic value of the service is twofold:

1. For the EV owners, it stems from the modulation of the power to reduce the equivalent CO2 emissions from the charging process, which in general coincides with periods of lower electricity costs.
2. For the CPO (Spirii) or charging point owner, it stems from both their possibility of being a "green charging" company, which could be a driver for EV owners to choose them among the competitors and unlock additional revenues/funding opportunities. Externality costs, such as green certificates, could also be considered as an economic revenue stream.

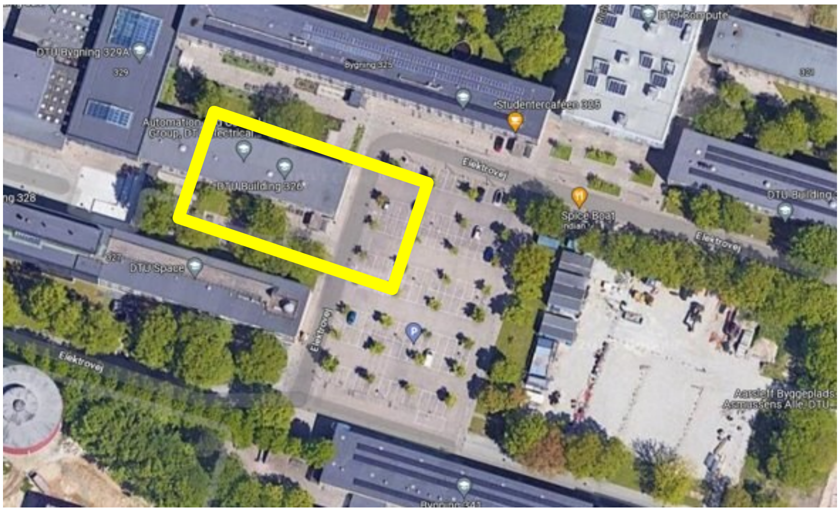

Figure 16 - Use case location in Lyngby, Denmark.

2.2.3.2.2 DK2: Conditional Connection Agreements for transformer capacity allocation use case

In this use case, the technical feasibility of a Conditional Connection Agreement (CCA) between the DSO and the CPO is going to be tested.

This use case does not involve a direct scheduling of the single EVs connected to the two parking lots under study, located in the municipality of Frederiksberg (Copenhagen, DK), but rather the regulation of the maximum current absorbed by each parking lot in a predefined time slot. Each location features three Zaptec Pro 22 kW charging stations, capable of performing load sharing and phase rotation, based on the grid conditions.

The economic value of the service is threefold:

1. For the CPO (Spirii), the CCA should be cheaper than paying for a fixed fuse capacity, especially considering that capacity is rarely reached. The CCA also increases the turnover of cars in the locations thanks to the higher number of not-curtailed sessions, hence an increased revenue.
2. For the DSO (Radius), the CCA improves the utilization of the transformer, hence the increased revenues from its usage, all while delaying the grid reinforcement needs, an additional value stream.

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3. For the EV owners, the economic value is unlocked only if the increased revenues for the CPOs are translated into a charging cost reduction, which, in-turn, could lead to an increased number of drivers connecting to the two parking lots.

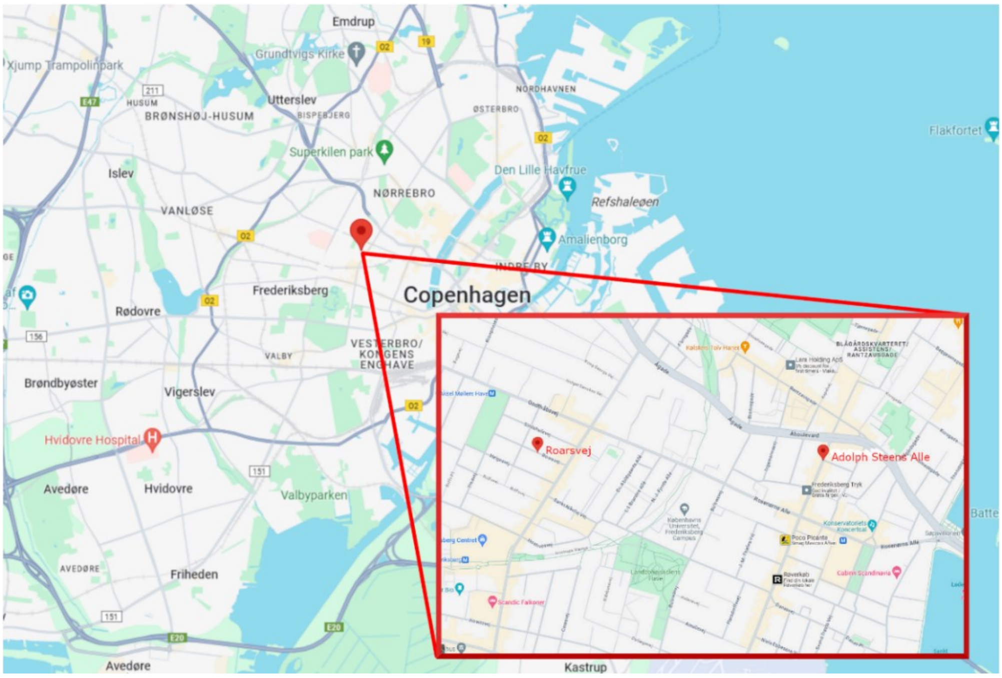

Figure 17 - Map of the use case location in Frederiksberg, Copenhagen.

2.2.3.2.3 DK3: RES usage maximization from a pool of public EV charging stations use case

In this use case, the maximization of the RES production usage will be tested from a pool of EV charging stations located in DTU's Risø Campus (Roskilde, Denmark).

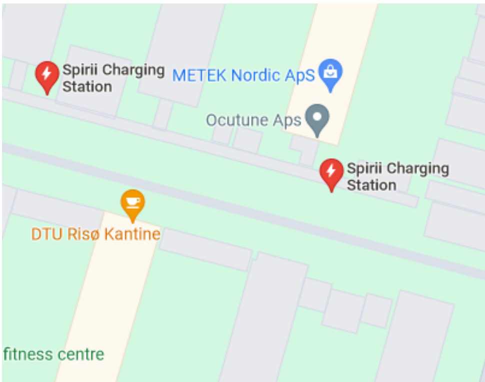

Figure 18 - Location for use case 3.

Figure 19 - DTU's Risø Campus.

The case study includes 11 Zaptec Pro stations, for a total of 22 outlets capable of delivering 22 kW each, operated by Spirii and owned by DTU's Campus Service (CAS).

The economic value of the "RES usage maximization" service is:

1. For the charging point owner/operator, from the possibility of being a "green charging" company, which could be a driver for EV owners to choose them among the competitors.

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Externality costs, such as green certificates, could also be considered as an economic revenue stream, together with the additional revenue from being in a local energy market schemes or renewable energy communities, where consuming local production is economically compensated.

2. For the EV owners, in the additional revenue from charging when the emissions are low, which typically coincides with periods of lower charging costs.

2.2.3.2.4 DK4: Cost-based smart charging for residential EV owners use case

The service will be tested is V1G smart charging based on the cost of electricity for residential EV charging stations. The case study will consist of a number of Spirii's customers, spread throughout Denmark, which are going to be selected on a voluntary basis to participate in this experiment of charging costs reduction. Each EV owner will be equipped with a Zaptec Go charger, with a nominal power of 22 kW.

The economic value of the service is twofold:

1. For the EV owner, it stems from charging in periods of time when the total cost of electricity (including taxes, final cost to customer from energy provider) is lower.
2. For the CPO (Spirii), it stems from the possibility of advertising that "smart charging" is performed at their stations, with the goal to save their users' money. This could lead to an increased number of customers due to the reduced charging tariffs. Externality costs, such as green certificates, could also be considered as an economic revenue stream.

The provider of the service will be Spirii, the CPO.

2.2.3.3 Products

This section is dedicated to the products for each use case in the Copenhagen demonstration.

2.2.3.3.1 DK1: Emissions-based smart charging with fuse capacity constraints use case

The product of this use case is a V1G emissions reduction algorithm, which minimizes the environmental impact of the charging process for the EV owners.

The provider of the service could either be Spirii, the CPO which bills the EV drivers, or DTU's Campus Service (CAS), which acts as the Charging Point Owner.

2.2.3.3.2 DK2: Conditional connection agreements for transformer capacity allocation use case

The product of this use case is a conditional connection agreement scheme between the CPO and the DSO, which translates into an improved utilization of the transformer, a cost reduction for both the CPO and DSO, and capacity trading/load sharing between the two charging clusters/charging point owners.

2.2.3.3.3 DK3: RES usage maximization from a pool of public EV charging stations use case

The product of this use case is a V1G CO_2 emissions minimization algorithm for public parking lots.

The smart charging service provided by Spirii and EATON, two of FLOW's project partners participating in the task, and involves the usage of Spirii's Advanced Dynamic Load Management (ADLM) tool, and EATON's Energy Management System (EMS).

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2.2.3.3.4 DK4: Cost-based smart charging for residential EV owners use case

The product of this use case is a V1G charging cost reduction algorithm that minimizes the charging cost for the EV owners. The provider of the service will be Spirii, the CPO.

2.2.3.4 Use cases sequence

This section shows the sequence of each of the use cases.

2.2.3.4.1 DK1: Emissions-based smart charging with fuse capacity constraints use case

The following flowchart represents the interaction between the different actors involved in the service. Each line represents the signal transporting some information from one actor to the other.

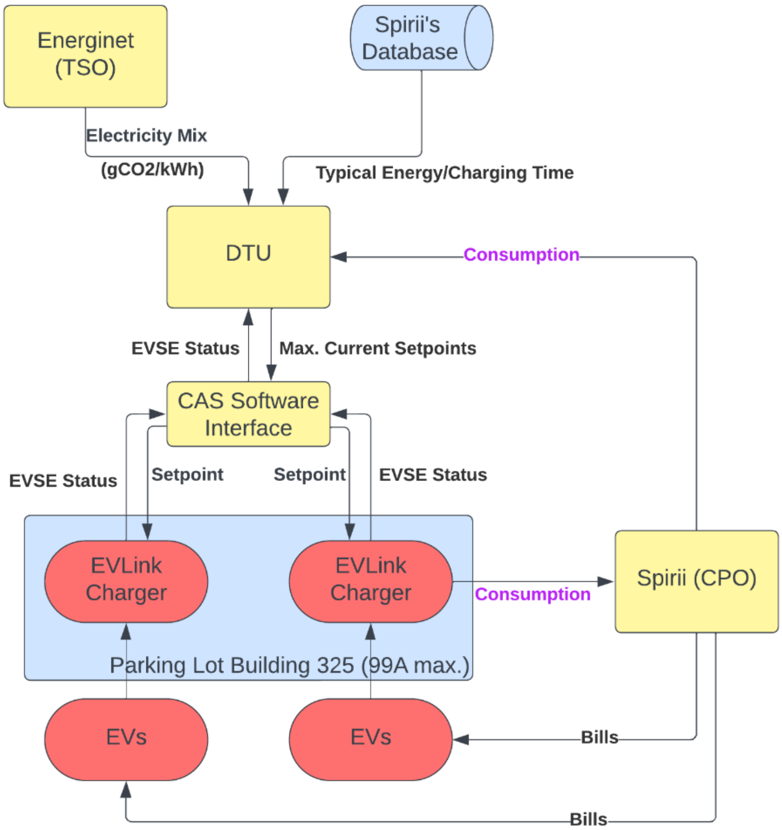

Figure 20 - Flowchart of use case DK1.

The smart charging service features the following different steps:

1. DTU analyses the database of charging profiles provided by Spirii, determining the typical energy charged and charging time for a session starting in a particular day of the week and month.
2. Once that is defined, the smart charging can begin, and will cover several consecutive days.
3. On a testing day, DTU will run an algorithm that checks in real time how many outlets are occupied in the parking lot and tries to deliver to the EVs the energy from point 1) in the amount of time also defined at point 1).

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4. The algorithm checks every few minutes if new EVs are connected through the CAS Software Interface and optimizes the charging power to minimize the equivalent CO2 emissions, based on a day-ahead signal coming from Energinet's (Denmark's TSO) website.
5. The whole process takes into consideration the charging limitations imposed by the circuit breakers installed at each outlet (20 A max.), at each station (32 A max.), and at the parking lot (99 A max.).
6. The resulting maximum current setpoints are sent to each outlet, and the result is a delayed session where the power is shifted to low-emissions during charging.
7. Whenever a new EV connects or disconnects, the optimization is run again, considering how much energy was delivered in the previous instants to the EVs that were already connected.
8. An energy measurement device continuously records the energy exchanged between the EVs and the station, and the resulting timeseries will be used by DTU to measure the success of the demonstration. The measurements are also available from Spirii, for EV owners billing purposes.

2.2.3.4.2 DK2: Conditional connection agreements for transformer capacity allocation use case

The following flowchart represents the interaction between the different actors involved in the service. Each line represents the signal transporting some information from one actor to the other.

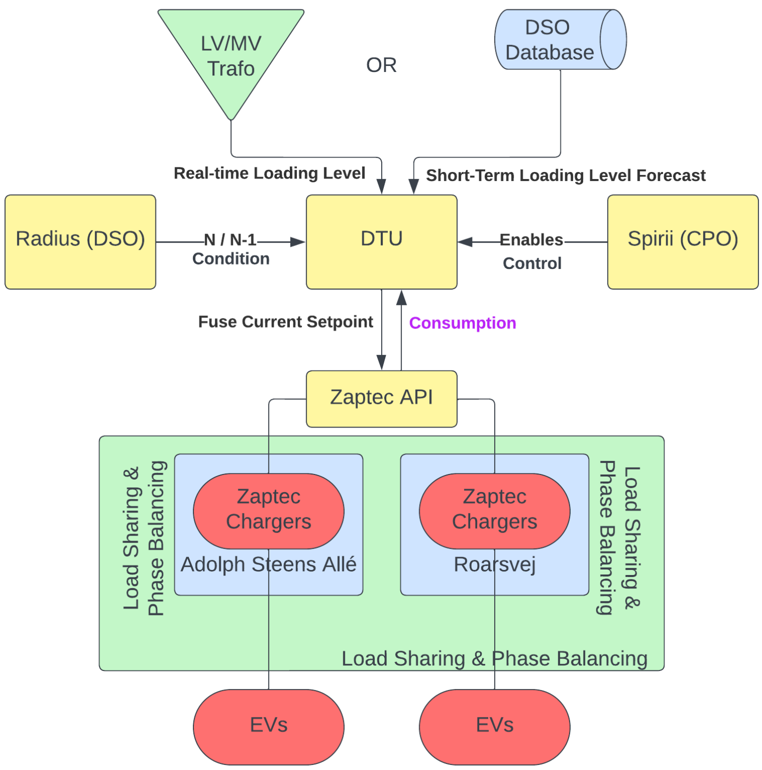

Figure 21 - Flowchart of use case DK2.

The smart charging service features the following different steps:

1. DTU analyses the database of transformer loading provided by the local DSO (Radius), determining the loading level for different days of the week and months. This is going to be

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used for the creation of a short-term load forecasting model, with a maximum time horizon of a week, and using the most recently available data.

2. If the service is run in "offline" mode, DTU's algorithm will forecast the short-term load at the transformer and dynamically allocate the capacity of the transformer for each parking lot, considering how many cars are connected at that time slot (available via the Zaptec Chargers' API).
3. If the service is run in "online" mode, DTU's algorithm will read the current loading level of the transformer from an energy measurement device located at the LV/MV transformer serving the two parking lots. The DSO can also communicate if the grid is in N or N-1 condition (available capacity = 100% or 66% of the transformer nameplate capacity).
4. DTU estimates a max. current setpoint for each parking lot, with the aim to improve the overall usage of the transformer, reducing its congestion level, and prioritizing the parking lot with the highest number of connected EVs.
5. This setpoint is then sent, Thanks to the Zaptec API, to the virtual fuse of each parking lot, to activate the service.

2.2.3.4.3 DK3: RES usage maximization from a pool of public EV charging stations use case

The following flowchart represents the interaction between the different actors involved in the services. Each line represents the signal transporting some information from one actor to the other.

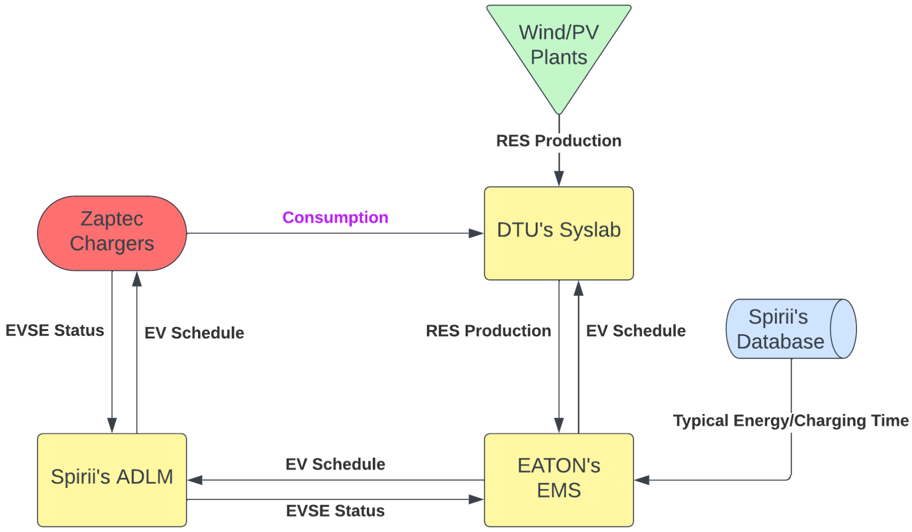

Figure 22 - Flowchart of use case DK3.

The following steps are foreseen:

1. DTU/EATON analyses the database of charging profiles provided by Spirii, determining the typical energy charged and charging time for a session starting in a particular day of the week and month.
2. Once that is defined, the smart charging can begin, and will cover a few consecutive days.

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3. On a testing day, EATON's EMS will receive RES production information from DTU's Syslab facilities, as well as the number of EV charging outlets that are occupied at a particular moment in time from Spirii's ADLM.
4. This information, together with the typical energy/charging time historical information, allows the EMS to optimize the EV charging profiles.
5. The profiles are then sent through Spirii's ADLM to the Zaptec chargers' API in the form of a current setpoint for each outlet, or for the entire cluster (to be defined).
6. An energy measurement device continuously records the energy exchanged between the EVs and the station, and the resulting time-series will be used by DTU to measure the success of the demonstration.

2.2.3.4.4 DK4: Cost-based smart charging for residential EV owners use case

The following flowchart represents the interaction between the different actors involved in the service. Each line represents the signal transporting some information from one actor to the other.

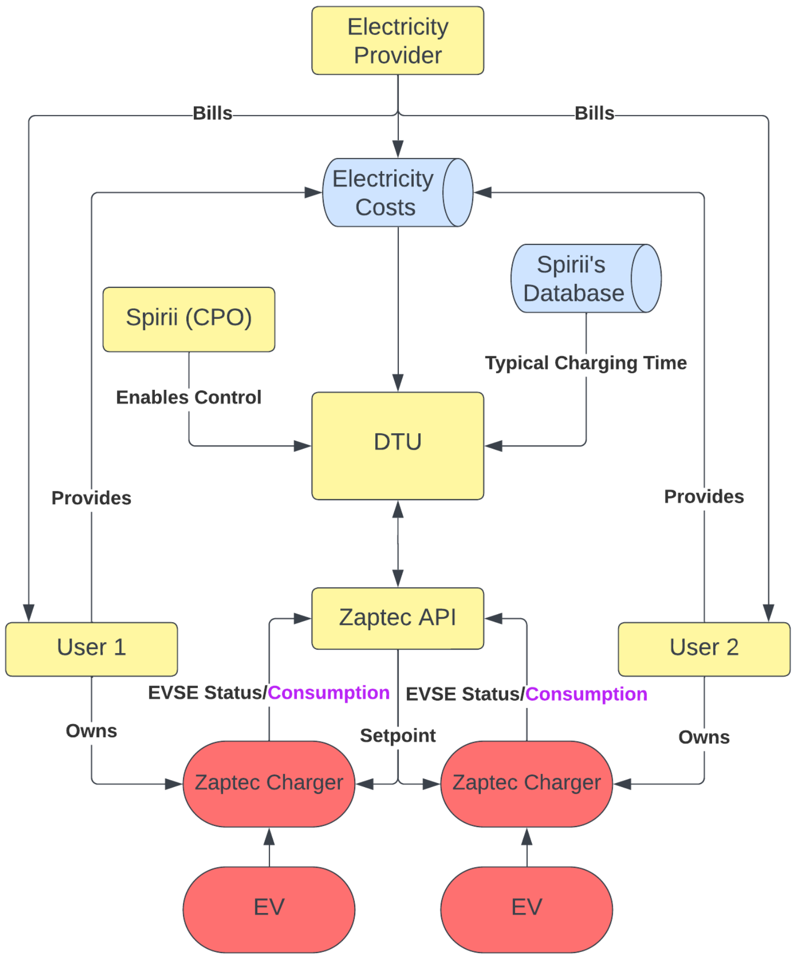

Figure 23 - Flowchart for use case DK4.

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The smart charging service features the following different steps:

1. DTU analyses the database of charging profiles provided by Spirii, determining the typical energy charged and departure time for a session starting in a particular day of the week and month.
2. Spirii will get some basic information from the EV owners, such as their car model and year of construction, which is going to be used to determine the maximum chargeable energy (battery capacity) and charging power.
3. Once that is defined, the smart charging can begin, and will cover several consecutive days, inside a specific hours' timeframe, which is defined by analyzing the historical charging profiles record.
4. On a testing day, inside the smart charging hours, DTU will run the algorithm every few minutes, to check if the car is connected to the station.
5. Once the car is connected, based on the price signals coming from the chosen electricity provider and day-ahead spot market price, DTU will optimize the charging session to try to charge the max. chargeable energy, in the pre-defined timeframe, while minimizing the charging costs.
6. That charging profile is sent, as a maximum current setpoint, to the charging stations, via Zaptec Go's API.
7. An energy measurement device continuously records the energy exchanged between the EVs and the station, and the resulting timeseries will be used by DTU to measure the success of the demonstration, especially considering how much the optimized charging schedule is influenced by the approximation on the charging power and maximum chargeable energy.

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3 Key Performance Indicators

A few important steps have been taken for the definition of the preliminary list of KPIs: the identification of the KPIs, the structuring of the important information that needs to be included, and the modification of the KPIs to reach a satisfactory version of the list.

In addition, as part of FLOW's participation in the Towards Zero Emission Road Transport (2Zero) Partnership, the KPIs were aligned as closely as possible to the "Strategic Research and Innovation Agenda (SRIA)" that aims to set an ambitious research programme to accelerate the development of zero tailpipe emission road transport in Europe. It also aims to develop a common vision and deliver a multi-stakeholders roadmap for a climate-neutral and clean road transport system [2].

3.1 KPIs definition methodology

For the FLOW project, a list of KPIs was developed to set the foundation for the impact assessment of the different solutions that will be tested with the three demonstrations in Rome, Menorca, and Copenhagen.

These KPIs will be used as a starting point for the analysis of all demonstrations, their correlation, and their differences in Task 7.5 – Overall assessment, conclusions and lessons learned from testbeds and demos. The list is created so that it can evaluate the effects of the solutions on economical, technical, user-focused and environmental level. In addition, the KPIs intend to help draw the conclusions and lessons learned regarding the best practices, the aspects to consider along the different stages (design, installation, operation), the impacts on the transmission and distribution systems and the experience of the participating stakeholders (users, market operators, energy system operators, and service/technology providers).

Another important aspect that is considered are the Specific Objectives (SOs) and the Innovation Pillars (IOs) of the FLOW project. For each KPI, the corresponding SOs and IPs are identified and assigned. The summary of all SOs and IPs are provided in Table 5 and Table 6, respectively.

Table 5 - FLOW's Specific Objectives.

Specific Objectives (SOs)	
SO1	Create and validate <u>user-centric smart charging EV experiences</u> that foster user's satisfaction and active participation by addressing their needs and concerns through the delivery of intuitive and practical multi-benefit solutions.
SO2	Promote <u>harmonisation, standardisation and interoperability of solutions</u> by delivering open architecture, data models, communication protocols and data governance while being mindful of data privacy and cybersecurity.
SO3	Define, improve and validate a portfolio of <u>EV smart charging configurations, technologies, and strategies</u> for a range of applications and use cases.
SO4	Deliver a range of <u>advanced digital-based tools for the planning, design and operation of integrated charging solutions</u> to maximise flexibility, user satisfaction, overall energy system cost-efficiency and associated benefits.
SO5	Enhance <u>EV flexibility valorisation</u> to alleviate grid challenges by optimal orchestration across actors.

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Specific Objectives (SOs)	
SO6	Demonstrate and validate solutions and approaches in a wide range of scenarios and countries, engaging users and relevant actors to deliver quantified benefits valorising flexibility and fostering EV and RES penetration.
SO7	Boost replication and mass upscaling of EV/EVSE via scenario optimisation, multi-criteria assessment, innovative business models and dissemination/exploitation.

Table 6 - FLOW´s Innovation Pillars.

Innovation Pillars (IPs)	
IP1	***User centric design*** - enhanced user participation and satisfaction through planning, design, and communication.
IP2	***Interoperability*** - open data sharing model, standardisation, sharing protocol considering data privacy and cybersecurity.
IP3	***Novel charging solutions*** - configurations and strategies to improve performance and enable flexibility services.
IP4	***Open digital tools*** for modelling, planning, and design allowing actors to quickly assess impacts and maximise benefits.
IP5	***Interoperable solutions*** for the optimal operation of charging station and integration into energy systems.
IP6	***Orchestration*** to enable communication across different actors and respective tools.
IP7	***Scalability & mass deployment*** - leveraging robust services, business models, pricing and incentives.

To initiate the process of creating the KPI list, a thorough review of several European projects was performed. The projects were chosen based on their relevance to the FLOW projects in two aspects, flexibility and EV integration.

The KPIs of a total of 7 projects were reviewed, both from ongoing and already finished projects. The flexibility related projects include: SmartNet [3], CoordiNet [4] and OneNet [5]. The EV integration related project include: SCALE [6], ASSURED [7], eCharge4Drivers [8] and EV4EU [9].

The initial list consisted of KPIs taken directly from these projects as defined there, in addition to KPIs that were defined specifically for FLOW. This initial list was shared with all partners of Task 7.1, with special request for feedback for the demonstration leaders.

After several iterations and discussions, all partners and demo leaders agreed on the KPI list defined in this document. In the iteration process, many of the KPIs underwent modifications to fit the needs of the FLOW project. Moreover, a list with the KPIs per demonstration was added, to indicate which KPIs are relevant and calculable for which demonstration.

Although the KPIs presented in this document have been thoroughly discussed and carefully defined, due to the early stages of the demonstrations, the result is a preliminary KPI list that is expected to

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undergo additional changes as WP7 progresses and the demonstrations reach a more advanced stage. Any changes that might occur to the KPIs will be documented in the remaining deliverables of WP7.

The KPIs list was also revised following the SRIA recommendations to check if they are aligned with this agenda. The relation between the FLOW KPIs and SRIA recommendations are presented in section 3.4.

The summarized methodology for the preparation of the KPIs is provided in Figure 24.

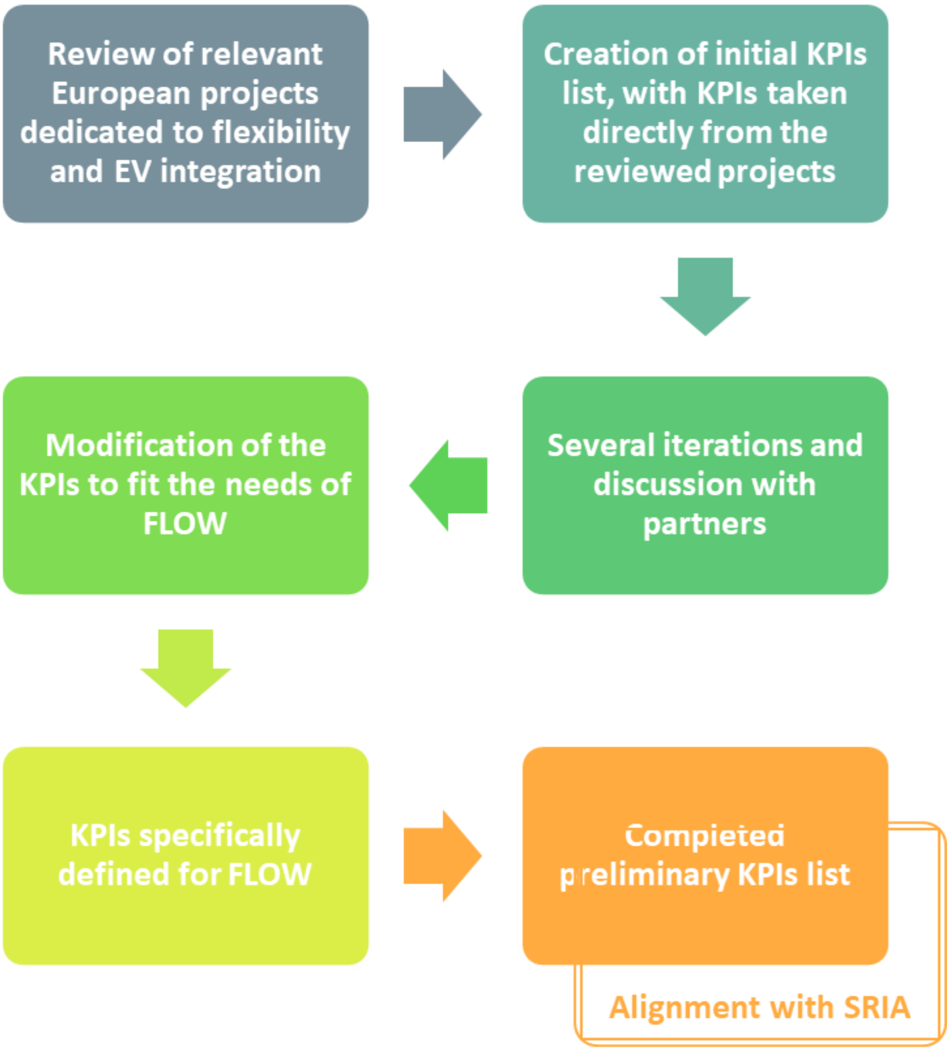

Figure 24 - KPIs methodology.

3.2 KPIs information structure

To present a cohesive formulation of each of the KPIs, a template was developed and used for all of them. The template includes the most important KPIs information, namely, the description, the mathematical formulation that will be used to calculate them as well as the connection with the project's SOs and IPs and the related demonstration.

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The KPI information structure template is the following:

1. **ID** - the ID that is used to reference the KPI, from this point in the project forward. The format of the ID is KPI_XX, where XX represents the number of KPI.

2. **Name** - the name of the KPI that points to the definition of it.

3. **Specific Objective connection** - indicates which SOs are addressed by the KPI. The relevant SOs are referenced with their number as provided in Table 5.

4. **Innovation Pillar connection** - indicates which IPs are addressed by the KPI. The relevant IPs are referenced with their number as provided in Table 6.

5. **Definition** - the main description of the KPI and what it is used for.

6. **Mathematical formulation** - a mathematical representation representing all variables and for calculating the KPI values.

7. **Unit** - the unit of the KPI value.

8. **Related demonstration** - indicates which demonstration the KPI is important for.

9. **Additional comments** - a section to provide further clarification if necessary.

The template in table format is provided in Table 7.

Table 7 - KPI information structure template.

KPI Definition	
ID	
Name	
Specific Objective connection	
Innovation Pillar connection	
Definition	
Mathematical formulation	
Unit	
Related demonstration	
Additional Comments	

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3.3 List of KPIs

This section presents the full preliminary list of the KPIs. There is a total of 27 KPIs that are divided per type: economic, technical, user-focused and environmental.

3.3.1 Economic KPIs

KPI Definition	
ID	KPI_1
Name	CAPEX for solution implementation
Specific Objective connection	SO4, SO7
Innovation Pillar connection	IP3, IP4, IP7
Definition	Capital expenditures are funds used by a company to acquire, upgrade, and maintain assets. Includes all investments need to implement the solution.
Mathematical formulation	$$CAPEX = \sum_{i \in I} CAPEX\_invest_i$$ $CAPEX\_invest_i$: CAPEX of investment i (€) $i \in I$: index of investment i in set of investments I for the duration of the project
Unit	Euros (€)
Related demonstration	DK, IT, SP
Additional Comments	
Some of the capex expenditures values might not be disclosed due to IP reasons (not related to Horizon fundings)	

KPI Definition	
ID	KPI_2
Name	Overall OPEX
Specific Objective connection	SO4, SO7
Innovation Pillar connection	IP3, IP4, IP7
Definition	Operating expenses are the costs that the companies incur while performing its normal operational activities. Overall operational costs for equipment and software maintenance, personal costs, etc…

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KPI Definition	
Mathematical formulation	$$OPEX_{overall} = \sum_{t \in T} \sum_{i \in I} recC_i^t$$ $recC_i^t$: ith recurrent cost at time t (€) $i \in I$: set of recurrent costs $t \in T$: examined period (project duration)
Unit	Euros (€)
Related demonstration	DK, IT, SP
Additional Comments	
Some of the OPEX expenditures values might not be disclosed due to IP reasons (not related to Horizon fundings)	

KPI Definition	
ID	KPI_3
Name	OPEX for service procurement
Specific Objective connection	SO6, SO7
Innovation Pillar connection	IP5, IP6, IP7
Definition	Operational expenses only concerning the flexibility service
Mathematical formulation	$$OPEX_{service} = \sum_{t \in T} \sum_{i \in I} (Pflex_i^t \cdot CPflex_i^t + Eflex_i^t \cdot CEflex_i^t)$$ $Pflex_i^t$: reserved capacity for flexibility of ith unit at time t (kW) $CPflex_i^t$: cost of reserved capacity for flexibility of ith unit at time t (€/kW) $Eflex_i^t$: provided energy for flexibility of ith unit at time t (kWh) $CEflex_i^t$: energy cost for flexibility of ith unit at time t (€/kWh) $i \in I$: set of flexible resources (with and without aggregator) $t \in T$: examined period (use case duration)
Unit	Euros (€)
Related demonstration	DK, IT, SP
Additional Comments	

KPI Definition	
ID	KPI_4
Name	Average cost per service for the examined period
Specific Objective connection	SO6, SO7

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KPI Definition	
Innovation Pillar connection	IP5, IP6, IP7
Definition	Cost of total flexibility capacity/energy procured in the considered period divided by the capacity/energy
Mathematical formulation	$$Cavg_P = \frac{\sum_{i\in I}\sum_{t\in T}(Pflex_i^t \cdot CPflex_i^t)}{\sum_{i\in I} Pflex_i^t \cdot T}$$ $$Cavg_E = \frac{\sum_{i\in I}\sum_{t\in T}(Eflex_i^t \cdot CEflex_i^t)}{\sum_{i\in I} Eflex_i^t \cdot T}$$ $Pflex_i^t$: reserved capacity for flexibility of ith unit at time t (kW) $CPflex_i^t$: cost of reserved capacity for flexibility of ith unit at time t (€/kW) $Eflex_i^t$: provided energy for flexibility of ith unit at time t (kWh) $CEflex_i^t$: energy cost for flexibility of ith unit at time t (€/kWh) $i \in I$: set of flexible resources (with and without aggregator) $t \in T$: examined period (use case duration)
Unit	Euros (€)
Related demonstration	DK, IT, SP
Additional Comments	

KPI Definition	
ID	KPI_5
Name	Cost for availability
Specific Objective connection	SO6, SO7
Innovation Pillar connection	IP5, IP6, IP7
Definition	Cost for reserved flexibility
Mathematical formulation	$$CPflex_{total} = \sum_{t\in T}\sum_{i\in I} Pflex_i^t \cdot CPflex_{i\,i}^{t\,t}$$ $Pflex_i^t$: reserved capacity for flexibility of ith unit at time t (kW) $CPflex_i^t$: cost of reserved capacity for flexibility of ith unit at time t (€/kW) $i \in I$: set of flexible resources (with and without aggregator) $t \in T$: examined period (use case duration)
Unit	Euros (€)
Related demonstration	DK, IT, SP
Additional Comments	

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KPI Definition	
ID	KPI_6
Name	Cost for provided energy
Specific Objective connection	SO6, SO7
Innovation Pillar connection	IP5, IP6, IP7
Definition	Cost for the used flexibility
Mathematical formulation	$$CEflex_{total} = \sum_{t \in T} \sum_{i \in I} Eflex_i^t \cdot CEflex_i^t$$ $Eflex_i^t$: provided energy for flexibility of ith unit at time t (kWh) $CEflex_i^t$: energy cost for flexibility of ith unit at time t (€/kWh) $i \in I$: set of flexible resources (with and without aggregator) $t \in T$: examined period (use case duration)
Unit	Euros (€)
Related demonstration	DK, IT, SP
Additional Comments	

KPI Definition	
ID	KPI_7
Name	EV users economic benefits
Specific Objective connection	SO1, SO6, SO7
Innovation Pillar connection	IP1, IP5, IP6, IP7
Definition	Remuneration for the flexibility to the EV users
Mathematical formulation	$$B_{ev} = \sum_{t \in T} \sum_{i \in I} (PflexEV_i^t \cdot CPflexEV_i^t + EflexEV_i^t \cdot CEflexEV_i^t)$$ $Pflex_i^t$: reserved capacity for flexibility of ith unit at time t (kW) $CPflex_i^t$: cost of reserved capacity for flexibility of ith unit at time t (€/kW) $Eflex_i^t$: provided energy for flexibility of ith unit at time t (kWh) $CEflex_i^t$: energy cost for flexibility of ith unit at time t (€/kWh) $i \in I$: set of flexible resources (with and without aggregator) $t \in T$: examined period (use case duration)
Unit	Euros (€)
Related demonstration	DK, IT, SP
Additional Comments	

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3.3.2 Technical KPIs

KPI Definition	
ID	KPI_8
Name	Estimation of the increment of active power flexibility for the network operators (TSO and DSO)
Specific Objective connection	SO3, SO5, SO6, SO7
Innovation Pillar connection	IP3, IP5, IP6, IP7
Definition	Estimation of the increment of active power flexibility for the network operators (TSO and DSO)
Mathematical formulation	$$IAPflex = \frac{(APflex_{R\&I} - APflex_{BaU}) \cdot 100}{APflex_{BaU}}$$ $$APflex = \sum_{i \in I} \sum_{t \in T} Pflex_i^t$$ $APflex_{R\&I}$: active power flexibility for new solution $APflex_{BaU}$: active power flexibility in business as usual $i \in I$: set of flexibility providers $t \in T$: time period (annually)
Unit	Percentage (%)
Related demonstration	DK, IT, SP
Additional Comments	

KPI Definition	
ID	KPI_9
Name	Potential offered flexibility from EVs
Specific Objective connection	SO3, SO5
Innovation Pillar connection	IP5, IP6
Definition	Maximum flexibility that can be offered from the considered EVs (load and in-feed)
Mathematical formulation	$$EVflex\_pot = \sum_{i \in I} EVflex\_pot_i$$ $EVflex\_pot_i$: flexibility potential of EV i (kW) $i \in I$: set of EVs in the project
Unit	Kilowatt (kW)
Related demonstration	DK, IT, SP
Additional Comments	

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KPI Definition	
ID	KPI_10
Name	Increase in the amount of load capacity participating in demand response
Specific Objective connection	SO3, SO5, SO6
Innovation Pillar connection	IP3, IP5, IP6
Definition	The increment of flexibility in the role of load from the EVs
Mathematical formulation	$$LCII = \frac{(LCI_{R\&I} - LCI_{BaU})}{LCI_{BaU}}$$ $$LCI = \frac{\sum_{i\in I}\sum_{t\in T} Pflex\_load_i^t \cdot 100}{\sum_{i\in I}\sum_{t\in T} Pload_i^t}$$ $LCI_{R\&I}$: EV load capacity for new solution LCI_{BaU}: EV load capacity in business as usual $i \in I$: set of EV flexibility providers $t \in T$: time period (use cases)
Unit	Percentage (%)
Related demonstration	DK, IT, SP
Additional Comments	

KPI Definition	
ID	KPI_11
Name	Volume of transactions
Specific Objective connection	SO3, SO5
Innovation Pillar connection	IP5, IP6
Definition	Flexibility traded/obtained in total in the considered time period

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KPI Definition	
Mathematical formulation	$$Pvolume = \sum_{i \in I} \sum_{t \in T} P_i^t$$ $$Evolume = \sum_{i \in I} \sum_{t \in T} E_i^t$$ $Pvolume$: total volume of offered power capacity (kW) P_i^t: volume of offered capacity by i-th EV at time t (kW) $Evolume$: total volume of used energy (kWh) E_i^t: volume of used energy from i-th EV during time interval Δt (kW) $i \in I$: set of EV flexibility providers $t \in T$: time period (use cases)
Unit	kilowatt (kW), kilowatt-hour (kWh)
Related demonstration	DK, IT, SP
Additional Comments	

KPI Definition	
ID	KPI_12
Name	Number of transactions
Specific Objective connection	SO1, SO3
Innovation Pillar connection	IP2, IP5, IP6
Definition	Transactions made to obtain the needed flexibility in the considered time period
Mathematical formulation	$$transactions = \sum_{t \in T} transaction_t$$ $transaction_t$: Flexibility service transaction $t \in T$: time period (total number per use case, if aplicable)
Unit	-
Related demonstration	DK, IT, SP
Additional Comments	

KPI Definition	
ID	KPI_13
Name	Deviation between accepted and actually activated flexibility
Specific Objective connection	SO3, SO5, SO6
Innovation Pillar connection	IP5, IP6

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KPI Definition	
Definition	Self-explanatory; For the non-market-based cases, difference between the measured activated flexibility and the flexibility set-point received by the aggregate
Mathematical formulation	$$\Delta flex = \sum_{i \in I} \sum_{t \in T} (Eactual_i^t - Eaccepted_i^T)$$ $Eactual_i^t$: measured activated flexibility $Eaccepted_i^T$: flexibility set-point received $i \in I$: set of EV flexibility providers $t \in T$: time period (use cases)
Unit	kilowatt-hour (kWh)
Related demonstration	DK, IT, SP
Additional Comments	

KPI Definition	
ID	KPI_14
Name	Increased grid connections of EVs
Specific Objective connection	SO1
Innovation Pillar connection	IP1, IP3
Definition	Number of additional EV connections in the grid during the project. To be compared with Business as Usual case.
Mathematical formulation	$$EVconnect = \sum_{t \in T} EVconnect_t$$ $t \in T$: time period (total number per use case, if applicable)
Unit	kilowatt-hour (kWh)
Related demonstration	DK, IT, SP
Additional Comments	

KPI Definition	
ID	KPI_15
Name	Peak load demand reduction/increase
Specific Objective connection	SO3, SO5, SO6
Innovation Pillar connection	IP5, IP6
Definition	Peak load increase/decrease due to the integration of more EVs in the grids in question.

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KPI Definition	
Mathematical formulation	$$\Delta PL = \sum_{t \in T} PL\_EVs_t - \sum_{t \in T} PL_{noEVs_t}$$ PL_EVs: peak load at time t if the additional EV load capacity is considered (kW) PL_noEVs: peak load at time t without the additional EV load capacity (kW) t∈ T: time period (duration of the demos)
Unit	kilowatt (kW)
Related demonstration	DK, IT, SP
Additional Comments	

KPI Definition	
ID	KPI_16
Name	Total activation time of flexibility
Specific Objective connection	SO3, SO5
Innovation Pillar connection	IP5, IP6
Definition	Total activation time of flexibility
Mathematical formulation	$$T_{activation} = n_{activations} \cdot t$$ $n\_activations$: total number of activations in the demo t: time of activation (min)
Unit	Minutes (min)
Related demonstration	DK, IT, SP
Additional Comments	

KPI Definition	
ID	KPI_17
Name	Total computation time
Specific Objective connection	SO4
Innovation Pillar connection	IP4
Definition	Total computation time needed for all SW involved in the provision of the flexibility service
Mathematical formulation	$$T_{comp} = T_{stop} - T_{start}$$ T_{stop}: stopping of simulation (algorithm start) T_{start}: starting of simulation (algorithm start)

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KPI Definition	
Unit	Seconds (s)
Related demonstration	DK, IT, SP
Additional Comments	

KPI Definition	
ID	KPI_18
Name	Power demand for overnight charging stations
Specific Objective connection	SO5, SO6
Innovation Pillar connection	IP5, IP6
Definition	Power demand for overnight charging stations
Mathematical formulation	$$Cdemand\_night = \sum_{i \in I} \sum_{t \in T} P_i^t$$ P_i^t: power demand between 20:00-06:00 (this is suggestion, can be modified) from charger i at time t $i \in I$: set of chargers $t \in T$: time period (total night charging time for all demo or per use case)
Unit	kilowatt (kW)
Related demonstration	DK, IT, SP
Additional Comments	

KPI Definition	
ID	KPI_19
Name	Power demand for daytime charging stations
Specific Objective connection	SO5, SO6
Innovation Pillar connection	IP5, IP6
Definition	Power demand for daytime charging stations
Mathematical formulation	$$Cdemand\_day = \sum_{i \in I} \sum_{t \in T} P_i^t$$ P_i^t: power demand between 06:00-20:00 (this is suggestion, can be modified) from charger i at time t $i \in I$: set of chargers $t \in T$: time period (total night charging time for all demo or per use case)
Unit	kilowatt (kW)

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KPI Definition	
Related demonstration	DK, IT, SP
Additional Comments	

KPI Definition	
ID	KPI_20
Name	Total capacity of charging stations
Specific Objective connection	SO3, SO5
Innovation Pillar connection	IP3
Definition	The total installed capacity of charging stations
Mathematical formulation	$$Pcs = \sum_{i \in I} Pcs_i$$ Pcs_i: capacity of charging station i $i \in I$: set of charging stations
Unit	kilowatt (kW)
Related demonstration	DK, IT, SP
Additional Comments	

KPI Definition	
ID	KPI_21
Name	Volume of aggregation from charging stations
Specific Objective connection	SO3, SO5
Innovation Pillar connection	IP3
Definition	Volume of aggregation from charging stations aggregated from the available charging stations
Mathematical formulation	$$Pcs\_total\_agregation$$
Unit	kilowatt (kW)
Related demonstration	DK, IT, SP
Additional Comments	
The value of this KPI does not need calculation. It is a value that is received directly after the use cases are completed.	

KPI Definition	
ID	KPI_22
Name	Number of charging stations
Specific Objective connection	SO3

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KPI Definition	
Innovation Pillar connection	IP3
Definition	Number of charging stations
Mathematical formulation	n_{cs}
Unit	-
Related demonstration	DK, IT, SP
Additional Comments	
The value of this KPI does not need calculation. It is a value that is received directly after the use cases are completed.	

3.3.3 Users KPIs

KPI Definition	
ID	KPI_23
Name	EV users recruitment
Specific Objective connection	SO1
Innovation Pillar connection	IP1
Definition	Number of recruited EV users
Mathematical formulation	$$RecruitEVs = \sum_{i \in I} recruits_i$$ $recruits_i$: recruited users $i \in I$: set of recruited users during the entire project
Unit	-
Related demonstration	DK, SP
Additional Comments	

KPI Definition	
ID	KPI_24
Name	Active participation of users
Specific Objective connection	SO1, SO7
Innovation Pillar connection	IP1, IP7
Definition	Number of users of the final sample: EV users recruited that actually participated

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KPI Definition	
Mathematical formulation	$$ParticipantEVs = \sum_{i \in I} participants_i$$ $participants_i$: user who has participated from the recruited ones $i \in I$: set of recruited users who have participated in the demos
Unit	-
Related demonstration	DK, IT, SP
Additional Comments	

KPI Definition	
ID	KPI_25
Name	Acceptance and satisfaction
Specific Objective connection	SO1, SO7
Innovation Pillar connection	IP1, IP7
Definition	Users' perceived acceptance and usability of smart charging solutions
Mathematical formulation	$$SuccessRate = \frac{\sum_{i \in I} SatisfiedUsers_i}{Total\ ParticipantEVs}$$ $SatisfiedUsers_i$: Satisfied EV users $TotalParticipantEVs$: Total EV users $i \in I$: set of recruited users who have participated in the demos
Unit	Percentage (%)
Related demonstration	DK, IT, SP
Additional Comments	

KPI Definition	
ID	KPI_26
Name	Ratio of number and duration of EV charging sessions with and without providing flexibility
Specific Objective connection	SO3
Innovation Pillar connection	IP5, IP6
Definition	Ratio of number and duration of EV charging sessions with and without providing flexibility

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KPI Definition	
Mathematical formulation	$$rat_{n_{EV\_flex}} = \frac{n_{CS_{flex}} \cdot 100}{n_{CS_{noflex}} + n_{CS_{flex}}}$$ $$rat_{n_{EV\_noflex}} = \frac{n_{CS_{noflex}} \cdot 100}{n_{CS_{noflex}} + n_{CS_{flex}}}$$ $$rat_{t_{EV\_flex}} = \frac{t_{CS_{flex}} \cdot 100}{t_{CS_{noflex}} + t_{CS_{flex}}}$$ $$rat_{t_{EV\_noflex}} = \frac{t_{CSno_{flex}} \cdot 100}{t_{CS_{noflex}} + t_{CS_{flex}}}$$ $n_{CS_{flex}}$: number of charging sessions with providing flexibility $n_{CS_{noflex}}$: number of charging sessions without providing flexibility $t_{CS_{flex}}$: time of charging sessions with providing flexibility $t_{CSno_{flex}}$: time of charging sessions without providing flexibility
Unit	-
Related demonstration	DK, IT, SP
Additional Comments	

3.3.4 Environmental KPIs

KPI Definition	
ID	KPI_27
Name	CO2 emissions increase/decrease due to the provision of flexibility services
Specific Objective connection	SO6, SO7
Innovation Pillar connection	IP5, IP6, IP7
Definition	How much the offered services increase/decrease the CO2 emissions in the system; only for the duration of the demos

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KPI Definition	
Mathematical formulation	$$\Delta CO_2 = \frac{\sum_{t=1}^{T}(cons_{no\ flex,t} - cons_{flex,t}) \cdot CO_{2_{MW,t}}}{\sum_{t=1}^{T} cons_{no\ flex,t} \cdot CO_{2_{MW,t}}}$$ $CO_{2_{MW}}$: CO2 associated to the generation at the moment of the use cases executions $cons_{flex,t}$: total amount of EV power taken from the grid with flexibility activations (MW) $cons_{no\ flex,t}$: total amount of EV power taken from the grid without flexibility activations (MW) t∈ T: time period (duration of the demos)
Unit	tCO2
Related demonstration	DK, IT, SP
Additional Comments	

3.4 Alignment with SRIA recommendations

The 2Zero SRIA outlines various research and innovation activities essential for achieving climate-neutral road transport. It also specifies technical and specific objectives, establishes milestones, and provides a timeline for these R&I activities and their anticipated outcomes [2].

The SRIA presents in a concise way the different objectives (general, specific and operational) of the 2Zero Partnership and the KPIs identified to monitor the advancements. The table was used to align as closely as possible the KPIs from FLOW to the objectives and KPIs indicated in SRIA.

The KPIs from FLOW are assigned to each of the corresponding SRIA objectives with their number, name and connection. This is shown in Table 8.

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Table 8 - Alignment of FLOW's KPIs with SRIA recommendations

SRIA 2Zero Objectives						FLOW Demonstration		
European Partnership 2Zero			Monitoring and evaluation framework			KPIs		
Objectives		What is a measure of success? Please use quantitative (Key Performance) and qualitative indicators, and link them to a point in time	Which is the data source and methodology used [project data, study,]	Who is responsible for monitoring and providing the data / information When will it be collected?	Baseline and target	No.	Name	Connection (direct / indirect)
General objectives	Contribute to Europe having the first carbon neutral road transport system by 2050; Technology leadership supporting economic growth and job creation	Proportion of climate related spending (climate mainstreaming) in Horizon Europe spending	CORDA Reporting	EC Part of the ex-post evaluation	Baseline 2020	N/A		
		FTE jobs supported in entities involved in Horizon projects addressing the European Green Deal per year	Horizon Dashboard	EC Part of the ex-post evaluation	Baseline 2020	N/A		

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SRIA 2Zero Objectives						FLOW Demonstration		
European Partnership 2Zero			Monitoring and evaluation framework			KPIs		
	all over Europe; **Ensure European competitiveness thanks to solutions for an integrated carbon neutral road transport ecosystem;** **Improve the quality of life of EU citizens and ensure mobility for people and goods.**	Reduction of CO2 emission from road transport for all types of vehicles	EEA report	EC / Association Part of the ex-post evaluation	Baseline 1990 Contribution to the overall target of 55% reduction of CO2 emission in 2030 (public target) e.g. number of projects contributing to CO2 reduction	27	CO2 emissions increase/decrease due to the provision of flexibility services	Direct.
		Number of New Vehicle Registrations of zero tailpipe emission vehicle in Europe in 2030, both for passenger cars/ light duty vehicles (L Cat included) and for commercial vehicles	ACEA report ACEM	Association Part of the ex-post evaluation	Baseline 2020 At least 30mil BEVs will be on the roads by 2030 At least 280.000 Zero Emission HDV will be on the roads by 2030, 180.000 of these Trucks are for long haul use. More than 50% new	7	EV users' economic benefits	Indirect. If the economic benefit for the user increase, then there are going to be more EV registrations.
						11	Volume of transactions	Direct. The number of transactions grows due to more registrations of EVs.

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SRIA 2Zero Objectives						FLOW Demonstration		
European Partnership 2Zero			Monitoring and evaluation framework			KPIs		
					vehicle registrations for urban mobility PTW will be electric vehicles, provided that enabling conditions are met.	12	Number of transactions	Direct. The number of transactions grows due to more registrations of EVs.
						25	Acceptance and satisfaction	Direct. User acceptance is one of the strongest predictors for the purchase and use of EVs. If we manage to increase acceptance and satisfaction with charging EVs. It can be assumed that this will have a significant influence on the purchase intention of EVs in general.

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SRIA 2Zero Objectives						FLOW Demonstration		
European Partnership 2Zero			Monitoring and evaluation framework			KPIs		
		Increased affordability of the zero tailpipe emission vehicles	Publicly available information (market studies)	EC, Association Part of the ex-post evaluation	Contribution to a reduction of at least a 60% reduction of the sale price differential between conventional vehicles and zero emission vehicles of at least 60% by 2025 and 90% by 2030.	7	EV users' economic benefits	Direct. This is directly impacting the affordability of the EVs.
		Number of (publicly available) electric recharging and hydrogen refuelling stations available in the EU in 2030	CEF report Dir 20014/94/EU (AFID) related reporting (National Implementation Reports – NIRs) EAFO	EC Part of the ex-post evaluation	Baseline 2020 Contribution to achieve 3 million public charging points in 2030 (public target)	18	Power demand for overnight charging stations	Indirect. They indirectly give an estimate of how many stations are going to be required to provide the demand.
						19	Power demand for daytime charging stations	
						20	Total capacity of charging stations	Direct. These directly indicate the number of charging stations.
						22	Number of charging stations	

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SRIA 2Zero Objectives						FLOW Demonstration		
European Partnership 2Zero			Monitoring and evaluation framework			KPIs		
Specific objectives	**Develop zero tailpipe emission, affordable user-centric solutions (technologies and services) for road-based mobility all across Europe and accelerate their acceptance to improve air quality in urban areas and**	Ability of determining realistically and reliably the energy intensity (tank-to wheel)	Projects results via digital twin[35].	Association / EC / CINEA / funded projects (biannual)	Baseline 2020 Targets: Reduction of GHG and energy intensity of mobility by 30% for personal mobility and 25 % for freight by 2030	N/A		
		Reduce GHG of mobility of people and goods (expressed in tonCO2eq /pkm or tkm and toe[36] /pkm and toe/tkm)	Projects results via digital twin	Association / EC / CINEA / funded projects (biannual)		11	Volume of transactions	Indirect. The increased number and volume of transactions indicates higher number of EVs and reduction of GHG.
						12	Number of transactions	
						27	CO2 emissions increase/decrease due to the provision of flexibility services	Indirect. The provision of flexibility from EVs can contribute to the reduction of GHG emissions
		Reduction of development time and effort	Projects results analysis	EC / CINEA / funded projects / Association (biannual)	Estimated 20% decrease of development time and effort including via digitalisation	N/A		

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SRIA 2Zero Objectives						FLOW Demonstration		
European Partnership 2Zero			Monitoring and evaluation framework			KPIs		
	Develop affordable, user-friendly charging infrastructure concepts and technologies that include vehicle and grid interaction;	Improvement of the integration of EVs into the grid (and related improvement on the load curve management and integration of Renewable Energy Sources)	Projects results analysis Dir 20014/94/EU (AFID) related reporting (National Implementation Reports – NIRs) Directive 2009/28/EC (RES) related reporting	EC / CINEA / funded projects / Association (biannual)	Baseline 2020 Targets: Commonly agreed charging protocols enabling V2G options for BEV options by 2030 100% of new BEV and infrastructure offering smart charging possibilities by 2030	8	Estimation of the increment of active power flexibility for the network operators (TSO and DSO)	Direct. These KPIs directly show the improvement of the integration of EVs in the grid.
						14	Increased grid connections of EVs	
						15	Peak load demand reduction / increase	
						25	Active participation of users	Indirect. The integration of EVs in the grid is facilitated, By a more active participation of the users.
		Improvement of charging efficiency demonstrated - For slow charging (3kW up to 22kW) - For fast (>150 kW) and ultra-fast charging (> 300 kW) - For fast (>150 kW) and ultra-fast charging (> 300 kW)	Projects results analysis Directive (EU) 2018/2002 on Energy Efficiency of 11 December 2018 related reporting	EC / CINEA / funded projects / Association (biannual)	At least 25 % reduction of energy losses during charging (considering both charger and vehicle) by 2030 for all types of chargers	6	Cost for provided energy	Indirect. The charging efficiency in these terms is not analysed in FLOW. However, KPI6 and 7 can indirectly show if the charging efficiency is increasing.
						7	EV users' economic benefits	

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SRIA 2Zero Objectives						FLOW Demonstration		
European Partnership 2Zero			Monitoring and evaluation framework			KPIs		
	Demonstrate innovative use cases for the integration of zero tailpipe emission vehicles and infrastructure concepts for the road mobility of people and goods;	Development of well-established decision-making tools and stakeholder engagement practices to implement integrated deployment strategies for boosting e-mobility as project follow-ups	Projects results analysis SUMPs reports SECAP reporting (Covenant of Mayors)	EC / CINEA / funded projects / Association (biannual)	Baseline 2019 Decision-making tools and stakeholders engagement practices developed in funded projects are part of the SUMP guidelines and are implemented by at least 30 cities, also taking into account the mission "100 Climate Neutral cities"	23	EV users' recruitment	Indirect. These relate to user engagement that can be indirectly concidered as a practice to boost e-mobility.
						24	Active participation of users	
						25	Acceptance and satisfaction	
		Well established fleet managerial tools to smoothly incorporate zero tailpipe vehicles in transportation fleets	Public reports Projects results analysis	EC / CINEA / funded projects / Association (biannual)	Successful demonstration of cities with logistics emissions free by 2030 (>150.000 inhabitants)	N/A		

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SRIA 2Zero Objectives						FLOW Demonstration
European Partnership 2Zero			Monitoring and evaluation framework			KPIs
		Number of (public and private) transport operators implementing zero tailpipe business models and use cases for freight transport and people mobility Demonstrated innovative use cases using zero tailpipe trucks for regional, medium and long-haul addressing payloads from 7.5 tn to 40+ tn by 2025-2027	Projects results analysis	EC / CINEA / funded projects / Association (biannual)	30 companies involved in the demonstration of innovative use cases over lifetime of the partnership demonstrating the zero tailpipe emission vehicles 30 passenger transport and freight transport and logistics use cases demonstrated in projects over the lifetime of the partnership. 70-80 % of the volume of the current use cases/freight transport needs are addressed in projects	

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SRIA 2Zero Objectives						FLOW Demonstration
European Partnership 2Zero			Monitoring and evaluation framework			KPIs
	Support the development of life-cycle analysis tools and skills for the effective design, assessment and deployment of innovative concepts in products/ services in a circular economy context.	Commonly accepted LCA approach	Projects results analysis	EC / CINEA / funded projects / Association (biannual)	Baseline 2020 Reliable and consistent tools and methodologies available with reduced uncertainties supporting the applicability of LCA/ CE strategies	N/A
		Implementation of an LCI database	Projects results analysis	EC / CINEA / funded projects / Association (biannual)		
		Feasibility of advanced circular economy strategies in zero emission mobility solutions demonstrated by performed use cases	Projects results analysis Benchmarks conducted in projects	EC / CINEA / funded projects / Association (biannual)	20% of the vehicle mass is linked to CE-based product design demonstrated at project level	

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SRIA 2Zero Objectives						FLOW Demonstration		
European Partnership 2Zero			Monitoring and evaluation framework			KPIs		
Operaional objectives	**Development of affordable innovative Battery Electric Vehicles (BEV) and Fuel Cells Electric Vehicles (FCEV) concepts and technologies**	Demonstration of technologies, components, systems and their integration in vehicles enabling affordability, high efficiency and fast charging capability	Projects results analysis	EC / CINEA / funded projects / Association	Baseline 2020 Targets Technologies and mass market vehicle38 achieving: • Vehicle consumption 12 kWh/t/100km • Charging time per 100 km, 8 Minutes with minimal impact on battery degradation	N/A		
	Demonstration of zero-emission Light Duty Vehicles (LDV), passenger cars and commercial use, to reduce total cost of ownership compared to conventional vehicles by 20%	Demonstrator vehicles and concepts realized in 2Zero with an optimized cost vs. benefit and an expected positive impact on cost drivers such as for example: • energy consumption in production, in	Projects results analysis with their effect on cost drivers	EC / CINEA / funded projects / Association	Baseline MY 2020 Targets Successful demonstration of zero-emission Light Duty Vehicles (LDV) in representative use cases by 2Zero projects with an expected outcome	6	Cost for provided energy	Indirect. They all indicate how optimized the charging process is in support of a total cost of ownership reduction.

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SRIA 2Zero Objectives						FLOW Demonstration		
European Partnership 2Zero			Monitoring and evaluation framework			KPIs		
	for the widest usages	use and at the end-of-life;• material used • production steps and number of parts • Usage models and productivity (for commercial cases) • Usage models and willingness to pay			of 20% cost reduction in 2030 compared to the 2020	7	EV users' economic benefits	
						9	Potential offered flexibility from EVs	

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SRIA 2Zero Objectives						FLOW Demonstration
European Partnership 2Zero			Monitoring and evaluation framework			KPIs
	Demonstration of zero emission Heavy Duty Vehicles (HDV) matching the performance and TCO (Total Cost of Ownership) of current vehicles for most of the relevant use cases, including new usage models	Demonstrator vehicles and concepts realized in 2Zero with an optimized cost vs. benefit and an expected positive impact on cost drivers such as • energy consumption in production, in use and at the end-of-life; • material used • production steps and number of parts • Usage models and productivity	Project results and analysis	EC / CINEA / funded projects / Association	Baseline 2020 standard HDV Successful demonstration of zero-emission Heavy Duty Vehicles (HDV) in relevant use cases covered by 2zero projects with an expected outcome of nearly cost parity per tonne.km in 2030 compared to the 2020 baseline. FCEV powertrain efficiency (TtW): ~10 - 15% better than conventional ICE; BEV powertrain efficiency (TtW): ~ 35- 45% better than conventional ICE	N/A

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SRIA 2Zero Objectives						FLOW Demonstration
European Partnership 2Zero			Monitoring and evaluation framework			KPIs
	Development and demonstration of affordable new vehicle solutions, charging technologies and services for mass market to enable 1000km long distance trips with no more than 10% additional time compared to conventional solutions, considering economic and environmental assessment	Demonstration of technologies, components, systems and their integration in vehicles enabling affordability, high efficiency and fast charging capability	Project results and analysis	EC / CINEA / funded projects / Association	Baseline 2020 M1 BEV Targets Demonstrators (including M1 vehicles up to C-segment and according technology packs) enabling 1000 km trips with less than a 10% door-todoor time penalty with respect to a conventional vehicle39 • Vehicle consumption 12 kWh/t/100km • Charging time per 100 km, 8 Minutes with minimal impact on battery degradation	N/A
		Optimal balance between battery size, user needs and recharging infrastructure capabilities identified from EU funded projects				

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<table>
<tr><th colspan="6">SRIA 2Zero Objectives</th><th colspan="3">FLOW Demonstration</th></tr>
<tr><th colspan="3">European Partnership 2Zero</th><th colspan="3">Monitoring and evaluation framework</th><th colspan="3">KPIs</th></tr>
<tr><td rowspan="5"></td><td rowspan="5">Development and demonstration of solutions for pervasive, user-friendly, lowcost and interoperable low-power (22 kW) and efficient high (~150kW) / ultrahigh-power (~300 kW) charging infrastructure</td><td>More efficient technologies and solutions developed in EU funded projects for the development of low-power charging infrastructure (<22 kW) and high/ ultrahigh-power charging (>300 kW, up to 1MW for long haul trucks)</td><td>Project results and analysis</td><td>EC / CINEA / funded projects / Association</td><td>Baseline 2020

Targets
At least 25 % reduction of energy losses during charging (considering both charger and vehicle) by 2030 for all types of chargers</td><td colspan="3">N/A</td></tr>
<tr><td rowspan="4">Safe, secure and smooth communication exchange between vehicle and charging infrastructure,including communication with the grid and roaming platforms (including access of third parties to the charging infrastructure)</td><td rowspan="4">Project results and analysis</td><td rowspan="4">EC / CINEA / funded projects / Association</td><td rowspan="4">Interoperable charging solutions are available in Europe</td><td>11</td><td>Volume of transactions</td><td rowspan="4"><u>Indirect.</u>

All of these KPIs indirectly show the quality of the communication exchange between EVs, charging infrastructure, grid and platforms.</td></tr>
<tr><td>12</td><td>Number of transactions</td></tr>
<tr><td>13</td><td>Deviation between accepted and activated flexibility</td></tr>
<tr><td>17</td><td>Total computation time</td></tr>
</table>

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SRIA 2Zero Objectives						FLOW Demonstration		
European Partnership 2Zero			Monitoring and evaluation framework			KPIs		
						24	Active participation of users	
						25	Acceptance and satisfaction	
	Development and demonstration of smart charging and bi-directional energy services solutions accepted by the users and providing services to the energy grid	Definition of dynamic load management profiles for specific smart and bidirectional charging scenarios (office building, private house/garage, public space) by EU funded projects, allowing effective grid load management that can lead to increase RES penetration	Project results and analysis	EC / CINEA / funded projects / Association	Baseline 2020 Targets Development and testing of commonly agreed protocols for V2G for efficient integration with the grid, storage and smart charging Number of projects delivering deployment plan of parking spots and logistics facilities combined with smart charging strategies	8	Estimation of the increment of active power flexibility for the network operators (TSO and DSO)	Direct. All of these KPIs directly show the effectiveness of load management using flexibility from EVs.
						9	Potential offered flexibility from EVs	
						14	Increased grid connections of EVs	
						15	Peak load demand reduction / increase	

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SRIA 2Zero Objectives						FLOW Demonstration		
European Partnership 2Zero			Monitoring and evaluation framework			KPIs		
						21	Volume of aggreagtion from charging stations	
		Demonstrated charging operations answering the freight and logistics requirements avoiding logistics losses	Project results and analysis	EC / CINEA / funded projects / Association		N/A		
	Support a broad stakeholder coverage over the different sectors involved, including a good representation of industrial SMEs in projects funded by the partnership	Breakdown of EU funding across stakeholder types	CORDA	EC	N/A	Related to the project, but not the demos KPIs		
		Breakdown of members in the association	Association report	Association				
		Share of funding going to SMEs	CORDA	EC				

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SRIA 2Zero Objectives						FLOW Demonstration		
European Partnership 2Zero			**Monitoring and evaluation framework**			**KPIs**		
		Number of organisations reached in the engagement activities of projects: Advisory boards, dissemination activities.	Project reports	CINEA		23	EV users recruitment	Direct. The recruitment process involves reaching out to organisations.
	Support standardisation activities in close cooperation with standardisation bodies	Number of projects launching standardisation activities	Projects report / Horizon EU dashboard	EC / CINEA / funded projects	N/A	N/A		
		Number of standardisation committee working on topics related to the partnership area	CEN CENELEC reports	EC / Association				
	Number of patent application and IPR generated in projects funded by the partnership	IPR (Patent / Utility Model / Industrial Design / Copyright / Trade Mark / Confidential Information) generated in funded projects	Horizon EU dashboard	EC / CINEA	N/A	N/A		
	Number of publications in projects funded by the partnership	Number of publications from funded projects	Projects report / Horizon EU dashboard	EC / CINEA / funded projects	N/A	N/A		

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SRIA 2Zero Objectives						FLOW Demonstration
European Partnership 2Zero			Monitoring and evaluation framework			KPIs
	Provide scientific input for informed regulation and related Union policies	2Zero contribution to roadmaps preparation	Association report	Association / EC / CINEA / funded projects	N/A	N/A
		SRIA updates	Association report	Association		
		Number of policy recommendations issued by funded projects	Project reports	CINEA		
	Ensure a wide communication and dissemination of activities and results, as well as of the potential of new vehicles, mobility and logistics systems to the public for further acceptance	Total number of events organised by funded projects	Projects reports / Horizon EU dashboard	EC / CINEA / funded projects	N/A	N/A
		Number of events organised by the Association	Association report	Association		
		Number of events organised by supporting platforms	Public information	Supporting platforms		
	Contribute to the education of future workers and the public	Number of professionals trained in funded projects	Project results analysis	EC / CINEA / funded projects	N/A	N/A

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SRIA 2Zero Objectives						**FLOW Demonstration**		
European Partnership 2Zero			**Monitoring and evaluation framework**			**KPIs**		
	about the new mobility and logistics usage	Number of training materials provided by funded projects	Project results analysis	EC / CINEA / funded projects				
		Number of members of the public reached by funded projects	Project results analysis	EC / CINEA / funded projects		23	EV users recruitment	Direct. These KPIs directly show the public that is reached by the project.
						24	Active participation of users	

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4 Validation and Impact Assessment Methodologies

This section is dedicated to defining the validation and impact assessment methodologies that serve to ensure successful demonstrations and to evaluate the impact of the results. It defines the important aspects of each methodology and sets the base for the calculation of the previously defined KPIs.

4.1 Validation

Successful validation of the obtained results depends on careful planning, definition and execution of the demonstration. The demonstrations contain many intricate processes that run in different stages. As an outcome, the validation of the results depends on the actions taken in each of these stages. The demonstrations in FLOW intend to test novel technologies and interactions between different actors, which requires a custom validation methodology.

4.1.1 General stages of the demonstrations

Before defining the validation methodology, it is important to establish the general stages of the demonstrations. The simplified flowchart is shown in Figure 25.

The first stage of the demonstration consists of the preliminary establishment of the use cases. This stage includes the mapping and general description of the use cases, as provided in section 2 of this document.

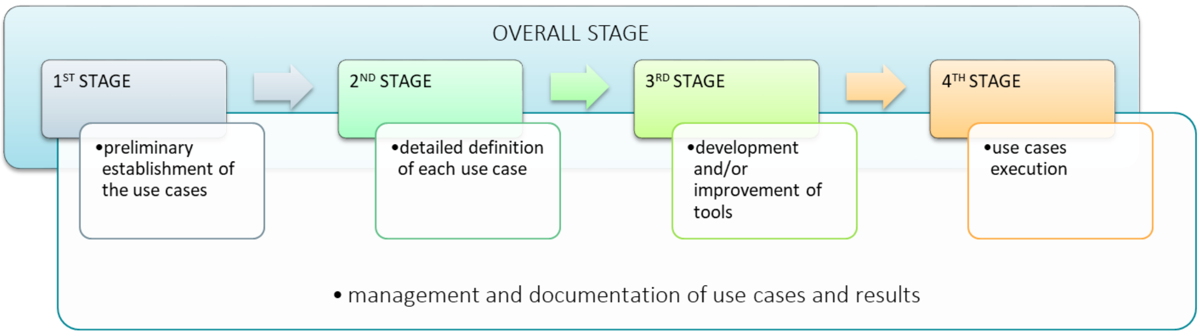

Figure 25 - General Stages of the Demonstrations.

The second stage then proceeds to the more detailed definition of each use case within the respective demonstration campaigns. The details involve the use cases architectures, the services and/or products to be tested, the involved actors, the tools necessary for the execution of the tests and the communication infrastructure.

The third stage involves the development and/or improvement of the software and hardware tools necessary for the execution of the use cases.

The fourth stage starts with running the use cases. This stage includes the preliminary tests if these are necessary for the respective cases.

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The overall stage is dedicated to the management and documentation of the use cases starting from the definition and following through until the end of the execution of the use cases and the preparation of the deliverables. This stage runs throughout the entire process of the demonstrations.

4.1.2 Validation methodology

The validation methodology of the obtained results involves several important actions that need to be taken in each of the previously defined stages. To have an easier overview of all necessary validation actions and the respective stages of the demonstration, a flowchart is provided in Figure 26.

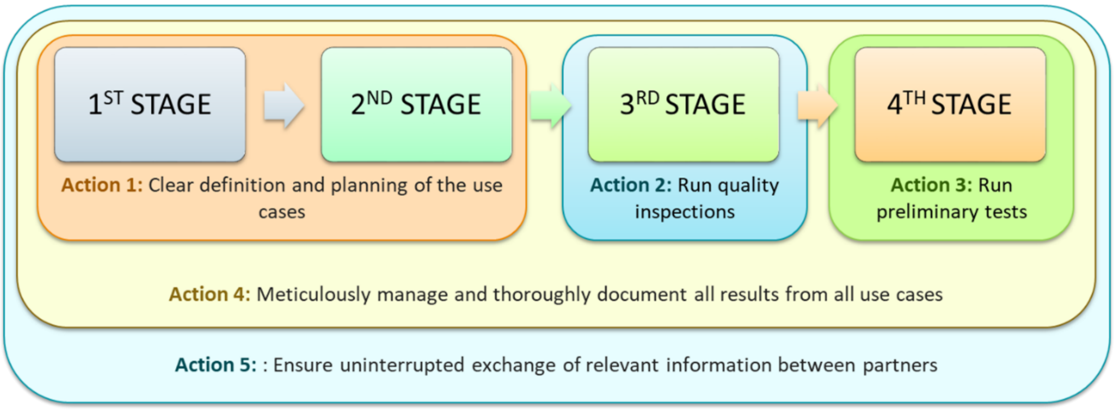

Figure 26 - Validation Methodology Flowchart.

This section defines each action of the validation methodology and what stage is affected by it. The actions consist of:

1. ***Action 1**: Clear definition and planning of the use cases.* This action is important for the precise definition of the tests, procedures, actors' interactions and communication framework, which would help avoid unnecessary complications and mistakes during the execution of the demos. This action is relevant in the first and second previously defined stages.

2. *Action 2: Run quality inspections in each development stage, where relevant.* Quality inspections are necessary when new tools are developed or when tools need updates. This is also necessary for the cases where new hardware needs to be implemented. This action is crucial in the third stage of the demonstrations.

3. *Action 3: Run small-scale preliminary tests where necessary.* Before the main execution of the demonstrations, some preliminary tests might be necessary to ensure the correct functioning of all parts of the use cases. This action is relevant for the fourth stage of the demonstration.

4. *Action 4: Meticulously manage and thoroughly document all results from all use cases, as well as perform quality control of the documentation.* This action can help avoid mismatches and errors throughout the whole demonstration process. It is important for all stages of the demonstration.

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5. *Action 5: Ensure uninterrupted exchange of relevant information between partners.* The flow of information between all participants of the demonstrations is crucial for the successful execution of the use cases. This action is also important for all stages of the demonstration.

4.2 Impact Assessment

The impact assessment can be performed when all use cases are finalized and all results are available. This section is dedicated to the impact assessment methodology and the steps it involves.

4.2.1 Impact Assessment methodology

The KPIs list presented in this document is the starting point of the impact assessment. It contains the foundation for the impact assessment on economical, technical, environmental and user-experience level.

The impact assessment methodology was defined and customized to fit the FLOW demonstrations, following relevant strategies from the "Study to support the monitoring and evaluation of the Framework Programme for research and innovation along Key Impact Pathways - Baseline and Benchmark Report" [10].

The flowchart of the impact assessment methodology is presented in Figure 27.

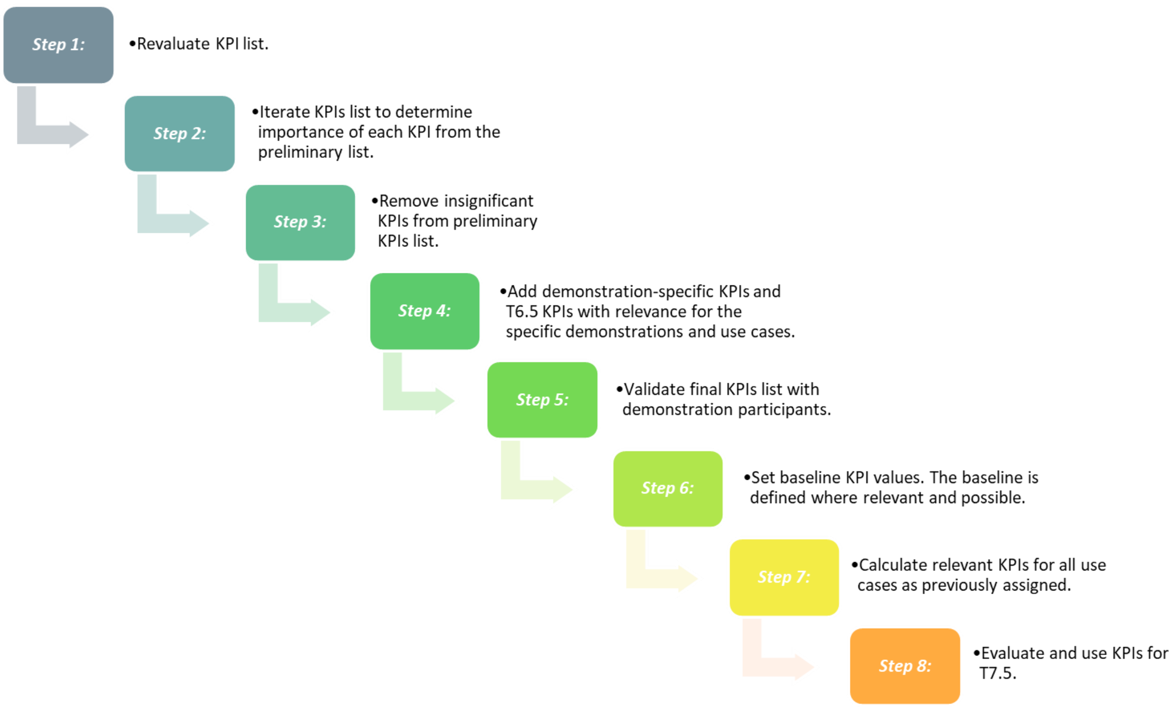

Figure 27 - Impact Assessment Methodology Flowchart.

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It contains eight steps that facilitate and guide the evaluation of the results. These steps are:

1. ***Step 1:*** Revaluate KPI list after use cases completion and check KPIs developed in T6.5.
2. ***Step 2:*** Iterate KPIs list to determine importance of each KPI from the preliminary list for the specific demonstrations and use cases.
3. ***Step 3:*** Remove insignificant KPIs from preliminary KPIs list.
4. ***Step 4:*** Add demonstration-specific KPIs and T6.5 KPIs with relevance for the specific demonstrations and use cases.
5. ***Step 5:*** Validate final KPIs list with demonstration participants.
6. ***Step 6:*** Set baseline KPI values to compare conventional solutions with new ones. The baseline is defined where relevant and possible.
7. ***Step 7:*** Collect necessary data and calculate relevant KPIs for all use cases as previously assigned.
8. ***Step 8:*** Evaluate and use KPI values for T7.5.

The impact assessment starts during and continues after the fourth stage of the demonstrations. Steps 1-5 are necessary to ensure that the KPIs list is complete and can provide the best assessment of the results. The following step, step 6, is needed so that the KPIs are compared to a baseline that can provide the best evaluation. Step 7 is dedicated to the calculation of the KPIs for all use cases, which also involves the collection of the data. In order to facilitate the collection of the data, a template is provided with Table 9. The table includes the part for the baseline definition as well, so that it can be defined where relevant. The last step, steps 8, is dedicated to the proper calculation of the KPIs and posterior analysis of the demonstrations.

Table 9 - KPIs calculation data template.

KPIs calculation data template					
KPI ID	**Baseline (where relevant)**	**Demonstration and use case**	**Type of data**	**Value**	**Responsible partner**

5 Conclusions

Deliverable 7.1 reports the important steps taken to reach the objectives set for task 7.1 -Validation Plan and Impact Assessment & KPIs. It provides a methodical approach for the definition of the use cases, the KPIs list and the validation and impact assessment of the demonstrations.

The use cases are defined for the Menorca and Copenhagen demonstrations, whereas the important directions for the use cases definitions are set for the demonstration in Rome.

A KPIs list is assembled taking into account the SOs and IPs of the FLOW project, as well as the economical, technical, environmental and user-focused aspects of the demonstrations. Moreover, the alignment of the project's KPIs with the SRIA recommendations is provided.

For the validation and the impact assessment, two methodologies are developed, specifically for the needs of the project. The validation methodology involves five actions for the specific stages of the demonstrations in order to ensure the validity and reliability of the results. The impact assessment methodology contains eight steps that are necessary for the proper analysis of the use cases and uses the provided KPIs list as a starting point.

This report also contains the templates that are created in order to facilitate the definition and data collection processes. The developed validation plan and impact assessment methodology will be used to guide the use case development, validation and assessment in each of the demos. In this way the work done for this report as part of T7.1 will support the demonstrations for the FLOW project (T7.2-T7.4). The developed methodologies will be realized through the preparation of deliverable 7.5 after the completion of the demonstrations.

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