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Abstract:

The purpose of this report is to set the ground for the impact assessment of the WiseGRID project. As such, it presents the methodology to be utilised as well as the planning horizon on when it will be implemented and the anticipated results. Moreover, goes beyond that by completing the first steps of the methodology, including the definition of the Key Performance Indicators as well as the first steps of the Cost Benefit Analysis (CBA).

Keywords:

Smart grid, Energy security, Renewable energy, Electricity, Demand response, Storage, Electric vehicle, Circular economy, Business models, CBA, Data protection, Privacy, Legislation, Regulation, Smart meters, Wholesale Markets, Ancillary Services and Flexibility.

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EXECUTIVE SUMMARY

WiseGRID aims to demonstrate the real-life optimisation of intelligent electricity deployment, management, and consumption through the provision of a set of solutions and technologies that typify a smart, stable, secure and open, consumer-centric energy grid. The project is part of the European Union's Horizon 2020 research and innovation programme and combines an enhanced use of storage technologies, a highly increased share of RES and the integration of charging infrastructure to favour the large-scale deployment of electric vehicles. WiseGRID is aiming for cutting edge and interoperable tools and applications to enable better grid monitoring and control, incorporating storage technology, demand response schemes and easy-to-use interfaces for the energy consumer, being it a household or energy manager of a company.

Deliverable D16.1, outcome of *WP16: Technical evaluation and socio-economic impact assessment* and in particular of *Task 16.1 Impact assessment and Cost Benefit Analysis planning*, sets the ground for the impact assessment of the WiseGRID project. In that context presents the methodology to be utilised as well as the planning horizon on when it will be implemented and the anticipated results. Moreover, goes beyond that by completing the first steps of the methodology, including the definition of the Key Performance Indicators as well as the first steps of the Cost Benefit Analysis (CBA).

Deliverable is divided into 3 core sections dealing with the impact in different areas as shown in the figure below, presenting our holistic approach towards impact evaluation.

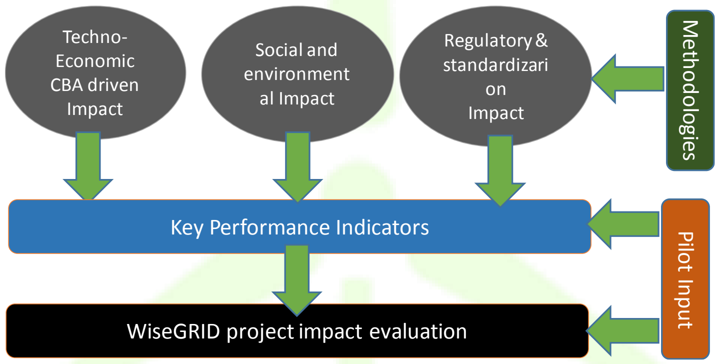

Figure 1 - Areas of WiseGRID impact evaluation

The first part deals with the methodology for evaluating the techno-economic impact. This is based on a modified and WiseGRID tailored version of the methodology for Smart Grid Cost-benefit analysis (CBA) [3] created by the European Unions' Joint Research Centre (JRC) [1] and the US Department of Energy (DoE) [2]. As part of the "Benefits" analysis, all the expected WiseGRID products have been analysed in terms of the potential benefits in the Smart Grid and how these are going to be evaluated using the project's defined use cases and pilots. The analysis considered both technical impact factors as well as economic ones, based on the current market status. As a rough average the project anticipates an Internal Rate of Return of approximately 10%.

Next, the project defined the "baseline conditions, KPIs, benefits monetization and beneficiaries", for each one of the Business Models described in Deliverable 1.1. The former consists the definition of the "Business as Usual" state, used as a comparison benchmark for the state of the grid after the implementation of the WiseGRID project. The comparison between the two states reflects the added value provided by the functionalities of the involved tools. Finally, it established the evaluation metrics to be utilised for comparing the costs and benefits of the projects using well-defined econometrics like the Net present value, Internal rate of return, Return on investment, Earnings Before Interest and Taxes, Net operating Profit After Tax, etc.

The second part of the delivered focused on the social and environmental impact. WiseGRID is a Smart Grid project with distinct social goals to increase quality of living in Smart Grid enabled neighbourhoods. As such we have defined a set of goals and KPIs in various categories such as social (jobs creation, gender issues, citizen's satisfaction), environmental (increasing the share of renewables and reducing emissions) and user related (social acceptance, time saved by consumers, safety, etc) that will be measured using both quantitative and qualitative instruments. One of our valuable tools for collecting data will be questionnaires such as the one created for the consumers and prosumers of our pilots, presented in Annex A.

Finally, the last part of the current document discusses how the impact concerning regulations and standardizations is going to be assessed. The discussion emphasizes on the EU targets around policies, transport and circular economy as well as on the EC's strategic goals. Moreover, as mentioned, in the framework of the Winter Package, WiseGRID will provide important insights against specific pieces of legislation/regulation such as the RES Directive, the Electricity Market Design Directive and Regulation, the Energy Efficiency and Data security and protection. Finally, this part examines how different sets of regulations will impact the project pilots i.e. in the specific national and socio-economic environment that are tools and services are going to be deployed and evaluated. Furthermore, the project will pay specific attention on how the project's results will be compatible and create links with other European Commission ongoing work and initiatives, such as the Bridge Cooperation group of H2020 Smart Grids and Storage projects and the Smart Grid Task Force and its Experts Groups.

The work in the context of this WP will continue towards collecting and analysing the necessary input and data from project pilots. Interactions and feedback from other WPs are expected both on the technical front (WP14, WP15) as well as on the business one (WP17, WP21). The KPIs indicated in the current document will be regularly monitored, assessed and refined if needed while the project to keep up with the current market status and developments in the Smart Grid area.

1 INTRODUCTION

1.1 Purpose of the document

Deliverable D16.1 aims to set the ground for the impact assessment of the WiseGRID project. As such, it will present the methodology to be utilised as well as the planning horizon on when it will be implemented and the anticipated results. Moreover, will go beyond that by completing the first steps of the methodology, including the definition of the Key Performance Indicators as well as the first steps of the Cost Benefit Analysis (CBA).

1.2 Scope of the document

Deliverable *D1.1: Legislation, business models and social aspects*, in Section 4, presented the overall methodology followed by WiseGRID for the business and economic analysis and evaluation. This holistic approach combines various elements (technical, economic, social, etc).

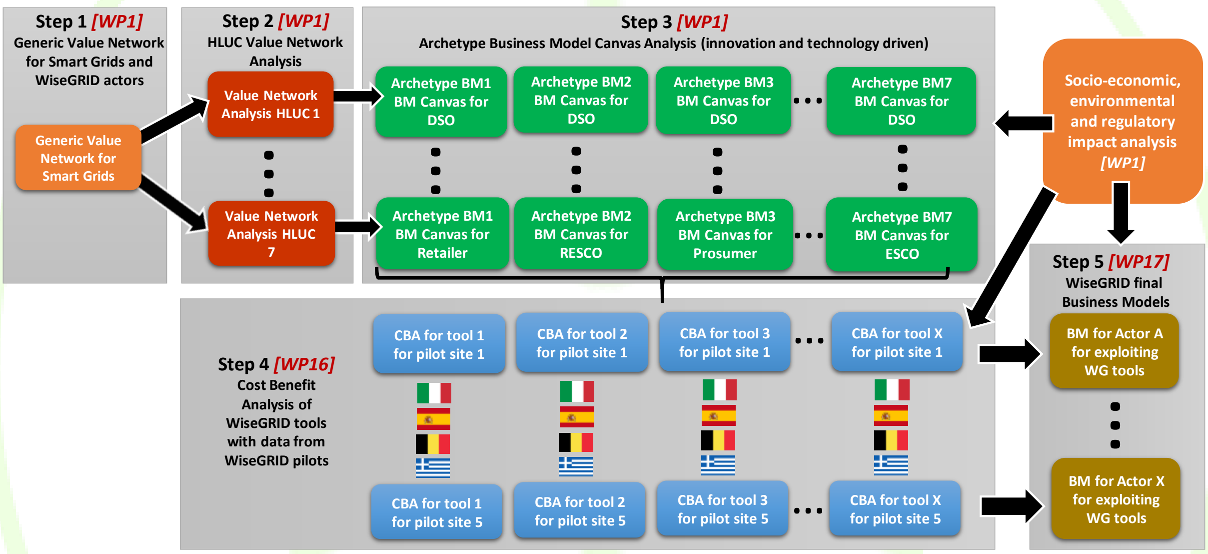

Figure 2 - The overall methodology for the WiseGRID business and economic analysis and evaluation

WP16 will focus on analysing the results of the aforementioned steps and use them to evaluate the associated impact on number of fronts as shown in Figure 3.

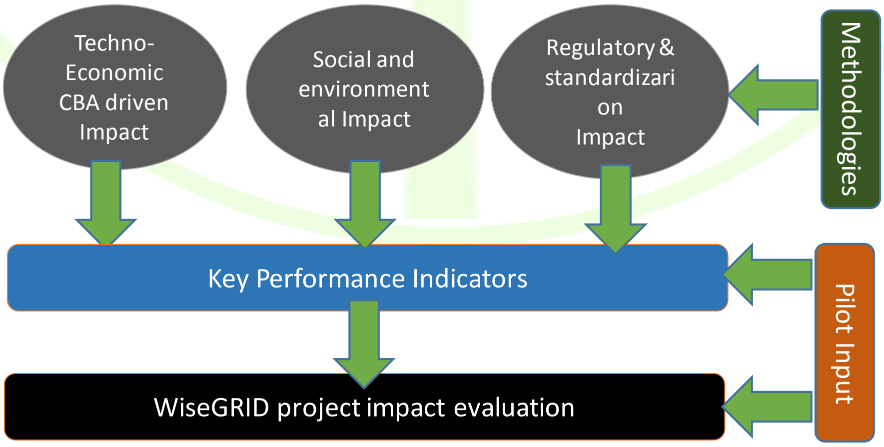

Figure 3 - Areas of WiseGRID impact evaluation

As shown, WiseGRID will evaluate the impact of the project in 3 distinct pillars:

A. The **techno-economic impact** pillar, driven by a Cost Benefit Analysis and by exploiting input from the business modelling work of WP1, and WP17, as well as from the project pilots.
B. The **social and environmental impact** pillar, using both input from project developments as well as from the direct involvement of users from our pilots.
C. The **regulatory and standardization impact** pillar, that will assess our efforts in contributing in these areas.

The impact assessment will be **quantitative or/and qualitive** depending on the area.

Furthermore, our evaluation will utilise **transparent, well-defined and measurable KPIs** that will be monitored and assessed in different phases during the development of the project. These are going to be presented in the current document.

1.3 Structure of the document

This document has been structured in a way that will provide for each of the 3 pillars the following:

- Our methodology and relevant work
- The Key Performance Indicators per area and the associated targets, where applicable
- The first steps of the work for all these areas

Particularly, Section 2 addresses the techno-economic impact based on a Smart Grid tailored CBA methodology, Section 3 presents the social and environmental impact, using both quantitative and qualitative instruments whereas Section 4 discusses how the impact concerning regulations and standardization is going to be assessed. Finally, Section 5 concludes the document and presents the next steps.

The document also includes two Annexes that elaborate in detail on specific aspects mentioned in the main body of the document.

2 TECHNO-ECONOMIC IMPACT AND KPIS (CBA BASED)

2.1 WiseGRID approach and related work

The European Unions' Joint Research Centre (JRC) [1], Institute for Energy and Transport has developed together with the US Department of Energy (DoE) [2] a methodology for Smart Grid Cost-benefit analysis (CBA) [3].

This impact-assessment methodology provides the scientific framework for the CBA section of the EC recommendations on smart metering deployment [4] and is in accordance with the Commission's 'Proposal for a Regulation of the European Parliament and of the Council' for the implementation of Smart Grid projects in line with the priority thematic area 'Smart Grids deployments'.

The methodology provides the scientific framework for the CBA of Smart Grid projects and consists of 3 steps:

1. An economic analysis in terms of a monetary appraisal that entails the a) the definition of boundary conditions i.e. conditions that will shape the quantification of benefits in the environment under consideration), b) the identification of costs and benefits and c) a sensitivity analysis.
2. A qualitative impact analysis in terms of a non-monetary appraisal i.e. considering (not measurable in absolute numbers) externalities such as cost and benefits derived from broader social impacts like security of supply, consumer participation, improvements to market functioning, contribution to policy goals etc.
3. A combination of the above monetary and non-monetary appraisals that employs weights to combine the different impacts of the qualitative analysis in accordance with their foreseen relevance.

It is important to note that this methodology is also combined with the assessment framework for Smart Grid projects [5] that, among others, proposes a set of KPIs for evaluating the performance to Smart Grid networks.

The methodology "provides a framework for evaluating economic, environmental, reliability, safety and security benefits from the perspective of all the different stakeholders' groups (utilities, customers and society). Its aim is the identification of easy-to-understand, directly measurable and quantifiable benefits" [3]. It is considered as the only Smart Grid targeted CBA in the literature, this being the main rationale behind our selection as the basis of our framework, together of course with the fact that it is indeed a holistic CBA framework covering in detail a wide variety of aspects.

The different parameters of the CBA analysis that WiseGRID will utilize are presented in the next picture.

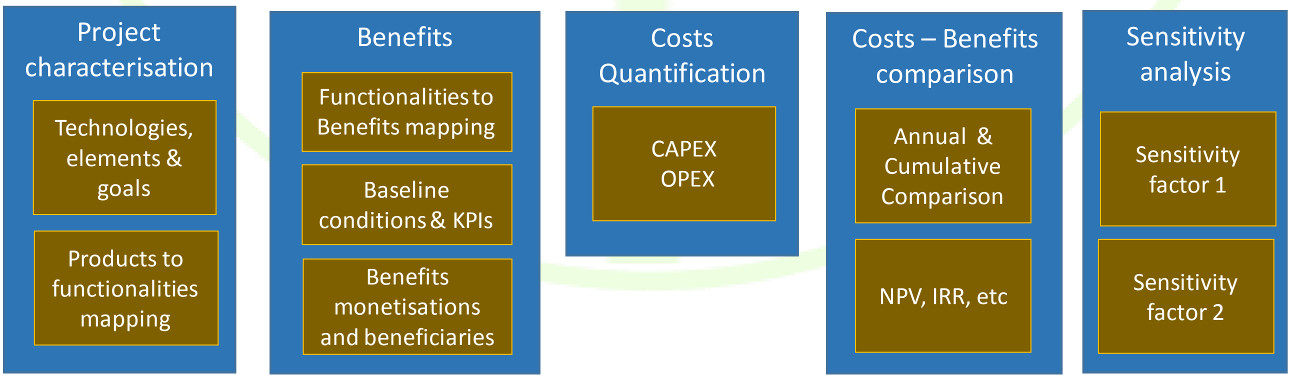

Figure 4 - CBA analysis 5 steps

Where needed, <u>the above methodology is going to be adapted and tailored to the WiseGRID project</u> as we are implementing an innovation project with multiple outputs (both research and commercially wise) and partners and not a single industrial-based project, thus the analysis would be more intricate.

In the context of this deliverable we:

1) Elaborate more on the different analysis as part of the methodology and explain how exactly this is going to be performed in WiseGRID.
2) Complete the first two steps of the analysis while setting the ground for the rest to follow in the duration of the project.
3) Present how projects' defined KPIs are going to be integrated in this analysis as well as define the targets per KPI based on which the project impact and success is going to be evaluated.

2.2 Core Impact Indicators

WiseGRID project is built around four main objectives stated in Description of Work (DoW), which have technical, economic, social and regulatory extensions. From a technological point of view, these objectives are formulated as:

- Integration of advanced Demand Response Mechanisms.
- Smartening the distribution of grid by means of the monitoring of the generation and consumption points and integrating VPPs.
- Integration of renewable energy storage systems in the network for an optimal management and balancing of the grid.
- Integration of electric mobility services, managing loading and unloading of these vehicles and using them as storage systems.

If we attempt to go more in depth of the general technological objectives and expected impact of the project, the following table is created.

Technological Objectives	**Measure of success**
Reduced electrical losses	WiseGRID project will provide services and tools to improve the control and automation of the variable and intermittent generation of the distributed energy resources, promoting local generation, and at the same time reducing electrical losses, estimated in 25% *(DoW Section 2.1.2).*
Renewable energy integration	Integration of 22% of renewable energy into the grid (*Impact 2 in DoW Section 2.1.1*) reducing curtailment of local generation as much as possible (Dow section 1.3.4)
Reduction of energy consumption	WiseGRID project is expected to provide on average a 20% of energy consumption reduction. This results from an unbundled calculation taking into account savings on facilities, Smart Cities, RES cooperatives, aggregators, retailers, DSOs, households and EVs. Substantial amount of these savings comes from households and EVs.
Technological readiness levels (TRL) of WiseGRID products with the necessary replicability and scalability of these tools.	Stage of development per WG tool at start and end of the project. (according to Table 3 of DoW section 1.3.2) WGIOP: from TRL 5 to 8 WG Cockpit: from TRL 5 to 8 or 9 WiseCORP: from TRL 6 to 8 or 9 WiseCOOP: from TRL 5 to 8 or 9

	WiseHOME: from TRL 6 to 8 or 9 WiseEVP: from TRL 6 to 8 or 9 WG FastV2G: from TRL 4 to 8 WG RESCO: from TRL 5 to 8 WG STaaS/VPP: from TRL 4 to 7
Smartening the distribution grid: methodologies for improved control and automation of distribution networks	The project will provide advanced methodologies and tools to DSOs that will enhance the control, management, automation and maintenance of the grid, reducing losses and providing more stable and secure energy networks.
Smart integration of grid users from transport	The project will provide advanced energy services that facilitate the integration of EVs into the grid to provide flexibility to the grid. The project services will flatten the daily load curve and will demonstrate how EVs can be used as dynamic distributed storage devices.
Demand response schemes for the benefit of the grid	WiseGRID will demonstrate and integrate into the grid, effective, advanced and innovative demand response schemas. The benefits produced by them, include reinforcement of the electrical grid reliability, ensuring that demand doesn't exceed supply and flattening demand curves by redistributing consumption from peak periods to off-peak times.
Integration of energy storage technologies	By means of energy storage systems, the project will supply more flexibility and balancing to the distribution grid, providing a back-up to intermittent renewable energy.
Validated contributions from improved stability and flexibility in the distribution grid, avoid congestion	WiseGRID will contribute to the improvement of the control and automation of distribution networks, of the observability of variable generation and consumption loads. By means of WiseGRID project results, it is expected to increase grid reliability and stability avoiding power interruptions and estimate Grid Asset condition through real-time and react accordingly.
Contribution to the state of the art of the CIM for Smart Grids and of open protocols (OSCP and OCPP)	Through validation in large scale pilots the IEC 61970 and IEC 61968 standards, through validating communication protocols between charge point management system and energy management system. WiseGRID will address CIM such that smart metering, Smart Grid and electrical vehicles can be described with a common approach, with a higher compatibility between different data models.

Figure 5 - WiseGRID core impact targets

2.3 WiseGRID products impact to Smart Grid

In this section, the technological impact of the implementation of the WiseGRID tools will be explored based on the methodology described in Section 2.1 and in alliance with the project's objectives. This is part of the "Benefits" analysis step of our methodology as seen in Figure 4.

2.3.1 Products analysis

2.3.1.1 WG Cockpit

As it has been described in previous Deliverables too, WG Cockpit is a tool for Distribution System Operators (DSOs) that will:

- control, manage and monitor their own grid in an efficient way, improve its flexibility, efficiency, stability and security, while considering an increasing share of distributed renewable resources,
- provide an intelligent distributed control to detect faults, self-protect and self-configure the network in a robust way to restore the power system without the intervention of a central intelligence (self-healing),
- enable smooth integration of heterogeneous and distributed energy resources and systems (such as renewable energy sources (RES), renewable energy storage systems, e-mobility and electric transport systems, cogeneration) by means of monitoring, decision support, control and optimized operation,
- support the increase of RES penetration through the coordinated controllability of the energy storage and the demand response schemes, providing more balanced and stable energy networks and avoiding curtailment, and finally
- address the smartening of the distribution grid, including both technologies and methods to gain advanced monitoring awareness of variable generation and consumption loads, as well as the integration of VPPs and microgrids as active balancing assets.

These main objectives of WG Cockpit are supported by the modules of the developed tool as described in D13.1 and the Use Cases (primary and secondary) where WG Cockpit is involved wither as a main or auxiliary tool in the WiseGRID ecosystem. Further on, and to facilitate the realization of the initial steps of the Cost Benefit Analysis proposed by JRC, an attempt is made to identify and justify how these are related with some of the proposed services and functionalities.

Service A. Enabling the network to integrate users with new requirements

1. <u>Facilitate connections at all voltages/locations for any kind of devices</u>

   Related UC: PUC 1.4, PUC 2.1

   Module: Grid planning assistant

   Short justification: Through better monitoring and control of the distribution network, the connectivity potentials to several locations may increase and the connectivity of e.g. small renewable energy installations may be easier to be accepted by the responsible DSO. Also, advanced grid planning analysis methods allow for a more effective network deployment capable of integrating different kind of distributed sources and assets.

2. <u>Facilitate the use of the grid for the users at all voltages/locations</u>

   Related UC: PUC 2.1 (SUC 2.1.1, SUC 2.1.3, SUC 2.1.4, SUC 2.1.5), PUC 2.3, PUC 1.2

   Module: RT Monitor, link with WiseCOOP

   Short justification: The experience of using the network will be improved for all the users (consumers, producers), if the DSO can monitor the network on real-time, effectively control it in case of faults and operate proactively in order to absorb the power coming from renewable sources on the distribution network.

3. Use of network control systems for network purposes.

Related UC: PUC 2.3

Module: Grid fault manager, Failure treatment, Unplanned outage management

Short justification: The communication of WG Cockpit with SCADA/DMS system enables the use of network control systems for network protection, stability and optimization. The DMS is used for the fulfillment of DR as a service to the grid (SUC 2.3.2), since it provides data on grid status, is used for the comparison of the resources schedule and generates the necessary control signal in case of resource status deviations. Also, DMS supports the execution of the optimization algorithm (SUC 2.3.3) aiming to solve problems pertaining to the operational scheduling of the distribution grid under normal and abnormal situations, for which it provides data on grid status and network constraints, and upon calculation of the optimal status of the components of the distribution grid, it generates the necessary control signal per component. DMS plays a stronger role in the reconfiguration of the network (SUC 2.3.4) and the islanding procedures for the local grid (SUC 2.3.5). This functionality is further supported by WG Cockpit, as the latter includes the Failure treatment module (which allows DSO to define custom workflows automatically executed whenever a certain preconfigured condition is met and identified, and the Unplanned outage treatment/FLISR module, automatically calculating the optimum operations to recover from an outage in the distribution grid with the minimum possible impact.

4. Update network performance data on continuity of supply and voltage quality

Related UC: SUC 1.1.3, PUC2.1, SUC 2.1.3

Module: Power quality module

Short justification: Through a better monitoring of the network, collecting the necessary data and processing them using the corresponding KPIs and power quality functions, the DSO will be in position to have an updated view on the network performance regarding continuity of supply and voltage quality.

Service B. Enhancing efficiency in day-to-day grid operation

5. Automated fault identification/grid reconfiguration, reducing outage times.

Related UC: PUC 2.1 (SUC 2.1.4), PUC 2.3 (SUC 2.3.4)

Module: FLISR (Fault Location Identification and System Restoration), Grid Fault manager, Communication with SCADA

Short justification: This functionality allows to detect and restore faults and if necessary to restore the power system using reconfiguration (self-healing). This comes in accordance with the objectives of the tool to provide intelligent distributed control to the DSO and improve stability and security of the distribution grid. WG Cockpit implements this functionality using the module FLISR (Fault Location Identification and System Restoration).

6. Enhance monitoring and control of power flows and voltages.

Related UC: PUC 1.1 (SUC 1.1.1, SUC 1.1.2, SUC 1.1.4), PUC 1.3, PUC 2.1, PUC 2.2, PUC 2.3

Module: RT Monitor, Power flow calculator, State estimator, Communication with SCADA, Congestion forecast

Short justification: With the knowledge of the power flows and bus voltages, DSO has a broader and more complete overview of the grid and, thus, enhanced monitoring and control. WG Cockpit receives the measured data from the measuring infrastructure and the SCADA system, and using specifically developed Three Phase Power Flow and State Estimation algorithms estimates the power flows and voltages for a specific state of the distribution system. Also, based on Congestion forecast, the Congestion management is improved to highly efficient use of the grid.

7. Enhance monitoring and observability of grids down to low voltage levels.

Related UC: PUC 1.1 (SUC 1.1.1), PUC 2.1 (SUC 2.1.1), PUC 2.2 (SUC 2.2.3)

Module: RT Monitor, Short term DB, Long term DB

Short justification: To support the decision-making procedures and enable the effective control of the system by the grid operator, a wide observability spinning down to the low voltage levels is necessary. To achieve this, WiseGRID Cockpit is capable to receive and handle data from metering equipment installed at both MV and LV infrastructure and MV and LV customers thank to the available smart metering equipment.

8. Improve monitoring of network assets.

Related UC: PUC 2.1 (SUC 2.1.5), PUC 2.1 (SUC 2.1.1)

Module: Maintenance manager, Communication with SCADA

Short justification: Monitoring of network assets is possible using the appropriate measuring infrastructure and the appropriate handling of the available information. WG Cockpit collects the data (usually through WG IOP) from the available measuring infrastructure deployed at the various network assets and the SCADA system, and handles them accordingly using the various specialized modules (forecasting module, power quality module etc.). Even more, the Maintenance manager and the advanced User Interface of the tool enables the user to have an enhanced overview of the status of all the network assets.

9. Identification of technical and non-technical losses by power flow analysis.

Related UC: PUC 1.2 (SUC 1.2.2), PUC 2.2 (SUC 2.2.4)

Module: Power flow calculator, State estimator, Load demand and peak prediction.

Short justification: System losses – technical and non-technical – constitute a major indicator of the overall operational performance of the distribution system; therefore, the identification of them is important information for the DSO. WG Cockpit, using the power flow calculation modules, is capable of identifying the technical losses directly. However, there is no specialized module for the calculation and analysis of the non-technical losses. It should be noted though that all the required information is provided by the tool and the operator can collect, analyse and evaluate this information and indirectly draw conclusions considering the non-technical losses.

10. Frequent information exchange on actual active/reactive generation/ consumption.

Related UC: PUC 1.1 (SUC 1.1.1), PUC 2.1

Module: RT Monitor, Short term DB, Long term DB, SCADA communication

Short justification: As already stated, WG Cockpit will be capable to collect generation and consumption data from the network assets and the customers thanks to the advanced measuring infrastructure and the communication with the SCADA system. In general, the data collection frequency depends on the application requirements and the capabilities of hardware infrastructure. WG Cockpit has functionalities which require near real-time information of generation and production and, therefore, if infrastructure allows for that, the tool will collect and process this information.

Service C. Ensuring network security, system control and quality of supply

11. Allow grid users and aggregators to participate in ancillary services market.

Related UC: PUC 1.2, PUC 1.3, PUC 2.3 (SUC 2.3.2), PUC 3.4 (SUC 3.4.1)

Module: Ancillary services market hub

Short justification: The participation of the various actors in the ancillary services market can significantly benefit the operation of the grid, reduce the investment and other costs of the operators and increase the flexibility of the system. One of the main objectives of the WG Cockpit is to enhance the flexibility and increase the participation of the various actors in system operation with various means. For that purpose, the WG Cockpit tool uses a specialized module, the ancillary services market hub.

12. Operation schemes for voltage/current control.

Related UC: PUC 1.3, PUC 2.3

Module: Ancillary services market hub (Demand response), Power quality module

Short justification: Voltage and current control schemes can help the DSO to better manage power flows and, hence, to avoid congestion, balance and other technical issues. WG Cockpit as an operator's tool cannot directly control the various resources or loads of other actors. However, it can achieve voltage/current control indirectly through the ancillary services market hub and the implicit and explicit demand response campaigns which are possible using the ancillary services module.

13. Intermittent sources of generation to contribute to system security.

Related UC: PUC 1.3

Module: demand and production forecast service, Ancillary services market hub

Short justification: System security and reliability can be improved when the management of the intermittent resources is proper. For that, accurate generation and demand forecast services are required. WG Cockpit with the incorporated forecast modules can estimate the upcoming grid requirements and, using the ancillary services market hub, can increase the utilization and penetration of the intermittent sources.

14. System security assessment and management of remedies.

Related UC: PUC 1.1 (SUC 1.1.3 KPI Management), PUC 1.4, PUC 2.1 (SUC 2.1.4, SUC 2.1.5), PUC 2.3 (SUC 2.3.4, SUC 2.3.5)

Module: KPI engine module, Threshold monitor module, Outlier detector module, Congestion forecast module, Failure treatment module, Unplanned Outage Treatment/FLISR module, Maintenance Manager module.

Short justification: WG Cockpit provides all the tools to monitor the performance of the network through time and in real-time, to assess any possible risks or possibility of faults due to imbalances or assets failure and assist the DSO to act proactively in order to avoid them or reduce the extent of their impact.

16. Solutions for demand response for system security in the required time.

Related UC: PUC 1.2, PUC1.3, PUC 2.3 (SUC 2.3.2), PUC 3.4 (SUC 3.4.1), PUC 4.2, PUC 4.3, PUC 5.4, PUC 6.3, PUC 7.2

Module: Ancillary services market module, (congestion forecast and failure treatment)

Short justification: WG Cockpit can trigger demand response campaigns for system security as it occurs from the ancillary services module (upon processing of the network status, congestion forecast and failure treatment). WG Cockpit communicates with other WG tools for this purpose.

Service D. Better planning of future network investments.

18. Improve asset management and replacement strategies.

Related UC: SUC 2.1.5

Module: Maintenance manager module

Short justification: WG Cockpit is the main tool involved in the Asset Management use case (SUC 2.1.5) working on data collected by DMS, ERP and GIS, to update the catalogue asset and their maintenance program. WG Cockpit includes the Maintenance manager module assisting the DSO to properly perform the preventive and corrective maintenance of the elements.

19. Additional information on grid quality and consumption by metering for planning.

Related UC: SUC 1.1.1, PUC 2.1 (mainly SUC 2.1.1, SUC 2.1.3), SUC2.2.4, SUC 2.2.6, (PUC 1.4)

Module: Power quality module, Power flow calculator, Grid planning assistant

Short justification: As stated in the Deliverable D13.1, in the case of the WiseGRID Cockpit, the main data flows considered are those available by the DSO to monitor the distribution grid and in particular the Advanced Metering Infrastructure systems, SCADA systems and Unbundled Smart Meters (SMX) devices. All three data sources will provide energy readings and electrical measurements on different points of the grid (including RES, EVSEs, energy consumption etc.). These are used by the power quality module for the grid quality (after examined for bat data detection, identification and replacement SUC 2.2.6), and in coordination with power flow calculator and grid planning assistant (as in SUC 2.2.4 and PUC 1.4) will be integrated in the network planning.

Service E. Improving market functioning and customer service.

22. Facilitate consumer participation in the electricity market.

Related UC: PUC 7.2 (SUC 7.2.6, SUC 7.2.7)

Module: Ancillary services market

Short justification: The WG Cockpit initiates DR campaigns, based also on the output of the ancillary services market, through which consumers can participate in the electricity market assisted by aggregators or VPP operators, either as automated demand side management (DSM) strategies and direct load control, or manual DSM strategies.

27. Improve customer level reporting in the case of interruptions.

Module: Maintenance manager module, Failure treatment module

Short justification: In the Grid maintenance section in combination with the Maintenance manager module of the tool, there is the Grid maintenance – Phone call dialog window, which facilitates the registration of the phone calls received at DSOs customer desk, allowing those to record new incidents accordingly to the information received. Failure treatment module allows DSO to define custom workflows automatically executed whenever a certain preconfigured condition is met and identified. One of those workflows could be used to automatically notify affected customers (email for instance), update social media etc.

Beneficiaries:

DSO, VPP Operator, EVSE Operator, Prosumers, Consumers, Aggregator, Battery operator, TSO, Facility Manager, ESCO

2.3.1.2 WG IOP

In this section, the technological impact of the implementation of WG IOP will be explored based on the methodology described in Section 2.1 and in alliance with the project's objectives.

As it has been described in the Deliverable D4.2, WG IOP is a platform to manage and process the heterogeneous and massive data streams coming from the deployed distributed energy infrastructure.

The WG IOP as part of the WiseGRID framework:

- enables new services and reduces ICT costs for prosumers and smaller players,
- facilitates cross-network and cross-entity interoperability,
- enables the cooperation and synergies among the different actors targeted by the different WiseGRID technological solutions and
- facilitates complex coordination among devices (installations) connected to the distribution grid, allowing the application of advanced methods for distribution grid management while exploiting to the highest degree the capabilities offered by the various types of resources (generating capacities) connected to the distribution grid.

These main objectives of WG IOP are supported by the modules of the developed tool as described in D4.2 Further on, and to facilitate the realization of the initial steps of the Cost Benefit Analysis proposed by JRC, an attempt is made to identify and justify how these are related with some of the proposed services and functionalities.

Service A. Enabling the network to integrate users with new requirements

1. Facilitate connections at all voltages/locations for any kind of devices

Short justification: The WG IOP allows the integration of several kinds of devices/assets into the distribution grid via its message broker module and via the several offered micro-services. Some of these micro-services have been developed to translate data coming from different assets from a proprietary format to a more convenient format (custom or standard data model) that is known by the WiseGRID tools. This mechanism facilitates the connection and data transmission from any kind of devices.

2. Facilitate the use of the grid for the users at all voltages/locations

Short justification: The WG-IOP can indirectly facilitate the use of the grid by allowing the interaction between WG tools and the integration of different assets and services to manage the grid.

Service B. Enhancing efficiency in day-to-day grid operation

6. Enhance monitoring and control of power flows and voltages.

Short justification: The WG IOP, by allowing the exchange of data among tools and devices, can enhance the monitoring and control of the power flows and voltages managed by specific WG tools.

10. Frequent information exchange on actual active/reactive generation/ consumption.

Short justification: The WG IOP indirectly enables the exchange of frequent information on actual active/reactive generation/consumption through the exchange of messages between assets, micro-services and tools.

Service C. Ensuring network security, system control and quality of supply

11. Allow grid users and aggregators to participate in ancillary services market.

Short justification: The WG IOP indirectly enables ancillary services market participation through the exchange of messages between grid stakeholders that participate to this specific market.

Beneficiaries:

DSO, RESCO, VPP Operator, EV fleet manager, EVSE Operator, Prosumers, Consumers, Aggregator, Facility Manager, VPP Operator, ESCO, Facility Manager.

2.3.1.3 WiseCORP

According to the description provided in Deliverable D7.1, WiseCORP is the WiseGRID technological solution targeting businesses, industries, ESCOs and public facility consumers and prosumers, with the objective of providing them the necessary mechanisms to become smarter energy players. By means of energy usage monitoring and analysis, proper information can be given to facility managers helping them to reduce energy costs and environmental impact. A key factor towards achieving these objectives is a proper retrieval and analysis of energy usage data, and visualization of meaningful information extracted from it. This information may include:

- detailed visualization of energy demand at different areas of the building, helping facility managers to identify opportunities for enhancing energy efficiency,
- energy tariff comparison, enabling a direct economic cost reduction by shifting to a more adequate tariff,
- energy demand forecast, enabling medium to long term cost estimations and supporting operative decisions about the usage of the facilities and
- demand flexibility estimation, allowing the execution of optimization algorithms that will – either automatically or by providing advices – shift demand, to minimize economic costs – by maximizing

self-consumption or moving demand to off-peak periods – or minimize environmental impact – by shifting demand to periods where green energy is available.

Service B. Enhancing efficiency in day-to-day grid operation

10. Frequent information exchange on actual active/reactive generation/ consumption.

Related UC: SUC 7.1.1, SUC 7.1.2

Module: RT Monitor

Short justification: WiseCORP will retrieve all the information of the energy demand and energy production (if any). The collection of these data is basic for running most of the processes of the tool.

Service C. Ensuring network security, system control and quality of supply

11. Allow grid users and aggregators to participate in ancillary services market.

Related UC: SUC 7.1.3

Module: Flexibility Forecast

Short justification: The users of the WiseCORP tool will be able to participate in the ancillary services market through the Flexibility forecast module, which will calculate the available flexibility of the buildings and sell it to the aggregator.

Service E. Improving market functioning and customer service.

20. Participation of all connected generators in the electricity market.

Related UC: SUC 7.2.3

Module: Link with WiseCOOP

Short justification: The connection between WiseCOOP and WiseCORP allows WiseCORP to participate in the electricity market and perform net-metering strategies.

22. Facilitate consumer participation in the electricity market.

Related UC: SUC 7.1.3, SUC 7.1.4, SUC 7.1.5

Module: Link with WiseCOOP and Energy Usage Optimizer

Short justification: Through the performed energy optimization and the link with WiseCOOP, the users will be empowered and will become relevant actors in the electricity market.

24. Improvement to industry systems (for settlement, system balance, scheduling).

Related UC: PUC 7.1 (SUC 7.1.1, SUC 7.1.2, SUC 7.1.3, SUC 7.1.4, SUC 7.1.5)

Module: BMS Wrapper, Asset Dispatcher, Energy Usage Optimizer, GUI

Short Justification: According to the data collected from all the relevant assets of the building, WiseCORP will be able to schedule their time usages, their set points and provide flexibility to the grid. By giving a user-friendly tool which enables to manage the building assets to take part in demand response event, we will give access to the consumer to electricity market. Furthermore, by visualizing the different tariffs and being able to modulate the consumption depending on prices, we indirectly enable the consumer to participate in the electricity market.

25. Support the adoption of intelligent home/facilities automation and smart devices.

Related UC: SUC 7.2.6

Module: Asset Dispatcher

Short justification: The automated smart devices are very important for performing many types of DR strategies. Through the Asset dispatcher module, WiseCORP can control these automated devices since the tool enables to integrate a vast number of smart devices and manage/monitor it through the same application which facilitates their use.

26. Provide grid users with individual advance notice of planned interruptions.

Related UC: SUC 2.1.4

Module: Link with WiseCOOP

Short justification: WiseCOOP can send alerts and messages to WiseCORP to inform its user in case of possible failures or interruptions in the grid.

Service F. Enabling and encouraging stronger and more direct involvement of consumers in their energy usage and management.

28. Sufficient frequency of meter readings.

Related UC: SUC 7.1.1.

Module: AMI and USM wrapper

Short justification: WiseCORP is prepared for collecting regular measurements from the SLAM and the already installed smart meters of the pilot sites.

29. Remote management of meters.

Related UC: SUC 7.1.3, SUC 7.1.4

Module: BMS Wrapper

Short justification: WiseCORP is able to control and manage different types of devices (smart meters, HVACS, batteries, CHPs and Gas meters).

31. Improve energy usage information.

Related UC: SUC 7.1.2

Module: GUI

Short justification: Through all the devices managed by the tools, WiseCORP is able to show valuable and user-friendly information to its users. Data about energy usage (self-consumption, consumption, asset load, etc.) are collected and better forecast and models are done which enable a greater understanding of the energy usage.

33. Availability of individual continuity of supply and voltage quality indicators.

Related UC: SUC 1.1.3, SUC 7.1.2

Module: GUI and KPI engine

Short justification: WiseCORP can continuously show the main indicators of quality of supply to its users.

Beneficiaries:

Facility Manager, ESCO, Consumer, Prosumer, Gas Distribution Company.

2.3.1.4 WiseCOOP

WiseCOOP is the WiseGRID technological solution targeting aggregators of consumers and prosumers - particularly focused on domestic and small businesses -, supporting them in their roles of energy retailers, local communities and cooperatives – which may have different objectives.

The main goal of the solution is helping consumers and prosumers to work together in order to achieve better energy deals while relieving them from administrative procedures and cumbersome research. In the scenario of increasing share of distributed renewable energy resources, this goal can be achieved by pursuing several objectives:

- Net metering: supporting the operation of communities of prosumers that invest in renewable energy sources aiming at reducing their environmental impact.
- Member profiling: clusters of consumers and prosumers with common energy usage patterns may be identified, allowing the aggregator to negotiate special terms (for instance energy tariffs) particularly beneficial for those groups.
- Demand forecasting: by allowing the retailer to forecast the demand of its customers, optimization of energy purchase at the wholesale market is enabled.
- Tariff comparison: by offering to members a tool to compare their particular consumption with different available tariffs, those will have access to very valuable information to reduce their energy bills.
- Implicit price-based DR towards modulating the overall demand of the group to achieve a common objective (for instance, maximize usage of renewable energy sources produced within the group).
- Providing clear information to members to raise awareness on efficient energy usage and environmental awareness.

Service B. Enhancing efficiency in day-to-day grid operation

10. Frequent information exchange on actual active/reactive generation/ consumption.

Related UC: SUC 2.2.1

Module: RT Monitor

Short justification: WiseCOOP can control and monitor the consumption and production of its portfolio of prosumers and send it to WG Cockpit.

Service C. Ensuring network security, system control and quality of supply

11. Allow grid users and aggregators to participate in ancillary services market.

Related UC: SUC 7.2.6, SUC 7.2.7, SUC 2.3.2

Module: DR Campaign scheduler

Short justification: WiseCOOP can look into its portfolio of clients in order to find the most suitable ones for participating in explicit DR campaigns and participate in the ancillary services market.

13. Intermittent sources of generation to contribute to system security.

Related UC: SUC 1.3.1, SUC 1.3.2, SUC 2.2.1

Module: Production forecast module and DR campaign scheduler

Short justification: WiseCOOP will look into its portfolio of clients who have local generation and use the flexibility and voltage and congestion management opportunities to ensure the security of the grid.

16. Solutions for demand response for system security in the required time.

Related UC: SUC 2.3.2

Module: DR campaign scheduler, WG Cockpit connection and RT monitor

Short justification: WiseCOOP will be continuously monitoring and calculating the flexibility of its clients and it will be able to provide to WG Cockpit the required flexibility in the proper time frame.

Service D. Better planning of future network investments.

19. Additional information on grid quality and consumption by metering for planning.

Related UC: SUC 7.2.2

Module: SMX and AMI Wrappers

Short justification: WiseCOOP is continuously monitoring and performing calculations about the consumption and production data to provide valuable information for DSOs.

Service E. Improving market functioning and customer service.

20. Participation of all connected generators in the electricity market.

Related UC: SUC 7.1.4, SUC 7.1.5, SUC 1.1.2

Module: Production forecast, wholesale market module.

Short justification: WiseCOOP will allow its clients to participate in the wholesale market in an aggregated way.

21. Participation of virtual power plants and aggregators in the electricity market.

Related UC: PUC 7.2

Module: DR campaign scheduler, Wholesale market, Flexibility estimator, production forecast module

Short justification: WiseCOOP will allow its clients to participate in the wholesale and ancillary services markets in an aggregated way.

22. Facilitate consumer participation in the electricity market.

Related UC: PUC 7.2

Module: DR campaign scheduler, Wholesale market, flexibility estimator, demand forecast module

Short justification: WiseCOOP will facilitate its clients to participate in the wholesale and ancillary services markets in an aggregated way and become smarter energy players.

26. Provide grid users with individual advance notice of planned interruptions.

Related UC: SUC 2.1.4

Module: GUI, Link with WG Cockpit

Short justification: WG Cockpit will send a notification to WiseCOOP if a failure or a cut off in the grid is (or is going to be) produced. WiseCOOP can send this information to its portfolio of clients.

Service F. Enabling and encouraging stronger and more direct involvement of consumers in their energy usage and management.

28. Sufficient frequency of meter readings.

Related UC: SUC 7.1.1

Module: AMI and SMX Wrapper

Short justification: WiseCOOP is prepared to collect regular measurements from the SLAM and the already installed smart meters of the pilot sites.

29. Remote management of meters.

Related UC: SUC 7.2.5

Module: AMI and SMX Wrappers

Short justification: WiseCOOP is able to monitor the status of the smart meters deployed in Wise-GRID and collect all the required information.

30. Consumption/injection data and price signals by different means.

Related UC: SUC 7.2.3, SUC 7.2.4

Module: Tariff provider, Billing Management module

Short justification: WiseCOOP will send different price signals to its customers in order to inform them of profitable economic situations due to their production, flexibility, demand shifting, etc.

32. Improve information on energy sources.

Related UC: SUC 7.2.1

Module: GUI

Short justification: WiseCOOP will show the origin of the energy consumed by its clients and inform them of the carbon footprint of their consumption.

33. Availability of individual continuity of supply and voltage quality indicators.

Related UC: SUC 1.1.3, SUC 7.2.1

Module: GUI and KPI engine

Short justification: WiseCOOP can continuously show the main indicators of supply quality to its portfolio of clients.

Beneficiaries:

Aggregator, Supplier, Consumers, Prosumers, DSO

2.3.1.5 WiseHOME

As described in D11.1, the WiseHOME application is the dedicated user interface for domestic consumers and prosumers who want to take part in the WiseGRID ecosystem, enabled by market actors such as retailers or energy cooperatives using WiseCOOP.

It is the only tool that directly interfaces with domestic users. It interacts with other tools, such as WiseCOOP and WG RESCO to properly exchange the necessary information that will enable the provision of the target services to the users.

The WiseHOME provides different functionalities to help the domestic end-users to be easily informed and involved in the Smart Grid:

- Providing individual reports helping domestic users to gain insights in:
  - their actual power consumption vs the maximum of their connection/contract,
  - their electricity consumption vs a previous period,
  - the percentage of auto-consumption,
  - the actual balance of their bill and
  - the rewards they get for their participation in aggregation services.
- Views on the status of PV and Storage: actual production, actual charging/discharging, power/state-of-charge.
- Providing collective reports to help domestic users gain insights in:
  - the percentage of local generation of the electricity consumed in the neighbourhood,
  - the CO_2 intensity of the actual electricity consumed and
  - the status of the grid to indicate problems in the local grid.
- Providing pricing information to help domestic users gain insights in:
  - the actual dynamic pricing scheme vs a flat pricing scheme and
  - a simulation of the 2 different pricing schemes to show which one is more interesting.
- A notification center that can handle messages with different priority levels, that the retailer or aggregator can use as the preferred communication channel with the end-user.

Service C. Ensuring network security, system control and quality of supply

11. Allow grid users and aggregators to participate in ancillary services market.

Related UC: SUC 7.2.6, SUC 7.2.7, SUC 7.3.3

Short justification: The WiseHOME is the main information channel towards end-users for the WiseCOOP through which grid users could get involved in ancillary services.

Service E. Improving market functioning and customer service.

20. Participation of all connected generators in the electricity market.

Related UC: SUC 7.3.4

Short justification: The WiseHOME is the main information channel towards end-users for the WiseCOOP through which prosumers could get their generators and storage systems involved in the market.

21. Participation of virtual power plants and aggregators in the electricity market.

Related UC: SUC7.2.6, SUC 7.2.7, SUC 7.3.3

Short justification: The WiseHOME is the main information channel towards end-users for the WiseCOOP through which prosumers could get their generators and storage systems involved in virtual power plants and aggregators.

22. Facilitate consumer participation in the electricity market.

Related UC: SUC 7.2.5, SUC 7.2.7, SUC 7.3.4

Short justification: The WiseHOME is the main information channel towards end-users for the WiseCOOP through which prosumers could get more detailed market information as e.g. dynamic pricing schemes.

25. Support the adoption of intelligent home/facilities automation and smart devices.

Related UC: SUC 7.2.6, SUC 7.3.3

Short justification: The WiseGRID ecosystem enables smart devices as heat pumps, charging stations, storage systems and PV-systems to be integrated in the Smart Grid. The WiseHOME can provide information on these devices and their interaction.

26. Provide grid users with individual advance notice of planned interruptions.

Related UC: SUC 7.3.1

Short justification: The notification service could be used to send forward planned interruptions received in the WiseCOOP.

Service F. Enabling and encouraging stronger and more direct involvement of consumers in their energy usage and management.

28. Sufficient frequency of meter readings.

Related UC: SUC 7.3.1

Short justification: Through the WiseHOME app, users can see the actual power taken from the grid.

30. Consumption/injection data and price signals by different means.

Related UC: SUC 7.2.5, SUC 7.3.1, SUC 7.3.4

Short justification: The WiseHOME app gives users insight in their self-consumption.

31. Improve energy usage information.

Related UC: SUC 7.2.5, SUC 7.3.1, SUC 7.3.4

Short justification: A view on the self-consumption of local generated electricity is available.

32. Improve information on energy sources.

Related UC: SUC 7.2.5, SUC 7.3.1, SUC 7.3.4

Short justification: A view on the actual CO_2 intensity and the share of RES of the electricity grid is Available.

33. Availability of individual continuity of supply and voltage quality indicators.

Related UC: SUC 7.3.1

Short justification: A view on the status of the grid is available.

Beneficiaries:

Prosumer, Consumer, DSO, VPP Operator, EV fleet manager, Aggregator, battery operator.

2.3.1.6 WG STaaS/VPP

In this section, the technological impact of the implementation of WG StaaS/VPP will be explored based on the methodology described in Section 2.1 and in alliance with the project's objectives.

WG StaaS/VPP is the WiseGRID technological solution targeting aggregators with a respective portfolio based on distributed generation and storage. The main goal of this solution is helping consumers and prosumers (be them households or corporate) to be aggregated and offer to the market their unused storage capacity, as well as spare generation in the form of a VPP. The objective of the tool is the provision of services to different actors:

- Services to prosumers:
  - Benefit from participation in flexibility markets.
  - Avoid curtailment of RES (if storage is in place).
- Services to Balance Responsible Party:
  - Day-ahead/Intraday portfolio optimization.
  - Self-balancing.
  - Generation optimization.
- Services to DSOs and TSOs:
  - Voltage support.
  - Grid capacity management.
    - Deliver peak load electricity.
    - Load-following power generation at short notice (DRES + batteries combined).
  - Load frequency control.
  - Power quality support

Service A. Enabling the network to integrate users with new requirements

1. Facilitate connections at all voltages/locations for any kind of devices

Related: SUC 4.2.1, SUC 4.2.3, SUC 4.3.2, SUC 4.3.3

Short justification: The tool helps the stabilization of the grid, with higher penetration of renewable energy and electrical vehicles, which imply higher loads. For this reason, new devices with higher load peaks or causing unplanned behaviors as intermittent renewable generation are easier to deploy.

2. Facilitate the use of the grid for the users at all voltages/locations

Related: SUC 4.2.1, SUC 4.2.3, SUC 4.3.2, SUC 4.3.3

Short justification: WG StaaS/VPP improves the grid and hence facilitates its use, by providing a more resilient system, controlled and self-sustainable. The automatic operation of the system regulating voltage and frequency allows the incorporation of new users.

4. Update network performance data on continuity of supply and voltage quality

Related: SUC 4.4.1, SUC 4.4.2

Short justification: WG StaaS/VPP can provide grid data (in the first-place voltage) from different VPP assets that are located at different points in the grid. DSO might not have this information since there might not be enough monitoring points.

Service B. Enhancing efficiency in day-to-day grid operation

5. Automated fault identification/grid reconfiguration, reducing outage times.

Related: SUC 4.2.2, SUC 4.2.4.

Short justification: In general, batteries in a VPP can provide backup power, however demonstration in the project is not possible due to regulatory and technical aspects. Nevertheless, WG STaas/VPP increases the revenues of the deployment of batteries, and so indirectly increases the deployment and availability of backup power.

10. Frequent information exchange on actual active/reactive generation/ consumption.

Related UC: SUC 6.1.1

Short justification: WG StaaS/VPP receives data on actual active/reactive generation and consumption from the different assets and aggregates the data on supply point and VPP level. Due to the implementation of IOT protocols such as MQTT, the platform can have this data updated second to second.

Service C. Ensuring network security, system control and quality of supply

11. Allow grid users and aggregators to participate in ancillary services market.

Related UC: SUC 4.3.1, SUC 4.3.2, SUC 4.3.3, SUC 6.2.1, SUC 6.2.2, SUC 6.2.3, SUC 6.3.2

Short justification: WG StaaS/VPP will feature a direct link to the WG Cockpit and thus to the DSO. The aggregator will have the possibility to participate in the DSO Ancillary Service Market and provide capacities for grid support and management based on DSO requests. Moreover, the aggregation of distributed assets generally allows the participation in TSO Ancillary Service markets such as frequency support. Single units alone might not be capable of participating due to their limited size. It should be mentioned that in WiseGRID, frequency support can be seen as an optional service.

12. Operation schemes for voltage/current control.

Related UC: SUC 4.3.3, SUC 6.3.1, SUC 6.3.2, SUC 6.3.3

Short justification: By providing active power and reactive power, assets of WG StaaS/VPP can support voltage control. If the DSO sends a request with the information about the location, WG StaaS/VPP can react and provide capacities to cover the request. However, the DSO has to specify the necessary power and the location. WG StaaS/VPP then distributes the power to the single assets, whereas the monitored voltage of each asset is not included in the operation schemes.

13. Intermittent sources of generation to contribute to system security.

Related UC: SUC 4.2.1, SUC 4.2.3

Short justification: Sources of generation (in the first place PV) are included in WG StaaS/VPP. Aggregated Storage Units in WG StaaS/VPP can provide power when Renewables are not able to do so, e.g. at night. However, WG StaaS/VPP is not capable of estimating the system security, so it relies on requests from other energy players or tools.

16. Solutions for demand response for system security in the required time.

Related UC: SUC 4.2.1, SUC 4.2.3, SUC 6.4.3

Short justification: WG StaaS/VPP can contribute to demand response adapting the power output of the aggregated Storage Units. In case of a request from energy players or tools, WG StaaS/VPP distributes the overall VPP power to the distributed units. A premise is that enough flexibility is available.

Service D. Better planning of future network investments.

17. Better models of Distributed Generation, storage flexible loads, ancillary services.

Related UC: SUC 6.1.1, SUC 6.1.2, SUC 6.1.3

Short justification: The distributed generation and also the demand is continuously monitored, and the gathered data are used as input parameters for learning algorithms in order to forecast future generation and demand. Furthermore, algorithms for estimating the flexibility of different supply points that are relevant for WG StaaS/VPP are implemented. Based on the operation of WG StaaS/VPP better models of Distributed Generation and Ancillary Services can be derived.

Service E. Improving market functioning and customer service.

20. Participation of all connected generators in the electricity market.

Related UC: SUC 4.3.1, SUC 4.3.2, SUC 4.3.3, SUC 6.2.1, SUC 6.2.2, SUC 6.2.3, SUC 6.3.2

Short justification: For small-sized generation units, it's sometimes not possible to participate in certain energy markets. Through the aggregation of sources via WG StaaS/VPP, the critical limits for providing power/energy can be reached and thus, ease the market participation.

21. Participation of virtual power plants and aggregators in the electricity market.

Related UC: SUC 6.2.1, SUC 6.2.2, SUC 6.2.3

Short justification: This is the main purpose of WG StaaS/VPP. The tool aggregates generators and storage systems, estimates flexibilities and offers available capacities to different electricity markets. If an offer is accepted, WG StaaS/VPP schedules the distributed units to fulfill the offer.

22. Facilitate consumer participation in the electricity market.

Related UC: SUC 6.4.1, SUC 6.4.2

Short justification: Existing market structures usually require a minimum power/energy in order to participate in certain electricity markets. Consumers or prosumers, especially on household, are often not able to participate in the electricity market since their units are rather small. Through the aggregation, however, the prosumer becomes a part of a larger pool which is able to participate. Through WG StaaS/VPP, the consumer/prosumer thus can offer available capacities to the market.

25. Support the adoption of intelligent home/facilities automation and smart devices.

Related UC: SUC 6.1.1

Short justification: "Smart" batteries and meter infrastructure will be used by WG StaaS/VPP since the tool relies on these devices. With the propagation of providing services through aggregated units the penetration of such devices will increase by time. So, WG StaaS/VPP indirectly supports the adoption of smart devices.

Service F. Enabling and encouraging stronger and more direct involvement of consumers in their energy usage and management.

28. Sufficient frequency of meter readings.

Related UC: SUC 6.1.1

Short justification: Meter data is received by WG StaaS/VPP at high frequencies which can be configurable but due to the platform could be at a granularity of seconds. This registered data could be shared with the end user by IOP and billing management.

30. Consumption/injection data and price signals by different means.

Related UC: SUC 6.1.1

Short justification: Meter and inverter power data are received by WG StaaS/VPP. These registered data could be shared with the end user by IOP and billing management. Price signals are not part of the scope, since this tool does not cover implicit demand response.

32. Improve information on energy sources.

Related UC: SUC 6.1.1

Short justification: Meter and inverter power data from the PV generation and storage is received by WG StaaS/VPP. These registered data could be shared with the end user by IOP and billing management.

33. Availability of individual continuity of supply and voltage quality indicators.

Related: SUC 4.2.2, SUC 4.2.4.

Short justification: Batteries can enhance availability of supply. By enhancing WG STaaS/VPP, battery deployment might get enhanced as well, since the return of investment of such systems gets reduced. The batteries provide backup and hence continuity of supply.

Beneficiaries:

VPP Operator, Aggregator, Prosumer, Producer, Battery operator, Consumer, RESCO, DSO, EVSE operator.

2.3.1.7 WG RESCO

In this section, the technological impact of the implementation of WG RESCO will be explored, according to information already provided in the DoW, D12.1, D12.2 and HL-UC 1 PUC 5 from D2.1.

WiseGRID project, through its RESCO tool, intends to provide a set of services to support the RESCO and ESCO companies, by performing all the necessary functionalities required for the business operations, supporting the interoperability with external tools and incorporating functional user interface. The RESCO tool is based on three fundamental layers, the data capture/provider, the back-end and the front-end. Firstly, regarding the data capture/provider, the functionality is created to collect and centralise data from various sources such as smart meters, sensors and any service necessary to provide information for the well-functioning of the tool – usually from small RES equipment which do not have visibility to the DSO individually. The resulted data is long term stored to a centralised cloud-based database platform, called "WG RESCO". Secondly, regarding the back-end, the functionality is represented by the WG IOP platform, assuring the exchange of data between the different tools within WiseGRID. Thirdly, regarding the front-end, the most "visible" component of the RESCO tool is the web application comprising of eight modules: asset manager, maintenance manager, contract manager, billing manager, energy metering manager, energy surplus forecast manager, market bid manager and investment decision support manager.

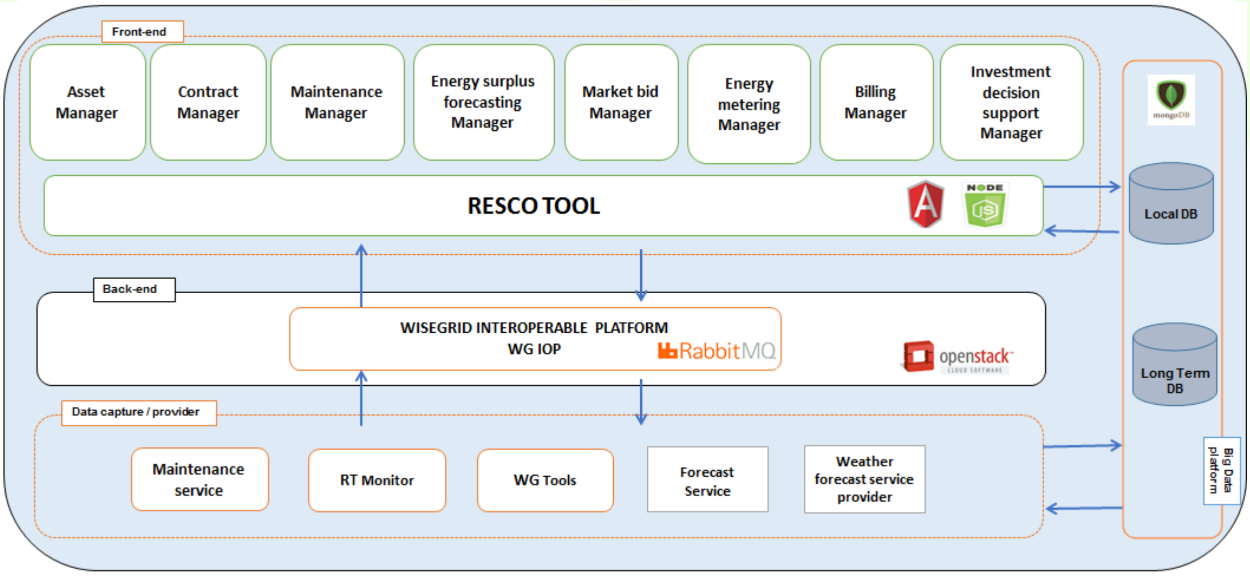

Figure 6 – WG RESCO tool architecture

The main objective of the RESCO tool is to put the focus on end users (both households and businesses) who do not want to invest in a RES system (usually PV, wind or micro-hydro), but are willing somehow to play an active role in the energy markets. To this end, three business models' options have been considered, namely (1) the RESCO pays a fee to the end user for using the whole produced energy, (2) the production is shared between the customer and the RESCO and (3) the production is consumed by the end user and they pay a fee to the RESCO for maintenance tasks.

The main functionalities of the RESCO tool are the demand and RES production forecast, energy quality monitoring, load flow/state estimation, congestion forecast and outage management (fault location, isolation and restoration). Moreover, the RESCO tool will encourage the integration of RES into the network, thus having a solid environmental impact. These objectives and functionalities are constitutive components of the basic objective of WiseGRID project, namely "to provide a set of solutions and technologies which will increase the smartness, stability and security of the consumer centric electricity grid".

The RESCO business model, hence of the RESCO tool, is an ideal solution for improving the European energy system, as also considered by the International Energy Agency and within the European Commission's Strategic Energy Technology Plan, namely the increase share of RES and storage, flexibility, advanced metering infrastructure, EVs deployment, active customers and energy efficiency. Together with the aspects already presented, RESCO could play a major role in grid balancing. To evaluate the impact of RESCO in the Smart Grid environment, three KPIs have been defined within D2.1, namely (1) increased RES and DER hosting capacity, (2) energy generation capability per investment ratio and (3) self-consumption ratio.

Service D. Better planning of future network investments.

17. Better models of Distributed Generation, storage flexible loads, ancillary services.

Related UC: PUC 1.5, SUC 1.5.1, SUC 1.5.2,

Module: Investment decision support manager; Energy forecasting manager.

Short justification: Through a better monitoring of the network and assets, collecting the necessary data and processing them using the corresponding KPIs, the RESCO is able to create real time models of its infrastructure. According to the energy balance between production and consumption in specific nodes and areas, the RESCO is able to decide where to invest according to precise data, in order to maximize ROI, minimize losses and hedge risks.

18. Improve asset management and replacement strategies.

Related UC: SUC 1.5.1, SUC 1.5.2, Module: Asset manager; Maintenance manager.

Short justification: (Similar to 17).

19. Additional information on grid quality and consumption by metering for planning.

Related UC: SUC 1.5.2, SUC 1.5.5, Module: Energy metering manager; Energy surplus forecasting manager.

Short justification: (Similar to 17).

Service E. Improving market functioning and customer service.

20. Participation of all connected generators in the electricity market.

Related UC: SUC 1.5.4Module: Market bid manager

Short justification: RESCOs introduces small generators, otherwise invisible to the DSO, into one entity that sells energy in the market, using real time data such as production estimations and real time pricing.

22. Facilitate consumer participation in the electricity market.

Related UC: SUC 1.5.3

Module: Market bid manager.

Short justification: (Similar to 20).

27. Improve customer level reporting in the case of interruptions.

Related UC: SUC 1.5.3.

Module: Maintenance manager; Energy metering manager.

Short justification: Through a better monitoring of assets and customers, collecting the necessary data and processing them using the corresponding KPIs, the RESCO is able to quickly and precisely identify any issues within its network of clients, which in turn allows to minimize reaction time in case of faults, minimize down-time at customer and maximize its profits by assuring continuity of supply, together with optimizing its use of maintenance resources.

Service F. Enabling and encouraging stronger and more direct involvement of consumers in their energy usage and management.

28. Sufficient frequency of meter readings.

Related UC: SUC 1.5.3, SUC 1.5.4, SUC 1.5.5, Module: Energy metering manager.

Short justification: Through a better monitoring of the assets, collecting the necessary data in real time and processing them using the corresponding KPIs, the RESCO is able to have an accurate view of the assets' performance regarding the quality of the service and of connected customers. These data also allow the implementation of DR programs, assure continuity of supply and power quality.

29. Remote management of meters.

Related UC: SUC 1.5.5Module: Energy metering manager.

Short justification: (Similar to 28).

30. Consumption/injection data and price signals by different means.

Related UC: SUC 1.5.2, SUC 1.5.3, SUC 1.5.4

Module: Energy metering manager; Billing manager; Market bid manager.

Short justification: Through a better monitoring of the assets, collecting the necessary data in real time and processing them using the corresponding KPIs, the RESCO is able to have an accurate view of the energy balance and assets' performance regarding the quality of the service and of connected customers. These data also allow the implementation of DR programs, assure continuity of supply and power quality.

31. Improve energy usage information.

Related UC: SUC 1.5.2, SUC 1.5.3, SUC 1.5.4, SUC 1.5.5Module: Energy metering manager; Bill manager.

Short justification: Through a better monitoring of the assets, collecting the necessary data in real time and processing them using the corresponding KPIs, the RESCO can have an accurate view of the energy balance and assets' performance regarding the quality of the service and of connected customers. These data also allow the implementation of DR programs, assure continuity of supply and power quality.

32. Improve information on energy sources.

Related UC: SUC 1.5.2, SUC 1.5.4, SUC 1.5.5.

Module: Asset manager; Energy surplus forecasting manager; Maintenance manager.

Short justification: Through a better monitoring of the assets, collecting the necessary data in real time and processing them using the corresponding KPIs, the RESCO is able to have an accurate view of the energy balance and assets' performance regarding the quality of the service and of connected customers. These data also allow the implementation of DR programs, assure continuity of supply and power quality.

33. Availability of individual continuity of supply and voltage quality indicators.

Related UC: SUC 1.5.2, SUC 1.5.3.

Module: Energy metering manager; Asset manager; Maintenance manager.

Short justification: (Similar to 32).

Beneficiaries:

DSO, RESCO, Aggregators, Suppliers, Consumer, Producer, Prosumer, Market operator, Public Authority.

2.3.1.8 WiseEVP

As it has been described in previous Deliverable too, WiseEVP is a tool for Vehicle-sharing companies or EV fleet managers and EVSE infrastructure operators in order to:

- Reduce the EV charging energy bill.
- Follow flexibility requests from DSO to help the electric distribution network operation in exchange for an economic consideration.
- Follow high shares of RES production.
- Manage and control the whole EV fleet.

These main objectives of WiseEVP are supported by the modules of the developed tool as described in 92.1 and the Use Cases (primary and secondary) of D2.1 where WiseEVP is involved wither as a main or auxiliary tool in the WiseGRID ecosystem. Further on, and to facilitate the realization of the initial steps of the Cost Benefit Analysis proposed by JRC, an attempt is made to identify and justify how these are related with some of the proposed services and functionalities.

Service A. Enabling the network to integrate users with new requirements

1. <u>Facilitate connections at all voltages/locations for any kind of devices</u>

Related UC: PUC 1.2 (SUC 1.2.2, SUC 1.2.3, SUC 1.2.4), PUC 3.2 (SUC 3.2.1)

Module: EVSE wrapper.

Short justification: The WiseEVP module, EVSE wrapper, allows the EV charging station integration in the DSO power distribution network, so that the service is accessible for any kind of device.

2. <u>Facilitate the use of the grid for the users at all voltages/locations</u>

Related UC: PUC 1.2 (SUC 1.2.2, SUC 1.2.3)

Modules: EV/Battery wrapper.

Short justification: The existing monitoring systems allow to push the retrieved information to the WG IOP in order to be used by the other WiseEVP modules.

3. <u>Use of network control systems for network purposes</u>.

Related UC: PUC 1.2 (SUC 1.2.2, SUC 1.2.3, SUC 1.2.4), PUC 2.1 (SUC 2.1.4)

Module: EVSE Wrapper

Short justification: WiseEVP architecture contemplates the possibility of EVSE managers controlling EVSEs as extra flexibility sources of the grid.

Service B. Enhancing efficiency in day-to-day grid operation

5. <u>Automated fault identification/grid reconfiguration, reducing outage times</u>.

Related UC: PUC 2.1 (SUC 2.1.4)

Module: Real-Time monitor

Short justification: Real-time monitoring module allows prompt fault identification and any required operation can be rapidly actuated to reduce the outage time.

6. <u>Enhance monitoring and control of power flows and voltages</u>.

Related UC: PUC 2.3 (SUC 2.3.2, SUC 2.3.3, SUC 2.3.4, SUC 2.3.5)

Module: Flexibility forecast

Short justification: By means of a proper flexibility forecaster, offers can be produced according to EV energy availability that may be used by the WiseEVP manager for trading in the ancillary services market; taking into account that whenever a flexibility offer is accepted, an order will be sent back to the WiseEVP to provide the accepted flexibility and, therefore, the EVSE scheduler module will have to react.

7. Enhance monitoring and observability of grids down to low voltage levels.

Related UC: PUC 1.2 (SUC 1.2.2, SUC 1.2.3), PUC 1.3 (SUC 1.3.1, SUC 1.3.2), PUC 2.2 (SUC 2.2.1)

Module: EV/EVSE/Battery wrappers

Short justification: All the wrapper modules considered as unique scanning modules provide a real-time picture of the whole grid down to low voltage levels.

Service C. Ensuring network security, system control and quality of supply

16. Solutions for demand response for system security in the required time.

Related UC: PUC 2.3 (SUC 2.3.2)

Module: Ancillary Services Market Hub

Short justification: This interface defines the interaction between the DSO and the rest of the applications which are in position of providing ancillary services.

Service D. Better planning of future network investments.

17. Better models of Distributed Generation, storage flexible loads, ancillary services.

Related UC: SUC 2.2.1

Module: Flexibility forecast

Short justification: By means of a proper flexibility forecaster, offers can be produced according to EV energy availability that may be used by the WiseEVP manager for trading in the ancillary services market; taking into account that whenever a flexibility offer is accepted, an order will be sent back to the WiseEVP to provide the accepted flexibility and, therefore, the EVSE scheduler module will have to react.

19. Additional information on grid quality and consumption by metering for planning.

Related UC: PUC 1.3 (SUC 1.3.1, SUC 1.3.2), PUC 3.1 (SUC 3.1.1)

Module: EVSE wrapper

Short justification: The existing monitoring systems allow to push the retrieved information to the WG IOP to be used by the other WiseEVP modules.

Service E. Improving market functioning and customer service.

22. Facilitate consumer participation in the electricity market.

Related UC: PUC 3.2 (SUC 3.2.1, SUC 3.2.2, SUC 3.2.3)

Module: Booking Service, EVSE scheduler, Ancillary Services Market Hub

Short justification: The booking module is the main interaction between the users and provided services like e-mobility and optimized RES usage calculated by the EVSE scheduler and linked with the market with the Ancillary Services Market Hub.

23. Open platform (grid infrastructure) for EV recharge purposes.

Related UC: PUC 3.2 (SUC 3.2.2, SUC 3.2.3), PUC 3.3 (SUC 3.3.1, SUC 3.3.5), PUC 3.4 (SUC 3.4.1, SUC 3.4.2)

Module: GUI

Short justification: The GUI is the main interface between the users and provided services like e-mobility and optimized RES usage.

Service F. Enabling and encouraging stronger and more direct involvement of consumers in their energy usage and management.

31. Improve energy usage information.

Related UC: PUC 3.1 (SUC 3.1.1, SUC 3.1.2), PUC 3.3 (SUC 3.3.1, SUC 3.3.2, SUC 3.3.3, SUC 3.3.4, SUC 3.3.5), PUC 3.4 (SUC 3.4.2)

Module: Demand forecast

Short justification: A proficient information collection about the present and past energy usage, as well as the booked charging session, is the basis of a reliable forecast.

32. Improve information on energy sources.

Related UC: PUC 2.2 (SUC 2.2.1), PUC 3.3 (SUC 3.3.2)

Module: Energy mix provider

Short justification: Based on the details of the generation energy sources of the country, the information about the forecast of generation of renewable energy is one of the main inputs to assess the cost of the energy in terms of environmental impact in order to enable optimization for promoting usage of green energy in the charging sessions.

Beneficiaries:

EVSE Operator, EV Fleet Manager, EV User, DSO, Prosumer, Aggregator, VPP Operator

2.3.1.9 WG FastV2G

The main aim of WG FastV2G is the provision of auxiliary services to help the distribution network operation and maximize renewable resources integration, by providing:

- regulation services,
- spinning reserves and
- peak-shaving capacity in order to flatten out the demand curve.

These features are supported by the modules of the developed tool as described in D8.2 and the Use Cases (primary and secondary) where WG FastV2G interacts with the WiseGRID ecosystem.

Service A. Enabling the network to integrate users with new requirements

1. Facilitate connections at all voltages/locations for any kind of devices

Related UC: SUC 3.2.1, SUC 3.2.2, SUC3.3.2

Short justification: The user can interact with the network through an EVSE operator using WG FASTV2G. This tool manages locally a new dynamic load of the grid that will depend on the requirements of the user.

2. Facilitate the use of the grid for the users at all voltages/locations

Related UC: SUC 3.3.2, SUC 3.3.5, PUC3.4

Short justification: The FASTV2G EVSE can be installed and implemented in any location where there is a LV / MV network. Then, the same user could use this tool in any place where a FASTV2G EVSE is operational, and therefore on different nodes of the electrical grid.

Service B. Enhancing efficiency in day-to-day grid operation

10. Frequent information exchange on actual active/reactive generation/ consumption.

Related UC: SUC 3.3.1, SUC 3.3.5, SUC 3.4.1, SUC 3.4.2

Short justification: The EVSE operator manages periodic information exchange between the FASTV2G station and electrical network, to update the status of the connected or booking vehicles, as well as the requirements of the user, knowing the current and the expected consumption.

Service C. Ensuring network security, system control and quality of supply

11. Allow grid users and aggregators to participate in ancillary services market.

Related UC: PUC 3.1 (SUC 3.1.1, SUC 3.1.2), SUC 3.2.1, SUC 3.2.2, SUC 3.4.1, SUC 3.4.2

Short justification: Both users and aggregators can use the operating modes of FASTV2G EVSE and request the energy injection from an available EV into the grid, participating as ancillary services market players.

Service D. Better planning of future network investments.

17. Better models of Distributed Generation, storage flexible loads, ancillary services.

Related UC: SUC 3.3.1, SUC 3.3.5, SUC 3.4.1, SUC 3.4.2

Short justification: The FASTV2G EVSE allows the EVs to operate as an Energy Storage System (ESS). So, EVs can provide support services to a DER system or auxiliary services to the DSO in case of regulation issues or flatten out the demand curve in any moment.

Service E. Improving market functioning and customer service.

23. Open platform (grid infrastructure) for EV recharge purposes.

Related UC: SUC 3.3.1, SUC 3.3.2, SUC 3.3.5

Short justification: EV User interacts with the FASTV2G EVSE in order to authenticate, start a charging session or book an EVSE. The user can be able to select three different types of charging sessions: Charging on user demand, Smart charging or Smart charging with V2G.

24. Improvement to industry systems (for settlement, system balance, scheduling).

Related UC: SUC 3.2.3, SUC 3.3.1, SUC 3.3.5, SUC 3.4.1, SUC 3.4.2

Short justification: One of the main goals and tasks of FastV2G EVSE is to perform dynamic charging, where the EVSE has the option to limit the power supplied to the EV at any moment during the charging process in order to perform energy balancing.

Service F. Enabling and encouraging stronger and more direct involvement of consumers in their energy usage and management.

31. Improve energy usage information.

Related UC: PUC 3.1 (SUC 3.1.1, SUC 3.1.2), SUC 3.3.2

Short justification: The FASTV2G EVSE can collect and record information of the charging performed as well as the V2G operations, reporting to the EVSE Operator and DSO about energy flows associated with their EVSE activities. So, they can use this information to improve the grid services for a better user experience.

Beneficiaries:

DSO, EV fleet manager, EVSE Operator, Prosumers, Consumers, Aggregator, RESCO, EV User.

2.3.2 Summary and target KPIs

Based on the information collected and analysed in the previous section, the project has compiled the table presented in Annex B. WiseGRID products to Smart Grid Functionalities mapping that maps the WiseGRID products/tools/solutions to the Smart Grid functionalities, according to our methodology, as described in [3]. Our initial analysis indicated that WG Cockpit, WG STaaS/VPP and WG RESCO tools exhibit the highest impact. However, all tools present significant impact, to different degrees according to their scope. During the evaluation phase of the project we will assess whether the KPIs for this impact (the numbers presented in the chart) correspond to the final ones based on the implementation and validation of the tools.

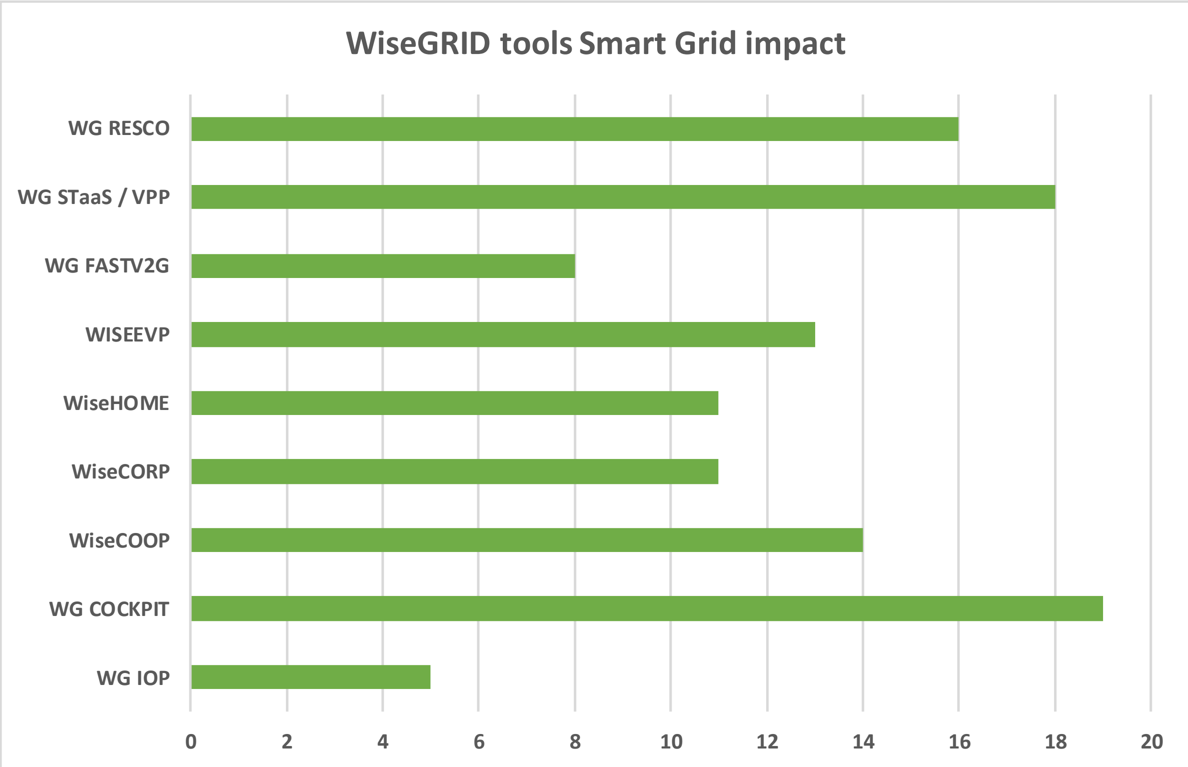

Figure 7 - WiseGRID tools and impact in terms of Smart Grid functionality

2.4 WiseGRID products economic impact

The following metrics are consortiums preliminary calculations, based on the current market status. They will be updated and refined if needed in a later phase and before the final project evaluation to represent the market status at that current point, thus rendering our evaluation KPIs more realistic and accurate. Furthermore, the final target KPIs will consider the development of the tools and the updated business models that might affect these numbers (for example in the case the functionality of a tool has been changed).

2.4.1 WG Cockpit

Expected income 5 years after the project: 26.804.500€

IRR: 15,7%

Payback Period: 36 Months

Assumptions:

The WG Cockpit can be marketed by itself or as Software as a Service. This product is focused on small DSOS and in 2016 were 2278 of these utilities in Europe. The target for the WG Cockpit itself are a 10% of those 2278 small DSOs but it is expected to sell the Software as a Service to the 26%. The revenues will come from yearly licenses and consultancy services.

2.4.2 WG RESCO

Expected income 5 years after the project: 16.695.100€

IRR: 11,77%

Payback Period: 38 Months

Assumptions: Revenues were based on a mix of consultancy services and a yearly fee per kW unit, being the cooperatives (as producers) facility managers and big infrastructures the potential customers. In this context, as reaching cooperatives is the easiest way to introduce the product in the market (thanks to the contacts of the partners and the cooperatives already involved in WiseGRID), it is expected that WG RESCO will reach 50% of the 2397 cooperatives established in 2016. These cooperatives will take the role of a RES-CO.

2.4.3 WG IOP

Expected income 5 years after the project: 27.695.100 €

IRR: 8,41%

Payback Period: 36 Months

Assumptions: The targeted customers for the WG IOP are Smart Cities with less than 500.000 inhabitants that want to create an interconnected energy framework. In addition, WG IOP addresses also renewable energy cooperatives to allow them to offer different kind of interconnected services to their users. There are 676 Smart Cities with less than half million inhabitants and it is expected that WG IOP will reach 50% of them. Moreover, it is expected that WG IOP will reach 25% of the above-mentioned cooperatives. The income will come from monthly licenses.

Moreover, it is clarified that the profitability of the WG IOP tool will not be analysed in the context of a separate BM focusing on the functionalities of this tool, because the WG IOP implicitly participates in each BM (apart from BM2) acting as an intermediate between the involved actors and providing the necessary information exchange for each service realization. To this end, the CBA for this tool will consider that all the involved actors whose business activity depends on the functionality of the WG IOP tool, pay a participation fee on a monthly or yearly basis and provide a portion of their revenues to the manager of the tool. For instance, in the case that the DSO requests an explicit DR event, then all the aggregators who participate in the platform and have access to this kind of information pay the participation fee, but additionally the aggregator who offered the best bid and will actually implement the service may pay part of its compensation to the WG IOP for acting as an intermediate with the DSO. It becomes apparent that the profitability of this tool strongly depends on the profitability of the others, since the CBA may reasonably assume that both of the two aforementioned types of income should not exceed a small portion of the profits achieved by the other actors from their engagement with the WG IOP platform.

2.4.4 WiseCORP

Expected income 5 years after the project: 25.787.474€

IRR: 9.11%

Payback Period: 36 Months

Assumptions: The main target were large facilities and Smart Cities that want to increase energy efficiency in their premises. The Smart Cities targeted were those with a population lower than 100.000 inhabitants and WiseGRID will try to reach 50% of them (that means to reach 135). In case of facilities, it is expected to reach 0,5% of the total market of Greece, Spain and Italy; that implies to reach 23.720 buildings. Revenues will come from license fee payments, and specific consultancy services to deploy and adapt the product.

2.4.5 WiseCOOP

Expected income 5 years after the project: 33.288.711€

IRR: 19,49%

Payback Period: 36 Months

Assumptions: The target of this product are European cooperatives aiming to have better control of their businesses. The objective was to reach 40% of the European cooperatives in Europe (that means 959). Revenues will come from the commercialization of the software and engineering services.

2.4.6 WiseHOME

Expected incomes 5 years after the project: 44.935.714€

IRR: 14,93%

Payback Period: 24 Months

Assumptions: Commercialization opportunities are high as it is expected that 30 million houses in the EU will become Smart Homes by 2019. It is expected that WiseHOME will address 10% of this huge market. The product will be commercialized by a yearly license. It is noteworthy that these are the assumptions at the proposal phase. Now, during the project development, WiseHOME has a front-end app of WiseCOOP so WiseHOME cannot be sold without WiseCOOP.

2.4.7 WiseEVP

Expected income 5 years after the project: 26.687.648

IRR: 14,28%

Payback Period: 36 Months

Assumptions: The platform contains two different control frameworks: one for EV fleet managers and the other for the Charging Manager. It is expected that WiseEVP will provide services to approximately 5000 charging points and 10000 EVs. Revenues will come from yearly license fees.

2.4.8 WG FastV2G

Expected income 5 years after the project: 205.500.000

IRR: 19,31%

Payback Period: 24 Months

Assumptions: The product is addressed to EVSE managers and it is expected to reach 10% of the European charging points market. The revenues will come from selling the WG FastV2G charging station as a standalone product.

2.4.9 WG STaaS/VPP

Expected incomes during 5 years after the project: to be analysed

IRR: to be analysed

Payback Period: to be analysed

Assumptions: The product is mainly addressed to aggregators, VPP and cooperatives with storage infrastructure. Revenues could be based on a mix of consultancy services and a yearly license fee.

It is realistic, in the first 5 years after the project, to think to reach about the 10% of all the European potential customers.

2.5 The WiseGRID baseline scenarios, benefits monetization and beneficiaries

This section covers the step 2 of the CBA and contains the “baseline conditions and KPIs” and “benefits monetization and beneficiaries’ definition, for each one of the BMs described in the Deliverable 1.1. The former consists to the definition of the “Business as Usual” (BaU) state, i.e., the situation of the grid ecosystem in the absence of the tools and technology considered in the context of the WiseGRID project. The BaU state is used as a comparison benchmark for the state of the grid after the implementation of the WiseGRID project. The comparison between the two states reflects the added value provided by the functionalities of the involved tools, which are designed with the objective for the most profitable utilization of the innovative equipment (RES, EVSE, batteries, CHP) and the active participation of the prosumer in the markets. Then, the computation of the benefits is feasible by comparing the costs (for each involved actor) if the grid remains at its current state with the cost savings or revenues gained from its evolution. Thus, for the reader’s convenience and the self-standing property of the document, each of the following sections provides a brief but comprehensive description of the objective of each BM along with the baseline scenario.

Furthermore, the following sections identify for each BM those KPIs documented in Deliverable 2.1, which are of economic interest (measured in euros) and thus may be directly utilized for the computation of the benefits. Additionally, they mention how the KPIs which are designed for the technical performance evaluation of the tools may be combined with data revealing the actor's activity in the market, for jointly computing the economic benefits provided by the tools for all the participating actors. Finally, the analysis identifies those KPIs with technical orientation whose impact is already captured by the economic ones and propose for them to be subjected to the sensitivity analysis (Section 2.8) of the CBA, targeting to measure at which extend an improvement of the tool's performance may affect their economic results. In this sense, the following section do not monetarize the benefits by assigning actual values to them but provide the roadmap for their quantification when the trials will be specified at the pilot sites. Concerning the beneficiaries, they are defined in terms of the actors participating in each BM, while the allocation of the benefits among them depends on the contribution of each individual to the realization of the considered services.

It must be clarified that each BM may include multiple services requested and offered by the involved actors. For instance, section 2.5.6 refers to the BM of the VPP Operator who may offers a variety of services to the DSO such as the DR campaigns for congestion or voltage control. But, the VPP Operator also offers the capability for its members to utilize more profitably their RES by trading their generation in the market. Even though all those services have as a prerequisite the presence of the WG STaaS/VPP tool which orchestrates the activities of the VPP assets, each one of them involves different actors and results to unequal levels of benefits. To this end, in those cases the CBA will be decomposed for each particular service targeting to quantify the added value from each one of them and identify the relevant beneficiaries. Then, the step 7 which computes the added value should take into consideration all the sources of benefits for computing the total revenues for each individual actor.

2.5.1 Archetype BM1: Promoting RES installations via RESCOs

BM1, considers the scenario of a RESCO bearing the installation and management cost of the RES equipment at the prosumer's premises when the occupants of the buildings cannot afford the investment cost or are not willing to be exposed at the investment risk. Three alternatives are considered for the utilization of the RES generation (self-consumption, commercialization or their combination) and the profits sharing between the two participating actors. More particularly, as reported in the Deliverable 12.1:

- -S1 - In the first scenario, the RESCO pays a fee to its customers for being allowed to use their premises (e.g. for installing PVs on their roof), to install and maintain the RES assets, and to trades with all the produced energy.
- -S2 - In the second scenario, the RESCO provides to customers the supply of energy coming from RES owned by the RESCO (i.e. allowing its customers to self-consume the produced energy) and trades with the production surplus. Customers under this contractual relationship should pay a fee to the RESCO to cover the provided energy – at prices lower than the ones of the retail market – and the maintenance of the equipment.
- -S3 - In the third scenario, the RESCO provides to customers the installation of RES equipment (e.g. PV panels and batteries) which are still owned and maintained by the RESCO but fully exploited by the end customers. This third scenario describes basically a RES renting business model.

The RESCO is based on the functionalities of two tools that will be developed in the context of the WiseGRID project for making its business decisions. More specifically, the WG RESCO tool defines the most suitable places for the RES installation (in terms of the generation maximization), forecasts their generation and provides monitoring and control capabilities of the installed equipment. The WiseCOOP tool is utilized for the most profitable utilization of the RES generation, combining various sources of information such as the wholesale market prices, the forecast of the RES generation and the occupants' consumption and the state of the grid. For instance, if the RESCO forecast a generation level that is higher compared to the maximum value that may be injected in the grid (according to the contractual agreement with the DSO), then it may request from its clients to temporarily increase their consumption and avoid the RES curtailment. For clarity reasons, it is mentioned that the aforementioned requests may refer to the occupants of the same building (as the one that the RES are installed) or in wider geographical terms, i.e., to consumers who are served by the same feeder or transformer. Similarly, in periods of high wholesale prices, the RESCO may request from its clients to reduce the local consumption (from the RES) below them between agreed level and gain higher revenues from selling it in the wholesale market. Such dynamic synergies may be stimulated by means of economic incentives offered from the RESCO. In the former case the RESCO may sell the energy to its clients at a price lower than the ordinary one (and much lower compared to the retail price), while in the latter it may offer to them a portion of its increased revenues in the wholesale market as a compensation for efficiently shifting or shedding their needs for the RES local consumption. Notice that the synergies between the participating actors are only feasible in the case of the second type of contract, as described above. Thus, the objective of the CBA is not only to investigate the added value of the tools compared to their incumbent competitors, but also to determine the most profitable type of contract to be adopted by the RESCO, depending on the correspondence of its clients to the requests for their consumption rescheduling.

In this context, the BaU scenario considers a RESCO which lacks the sophistication of the two tools involved. The CBA will be mainly based on KPI 26 (“Energy generation capability per investment”), targeting to estimate at which extend the functionalities of the WG RESCO tool (for choosing the most suitable areas for the RES installation) may increase the RES generation and compare the measurements with market data about the relevant average values in the range of each particular pilot-site or (if not available in that detail) in the European Union. Following the same rationale, KPI 1 (“Increase RES and DER hosting capacity”) is of great economic interest also, since it measures the additional RES generation that may be hosted by the grid assuming the same structure and capacity, i.e., it reveals at which extend the RESCO may grow its business without requiring grid reinforcements. The aforementioned findings will be combined with market data about the price of energy in the wholesale market for computing the potential additional revenues for the RESCO. KPI 8 (“Voltage variation”), even though technical, may be utilized for validating that the RESCO follows the DSO’s requirements for maintaining nominal values of the voltage and avoid the relevant penalty (or pay it in the opposite case). Similarly, the KPI 46 (“Self-consumption ratio”) measures if the RESCO meets its obligations towards the occupants for providing local consumption from the RES generation (according to the second scenario, as mentioned above), or otherwise pay the relevant penalty according to their between contractual agreement. Concerning KPI 2 (“RES curtailment”), it may be used for quantifying the avoidance of curtailment that may be achieved by the dynamic synergies between the RESCO and its clients and determine that type of contract to be chosen by the RESCO. In the opposite case, the RESCO has not any economic incentive to invest in the necessary communication channels (for the propagation and the implementation of the DR) and consequently will choose one of the two other types of contracts depending on the comparison between the fee it has to pay in the first case and the one that it receives in the third. Finally, KPI 27 (“Network RES visibility”) is of technical interest, and its economic impact is captured by KPI 2. This is because it refers to the capability of the DSO to have real time information about the RES generation and consequently to inform timely about an upcoming RES curtailment, such that the RESCO may efficiently react for its avoidance as explained above.

For completeness reasons, it is mentioned that the BM involves also the WiseHOME and WiseCORP tools that manage the consumption of the residential and tertiary prosumers respectively. For instance, if part of the prosumers’ elastic loads do not coincide with the RES generation, then the tools suggest their rescheduling such that the prosumers may be favored from the lower prices offered by the RESCO for the consumption of the local generation. Such suggestions may also be provided, targeting to meet the shifting requirements propagated by the RESCO as extensively explained above. The BM considers two cases for the management of these tools. In the former, an ESCO is responsible for their operation and receives as payment a portion of the prosumer’s cost savings due to the reduced electricity bill or a portion of the compensation offered by the RESCO for the prosumer's contribution in the more profitable utilization of the RES generation (in the wholesale market rather than from local consumption). In the latter, these tools are provided by the RESCO to the prosumers, targeting to simulate their efficient consumption scheduling the most profitable commercialization of the RES production. Thus, depending on the considered case the potential revenues of each actor must be compared with the development and maintenance costs of the tools that this specific actor operates, resulting to the computation of the payback period required for the amortization of relevant costs and the return of investment.

2.5.2 Archetype BM2: Efficient monitoring and management of the distribution grid

BM2 focuses on the advanced capabilities provided by the WG Cockpit tool to the DSO, for the efficient monitoring and management of the grid under his responsibility. The WG Cockpit tool consists by various algorithms for the data collection and elaboration that jointly compose its functionality. Thus, the CBA in this case may be decomposed targeting to identify the added valued provided by each of the components and in the sequel to compute the cumulative benefits for the DSO, in terms of cost savings for meeting its obligations. The reasoning of this approach is because not all the algorithms contribute to the realization of the same service, and additionally some of them may be difficult to be demonstrated and evaluated over a real network at the pilot sites. Consequently, the CBA will be based both on actual measurements and on results from theoretical analysis and simulated experiments (when the collection of the former is not feasible) for evaluating the performance of the WG Cockpit tool and conclude at which extend it outperforms the BaU case, i.e., the incumbent solutions that are currently adopted in the market.

More specifically, the DSO is responsible for placing sensors at specific locations of the grid for performing in real time the observability of its operational conditions. The algorithm related with the observability analysis may determine the most suitable locations for the installation of the monitoring devices, such that the minimum number of measurements are required for a reliable estimation of the grid state. The CBA will utilize the KPI 21 ("Measurements redundancy") for its performance evaluation, for computing the ratio of the redundant measurements required over the critical ones and conclude to its economic impact in terms of the reduced cost needed for the installation and maintenance of the corresponding equipment. The collected data from the sensors, are provided as input to the "state estimator" algorithm which estimates the state of the grid, i.e., if it operates under its normal conditions or if an emergency has occurred. Its evaluation will be based on KPI 10 ("State estimator performance evaluation") which measures the error ratio between the estimated and the actual conditions. Notice that the accurate estimation of the grid state is of critical importance for various corrective actions that must be performed from the DSO which are related with cost savings. For instance, the DSO may identify an upcoming or already occurring grid outage and react by reconfiguring in real time the network topology (e.g., by changing the state of sectionalizing switches), targeting to prevent it or limit the region that it affects (related with the KPIs 3-7). Thus, the CBA will combine the performance metric of the algorithm with market data about the recompense that the DSO must pay to the consumers in the case of an outage (due to the inconvenience caused and the decline of their economic activity that strongly depends on the uninterrupted supply of electricity) for computing the cost savings.

Further parameters that characterize the performance of the "state estimation" algorithm are of economic interest, especially those related with services that require a particularly prompt reaction, such as the frequency and voltage control. To this end, the KPI 22 ("State estimation convergence") and KPI 20 ("System awareness total time latency") may be utilized for measuring the time needed for the state estimation. In this way, the CBA will quantify the portion of the emergency cases whose timely identification allowed the DSO to successfully overcome them before their impact affected the normal operation of the grid or compute the cost savings due to the decreased duration of such events if their economic impact depends on the time that they last.

Additionally, the DSO has the obligation to maintain in balance the generation and consumption at the grid under its responsibility. Notice that a balanced grid is related with multiple sources of cost savings, such as the avoidance of bidirectional reverse power flows with the TSO and the RES curtailment (KPI 2). In this context, the CBA will be based on KPI 18 ("Load forecasting accuracy") for measuring at which extend the improved forecasting functionality of the WG Cockpit tool (compared to its competitors) may decrease the frequency and magnitude of any possible imbalances. These findings will be combined with market data about the penalty that the DSO has to pay in any of the cases mentioned above (to the TSO and the RES generators respectively) for computing the relevant cost savings. For clarity reasons it is mentioned that the impact of KPI 27 ("Network RES visibility") is captured by the KPI 18, since the real time monitoring of a greater percentage of the connected RES, contributes to the more accurate estimation of the injected loads. It must be emphasized that the computation of the cost savings is strongly correlated with the CBA of the tools involved in services that are requested by the DSO (and presented in the sections that follow). Indeed, for instance the cost savings from the reduced RES curtailment determine the maximum compensation that the DSO may offer to other actors (e.g., EV fleet Operator, VPP Operator) for the provision of an explicit DR event such that the same amount of curtailment is avoided. In other words, the level of the cost savings is equal with the maximum monetary amount that may be allocated to all the participating actors of a DR event, who contribute for the realization of the service. For clarity reasons it is mentioned once again that the CBA in this section focuses on the reduced need for such services due to the performance of the WG Cockpit, but still a level of imbalance is expected to occur that will be dealt by means of the DR events implementation. Alternatively (as to be mentioned in the following sections), the CBA will be based on the available market data for deriving the level of compensation offered by the DSO for the provision of the services.

Furthermore, the "asset management" algorithm of the WG Cockpit tool, informs the DSO about malfunctioning equipment such that to be repaired or the proactive replaced. The CBA will utilize the KPI 25 ("Technical losses") for the performance evaluation of the algorithm, targeting to quantifying the energy losses (due to technical reasons) that may be prevented, and the relevant cost savings due to lower amount of monetary recompense that the DSO must pay to the corresponding generators.

Finally, the KPI 44 ("Peak to average ratio") and KPI 43 ("Peak load") are of great economic interest for the DSO since they determine the utilization factor of the grid capacity and the saturation of the distribution lines respectively. Notice that a peak load relatively close to the grid capacity implies the need for grid reinforcement, while a low peak-to-average ratio means that the investment may be avoided by means of efficient DR events which shift part of the demand during the off-peak hours. Thus, those metrics will be utilized for computing the benefits achieved for the DSO in terms of cost savings from the avoidance of the investments related with new distribution lines, targeting to meet the increasing demand of its clients.

2.5.3 Archetype BM3: Exploiting the integration of EVs in the grid

BM3 focuses on the electrification of the transportation sector that arises due to the penetration of EVs in the market, and the advanced capabilities of their owners to utilize their inherent storage capacity. In the core of the BM is the WiseEVP tool (managed by the EV fleet manager) which is designed to schedule the EVs' smart charging, targeting to avoid periods of high prices or offer to other actors (e.g., the DSO) flexibility and ancillary services (DR events and voltage control respectively). In this way, the tool achieves not only to reduce the charging cost but also to create a further source of revenues and consequently offer to their owners a competitive advantage compared to the conventional (fossil fuel) counterparts. For completeness reasons it is mentioned that the WiseEVP takes into consideration the technical limitations of the EVs (e.g., maximum charging rate) and the convenience limitation of the relative drivers such as the required charging level of the battery until a specific time.

In this context, the BaU scenario for the EV fleet manager should consider the charging cost in the absence of the sophisticated scheduling algorithm of the EVP tool, which is designed to meet the objective of the charging cost minimization. In this case, the EV fleet manager would be unable to optimally react to high levels of prices (due to dynamic pricing schemes) that may arise during the charging session, while guaranteeing the satisfaction of the drivers' preferences and constraints. Furthermore, the EV fleet manager would lack the means for the efficient participation in explicit DR events (G2V and V2G) or ancillary services which are initiated by the DSO, while meeting the aforementioned constraints. In this case, the EV fleet manager would lose the compensation offered by the DSO for either temporarily reducing the consumption (G2V - by adapting the charging rate) or injecting electricity back to the grid (V2G), and consequently has no opportunity to reduce the charging cost. The analysis of the scenarios should make pilot-site-specific assumptions on the charging patterns of the EVs and the time within the day that the dynamic prices or the DSO-initiated DR events are realized. For instance, if the investigated scenario considers an EV fleet manager who is responsible for the charging process of the vehicle at a companies' premises, then the planning horizon of the cost minimization algorithm should be the time interval including the working hours of the weekdays. The analysis could also utilize historical data that should reveal the necessity and frequency of DR events and the level of the prices during the planning horizon of the EV fleet manager.

For the objectives of the CBA, the WiseEVP tool will be mainly evaluated with respect to the KPIs 18 ("Load forecasting accuracy") and 13, 14 ("Increase EV demand flexibility availability and execution respectively) since they jointly estimate the magnitude of DR that may be offered to the DSO and the accuracy of the aforementioned estimation. Recall that if the EV fleet manager fail to satisfy the DSO's requirement about the adjustment of the EVs' consumption during the specified time frame, then he will have to pay a penalty, meaning that the accuracy is of the flexibility capabilities is of economic importance. Additionally, KPI 48 ("Energy Cost") measures the achieved reduction of the charging cost from the efficient reaction to the dynamic prices. Furthermore, the KPI 36 ("Success in meeting the user charging objectives") is of economic interest because it is correlated with the compensation that the EV fleet manager is obligated to offer in the case that the users' charging constraints are violated. Finally, KPI 28 ("GHG emissions") is of great importance since many users are incentivized to offer their flexibility driven by their environmental sensitivity and consequently it may affect the DR capabilities of the EV fleet manager.

For completeness reasons it is mentioned that the KPIs 24, 32-35 and 37 are of technical interest and their economic impact is captured by the KPIs 13 and 14. More specifically, the KPIs refer to the reliability of the communication channels between the EVSE and the WiseEVP and consequently affect the available demand flexibility (KPI 13) and the capability for its execution (KPI 14). Indeed, even though the drivers may agree to offer their EVs for the realization of a DR event, an insufficient technical performance may prevent their flexibility from being correctly communicated and elaborated by the WiseEVP. Still, these parameters will be investigated in the context of the sensitivity analysis, in the sense that an improved technological performance of the tools will increase the available flexibility and consequently the revenues of the involved actors. Finally, KPI 15 ("Active participation in EV demand flexibility") is of social interest, since it measures the acceptance rate of the service between the investigated users and its economic impact will be considered in the sensitivity analysis following the same rationale as described for the two technical KPIs above.

Regarding the other actors participating in the BM, the BaU scenario for the EVSE Operator will consider lack of communication channels with the DSO that allows the former actor to inform the EV fleet manager about the required DR events and the absence of the charging equipment with the advanced capabilities (WG FastV2G), that make feasible the injection of electricity from the batteries back to the grid. In this case, the EVSE Operator would lose part of the compensation offered by the DSO that would result to the faster amortization of the installation costs, even in the case that the EVSE Operator bears part of the installation cost and the rest is subsidized by the DSO as will be mentioned below.

Concerning the DSO, the BaU scenario will consider the incurred cost in the case that the required DR events are not implemented. As already mentioned in the section related with the BM2, the DR events may be beneficial for the DSO under various conditions, including the avoidance of reverse power flows, the penalty from the curtailment of RES generation and the necessity of capacity expansion at the distribution grid. The quantification of those cost savings is the factor that should determine the decision of the DSO on whether and at which level to subsidize the installation cost of the WG FastV2G equipment.

2.5.4 Archetype BM4: Prosumers driven energy storage integration

BM4 focuses on the integration of energy storage systems at the prosumers' premises and investigates the added value to be gained mainly from the prosumers by their participation in services that utilize the capabilities of the batteries. The analysis clusters the benefits depending on the level that the relevant service is implemented. More specifically, at the local level a prosumer who has installed the storage system has advanced flexibility capabilities and may react more efficiently to the dynamic pricing schemes propagated by the retailer, while remaining within his comfort zone. This is feasible by charging the batteries during periods of low retail prices and then cover his electricity needs (even partially) by the batteries during the implicit DR event (high level of prices). In this way, the prosumer avoids consuming his inelastic loads from the grid and consequently achieves to both reduce the electricity bill and satisfy his convenience constraints. In the same manner, the prosumer may reduce his consumption during the periods that the grid is congested and avoid the relatively high grid charges. Additionally, such a prosumer may utilize more profitably the RES installed at his premises, by deciding whether to store his local generation for covering his own future needs or to inject it in the grid and gain the relevant payment. Further revenues may be gained at the aggregation level, i.e., by the participation of the prosumers in the VPP. For instance, the prosumer may offer (collectively with others) to the DSO services such as the frequency-control, the reactive power and voltage control, and peak shaving for grid congestion management.

The scheduling of the batteries' is performed by the ESCO by means of the tools that manage the assets of the prosumers at the local level, i.e., the WiseHOME and the WiseCORP for the domestic and the tertiary buildings respectively. These tools take into consideration the prosumers' convenience preferences and decide the optimal set-point of the batteries (charging or discharging, from the grid or from the RES), having the objective to maximize the cost savings and the compensation provided by the VPP Operator. For clarity reasons, it is mentioned that the potential added value from the prosumer's participation in the VPP is investigated in the context of BM6. Despite this fact, the rest of this section describes the services that strongly depend on the existence of batteries for their realization and correlates their performance evaluation with the relevant success measuring KPIs. This documentation is followed due to consistency reasons with the Deliverable 2.1, where the HLUC4 includes all the batteries-related services both at the local and aggregation level. In this manner, the two sections contribute complementarily for the compilation of the CBA for the energy-storage capable prosumers and for VPP Operator who manages the STaaS/VPP tool.

In this context, the BaU scenario will consider prosumers without storage capabilities. Targeting to quantify the potential added value at the local level, the analysis needs to quantify the inelastic loads of these prosumers, i.e., the magnitude of their consumption that cannot be shifted or shed despite the propagation of dynamic prices. To this end, the analysis may utilize the results from the trials in the context of BM7 (implicit DR) that reveal the limitations of the prosumer's flexibility. These measurements will be combined with market data (or with reasonable assumptions) for the frequency of the implicit DR events and the level of prices propagated during them, compared to the flat fees. Additionally, the analysis will be based on the technical specification of the storage and RES equipment under investigation, for computing the portion of the inelastic loads that may be covered locally (KPI 46: "Self-consumption ratio" and KPI 47: "Self-sufficiency"), resulting to the estimation of the expected cost savings (KPI 48: "Energy Cost"). Concerning grid charges, the relevant measurements are strongly related with the KPI 43 ("Peak load"), and their avoidance depends on the contribution of the storage systems to the peak load reduction. It must be mentioned that the small-scale trials in the context of the WiseGRID project (compared to the whole population of the pilot-site area) are not expected to have a noteworthy impact on this metric. Still, useful conclusions may be derived by comparing the consumption patterns of the participating prosumers only, before and after the installation of the batteries and projecting these results for the estimation of the collective behavior of a much larger population (whose aggregate consumption is comparable to the grid capacity).

Concerning the services requested by the DSO and provided at the aggregation level by energy-storage capable prosumers, the CBA will be based on market data (or will make reasonable assumptions depending on the current state of the grid) for computing the frequency of their occurrence and the relevant compensation offered. These data will be combined with the success rate of the VPP, in terms of meeting the DSO's requirements for the requested services. To this end, KPI 8 ("Voltage variation") and KPI 9 ("frequency deviation") should be used as success metrics since they characterize the state of the grid, compared to the nominal values, before and after the relevant service is realized. Indeed, if the deviations still appear after the implementation of the relevant service, then the VPP must pay the agreed penalty to the DSO, while its members gain the compensation in the opposite case. Additionally, KPI 17 ("Ancillary services cost") is of economic interest since it quantifies the prosumers' cost for providing the aforementioned ancillary services and should be compared with the portion of the compensation (provided by the DSO) that is allocated to each participating VPP member for computing the individual revenues. Finally, the KPIs 39 ("Battery balance") and 40 ("Reaction time improvement for providing primary control reserves") are of technical interest since they measure the performance improvements of the STaaS/VPP tool compared to the incumbent competitive products. Still, the CBA should take into consideration their evaluation measurements for estimating the portion of the requested services in the wholesale market that will be actually offered by the VPP. For instance, if the STaaS/ VPP tool has the faster response time compared to all its competitors (for offering a service request initiated by the DSO), then the CBA may reasonably assume that the VPP will commercialize all the capabilities of its assets and only the remaining needs for such services will be covered by the other participants in the market. Following the same rationale, if the algorithm of the STaaS/VPP tool that determines the subset of assets for contributing in each service succeed in selecting the least costly of them (KPI 39 – depending on their ageing), then the VPP Operator will be able to make lower bids compared to its competitors and gain a greater portion of the market.

Concerning the sharing of the potential revenues between the participating actors, recall that the BM considers the VPP Operator keeping a portion of the compensation offered by the DSO for acting as an intermediary between the prosumers and the wholesale markets and allocates the rest to its members according to their contribution in each service realization. In the same way, the ESCO that manages the prosumers' assets at the local level for meeting their own needs and their obligations from the VPP participation, keeps a portion of the energy bill savings and the offered compensation respectively. Consequently, the computation of the anticipated revenues and the values of the aforementioned portions (based e.g., on the contractual agreement between the actors) will determine the payback period and return of investment for the participating tools and technology.

2.5.5 Archetype BM5: Exploiting co-generation in domestic and tertiary buildings

BM5 focuses on the Combined Heat and Power (CHP) technology and the potential benefits that may arise mainly for the end users from the installation of the relevant equipment within their premises. As described for the BM4, the benefits may be realized at the local level, meaning that the prosumer uses the generation capabilities of the CHP for covering only his own needs and injecting the surplus in the grid for receiving the feed-in tariffs. More particularly, such a prosumer can be favored by the difference between the gas and the electricity retail prices and reduce his energy bills. This advantage becomes more intense in the case of dynamic electricity pricing schemes, since he may react more efficiently by switching to gas consumption during the periods of high prices for meeting his thermal and electricity needs while remaining within his comfort zone. Additional revenues may be achieved at the aggregation level, i.e., if the prosumer under interest participate as a member in the VPP. In this case, the prosumer may also participate in explicit DR events utilizing the advanced flexibility capabilities (provided by the CHP generation) and even inject power in the grid when requested, achieving higher revenues compared to the feed-in tariffs. The management of the CHP equipment is performed by an ESCO by means of the WiseCORP tool (the WiseHOME tool is not mentioned here because the scenario considers that the CHP is suitable for tertiary buildings only, for instance buildings of the public sector such as hospitals, due to the heavy loads that this technology may generate). The ESCO, computes the optimal schedules of the CHP operation (generation, self-consumption, grid injection) with the objective of the revenues or cost savings maximization, such that the convenience constraints of the occupants are satisfied.

In this context, the BaU scenario will consider consumers who have not installed the CHP equipment and consequently covers their energy needs by the electricity grid alone. The analysis will compute the electricity cost according to the consumption patterns of the end users participating in the pilot sites and investigate the potential economic savings (and earnings) from the CHP technology. For the aforementioned computations, the analysis will be based on the technical specification about the efficiency of the CHP technology, targeting to estimate the portion of energy needs (electricity and thermal) that may be covered by the CHP equipment and the potential surplus that may be injected in the grid. This process will be combined with available pilot-site-specific market data concerning the ratio between the gas and electricity retail prices and the level of the feed-in tariffs, resulting to the quantification of the expected benefits. These measurements will be based on KPI 49 (“Energy Savings in KWhs”) and the relevant KPI 48 (“Energy Cost”), since they correspond to the achieved reduced consumption from the electricity grid and the consequent reduction of the electricity bill.

The analysis will be extended aiming to investigate the impact of DR events (either implicit or explicit) on the consumer’s decision for the profitability of the CHP equipment. At this phase, the analysis of the BaU scenario targets to estimate the portion of the loads that are inelastic and cannot be shifted/shed without violating the consumer’s convenience constraints. To this end, the analysis may utilize the results from the trials in the context of BMs 6 and 7, which consider the explicit and implicit DR events respectively and will reveal the limitations of the prosumer’s shifting/shedding capabilities. These loads may be covered by the CHP equipment, meaning that such a consumer may participate more actively in DR events and thus attain a further source of revenues. Here also, the findings must be combined with market data about the frequency of DR events, the compensation provided for the participation in explicit DR and the level of the dynamic prices during the implicit DR events, for computing the (additional compared to the BaU case) expected revenues and savings respectively. The KPI 19 (“Support the distribution grid using co-generation”) and 52 (“Optimal use of thermal resources”) are relevant with the computations, since they include the costs for providing the relevant services and the potential revenues that may be achieved. Finally, KPI 51 (“Comfort Level”) is of great importance for the ESCO, since it is related with the satisfaction of the prosumers’ convenience preferences and the relevant penalties that the company may pay (depending on the contractual agreement) in the case that the occupants’ comfort level is not met.

Recall that the income of the ESCO for providing its services, is a portion of the prosumers’ savings achieved by the reduced energy bills and the revenues from their participation in the VPP. Thus, the economic findings will be utilized for determining the return of investment and the time interval needed for the amortization of the CHP installation cost and the development cost of the WiseCORP tool. Additionally, the CBA will further utilize the estimation of the benefits for investigating the economic margins of the gas DSO or retailers to subsidize the cost of the equipment, targeting to stimulate the switch (partially) from electricity to gas and consequently increase their profits. The same findings may also be utilized by the aggregator / VPP Operator (in the case of explicit DR) for deciding if it is beneficial to include a consumer with CHP capabilities to the VPP assets. The aggregator must compare his additional revenues due to the advanced shifting capabilities provided by such a prosumer, with the communication and automation costs required for the management of the equipment. This decision process (for all the assets that may participate in the VPP) is analytically described in the context of BM6 but is also mentioned here for consistency reasons with the description of the BM5 in Deliverable 1.1.

2.5.6 Archetype BM6: Exploiting the VPP assets

BM6, investigates the potential added value that may be gained by the prosumers from their participation in the Virtual Power Plant (VPP). The VPP integrates various resources (distributed energy generators, storage units, consumption flexibility) and pools their capabilities, targeting to bid for the provision of services in the wholesale markets. In this way it provides to its members the opportunity to utilize their assets more profitably and gain an additional source of revenues. More particularly, the prosumers may sell their energy surplus, participate in explicit (reward-driven) DR events and contribute to the provision of ancillary services such as the frequency and voltage control. Notice that the limited capabilities of each individual prosumer are restrictive for his participation in the market if they act alone. The actor who manages the VPP is the VPP Operator by means of the WG STaaS/VPP tool that will be implemented in the context of the WiseGRID project. The VPP operator acts as an intermediary between the prosumers and the wholesale markets and orchestrates the functionality of its assets for the provision of the requested services. Having the objective to maximize the revenues of its members, the VPP Operator decides the optimal set of assets for participating in the realization of each service and communicates the requirements to the corresponding members (prosumers). The aforementioned communication is feasible by means of the synergies between the WG STaaS/VPP and the tool that manage the VPP assets at the local level, i.e., the WiseCORP at the tertiary buildings. The functionality of the latter tool is managed by the ESCO which decides the suitable reschedule of each asset functionality, targeting to meet the VPP Operator's requirements, while not violating the prosumers' convenience constraints.

In this context, the CBA will consider a set of prosumers participating or not in the VPP, considering in both cases the same set of available resources, where the BaU scenario corresponds to the latter case, i.e., prosumers that do not participate in the VPP meaning that they utilize their assets only locally. The process to be followed, will estimate the potential additional revenues from all the services that the prosumers may contribute for their realization. Concerning the injection of electricity in the grid, the analysis will elaborate pilot-site-specific market data targeting to compute the additional income to be derived from the energy prices in the wholesale market, compared to the predefined feed-in tariffs. For the explicit DR events and the ancillary services (e.g., the frequency and voltage control), the analysis will collect data for quantifying the frequency and magnitude of such service and the compensation offered in the wholesale markets from other actors (e.g., the DSO, retailers) who request them. In the analysis framework, critical role has the performance of the STaaS/ VPP tool, concerning its efficiency to optimally assign the relevant tasks to its members with the objective to simultaneously offer the most profitable combination of services that maximize the revenues. This assignment should take into consideration the technical specifications and the security operational limitations of the devises as long as the convenience preferences and constraints of the occupants. To this end, the CBA will be mainly based on KPI 12 ("VPP participation in flexibility requests) and KPI 30 ("VPP participation in voltage control requests"), aiming to quantify the portion of the requested (by the DSO) services that may be offered by the VPP. The combination of these measurements with the market data concerning the frequency that such services are requested and the offered compensation (or bid made by the VPP Operator) will result to the estimation of the anticipated revenues.

Additionally, KPI 29 ("Flexibility forecasting accuracy") is of great economic interest since it is explicitly related with economic losses (penalties to the DSO) in the case that the VPP Operator agree to offer higher levels of flexibility than the actual capabilities of its assets or reduction of revenues in the opposite case (make a lower offer or even not bid for the service although its assets can provide it). For the former case (penalties), the CBA must determine who from the involved actors is responsible for any possible inaccuracy of the flexibility forecasting and consequently is obligated from the contractual agreement to pay the penalty. It is reasonable to consider that in the case of direct load control the VPP operator is the responsible actor, since the possible inaccuracy is a result of its own misestimations (and not the deviation of the prosumers from the expected shifting behavior). In the opposite case, that the VPP Operator provides a compensation to the prosumers for rescheduling their consumption patterns, then the penalty charges should be paid either by the ESCO if its recommendations did not achieve to meet the Operator's requirements or the prosumer if he decided not to follow the reaction proposed by the ESCO. Additionally, KPI 24 ("Asset data collection reliability") is related with the technical performance evaluation of the VPP and its economic impact is reflected on the KPIs. Indeed, the data of poor reliability or not timely collected will have a severe impact on the Operator's decisions concerning the type and magnitude of services that may be offered, leading to revenues losses. As proposed for the other BMs, the measures of the technical KPIs will be considered in the sensitivity analysis, targeting to investigate at what extend the improvement of the technical performance of the WiseGRID tools may affect their economic results. Finally, KPI 16 ("Improve competitiveness the electricity market) is of socio-economic interest, as it is a metric for the market share among the participants. It is expected that the sophisticated functionalities of the WG STaaS/VPP tool that provide to the prosumers the opportunity to be engaged in the wholesale markets will have a positive impact on this KPI by increasing the competitions and consequently the quality of the offered services.

As already analytically described in Deliverable 1.1, the VPP Operator keeps a portion of the monetary amount paid by the third actors who request the services (e.g., the DSO for the DR, retailers for purchasing energy) for performing his role as an intermediary between the prosumers and the wholesale markets. The remaining amount is allocated to the VPP members according to their contribution for each service realization (the distributed generators for selling energy, the members that shifted/curtailed their load for achieving the requirements of an explicit DR event, the owners of the batteries for the frequency control, etc.). Furthermore, a portion of the amount offered to each member (prosumer) is the revenues of the ESCO for providing the optimal suggestions at the local level, such that the service is efficiently implemented without affecting the convenience levels of the occupants. Consequently, the expected revenues of the VPP and the portions that define the allocation of its revenues between the participating actors will be utilized to compute the payback period required for the amortization of the development, maintenance and operational costs of the tools and the return of investment for the involved actors.

2.5.7 Archetype BM7: Supply-demand balancing by means of implicit DR events

BM7, focuses on the added value created both for the retailer and the prosumers when they jointly perform successfully an implicit (price based) DR event, by means of the synergies between the WiseCOOP and the WiseHOME / WiseCORP tools respectively. More specifically, if the retailer foresees any imbalance between the reserved energy in the day-ahead market (adding also the production of the generators that it manages, if any) and its prediction about the consumption of its clientele, then the WiseCOOP tool computes the level of the dynamic prices to be announced such that the collective reaction of the consumers results to the anticipated level of demand. Additionally, the retailer may be informed from the DSO about a period of severe congestion and may initiate the implicit DR event aiming to protect its clientele from the high distribution charges. At the consumers' premises, the WiseHOME/ WiseCORP tools receive the time-vector of the dynamic prices and provide the optimal suggestions for consumption rescheduling such that to minimize the electricity bill while satisfying their convenience preferences. From the retailer's perspective the DR event is beneficial because he avoids purchasing the additional energy in the particularly expensive intra-day market in the case of a negative imbalance (the demand is higher than the reserved energy), while he avoids paying the imbalance penalty to the TSO in the opposite case. For the consumers, their participation in implicit DR events is incentivized by accepting more favourable contracts provided by the retailer. Indeed, the flat charges of a mixed contract including both flat fees and dynamic prices (for just a few periods within a year), are lower compared to a contract that includes only flat fees. Furthermore, they may avoid the high grid charges, as mentioned above.

In this context, the BaU scenario considers the case of a retailer who lacks the means to perform the implicit DR events and consequently bears the cost of the imbalances (either the intra-day cost or the penalties). Targeting to quantify the potential benefits for the participating actors, the analysis will be based on historical data (or reasonable assumptions subjective to the sensitivity analysis), aiming to quantify both the magnitude of the imbalance and the frequency of its occurrence. These data will be combined with the available pilot-site-specific market records, concerning the difference between the day-ahead and the intra-day wholesale prices and the level of penalties, resulting to the estimation of the savings that may be achieved. A parameter of importance that should be taken into consideration, is the clearing price of the market and the way that the DR event will affect it. More specifically, the clearing price is determined by the most expensive resource that contributes to the energy mix, meaning that the DR event may affect not only the volume of energy to be purchased in the intra-day market but also its price (if the load curtailment /shifting is enough to prevent the necessity for the expensive resources generation).

From the retailer's perspective the economic evaluation of the WiseCOOP tool will be performed with respect to KPI 31 (Supplier portfolio imbalance"), as it quantifies the magnitude of the imbalance (expected to be lower than the one in the BaU case) after the implementation of the DR event. At the prosumers' side, the analysis will be based on the KPIs 48 ("Energy Cost") and 49 (Energy Savings"), as they measure the performance of the WiseHOME and WiseCORP tools with respect to the electricity bill savings. Concerning the avoidance of high grid charges, KPI 50 ("Flexibility on offer") measures the potential consumption shifting/shedding of the prosumers and the KPIs 43 ("Peak load") and 44 ("Peak to average ratio") refer to the impact of such actions on the distribution grid. It has to be mentioned that the limited scale of the implicit DR implementation at the pilot sites (in terms of the participating prosumers and compared to the much higher number of prosumers in the whole area), is not expected to have a noteworthy impact on the two latter KPIs at the grid level. Still, the analysis may conclude to useful results by comparing the behaviour of the involved prosumers only, before (BaU) and after the DR realization. These findings will be utilized to make reasonable projections when the propagation of the dynamic prices will be scaled-up to a larger population (whose consumption is not marginal compared to the grid capacity) and will be combined with the function (market data) that returns the network charges with respect to the level of congestion, resulting to the estimation of the potential savings.

In this BM also, KPI 28 ("GHG emissions") is of great interest since many users accept their exposure to dynamic pricing schemes not only for anticipating economic benefits but also for contributing to the achievement of the environmental targets. The KPIs 41 ("penetration of Dynamic Energy tariffs") and 42 ("Demand Response Campaign Penetration") are of social interest since they reveal the acceptance rate of the dynamic pricing schemes and their economic impact is captured by KPIs 31, 48 and 50 as described above. Still, they may be subjected to the sensitivity analysis, aiming to estimate the additional revenues that may be achieved if the sceptical consumers are convinced about the economic and environmental benefits and consequently accept to participate in implicit DR events. Finally, KPI 45 ("Net metering") which measures to which extend the energy produced within the portfolio of the retailer meets the demand of its clientele may be used for estimating the maximum level of the retailer's exposure to the intra-day prices and consequently the range of savings that may be achieved. Indeed, a retailer that may cover a great portion of its clientele's demand by its own generators is less vulnerable to the market prices and thus the WiseCOOP tool is less valuable for him. KPI 46 ("Self-consumption ratio") may be utilized with the same rationale, as a further evaluation indicator of the tools. Notice that in this case, a higher value indicates that the implicit DR is more valuable for the retailer, since its clients appear with noteworthy shedding capabilities (in the sense that they can significantly reduce their consumption form the grid during the DR and consume their own generation).

Concerning the allocation of the benefits to the participating actors, it is reasonable to consider that the retailer will keep a portion for amortizing the cost of the tools (see also below) and the rest will be received by the consumers in the form of beneficial contracts that combine periods of dynamic prices but also lower flat fees, as described above. The level of the estimated benefits and the value of the aforementioned portion defines the payback period of the tools and the return of investment for the actors who manage them. For completeness reasons, it is mentioned that the BM considers two alternatives for the management of the tools at the consumers' side (WiseHOME and WiseCORP). In the former case, the retailer offers them either free of charge or at a price lower compared to their development cost, aiming to stimulate the acceptance of the consumers to be exposed at dynamic pricing schemes, by mitigating the risk of high electricity bills. For this scenario, the cost-benefit-analysis will compare the achieved savings of the retailer with the additive development cost of the tools at both sides of the DR event (including also the WiseCORP). In the latter case, the ESCO is responsible for the management of these tools, receiving as income a portion of the consumer's savings (compared to the flat-fee contracts). For this scenario, the analysis will compare the earnings of the ESCO with the development cost of the tools at the consumer's side only.

2.6 Identifying and quantifying the costs

The cost of a project consists by those expenditures needed for its implementation, compared to the baseline scenario. In Deliverable 1.1 [6] and more particularly in the “business model canvas” sections, the main costs for all the actors who are involved in each BM are reported. This section describes the two main categories that the costs may be separated and describes the type of costs that fit into each one of them. More particularly, the Capital Expenditures (CAPEX), are the monetary amounts that the company spends for purchasing physical and digital goods or services that will be used for a long period (more than a year), while the Operational Expenses (OPEX) are the costs of a company which are necessary for its business operations on a daily basis. The reason for this separation is because the former type of costs is paid only once, usually at the beginning of the investment, and the CBA must compute their amortization throughout the planning horizon of the investment. The latter are related with the daily operation of the company and consequently must be included in the CBA for each year of the planning horizon.

2.6.1 CAPEX analysis

1) The purchases and installation of the innovative technological equipment, i.e., the CHP, PV panels and storage systems (batteries) that contribute to the self-consumption ratio of the prosumers and provide advanced flexibility capabilities. As already mentioned in the Deliverable 1.1, this type of cost may be covered by more than one actor. For instance, in BM5 the Gas DSO may subsidize the cost of the CHP equipment (the remaining amount is paid by the prosumer), aiming to increase the gas consumption in the market and consequently its profits.

2) The cost of the communication channels between the tools that participate in each BM, for the information exchange and the real-time elaboration of the data, which are prerequisites for the realization of all the composite services. For instance, the communications channels needed between the WiseCOOP and the WiseHOME/WiseCORP tools for the propagation of the dynamic prices in the case of an implicit DR event. In the case that the same actor (retailer) manages both these tools, then he bears the total cost, while in the opposite case (the ESCO manages the latter tools) the cost is allocated between the two interested actors.

3) The purchase and installation of the measurement devices which are used for the data collection. For instance, in BM2 the DSO must place sensors at the distribution grid for its more efficient observability. Additionally, the purchase and installation cost of the control equipment which is utilized for the management of the technological equipment, such as the operation set-points of the batteries and the CHP in BM4 and BM5 respectively.

4) The development cost of the software or the license fees paid to a third party. This parameter affects all the actors whose BM strongly depends on the sophisticated algorithms of the (software) tools that will be developed in the context of the WiseGRID project. For instance, the DSO bears the development cost of the WG Cockpit targeting to the efficient observability and management of the distribution grid under his responsibility. The retailer bears the development cost of the WiseCOOP for computing the level of the dynamic prices such as the collective reaction of its clients results to a balanced portfolio and so on.

5) Hardware purchases, such as computers and servers for the data elaboration. This type of cost is expected to affect more those actors who elaborate a large volume of data in limited time period, due to the advanced computational capabilities that are required. For instance, if will affect the DSO (BM2) who collects the data from the sensors for estimating the grid state, and proceeds to the real time transformation of the grid structure or decides the necessity of a DR event. Additionally, the purchase of a call center for

those actors whose business activity strongly depends on the frequent communication with their clients (such as the retailer and the VPP Operator).

2.6.2 OPEX analysis

1) The payroll cost related with the highly qualified staff for managing the advanced capabilities of the tools and making the optimal decisions with the objective of revenues maximization. Additionally, the payroll of the technical staff who installs the innovative technology and the necessary equipment for its control, and of those employees who are associated with serving the clients' requests at the call centers.

2) The necessary training cost for the efficient engagement of the employees with the innovative technology and the sophisticated tools of the WiseGRID project.

3) The cost for the maintenance of the technological equipment (CHP, PV panels and batteries) and the development cost related with the update of the software functionalities or the update of the licenses (paid to a third party).

4) The cost related with the consumers' engagement programs and their more active participation in the Smart Grid. For instance, the retailer may approach the citizens via ad campaigns in the magazines and on the television/internet, specialized events and brochures, aiming to convince them for the potential benefits that may be achieved from their exposure to the dynamic pricing schemes and increase their penetration in the market. Following the same strategy, the VPP Operator may stimulate the participation of the prosumers and of their assets (technological equipment) as members of the VPP. Notice that this process is very critical for the involved actors, because they need a large basis of clients for achieving to shift a considerable portion of loads and consequently have a noteworthy impact on the operation of the grid.

5) The taxation is a crucial parameter for computing the "Net Operating Profit after Tax" (NOPAT) and must be pilot-site specific for reflecting the taxation policy at each area under investigation.

6) The compensation that any actor has to pay to other actors for requesting their contribution to the implementation of a service. For instance, the DSO offers a compensation to the VPP Operator when requesting an explicit DR event. Additionally, the recompense (penalties) that any actor has to pay to others for not meeting his contractual obligations. For instance, the DSO must pay a penalty to the RES generators in the case of a curtailment (e.g., because of congestion at the distribution grid) that is not foreseen by them between contractual agreement. Finally, the participation fees that (e.g.) the VPP Operators has to pay for his market participation or similarly the participation fees paid from the prosumers for becoming a member of the VPP.

2.7 Evaluation metrics for comparing cost and benefits

This section presents the economic metrics and their definition, which will be used for the economic evaluation of the tools to be developed in the context of the WiseGRID project. For clarity reasons it is mentioned that the terms "gain", "income", "inflow" refers to the aggregate value of these parameters, i.e., to the total monetary amount that the manager of the tool (the corresponding actor) may achieve from all the services that the tool is involved. Similarly, the term "cost", "outflow" quantifies the aggregated necessary expenditures for the realization of all the aforementioned services.

EBITDA [7] (Earnings Before Interest, Taxes, Depreciation, and Amortization): It is a measure of a company's operating performance. Essentially, it's a way to evaluate a company's performance without having to factor in financing decisions, accounting decisions or tax environments [7].

EBITDA = Net Income + Interest + Taxes + Depreciation + Amortization

Where the "net income" factor represents the amount of money remaining after all operating expenses, interest, taxes and assets' depreciation have been deducted from a company's total revenue. For clarity reasons, it is mentioned that the CBA will consider a simpler formula, omitting the Interest and the Depreciation factors. This is because the analysis considers that the actors do not need to borrow money for making their investment (Interest factor), while the cost related with the depreciation of the digital goods is captured via the necessary updates that are included in their cost structure.

EBIT (Earnings Before Interest and Taxes) measures the profit that a business generates from its operations, making it synonymous with "operating profit." By ignoring tax and interest expenses, it focuses solely on a company's ability to generate earnings from operations, ignoring variables such as the tax burden and capital structure.

EBIT = EBITDA – Amortization

NOPAT (Net operating Profit After Tax.), It is a company's potential cash earnings if its capitalization were unleveraged — that is, if it had no debt. It is a more accurate look at the operating efficiency for leveraged companies, and it does not include the tax savings many companies get because of existing dept [8].

NOPAT = EBIT * (1- Tax rate)

Net present value (NPV) is the difference between the present value of cash inflows and the present value of cash outflows over a period of time. NPV is used in for analysing the profitability of a projected investment or project [9].

$$NPV = \sum_{t=1}^{n} \frac{R_t}{(1+i)^t} - R_0$$

Where, t is the number of time periods (in years), i is the discount rate, R_t is the net cash flow (cash inflow minus cash outflow) during the period t and R_0 is the initial investment of for the project. The discount rate takes into account the time value of money and quantifies the idea that any amount currently available is worthier than the same amount of money to be gained in the future.

Internal rate of return (IRR) is the metric used for estimating the profitability of potential investments. Internal rate of return is the discount rate that makes the NPV of all cash flows from a project equal to zero and consequently its computation relies on the same formula as NPV does. The firms often establish a required rate of return (RRR) to determine the minimum acceptable return percentage that the investment in question must earn to be worthwhile. Thus, any project with an IRR higher than the RRR should be considered as a profitable one. More generally, the higher a project's IRR is, the more profitable it is for the actors who made the investment [10].

Return on investment (ROI) measures how much money or profit is made on an investment as a percentage of the cost of the investment. ROI shows how effectively and efficiently investment monetary amounts are being used to generate profits. Investors use ROI to determine how successful their investment is performing, but also in comparing their ROI with the [11]

$$ROI = \frac{Gain\ on\ Investment - Cost\ of\ Investment}{Cost\ of\ Investment}$$

The **payback period**[1] is the length of time required to recover the cost of an investment. The payback

[1] https://www.investopedia.com/terms/p/paybackperiod.asp

period of a given investment or project is an important determinant of whether to undertake the position or project, as longer payback periods are typically not desirable for investment positions. The payback period ignores the time value of money (TVM), unlike other metrics such as the NPV [12].

2.8 Sensitivity analysis

The sensitivity analysis investigates at which extend the profitability of an investment is affected by a variation of the variables related with each business model and the main assumptions made for their values during the CBA. Its goal is to identify the range of the aforementioned parameters that result to a profitable outcome at the end of the considered planning horizon. To this end, the sensitivity analysis firstly computes the switching values of these parameters, i.e., these values that have as a result for the NPV to become zero, or more generally to become lower than the acceptable profitability level (as defined by the actors). Furthermore, the computation of the switching values is crucial for the risk management of the investment, i.e., they provide useful insights for the feasibility of a positive CBA outcome, according to the targets of the project. For instance, the BM7 investigates the profitability of the WiseCOOP and WiseHOME/WiseCORP tools, which jointly orchestrate the actions of the retailer and the prosumers respectively for the successful implementation of an implicit DR. It is apparent that the achievement of the anticipated benefits for these actors, strongly depends on the flexibility capabilities of the prosumers. The sensitivity analysis may conclude that a (e.g.) 5% of their load needs to be shifted or curtailed, such that the desired level of profitability is realized. If the expected shifting behaviour of the prosumers (or the actual measurements from the pilot sites) is not adequate to meet this threshold, then the retailer may finance promotion actions for demonstrating the benefits from their active participation in DR events. Similarly, the BM3 investigates the profitability of the WiseEVP and the Fast V2G tools. A critical parameter in this case is the number of EVs on which the sophisticated smart charging algorithms of the tools will be applied. Following the same rational, if the sensitivity analysis concludes that this number cannot be met by the EVs' estimated penetration rate in the market, then the analysis may reasonably conclude that the profitability of the tools is infeasible within the considered planning horizon.

Section 2.5 discusses the main parameters that are related with the objectives of each BM and potentially will be subjected to the sensitivity analysis. Additionally, these parameters were correlated with those KPIs (reported in Deliverable 2.1) which refer to the technical performance evaluation of the involved tools, meaning that the sensitivity analysis will be based on actual measurements from the trials at the pilot sites. The remaining of this section, documents those of the parameters that should be investigated by the sensitivity analysis process according to [3] and are related with the objectives of the WiseGRID project. For clarity reasons, it is mentioned that further parameters may be considered in the future Deliverables of this WP, when the trials will be clarified at the pilot sites. Additionally, it is emphasized that the sensitivity analysis will also define (apart from the switching values) the profitability of the tools (increase or decrease) with respect to the values of the parameters, estimating in this way the range of the profits for each involved actor.

2.8.1 Estimated growth rate of energy consumed and energy efficiency potential

This parameter is of interest for those tools that are involved in the implementation of the DR events, in the sense that the growth rate of the energy consumption is strongly related with the saturation of the distribution grid and affects the level of the distribution fees and the necessity for grid reinforcements (both aspects are sources of cost savings for the participating actors). In the context of the WiseGRID project the consumptions' growth rate will be utilized for estimating the frequency and magnitude of DR events (either implicit or explicit) and for the compensation offered by the actors who request them (mainly the DSO) for their successful realization. Notice that the potential revenues of actors who implement a DR event are increasing with the growth rate, since the need for peak load shifting becomes more intense. The sensitivity analysis will be based on assumptions or estimations from the related literature for defining the allocation of the consumption increase throughout the day. This factor is of great

importance since it determines the portion of peak load that may be shifted to other time slots without causing congestion rebound effects.
For clarity reasons it is mentioned that the tools whose profitability is affected by this parameter are the WiseEVP (BM3 – EVs' smart charging for reducing the charging cost), the WG STaaS/VPP (BM6 – orchestration of the VPP members' shifting capabilities for the implementation of explicit DR), the WiseCOOP and the WiseHOME/WiseCORP (BM7 – implementation of implicit DR event, targeting to avoid the high grid charged). Finally, the WG Cockpit is also implicitly affected, since one if its components (algorithm) is designed for the accurate forecast of the grid congestion and the timely request for DR events by the other actors.

2.8.2 Peak load transfer

This parameter affects also all the tools that are related with the successful implementation of DR events, since it is complementary with the previous one. Indeed, the profitability of these tools does not depend only on the frequency of the DR events and the offered compensation, but also on their capability to efficiently reschedule the prosumers' consumption and achieve great portions of load flexibility (meeting in this way the DSO's request for shifting large volume of loads). Notice that a higher "peak load transfer" implies higher revenues for the actors who offer their flexibility capabilities, since the compensation is measured in terms of monetary units per unit of shifted load. This parameter is explicitly captured by the KPIs 43 and 44 ("Peak load" and "Peak to average ratio) and can be measured by comparing the values of the peak-load before and after the implementation of the WiseGRID project at the pilot sites. But, the sensitivity analysis may also be based on those KPIs which are designed for the technical performance evaluation of the tools and implicitly refer to this parameter. For instance, the efficiency of the WiseEVP tool strongly depends on the reliable data collection about the EV's charging preferences (KPI 32). Notice that a better performance with respect to this KPI means that the flexibility potential of the EVs can be efficiently utilized by the EV fleet manager and consequently affect the "peak load transfer".

2.8.3 Estimated numbers of non-supplied minutes

This parameter is of economic interest mainly for the DSO and will be utilized for the computation of the economic savings in terms of the reduced (compared to the baseline scenario) recompense that the DSO must pay to the consumers in the case of an outage. The impact of this parameter is captured by the KPIs 3-6, meaning that the CBA will be based on actual measurements at the pilot sites or on simulated results if the collection of the former is not feasible. Additionally, the savings are achieved by means of the improved observability of the grid (via smart metering infrastructure) and improved distribution automation (via automatic grid reconfiguration). Notice that both these functionalities are provided by the advanced capabilities of the WG Cockpit tool. Thus, in this case the sensitivity analysis will compute the economic savings with respect to the portion of the non-supplied minutes that are prevented compared to the BaU scenario. This process is of particular importance if the CBA results are based only on simulated experiments, because such results may be followed by a high level of uncertainty, concerning the feasibility of their actual realization.

2.8.4 Discount rate

The discount rate refers to the time value of money and quantifies the fact that an available amount of money currently available, is more valuable than the same amount of money that will be gained in the future. A common practice is to set its value equal to the lowest rate that a society may borrow money in the long-term, and values in the range of 3.5% to 5.5 are suggested for the European Union. In this sense, this parameter has a major impact on the profitability of all the tools that will be developed in the context of the WiseGRID project (since the CBA includes a prolonged time period in order of years) and a wide range of its values will be investigated by the sensitivity analysis process. Actually, the discount rate is a factor in the mathematic formula of the "Net Present Value" (NPV) and consequently it directly affects the "Internal Rate of Return" of all the tools under investigation. For clarity reasons, it is mentioned that a higher discount rate results to a lower NPV of the future revenues and thus to lower profitability for the involved actors.

2.8.5 Implementation schedule

This parameter consists by three factors that should be considered in the sensitivity analysis process. The first, namely "Rural or urban" refers to the area that the project will be implemented and affects the investment costs and the number of citizens that may participate in the services of interest (e.g., DR event). The impact of this parameter will be captured by the fact that the CBA is pilot-site specific for each of the tools under investigation, meaning that the analysis will provide economic results for the profitability of the tools taking into consideration the characteristics of each pilot sites involved in the WiseGRID project.

The second, namely "dispersed or concentrated" refers to the portion of population that may contribute for the realization of the services. The WiseGRID project assumes that all the prosumers, independently of the volume of their loads, may participate at implicit DR event while the explicit ones may engage only heavy-load prosumers. In this context, the sensitivity analysis with respect to this factor will investigate how the revenues of the VPP Operator (managing the WG STaaS/VPP tool) vary as an increasing number of heavy-load prosumers accept to participate in explicit DR events and consequently the former actor may offer more flexibility to the DSO (related with the KPI 12: "VPP participation in flexibility requests"). Concerning the implicit DR event, the process will analyse the cost savings for the retailer (managing the WiseCOOP tool), as a greater portion of its clientele accepts its exposure to dynamic pricing schemes (related with KPI 41: "Penetration of dynamic energy tariffs" and 42 "Demand Response Campaign Penetration"). For completeness reasons it is mentioned that this process (with respect to the same factor) applies also to the profitability of the ESCO, which manages the WiseCORP and the WiseHOME tools for the optimal rescheduling of the prosumers' consumption patterns, such that the DSO's flexibility request is met without violating the occupants' comfort preferences or limitations. Notice that as the ESCO increases its clientele, the additional cost that it must cover is mainly the communication channels for the information exchange between the tools, while the replication and installation cost of the tool affects only marginally its profitability.

Finally, the third factor namely "technology maturity effect" refers to the decreasing cost of technology (EVs, PV panels, CHP, batteries) with time due to economies of scale. This factor is capture by the fact that the CBA considers a long period for computing the IRR of the involved actors and consequently its impact will be quantified in terms of the technology cost and its penetration rate in the market. For instance, the CBA of BM4 may consider a constantly increasing (with years) number of prosumers who own storage systems, as the purchase and installation costs are expected to decrease, and the profitability of this investment will gradually become more possible.

3 SOCIAL, ENVIRONMENTAL IMPACT AND KPIS

3.1 Introduction

One of the important areas that WiseGRID aims to address and improve in a European scale is energy poverty. The expenditure-based metric is one of the methodologies used to assess this. Energy poverty is measured on the basis of the required expenditure on household energy services above a specified share of total income after ensuring comparability (*e.g.* household occupancy and "after housing" costs to adjust household income) [13]. This metric requires the following data:

- Modelled household energy use by income group and dwelling type, the latter determined by building type and efficiency.
- Typical energy costs by income group.
- Household budget information to determine other costs (*e.g.* "after housing" costs) [13].

In addition to these basic pieces of information, there is a profusion of supporting indicators that can help to enrich the analysis of the factors related to the prevalence of energy poverty. These supporting indicators differ from the above data in that they are not in themselves deemed appropriate to measure energy poverty. Examples of supporting indicators include: demographic factors; energy prices; income; kind of household; heating systems; supply choice; building efficiency and building stock data; and policy intervention. Overall, the principal advantage of the expenditure-based metric is that it accurately reflects the extent of energy poverty by referring to a "required" expenditure perspective [13].

The WiseGRID solutions will contribute towards the proliferation of smart cities. Smart cities boast four main features: sustainability, quality of life, urbanisation and smartness [14]. The capacity of a city to preserve the ecosystem while performing city operations is understood as sustainability. The quality of life improvement is derived from the emotional and economic well-being of its citizens. Urbanisation focuses on the technological, economical, infrastructural and governing parameters related to the transformation from rural environment to urban environment. Finally, smartness is interpreted as the drive to encourage social, economic and environmental benchmarks of the city and its inhabitants [15].

More specifically, the European Environmental Agency (EEA) has developed an Urban Metabolism Framework to evaluate the sustainability of a city. This methodology is based on metabolic flows instead of performance or current status. This framework collates a vast range of indicators, all of which are readily available on municipal data bases. From this array of indicators, the EEA chose 15 which were deemed the most representative of the larger set. The Urban Metabolism Framework uses the following 15 indicators: production efficiency CO_2; energy efficiency transportation; consumption efficiency energy; efficiency of water consumption; waste intensity; recycling; urban land take; green space access; NO_2 concentrations; PM_{10} concentrations; unemployment; land use efficiency; public transport network; registered cars; and GDP per capita [16]. The strength of this practice revolves around its simplicity and its use of easily accessible sources. It is informative at a European level rather than at an individual-city level [16].

To evaluate the social and environmental impact of the project, a useful starting point is to consider its implications in terms of circular economy. As described in the report "*Legislation, Business Models and Social Aspects*" [6], the circular economy "*also known as a "closed loop" economy, aims to reach holistic sustainability goals and it is based on the concept of "no waste*". Its final aim is to decouple economic growth and development from the consumption of finite resources. The WiseGRID project contributes to build such an economic model and the EU Circularity Indicators Methodology can be used to measure how well WiseGRID's products or companies are doing on their transformation from linear to circular. The final report of this two year LIFE project summarises that: "*The developed indexes consist of a main indicator, the Material Circularity Indicator, measuring how restorative the material flows of a product or company are, and complementary indicators that allow additional impacts and risks to be taken into account*." [17] The project also have developed a web-site that offers different tools to evaluate circularity, hence, social and environmental impacts [18].

Regarding the benefits towards the building sector (and, in wider terms, towards energy efficiency), the United Nations Environment Programme (UNEP) proposed in 2011 a methodology called Life Cycle Sustainable Assessment (LCSA), that considers the economic, environmental and social sustainability aspects separately, before synthesizing the results at the end of the evaluation. "*The approach combines Environmental LCA (for energy impacts analysis with particular attention to materials/technologies), Economic LCA (for economic impacts analysis, through for example LCC), Social LCA (for social impacts evaluation). Furthermore, Social Life Cycle Assessment (SLCA), for evaluating the social impact produced by a low consumption or passive new building or retrofitting intervention, compared to a traditional construction, on the basis of best practices of energy saving and efficiency implemented by users*" [19].

A French study focuses on another methodology to address specifically the effects of Smart Grids on employment in France. Evaluating the impacts on jobs created, destroyed and induced requires:

"*- Modelling the jobs created in the Smart Grids industry by breaking down the costs of different solutions to identify the share corresponding to wages in France.*

- Modelling the consequences of Smart Grid deployment on the power system to quantify the effects in terms of jobs destroyed in sectors where substitution occurs (power generation, fuels, etc.) […].

- Modelling the effects on employment of the redistribution into the economy of the benefits generated by Smart Grids" [20].

3.2 WiseGRID approach

Social KPIs are typically non-monetary appraisals of the impact of a project. Social impact analysis is therefore part of a qualitative analysis. Social impacts are typically difficult to quantify, but should be considered, especially since WiseGRID has a strong environmental and social focus. In general, implementing Smart Grids benefit society as a whole, which implies positive social impacts on its citizens, although they may not perceive the benefits as directly applicable to themselves. However, negative social impacts can be also be identified. Since citizen concerns are not taken lightly in the deployment of smart technologies as part of a democratic process, it is imperative that citizens clearly and fully understand the impacts of Smart Grids, otherwise progress to full maturation may be slowed down.

WiseGRID is a Smart Grid project with distinct social goals to increase quality of living in Smart Grid neighbourhoods. The accomplishment of the WiseGRID goals will:

- Significantly impact business and innovation opportunities in a positive way
  - The ecosystem of the WiseGRID tools, which are all able to communicate with each other, allows for novel ways to combine functionalities to explore new business opportunities. The project has a large replication potential, due to the strong emphasis on information exchange and knowledge transfer, leading to quick deployment of the tools to establish Smart Grids in other European regions, expanding the innovation potential far outside the pilot sites of WiseGRID.
- Create durable jobs
  - New Smart Grid related jobs will arise, such as maintenance services on RES production installations, electric mobility services, engineering services, financial services, consultancy services, etc. As the WiseGRID tools that are being developed will cover all important Smart Grid fields, it is very likely that WiseGRID products and services will have a head start, and as such they may be able to maintain momentum and benefit from an early market entry. This can guarantee that the jobs sustaining the WiseGRID Smart Grid will last.
  - With centralized energy systems becoming obsolete when the Smart Grid matures, jobs are lost in the old centralized energy production. In contrast, valuable local jobs can be created as a direct and indirect effect of Smart Grid implementation. It is expected that Smart Grids will lead

to less long distances commutes to work and will allow people to find jobs nearby, due to the vast services needed locally to sustain the Smart Grid network.

- Provide citizens with new energy services
    - the extensive ecosystem of WiseGRID tools allows every citizen to participate and provides unique insights in energy flows, enabling new energy services from combining data and tools, e.g. peer-to-peer selling of energy.
- Create level playing field for new market players
    - WiseGRID aims to make tools available on an open source basis. This allows for a basic set of tools freely available at low cost for starting entrepreneurs. WiseGRID will give chances to people to start a business, without lock out effects due to monopolies disturbing the market.
- Put citizens at the centre of decision make leading to energy democracy with fair solutions and incentives
    - WiseGRID has a strong focus on setting public data freely available, as the first step to create informed citizens. Information leads to better decisions. Due to the open source nature of the tools, it is easier for citizens to participate in services on the local grid, to group themselves in structures such as cooperatives to collectively influence decisions, and to take ownership and responsibility of the local energy grid. It empowers citizens to value their assets and data correctly.
- Prevent energy poverty
    - Nearly 11% of the EU's population is in a situation where their households are not able to adequately heat their homes at an affordable cost. The problem of energy poverty is due to rising energy prices, low income and poor energy efficient homes. If well designed, a Smart Grid can sustain a lot of energy players on the market, lead to a healthy market functioning, and by doing so preventing energy poverty, by keeping downward pressure on prices and by allowing sharing energy between peers. Again, due to the open nature of the WiseGRID tools, a healthy energy market is more likely to develop.

Although above social impacts are explicitly stated as project outcome of WiseGRID, in our analysis we have identified additional impacts such as the following:

- National security
    - with the successful implementation of Smart Grids, a higher penetration of local renewable energy production is achieved. This directly leads to less dependency on imported fossil fuels, contributing to the local autonomy and providing a safer and more stable environment for the citizens.
- Reliability and predictability of the energy system
    - Due to the decentralized nature of the Smart Grid, it can be more resistant to natural disasters or other events that severely impact big parts of the electricity system. This resilience causes higher uptime of crucial services, such as medical equipment in hospitals but also at homes, or for food conservation devices such as freezers. These aspects provide more confidence to the citizens.
- Health of citizens
    - Air pollution and noise exposure are two of the major root causes of health problems in cities. A Smart Grid is better equipped to deal with high variability in production and consumption of electricity. Therefore, it can sustain a bigger penetration of electric mobility and heat pumps and other heating systems in society without emissions. Smart grids will lead therefore to a reduction in air pollution (from burning wood in stoves and from traffic) and sleep deprivation (due to continuous exposure to traffic noise). Smart grids will result in a healthier living environment for its citizens and a higher living quality.
- Economic activity

- Besides the already mentioned new Smart Grid services, a secure and reliable Smart Grid allows for improved conditions for economic activity. Smart technologies such as battery storage can sustain energy intensive businesses locally.

- Safety
    - With Smart Grid leading to higher RES penetration, society needs less fossil fuel decreasing the risk of explosions in gas pipelines, fuel stations or during road accidents. However, it remains to be seen whether other safety issues might arise in Smart Grids, such fires caused by batteries and electric shocks.
- Environment
    - With less need for fossil fuel in society, fossil fuel transportation and spills during transport will decrease. These oil and gas spills are a threat to the environment and to people's health and wellbeing. Smart grids allow for higher RES production and penetration to the electrical systems; therefore, they direct positive impact on the environment.
- Social acceptance and coherence
    - Smart grids such as the ones deployed by WiseGRID make citizens aware of their impact on the local energy grid. They feel responsible for their local neighbourhoods. WiseGRID wants people to understand where their energy comes from, which enables the citizens to make informed decisions. Since the state of the local Smart Grid is communicated to the consumers, everybody is involved in preserving the health of the local Smart Grid, and free-riding behaviour can be detected and acted upon. Furthermore, the application of Smart Grids in neighbourhoods can make the neighbourhoods more appealing to new inhabitants and (real estate) investors, causing the value of the properties to increase. These aspects might strengthen the community and coherence of these neighbourhoods.
- Time gain
    - The most stated advantage regarding time gain of Smart Grids in literature is the time gained from not having to manually read out meters. Nevertheless, the biggest time gain is most likely to be found in the locality of services and jobs close to citizens' residences. However, implementing and maintaining a Smart Grid also requires time of the end users. The result, time gain or time loss, depends on 1) how user friendly smart devices are set up (risk of losing time at installation), 2) how much of the Smart Grid's business models will depend on grabbing the end users attention for monetizing (risk of stimulating information addiction), 3) how smart the parameter setting of the smart devices are (risk of losing time during operation and setting-up of the devices), and 4) how standardized the legal aspects of collaboration with new services are for end users, without the need for lengthy procedures before being able to engage (i.e. user end terms acceptance, contract handling, etc).
- Privacy and security
    - Finally, an important aspect to society is privacy and security. Valuable data needs to flow freely to allow the smooth operation of Smart Grids. Consumer consumption can amongst others reveal 1) the assets in one's home, 2) activities end users do at home, 3) time patterns of those activities, and 4) periods of absence. This data is directly monetizable, but also much wanted for people with criminal intentions. Smart grids may therefore attract hacking activities, leading to more incidences of public exposure of valuable information. Therefore, clear security, privacy and data ownership rules are imperative for the deployment of Smart Grids. Data breaches must be dealt with to swiftly and adequately, otherwise end users will not willingly engage in sustaining Smart Grids. Nevertheless, the WiseGRID products are fully complying with personal data protection rules and GDPR requirements, based on by design and by default approach.

Following the above analysis, the project has compiled a set of KPIs that will evaluate the project in terms of its social and environmental impact. These are presented subsequently.

3.3 Key Performance Indicators

3.3.1 Social

Key Performance Indicator	Measure of success
Number of jobs creation	# of new jobs: • For suppliers of technologies in Smart Grids, DERs, energy storage, electric vehicles: R&D, project management, field deployment, operations • For utilities and network operators • For service providers (aggregators, system integrators etc.) The deployment and follow-up of the WiseGRID tools will allow to further employment opportunities. The hiring of 2 news employees per pilot site will be a good indicator of success.
Jobs: new skills	# of utility workers, field technicians and local grid operators to be trained in the management and operation of smart meters, distributed energy resources, energy storage and electric vehicles
Number of women testing WiseGRID	The objective is to achieve (at least) a 50% of women involved in WiseGRID tests (most of all focused on the WiseHOME tool)
Number of women promoting the project	The objective is to promote that the women working in WiseGRID present the project through different dissemination events in order to give them visibility and show that there are also women in the technology and innovation field (a field that traditionally has been masculinized). Target: (at least) 50%.
Pilot Sites citizens satisfaction	During the first period of the project, have been performed different customer engagement activities in the Pilot Sites. The objective is to increase the number of attendants a 5% and reach a satisfaction higher than 75%.
Ageing workforce – gaps in skills and personnel	# of field technicians who got trained on the installation and operation of smart technologies such as EVs, EV charging stations, battery storage etc. related to the deployment of the WiseGRID tools

3.3.2 Environmental

Key Performance Indicator	Measure of success
Cooperatives model for increase renewable energy shares	WiseGRID, by promoting solutions for cooperatives and non-profit organization, will foster the effective share of the benefits of the Smart Grids, giving more opportunities and power to the final consumers/ to benefit from playing an active role. WiseGRID in his Cooperative schema will support the self-consumption model. self-consumption can make an important contribution to finance the energy transition. Commercial consumers (e.g. business, industries, SMEs, smart cities. etc.) can attain high rates of renewable electricity self-consumption (e.g. 50%-80%).

3.3.3 Users related

Key Performance Indicator	Measure of success
DR Campaign penetration	As defined in D2.1, This KPI aims to track the increase of tertiary and industrial, or residential consumers participating in incentive-based DR campaigns in WiseGRID pilot sites, hence to quantify the improvement in the penetration of DR mechanisms among these final consumers.
Safety	% reduction of risk/accidents associated to manual or staffed operation of energy systems thanks to automated Smart Grid solutions
Social acceptance	% of end users who agreed to participate in the pilot site trials of the WiseGRID tools
Time lost/saved by consumers	# of minutes saved for end users due to automated services at home offered by WiseHOME such as automated temperature (heating and cooling) management # of minutes saved for network operators from automated operation and management of electrical grids and microgrids offered by WG Cockpit # of minutes saved by end users thanks to automated EV charging stations booking and charging session optimization offered by Wise EVP

A questionnaire will be distributed to the citizens directly impacted by the WiseGRID project at each of the pilot sites in order to create and understand the profile of the local citizens related to energy consumption and behaviour towards energy usage, smart meter familiarity, willingness to test innovative Smart Grid solutions etc. This questionnaire will be filled in before the implementation of the WiseGRID tools to create the base case scenario against which a second round of questions will be compared after WiseGRID final deployment and operation. In this way, it is expected that related KPIs will be measured in a “before and after” methodology. The questionnaire that will be distributed after the final deployment will be altered to address the experience of the citizens, to measure the success and acceptance of the WiseGRID project by the end users and to help the consortium extract the required results.

Apart from the analysis on the user’s side the project will try to also quantify the benefits per product, using the following table.

DEPLOYMENT MERIT MATRIX WISEGRID

SERVICES	WiseCOOP	Wise HOME	Wise Corp	Wise Cockpit	Wise EVP	FAST V2G	WG IOP	WG StaaS/ VPP	WG RESCO
Social aspects									
Business and innovation opportunities									
Jobs									
Energy services									
Level playing field in the energy market									
Fair solutions and incentives for end-users									
Energy poverty									
National security									
Reliability and predictability of the energy system									
Health of citizens									
Economic activity									
Safety									
Environment									
Social acceptance and coherence									
Time invested									
Privacy and security									

Table 1 - Contribution of the WiseGRID tools (top row, each column one tool) to a positive or negative impact on the social impact (left column, each row a social impact). Scale of the score: -3 to +3. 0 = no effect compared to BAU scenario.

3.4 The WiseGRID questionnaire for consumers and prosumers

The questionnaire can be found in Annex A. The WiseGRID questionnaire for prosumers and consumers. Below we discuss the methodology and the planning for its completion.

3.4.1 Methodology

The methodology is based on the direct involvement of the end users in a set of participatory questionnaires to extract the social impact that the implementation of the WiseGRID tools will have on the end users in the pilot site regions in Spain, Greece, Belgium and Italy. The main end users identified are domestic consumers/prosumers who are taking up the role as pilot users of the smart WiseGRID applications.

Domestic end users are consumers / prosumers that belong to the pilot sites: Members – customers or stakeholders of the local pilot site partners (Ecopower, Enercoop, ASM Terni, AEGEA & HEDNO), and hence, they are geographically located in the area of activity of the respective partners in the consortium. The only requirements for them to participate is their willingness to contribute and share information with the project partners and have domestic energy consumptions on yearly basis. In particular, domestic end users are customers and members of Enercoop in Crevillent, members of Energent & Ecopower in Ghent, customers of the distribution system operator in Terni and Mesogeia region in Greece and finally the citizens of the Kythnos island.

Several participatory processes are considered to collect each piece of information from end users. Keeping in mind several aspects like the type of information, how specific it is, the complexity, the need of a contextualization, the importance of the details and accuracy in the responses, the 'survey' was chosen as the most suitable participatory process to assign topics and questions. A survey is meant for a larger sample of respondents but gives little response resolution or low second level details.

3.4.2 The survey execution phases

The type of information is requested by means of a data sheet template. Inputs are screened out to eliminate redundancies, and they are classified by type of end-user. Then the second classification by topic is carried out. The information gathering needs to be done in three complementary phases. In order to ensure the full clarity of the process we use an IT tool to extract the answers and to share it with participants.

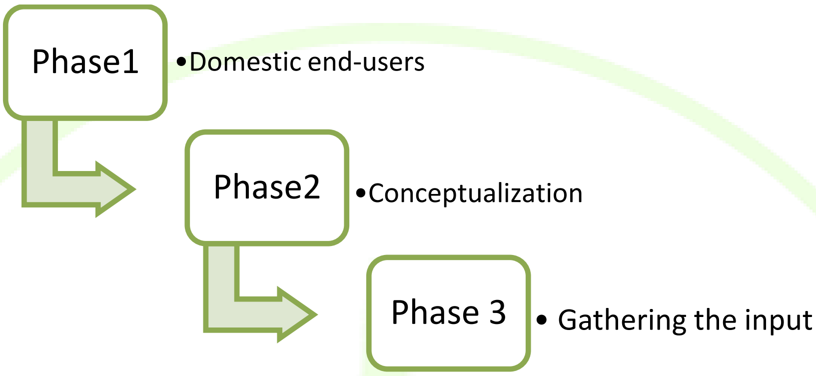

Table 1 - The phases of input screening from the end-user's questionnaires

Surveys are constructed under the premises of multiple-choice questions, additionally providing a field for other choices with comments, allowing flexibility for personal comments or options. This way, the survey is faster to respond, and the analysis is also facilitated.

The survey has a short introduction about the project concept, a non-disclosure statement and the contact data of the cooperatives in charge or launching the survey.

The type of information to gather from domestic end users is classified into the following groups:

- Profile information: such as personal profile data, household composition and building characteristics. This information is useful for segmentation and statistical analysis
- Attitude towards participation in DR markets and use of smart technology at home
- Familiarity with concepts such as Smart Grids, self-consumption, smart appliances, etc.
- Incentives and barriers towards the use of smart energy applications
- Social benefits of using the smart energy appliances at home

3.4.3 Survey implementation and processing

The surveys will be translated in the four local pilot site languages due to the importance of receiving valuable input. All pilot site citizens should be able to participate, without any language barrier. In addition, the survey will be anonymous in this way we can guarantee better data quality and allow for a more robust statistical analysis and accurate response rates. The main target is to have 40 respondents in each pilot sites which would equal to 200 respondents in five pilot sites. The timeline was chosen to create the valuable input the autumn period was described as the most suitable period for the distribution of the surveys, the process can be seen below:

June 28th

- First version created by REScoop.eu & sent to AEA and ENER

July 2nd

- The feedback received from AUEB and ENER

July 4th

- The final survey version sent to AUEB

September 10th

- Local pillot site partners deliver the translation of the questionaries in the local languages

September 19th

- Local pilot site partners sent out the translated questionnaires to the pilot site citizens /
- REScoop.eu publishes an English version on the WiseGRID website

December 3rd

- Gathering of the related input from the questionnaires

December 17th

- Analysis delivered to AUEB

Table 2 - The survey implementation timeline

Local pilot site partners will disseminate the results and facilitate the sharing and collection of the surveys. REScoop.eu will be responsible for the creation and dissemination of the surveys towards the local pilot site partners. In addition, the surveys will be accumulated, and the results will be presented in accumulative tables.

4 REGULATORY AND STANDARDIZATION IMPACT AND KPIS

The existing legal and regulatory framework in the European Union has been widely presented within D1.1, representing the ground for this section. A clear and predictable regulatory framework and a relevant standardization framework are key components to develop towards the low-carbon European economy, the clean energy future and the investment framework required for the clean energy transition. Regulations offer a clear framework for different actors operating in the energy sector. The regulatory framework is directly impacting the financial performance of the project, being responsible for the basis used by stakeholders to distribute costs and benefits of a certain project [21]. Moreover, the regulatory mechanisms influence the outcome of a project and might even be the reason a project is developed or not (i.e., incentive for Smart Grid deployment, such as smart metering; RES). Furthermore, standardization is important for providing a uniform baseline and for improving the security and integrity of the infrastructure. Consequently, the energy domain of the future is increasingly complex, covering and being influenced from various sides from technology to social, economic and environmental aspects. Moreover, energy is a transnational commodity, being regulated from micro (local/national), to mezzo (regional) and macro (European, global) levels.

Any proposal towards new or improved standards should take into account the experiences and lessons learned from the pilot sites. These proposals should also consider the section 1.4.8 from DoW. Below is a table with barriers and risks (both known and unknown):

Known risks (mapped before the pilot)	**Comments (how it was addressed)**
Inadequate funding	Project downsizing, additional funding sources (angel investor – common for innovation projects)
Unknown risks (identified during the pilot)	**Comments (how it was addressed)**
i.e. Specialised workforce	Relocation and trainings

Table 2- Barriers and risks – a good start is from 2.1.4 Barriers, Obstacles and Framework Conditions

4.1 WiseGRID approach and related work

WiseGRID strives to analyse the relevant regulatory frameworks both at the EU and Member State level. In the context of WP1, D1.1 provided a comprehensive review of the applicable legislation. At the EU level, the Deliverable focused on the legal framework for Smart Grids, demand response, electricity storage, electric vehicles as well as data protection and privacy. Thereafter, a national analysis was specifically carried out for the four WiseGRID pilot sites: Ghent (Belgium), Terni (Italy), Kythnos and Mesogia (Greece), and Crevillent (Spain). Consequently, the domestic policies and regulations in each of these jurisdictions were comprehensively assessed in respect of the prospective market penetration of the WiseGRID solutions. Data protection requirements are also being duly observed in accordance to the General Data Protection Regulation. Pursuant to this new EU regulation, the Data Protection Impact Assessment was carried out in the context of WP3.

Considering international commitments that have been adopted also at the EU level and that WiseGRID can contribute to reach, the EU internal and external policies are built in order to reach the Sustainable Development Goals (SDGs). The SDGs are 17 wide goals, divided in 169 targets, that the international community has decided that need to be reach by 2030. SDG 7 focuses on energy, and in particular on “ensuring access to affordable, reliable, sustainable and modern energy for all”. The progresses towards the achievement of the goal on energy can be measure against the following indicators: [22].

4.2 Impact to policies

4.2.1 Climate and Energy

The global and EU policy context against which WiseGRID is set to be implemented acknowledges the need to move towards a decarbonized economy. The Paris Climate Agreement foresees appropriate financial flows, a new technology framework, and enhanced capacity building so that vulnerable territories like (small) islands are in a position to meet the target of holding down global warming to well below 2 degrees Celsius above pre-industrial levels and to work toward holding the increase to 1.5 degrees Celsius in line with their own national climate and energy roadmaps. Actions among others include an inventory of all energy transition projects and sustainable energy actions supported within the bilateral cooperation programs of the European Commission with third countries.

Similarly, WiseGRID is aligned with and will actively contribute to key EU policies on energy, data protection and management, transport and climate. The technological solutions on Smart Grids, flexibility and cross-sectoral synergies, the regulatory analyses, business models and impact assessments that WiseGRID will develop and test to craft concrete decarbonisation pathways in the pilot sites, will provide valuable insights towards existing or under development EU policies in the aforementioned sectors. Already EU policies are placing increasing emphasis on decarbonizing Europe's energy system in all sectors – power generation, industry, transport, buildings, construction and agriculture. With more ambitious targets, reaching full-scale decarbonisation of the European economy by 2050 is feasible and in line with the Paris Climate Agreement. To this end, the European Commission (EC) is set to come up by the first quarter of 2019 with an updated 2050 low-carbon economy roadmap containing higher GHG emission reduction goals, i.e. up to 95% by 2050.

More so, key legislative files pertaining to WiseGRID's work including electricity market design, RES and energy efficiency are currently being revised and negotiated among EU institutions, in order to become EU law this or early next year. This revision takes place in the framework of the Clean Energy for all European Citizens package, the so-called Winter Package, tabled by the EC in November 2016 as the first mid-term milestone (2030) to reach the 2050 decarbonisation target. Essentially, the Winter Package is a new set of measures that puts in place the EU2030 climate and energy framework agreed by EU Member States in 2014 and in line with the Energy Union, the EU's flagship initiative for making access to energy more secure, affordable and sustainable in three steps: 1) putting energy efficiency first; 2) cementing the EU's global leadership in the promotion of renewable energy; and 3) providing a fair deal for energy consumers.

In the framework of the Winter Package, WiseGRID will provide important insights against specific pieces of legislation/regulation:

- RES Directive: Battery storage systems will be used to increase self-consumption and will be aggregated to provide ancillary services to the network operators while increasing the penetration of RES in the electrical systems with the combination of WG STaaS/VPP and WG Cockpit.
- Electricity Market Design Directive and Regulation: The draft Directive foresees the enabling of mechanisms that boost local consumer engagement and participation in the energy market. Hence, key findings from the pilots testing and deploying WiseCORP, WiseCOOP and WG RESCO, will inform the crafting and implementation of the Directive in all MS.
- Energy Efficiency: The EC has concluded that decarbonisation by 2050 is cheaper in the long run with a binding 30% EU energy efficiency target by 2030. Moreover, in December 2017 agreement was reached regarding the revised Energy Performance of Buildings Directive, which puts great emphasis on the smartening of buildings by encouraging the use of ICT and other innovative technologies (e.g. automation and control systems), including the roll-out of e-infrastructure in all buildings. Moreover, the agreement prioritizes interventions in old buildings, as a means to reducing energy poverty. WiseGRID will contribute to more optimized heating and cooling and electricity

consumption with WiseHOME. This will result in a more efficient, overall, use of loads in pilots, ensuring reduction of energy losses and higher penetration of RES in the electricity systems.

- Data security and protection: The EU General Data Protection Regulation (GDPR), which came into force on 25 May 2018, replaces the Data Protection Directive 95/46/EC and was designed to harmonize data privacy laws across Europe, protect and empower all EU citizens data privacy and to reshape the way organizations across the region approach data privacy. WiseGRID will abide by the new regulation and make sure to provide useful feedback with regards to the implementation of the regulatory provisions in the course of the demonstration activities and data collection.

4.2.2 Transport

With respect to EVs, the EU has set for itself an ambitious target of reducing the use of internal combustion engine vehicles by 50% by 2030 and phasing them out entirely by 2050 as part of efforts to reduce GHG Emissions. Further to this, the alternative fuels Directive (2014/94/EU) encourages Member States to develop systems which enable EVs to feed power back into the grid. In addition, the Commission has recently published the Europe on the Move Strategy for low-emission mobility which, amongst other things, seeks to promote the removal of obstacles to the scaling up of the use of EVs.

WiseGRID foresees deployment and fleet management of EVs and EV charging stations with Wise EVP in most pilot sites.

4.2.3 Circular Economy

The Circular Economy Action Plan, tabled by the Commission in December 2015, makes special reference to the need to boost the market for secondary raw materials and water reuse, by maximizing the synergies between energy, waste and water.

WiseGRID will showcase concrete examples of how synergies across the energy, water and transport sectors can be maximized through the use of cutting-edge technologies and processes, highlighting the added value for the local economy and environment.

4.3 WiseGRID Key Performance Indicators

Below are the regulatory aspects of the project's main objectives:

- <u>Innovative and advanced Demand-Response mechanisms</u>: The project will demonstrate the sustainable incentives schemas and business models, based on different technologies to create a win-win situation and benefit both the grid and the consumers. The project will issue recommendations to overcome non-technical (legal, regulatory) barriers for the proper integration of these mechanisms.
- <u>Integration of renewable energy storage systems in the network</u>
- <u>Integration of electric mobility services</u>

The project's results shall be compatible and create links with other European Commission ongoing work and initiatives, such as the following ones in the regulatory field:

- Bridge Cooperation group of H2020 Smart Grids and Storage projects, where it should pay special attention to the detected barriers in the context of regulatory and legislative framework and Business Models,
- Smart Grid Task Force and its Experts Groups, where it shall consider but also complement the ongoing work on the expert groups related with Smart Grid standards, regulatory recommendations for privacy, data protection and cyber-security, regulatory recommendations for Smart Grid deployment and implementation of Smart Grid industrial policy.
- European Energy Package

Below, as an example, is a table about impact indicators regarding the Kythnos pilot site:

Set of regulations	Impact on Kythnos pilot site
General Data Protection Regulation (GDPR) and procedures: COM (2012)0011 – C7-0025/2012 – 2012/0011(COD) Council of Europe Convention 108 Regulation (EC) No.45/2001 on the protection of individuals with regard to the processing of personal data by the Community institutions and bodies and on the free movement of such data	EV users (WiseEVP): driving behaviour Battery storage hosts (WG STaaS/VPP): building layout, electrical layout, electricity consumption
Regulatory recommendations for Privacy, Data Protection and Cyber-Security in the Smart Grid Environment	Network Operator (WG Cockpit): for the distribution grid Battery storage hosts (WG STaaS/VPP) EV users (Wise EVP) Desalination plant (WiseCORP)
Regulatory recommendations for Smart Grid deployment	Network Operator (WG Cockpit): for the distribution grid Battery storage hosts (WG STaaS/VPP) EV users (Wise EVP) Desalination plant (WiseCORP)
Regulatory recommendations for Smart Grid industrial policy	-

Table 3 - Impact indicators regarding the Kythnos pilot site:

The table below shows core impact indicators and measures of success:

Core Impact Indicator	Measure of success
UN Sustainable Development Goals (SDGs)	WiseGRID contributes to Sustainable Development Goal 7 (Ensure access to affordable, reliable, sustainable and modern energy for all). Also, within the Global Agenda for Accelerated SDG 7 Action, a series of policy briefs in support of the first SDG7 review at the UN High-Level Political Forum 2018 has been developed. This publication shows that the success of SDG 7 is a precondition for the success of all other SDGs, because it considers energy as an "intermediate" commodity.
Improve energy efficiency	The WiseGRID project provides solutions to harness the potential of volatile and intermittent renewable energy. This

	will increase local generation as well as reduce electrical losses (estimated at up to 25%). WiseGRID thus contributes to the energy efficiency goals set by various regulatory frameworks at the EU level: • 2020 Climate and Energy Package: 20% improvement in energy efficiency. • 2030 Climate and Energy Framework: at least 27% improvement in energy efficiency.
Increase the share of renewable energy	WiseGRID project will promote the integration of distributed renewable generation sources, such as wind and solar energy, in order to contribute to the EU aim of achieve the integration large share of renewables (exceeding 50% by 2030 according to DoW section 2.1.3). WiseGRID therefore contributes to the renewable energy objectives set by various regulatory frameworks at the EU level: • 2020 Climate and Energy Package: 20% share for renewable energy. • 2030 Climate and Energy Framework: at least 27% share for renewable energy.
Reduce greenhouse gas emissions	In this context, it is expected that the integrated WiseGRID solutions can reduce total European emissions to 20%, 14 million tons of CO2, five years after starting commercialisation. WiseGRID consequently contributes to the emissions reduction targets set by various regulatory frameworks and strategies at the EU level: • 2020 Climate and Energy Package: 20% cut in greenhouse gas emissions • 2030 Climate and Energy Framework: 40% cut in greenhouse gas emissions. • 2050 low-carbon economy roadmap: 80% cut in greenhouse gas emissions.
Comply with data protection requirements	The consortium will closely monitor the work of regulatory bodies and all relevant data protection recommendations will shape the requirements WiseGRID of applications and services. e.g. “data protection by design and by default” (Article 23 of the General Data Protection Regulation or “security of processing” (Article 30 of the General Data Protection Regulation).
Analysis of current regulations, standards and interoperability/ interfaces issues applying to their case, in particular in connection to ongoing work in the Smart Grid Task Force and its Experts Groups in	WiseGRID will adapt, upscale, integrate and deploy a modular, open interoperable set of ICT services over a smarter decentralized monitoring architecture deployed at LV and MV level. The consortium will bring into the project their involvement in the Smart Grid Task Force and in the BRIDGE

the field of Standardization.	group about regulation. WiseGRID will analyse in detail and propose recommendations regarding regulatory framework, standardization and interoperability of the Smart Grid systems in order to minimise trade barriers and increase a healthy market for innovative products and services.
Standardization and interoperable data models	WiseGRID has defined a standardization map considering any open relevant initiative; this map is essential also to properly redefine interoperable data models for Smart Grid, smart meters and other distributed energy systems. The advances reached at the project shall be used to contribute to new standardization developments.
"European Roadmap – Electrification of Road Transport (2nd edition)"	It establishes 2024 as the deadline to attain a broad establishment of V2H functionality in the European power grid. Thus, a broad establishment of V2G functionality in the European grid by 2030 is mandatory for covering the growing demand requirements of the EV fleet at the same time that the stability and reliability of the grid is maintained.
Interoperability and standards	WiseGRID will contribute to the state of the art of the CIM for Smart Grids by validating in large scale pilots the IEC 61970 and IEC 61698 standards, as well as to the state-of-the-art open protocols (OSCP and OCPP) for the integration of the electric vehicle by testing and validating communication protocols between charge point management system and energy management system. WiseGRID will contribute to the ongoing standardization developments and future standards proposal from the most relevant results of the project.
Data protection Directives of the European Parliament and of the EU Council: 95/46/EC, 2002/58/EC, 2006/24/EC. General Data Protection Regulation (GDPR) and procedures: COM (2012)0011- C7- 0025/2012 – 2012/0011 (COD) Council of Europe Convention 108 Regulation (EC) No.45/2001 on the protection of individuals with regard to the processing of personal data by the Community institutions and bodies on the free movement of such data	WiseGRID will consider • The GDPR main principles of data protection as well as other planned provisions for Smart Grid standardization • CoE108 for the Protection of Individuals with regard to Automatic Processing of Personal Data • The Data Protection Impact Assessment Template (2014/724/EU) • Commission Recommendation on preparations for the roll-out of smart metering systems (2012/148/EU)
Regulatory recommendations for Smart Grid deployment	WiseGRID will address the recommendations for • The deployment of flexibility • Regulatory and commercial arrangements • Incentives and Demand Response

Regulatory recommendations for Smart Grid industrial policy	WiseGRID will not only take into account the guidelines for performing a cost-benefit analysis of Smart Grid projects, but will also contribute with suggestions for including additional, real-life economic aspects and key insights from business models to be analysed.
COM (2014) 15: Policy Framework for Climate and Energy from 2020 to 2030 COM (2014) 330: European Energy Security Strategy COM (2013) 169: A 2030 Framework for climate and Energy Policies COM (2011) 885/2: Energy Roadmap 2050 COM (2011) 112: A Roadmap for Moving to a Competitive Low Carbon Economy in 2050	WiseGRID will both consider and contribute with its impact to the fulfilment of these policies and targets towards a sustainable and secure Smart Grid according to like EU roadmaps.

Table 4 - Core impact indicators and measures of success

The following mapping table shows which tools are benefiting the network operator based in the existing mechanism in a country.

Regulatory mechanism	WiseGRID Products									COMMENTS
	WG Cockpit	WG IOP	Wise EVP	WG FastV2G	Wise COOP	Wise CORP	WiseHOME	WG STaaS/VPP	WG RESCO	
Incentive based	x	x	x	x	x	x	x	x		These tools assist the DSO to work more efficiently and withhold the need for very expensive grid reinforcements.
Cost based	x	x								Since the incentive to invest in cost-effectiveness is reduced, it is probable for the DSOs to keep working as before without making efforts to achieve new synergies.
Hybrid	x	x	x	x	x	x	x	x		As in most of the cases, the hybrid models use incentive based regulation for CAPEX, the incorporation of these tools to the everyday activity may contribute to

										withhold very costly grid reinforcements.
Output based	x	x	x	x	x	x	x	x		In this case, the criteria are quality based, so the better the performance of the DSO, the higher the revenue. These tools ca contribute to a more stable and efficient operation of the network, with higher power quality, lower RES curtailment and better voltage regulation.

Table 5 – WiseGRID products benefiting the DSO and associated regulatory mechanism

All of this raises the question whether it is better to have a European legal and regulatory framework or national and even local realities. In other words, do we need a harmonised European regulatory framework or is it better to have national specific regulations? A European legal and regulatory framework seems to be more useful, respecting though the countries' peculiarities. One approach to answer this question could be to show how and whether the different regulations in the pilot site countries impedes the usage of these tools and the integration of related services. Based on that, certain recommendations may arise.

5 CONCLUSION

Deliverable D16.1 set the ground for the impact assessment of the WiseGRID project. In that context, presented the methodology to be utilised as well as the planning horizon on when it will be implemented and the anticipated results. Moreover, presented the first steps of the methodology, including the definition of the Key Performance Indicators as well as the first steps of the Cost Benefit Analysis (CBA).

The work in WP16 will continue towards collecting and analysing the necessary input and data from project pilots. Interactions and feedback from other WPs are expected both on the technical front (WP14, WP15) as well as on the business one (WP17, WP21). The KPIs indicated in the current document will be regularly monitored, assessed and refined if needed in the course of the project to keep up with the current market status and developments in the Smart Grid area.

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6.2 Acronyms

Acronyms List	
AND	Active Distribution Network
ADMS	Active Distribution Management Systems
AMI	Advanced Metering Infrastructure
ACER	Agency for the Cooperation of Energy Regulators
APIs	Application Programming Interface
AEEGSI	Authority for Electricity, Gas and Water
AMR	Automated Meter Reading
AV	Autonomous Vehicle
APMs	Award-Penalty Mechanisms
BMS	Building Management System
BMC	Business Model Canvas
CACM	Capacity Allocation & Congestion Management
CPO	Charge Point Operator
CHP	Combined Heat and Power
CIM	Common Information Model
CAGR	Compound Annual Growth Rate
CAES	Compressed Air Energy Storage
CEF	Connecting Europe Facility
CA	Consortium Agreement
CfD	Contracts for Difference
CBA	Cost Benefit Analysis
CEER	Council of European Energy Regulators
DPIA	Data Protection Impact Assessment

DAM	Day-Ahead Market
RES	Decentralized Production System
DR	Demand Response
DRMS	Demand Response Management System
DOI	Diffusion of Innovations
DERs	Distributed Energy Resources
DG	Distributed Generation
DRES	Distributed Renewable Energy Sources
DN	Distribution Network
DNO	Distribution Network Operator
DSO	Distribution System Operator
EV	Electric Vehicle
EVI	Electric Vehicle Initiative
EVP	Electric Vehicle Platform
ERDF	Electricité Réseau Distribution France
EB	Electricity Balancing
EMR	Electricity Market Reform
EED	Energy Efficiency Directive
ELI	Energy Law Institute
EMS	Energy Management System
ESCO	Energy Services Companies
ESS	Energy Storage System
EC	European Commission
EDSO	European Distribution System Operators
FLISR	Fault Location, Isolation and Service Restoration
FCA	Forward Capacity Allocation
FCR	Frequency Containment Reserve
FRR	Frequency Restoration Reserve
GDP	Gross Domestic Product
GIS	Geographical Information System
GPS	Global Positioning System
GB	Great Britain
GHG	Greenhouse Gas
HL-UC	High Level Use Cases
INC	Imbalance Netting Cooperation
IMC	In Motion Charging

ISO	Independent System Operators
ICT	Information Communication Technology
IT	Information Technology
IP	Intellectual Property
IEM	Internal Electricity Market
IGCC	International Grid Control Cooperation
IoT	Internet of Things
IMA	Intersection Movement Assist
LTA	Left Turn Assist
LCOE	Levelized Cost of Energy
LES	Local Energy Systems
LTE	Long Term Evolution
LCCC	Low Carbon Contracts Company
LV	Low Voltage
mFRR	Manual Frequency Restoration Reserve
MARI	Manually Activated Reserves Initiative
MV	Medium Voltage
MRPs	Multiyear Rate Plans
NRA	National Regulatory Authority
NTC	Net Transfer Capacity
NC LFCR	Network Code on Load Frequency Control and Reserve
NC OPS	Network Code on Operational Planning and Scheduling
NC OS	Network Code on Operational Security
NFV	Network Function Virtualization
NEMO	Nominated Electricity Market Operator
NIIES	Non-Interconnected Island Electrical System
OLEV	Office for Low Emissions Vehicles
Ofgem	Office of Gas and Electricity Markets
OCA	Open Charge Alliance
OCPP	Open Charge Point Protocol
OPEX	Operational Expenses
OEM	Original Equipment Manufacturers
OTC	Over-the-Counter
PBR	Performance-based Regulation
PV	Photovoltaic
PICASSO	Platform for the International Coordination of Automated Frequency Restoration and Stable System Operation

PLC	Power-Line Communication
PCI	Project of Common Interest
PPC	Public Power Corporation
PHES	Pumped Hydro Energy Storage
QoS	Quality of Service
RF	Radio Frequency
RTO	Regional Transmission Organizations
RAE	Regulatory Authority of Energy
RESCO	Renewable Energy Service Company
RES	Renewable Energy Sources
RR	Replacement Reserves
R&D	Research and Development
R&I	Research and Innovation
RIIO	Revenue, Incentives, Innovation, Outputs
SOA	Service Oriented Architecture
STOF	Service, Technology, Organization and Finance
SEM	Single Electricity Market
SGS	Smart Grid Solution
SNM	Smart Network Management
SDN	Software Defined Network
SWOT	Strengths, Weaknesses, Opportunities, Threats
SMES	Superconducting Magnetic Energy Storage
SCADA	Supervisory Control And Data Acquisition
SAIDI	System Average Interruption Duration Index
TCO	Total Cost of Ownership
TERRE	Trans European Replacement Reserves Exchange
TSO	Transmission System Operator
VISOR	Value Proposition, Interface, Service Platforms, Organizing Model, Revenue / Cost Sharing
V2B	Vehicle-to-Building
V2G	Vehicle-to-Grid
V2V	Vehicle-to-Vehicle
VPP	Virtual Power Plant
WtE	Waste-to-Energy
WG IOP	WiseGRID Interoperable Platform

Table 6 – List of Acronyms

ANNEX A. THE WISEGRID QUESTIONNAIRE FOR PROSUMERS AND CONSUMERS

QUESTIONNAIRE FOR PROSUMERS & CONSUMERS

English version

Brief introduction on the project, purpose and general guidelines to fill in the survey.

About our project

This survey is part of WiseGRID, a project financed by the European Commission that aims at providing a set of solutions and technologies to increase the smartness, stability and security of an open, consumer-centric European grid.

WiseGRID aspires to transform the European grid while reducing complexity and allowing participation with a set of technologies such as storage, electric vehicles, distributed energy resources integration and demand response. By doing so, the project hopes to set an example, aiming for energy democracy where citizens, cooperatives and small and medium-sized enterprises have a fair right to participate in the energy market.

Information we need

In order to better understand the profile of consumers we are working with, we need information related about the following items: Household and dwelling profile; energy consumption, energy equipment including generation and storage if any, awareness and specific knowledge on energy, incentives and barriers perceived for innovative services.

Estimated time to complete the questionnaire. 20 minutes

Personal data protection. WiseGRID project's partnership ensures the confidentiality and non-disclosure of the data provided in this survey. Data will be used in an aggregated way and only for the purpose of the project.

Want to know more? Please visit www.wisegrid.eu or write to contact@wisegrid.eu for more information about the WiseGRID project.

Profiling

This section requests generic information about the domestic consumer or prosumer, the household composition and the dwelling characteristics. If you do not know the answer, please select the option that you feel it describes best your case.

Your gender

- ☐ Female
- ☐ Male
- ☐ Other

Your age: ______________

Your educational level

- ☐ Early childhood and primary education/ Equivalent
- ☐ Secondary education/ Equivalent
- ☐ Tertiary education/ Equivalent or higher

Household composition. Please state the number of people in the household including yourself.

- ☐ Children and young under 18: ________
- ☐ Students: ______________
- ☐ Employed: _____________
- ☐ Unemployed: _________
- ☐ Retired and over 65: ______________¨

Size of dwelling

- ☐ Less than 50 m^2
- ☐ 50–100 m^2
- ☐ 100–150 m^2
- ☐ 150–200 m^2
- ☐ More than 200 m^2

Dwelling Tenancy regime

- ☐ Rented
- ☐ Ownership
- ☐ Usufruct

Building date of construction: ________

Is your dwelling well insulated?

- ☐ Yes
- ☐ No

Equipment and installations

This section is about the energy consuming devices that you have at home, mainly electric ones. Please, mark all the options that apply to you at each question. If none applies, please mark the closest to your case.

What is your main heating system at home?

- ☐ Heat Pump
- ☐ Electric radiators with heat storage
- ☐ Electric radiators without heat storage
- ☐ Electric portable heaters (with electric resistance)
- ☐ Gas/ Diesel boiler
- ☐ Biomass boiler
- ☐ Wood stove
- ☐ None
- ☐ Other: ________________________

What kind of cooling system do you have at home?

- ☐ Heat Pump (absorbs heat and removes it from the inside to the outside)
- ☐ Air conditioning
- ☐ Fans
- ☐ No cooling system
- ☐ Other: _______________________

What is your domestic water heating system at home?

- ☐ Electric water heater with storage tank
- ☐ Electric water heater without storage tank
- ☐ Gas/ Diesel boiler
- ☐ Biomass boiler
- ☐ Heat pump
- ☐ Solar thermal hot water
- ☐ Other: ________________________

Do you have an Electricity Smart Meter at home? (A Smart Meter is a meter equipped with communication capabilities and able to send instant consumption information remotely. Smart meters started to be rolled-out in the years 2010)

- ☐ Yes
- ☐ No
- ☐ I do not know what kind of metering I have at home.

Do you own an Electric Vehicle EV?

- ☐ Yes, I have a plug-in hybrid EV (PHEV).
- ☐ Yes, I have a non-plug-in hybrid EV (HEV).
- ☐ Yes, I have a pure EV (BEV).
- ☐ Yes, I have an electric bike.
- ☐ I do not have an EV myself, but I am shareholder of a local cooperative offering EV-services
- ☐ No. I do not have an EV.

Have you already installed any smart home product at home? (Smart devices are those that can be programmed and can be controlled remotely with an app or web browser).

- ☐ Smart TV
- ☐ Smart fridge
- ☐ Smart washing machine / dish washer
- ☐ Smart heating/cooling system
- ☐ Other. Please specify: ___________________________________
- ☐ None

Do you consider yourself as an energy ‘prosumer’ (meaning consuming and producing energy)?

- ☐ Yes, I have my own energy generation installation (f.e. rooftop solar panels)
- ☐ Yes, I have my own storage technology (f.e. house battery)
- ☐ Yes, I use a V2G electrical vehicle (vehicle to grid: selling demand response services)
- ☐ Yes, I am part of a local energy cooperative
- ☐ Yes, other. Please specify: ___________________________________
- ☐ No, I am not a prosumer

Contracting and consumption

This section requests information about the energy consumption at home, and the type of supply contract / tariff that you have. If you do not know the accurate answer, please mark what you think is the closest to your case.

How much is your energy bill each month (electricity and gas)?

- ☐ 50 €
- ☐ 50 -100 €
- ☐ 100 – 150 €
- ☐ 150 – 200€
- ☐ 200 € or more,
- ☐ I do not know

What impact does the energy bill have on your household budget?

- ☐ very high impact
- ☐ high impact
- ☐ medium impact
- ☐ low impact
- ☐ no impact
- ☐ I do not know

What is your electrical power hired, meaning, the maximum power you can use simultaneously? (You can find this data in your bills)

- ☐ ____ kW
- ☐ I cannot access this information
- ☐ I don’t know

What kind of electricity supply tariff do you have? Do you have a tariff that allows hourly discrimination?

- ☐ Regulated tariff (PVPC).
- ☐ Fixed price tariff.
- ☐ 2 period hourly discrimination tariff (usually day time tariff, night time tariff)
- ☐ More than 2 period hourly discrimination tariff
- ☐ I do not know.

Do you produce your own electricity and, if so, what is your facility nominal power?

- ☐ Yes, with my own facility: ___________ kW.
- ☐ Yes, with my own facility shared with my neighbourhood: ___________ kW.
- ☐ Yes, with my cooperative generation assets: ________________kW.
- ☐ No

Behaviour of Energy (pro)consumers

This section requests information about your energy behaviour and opinion regarding energy consumption and production.

Do you believe that energy is used efficiently in your household?

- ☐ Yes
- ☐ No
- ☐ Energy is being utilised efficiently but it can be used more effectively.

Can you imagine life without electricity and gas? How do you feel in the case of black-outs?

Are you satisfied with the provided services of the existing electricity grid?

- ☐ Yes
- ☐ No
- ☐ If no, please indicate what you are looking for

Do you trust that the information from your meter is accurate?

- ☐ Yes
- ☐ No
- ☐ No opinion

Do you think that your power is reliable?

- ☐ Yes
- ☐ No
- ☐ No opinion

Would you like to have a better understanding of your electricity consumption?

- ☐ Yes
- ☐ No
- ☐ No opinion

Have you heard of the term “Demand Response”?

- ☐ Yes
- ☐ No

Would you accept that some appliances at your house are switched of during peak hours (Peak hours are declared when demand for electricity threatens to outpace supply, which typically can occur during hot summer days and cold winter mornings?

- ☐ Yes, very much
- ☐ Yes
- ☐ Neutral
- ☐ Not at all

Do you think it is important that your electricity comes from renewable energy sources?

- ☐ Yes, very much
- ☐ Yes
- ☐ Neutral
- ☐ Not at all

Would you be willing to pay more for your electricity to make sure it comes from renewable energy resources?

- ☐ Strongly willing
- ☐ Willing
- ☐ Slightly willing
- ☐ Unwilling
- ☐ Undecided

Do you care about your waste of electricity (using electricity in an inefficient way)?

- ☐ Yes, very much
- ☐ Yes
- ☐ Neutral
- ☐ Not at all

Would you like to be able to control your purchase of electricity?

- ☐ Yes, very much
- ☐ Yes
- ☐ Neutral
- ☐ Not at all

Do you believe it is important to consume electricity in a more efficient way, knowing that it would reduce CO_2 emissions but might increase the price of electricity (become more expensive)?

- ☐ Yes, very much
- ☐ Yes
- ☐ Neutral
- ☐ Not at all

Preferences regarding Smart Grid technology

The WiseGRID Smart Grid will be based on an integration of new technologies, such as renewable energy, automation system in a household, storage and electric vehicles. This section is about your preferences regarding smart devices and Smart Grid Technology Adoption. Please, mark all the options that apply to you at each question. If none applies, please mark the closest to your case.

Would you be interested in using an system that integrates smart technologies for storage, electrical vehicles, energy monitoring, …?

- ☐ Yes
- ☐ Maybe in the future
- ☐ No
- ☐ I don't know

If you answered 'yes' at the previous question, what would be the reasons?

- ☐ It will reduce my electricity bills
- ☐ It will simplify daily activities and increase life quality
- ☐ I want to contribute to the environmental benefits these technologies bring along
- ☐ Other: ____

Would you be interested in knowing your real-time electricity consumption?

- ☐ Yes
- ☐ No, I do not need to access this kind of information.

Do you agree that a personal app is useful for monitoring and controlling the energy consumption at home?

- ☐ Strongly Agree
- ☐ Agree
- ☐ Neutral
- ☐ Disagree

How would you like to be charged for your electricity consumption?

- ☐ Flat rate
- ☐ Cheaper during fixed periods in a 24 hours timeframe such as the night
- ☐ Hourly priced (depending on market price)
- ☐ Average peak consumption

Would you be willing to produce your own electricity and sell it back to the grid when not using it?

- ☐ Strongly willing
- ☐ Willing
- ☐ Willing, but I don't know how to do it
- ☐ Willing, but I have no funds to do it
- ☐ Unwilling
- ☐ Undecided

Familiar with concepts

This section shows a number of concepts and asks for your awareness and familiarity with them.

Do you understand your electricity bill statement and charging concepts?

- ☐ Yes, I fully understand it.
- ☐ Yes, I understand it, with the exception of some concepts.
- ☐ No, I only understand it partially.
- ☐ No, I do not understand it at all.
- ☐ No, but I do not mind.

Are you familiar with the concept of electricity self-consumption?

- ☐ Yes, I fully understand it.
- ☐ Yes, I understand it, with the exception of some concepts.
- ☐ No, I only understand it partially.
- ☐ No, I do not understand it at all.
- ☐ No, but I do not mind.

Do you like having and using smart devices at home? (Smart Devices are those that can be programmed and controlled remotely with an app or web browser).

- ☐ Yes, I like them and use them.
- ☐ Yes, I like them, but I do not usually use them.
- ☐ No, I do not like them, but I use them sometimes
- ☐ No, I do not like them at all and never use them
- ☐ I do not have an opinion to this respect.

Are you making savings in your electricity bill by shifting the use of electrical devices at home from expensive peak hours to cheaper off-peak hours (e.g. day-time to night-time?)

- ☐ Yes. I already make full use of it.
- ☐ Yes, I make use of it, but I don't know how big my savings are.
- ☐ No, but I would like to benefit from this possibility.
- ☐ No, because I have a fixed hourly electricity tariff.
- ☐ No, because real savings are really low.
- ☐ No, because I have little chance to shift electricity consumptions to cheaper hours.
- ☐ No. I am not interested.

Are you willing to participate and benefit of the possibilities and compensations of participating in demand flexibility markets without affecting comfort at home?

- ☐ Yes, if there is a sufficient compensation
- ☐ No, I am not willing to change my consumption patterns at any time.
- ☐ No, I do not trust external companies accessing my consumption profile and taking control of my home devices remotely.
- ☐ No, I am just not interested at all.
- ☐ I do not know and I have no opinion yet to this respect.

Incentives and barriers

The WiseHome application is an interface that provides deep and comprehensive understanding of the energy consumption and informs the user about the state and performance of assets such as local generation, batteries or electrical vehicles. It will also make it possible for the end-user to participate in implicit demand response campaigns.

This section requests information about your perception of incentives and barriers to use a smart application such as the WiseHome. Please, mark how important the given statements are for you (5 most important to 1 least important)

In order for you to feel keener to use the WiseHome, how important are the following statements for you? (5 very important, 1 not important).

- ☐ (1 - 5):_______ Clear, transparent and consumer-protecting regulations that ensures customer rights and market rules.
- ☐ (1 - 5):_______Clear, transparent and unequivocal bilateral contracting with the market representative or service provider company that ensuring customer confidence and conflict resolution mechanisms.
- ☐ (1 - 5):_______Full respect to private information non-disclosure
- ☐ (1 - 5):_______Full respect to comfort standards as stated by the consumer.
- ☐ (1 - 5):_______Empowerment of small domestic consumers in electricity markets and balancing markets.
- ☐ (1 - 5):_______Savings in the energy bills for moving consumptions from high cost periods to low cost periods.
- ☐ (1 - 5):_______Positive experience and feedback given by early market players to gain confidence.
- ☐ (1 - 5):_______Contribution to the sustainability and greenness of the National and European electricity system
- ☐ (1 - 5):_______Be among the first to participate in a new technologically advanced initiative and give feedback to improve it.
- ☐ (1 - 5):_______Other reasons. Please state: _________________________

What of the following statements would make you feel more uneasy to use the WiseHOME application, evaluate from 1 to 5 the following statements in your case. 5 most important to 1 least important.

- ☐ (1 - 5):_______Initial investment in smart application
- ☐ (1 - 5):_______Possible misuse of personal information by third parties.
- ☐ (1 - 5):_______Possible occasional variation of usual comfort preferences.
- ☐ (1 - 5):_______Possible new technology failure or malfunctioning.
- ☐ (1 - 5):_______Lack of previous user experience in a new business market.
- ☐ (1 - 5):_______Other reasons. Please state: ________________________

What of the following reasons would make you willing to change your behaviour and start using a smart application in your house (like WiseHOME)? Evaluate from 1 to 3the following reasons in your case. 3 most important to 1 least important.

- ☐ (1 - 3):_______Monetary: Bill reduction
- ☐ (1 - 3):_______Non monitory: for example tickets to events, free restaurant meals, …
- ☐ (1 - 3):_______Environmental: for example CO2 reduction, forest protection, better air quality, …
- ☐ (1 - 3):_______Other reasons. Please State: ________________________

Free comments: (Add any missing information about you that you find relevant in this context)

Thank you very much for your time and your kind collaboration with the project!

ANNEX B. WISEGRID PRODUCTS TO SMART GRID FUNCTIONALITIES MAPPING

Services	A. Enabling the network to integrate users with new requirements				B. Enhancing efficiency in day-to-day grid operation						C. Ensuring network security, system control and quality of supply					
Outcome	Guarantee the integration of distributed energy resources (both large- and smallscale stochastic renewable generation, heat pumps, electric vehicles and storage) connected to the distribution network				Optimise the operation of distribution assets and improve the efficiency of the network through enhanced automation, monitoring, protection and real-time operation. Faster fault identification / resolution will help improve continuity of supply levels.						Foster system security through an intelligent and more effective control of distributed energy resources, ancillary backup reserves and other ancillary services. Maximise the capability of the network to manage intermittent generation, without adversely affecting quality of supply parameters.					
Functionalities	Facilitate connections at all locations for any kind of devices	Facilitate the use of the grid for the users at all the voltages/ locations	Use of network control systems for network purposes	Updated network performance data on continuity of supply and voltage quality	Automated fault identification/ grid reconfiguration, reducing outage times	Enhance monitoring and control of power flows and voltages	Enhance monitoring and observability of grids down to the low voltage levels	Improve monitoring of network assets	Identification of technical and non-technical losses by power flow analysis	Frequent information exchange on actual active / reactive generation/ consumption	Allow grid users and aggregators to participate in ancillary services market	Operation schemes for voltage/ current control	Intermittent sources of generation to contribute to system security	System security assessment and management of remedies	Monitoring of safety, particularly in public areas	Solutions for demand response for system security in the required time
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
WiseGRID Project Products																
WG IOP	1	1	0	0	0	1	0	0	0	1	1	0	0	0	0	0
WG COCKPIT	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1
WiseCOOP	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	1
WiseCORP	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
WiseHOME	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
WISEEVP	1	1	1	0	1	1	1	0	0	0	0	0	0	0	0	1
WG FASTV2G	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0
WG STaaS / VPP	1	1	0	1	1	0	0	0	0	1	1	1	1	0	0	1
WG RESCO	0	0	0	0	0	1	1	1	0	1	0	0	0	0	0	0
CHP	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1

Figure 8 - WiseGRID products to Smart Grid functionality mapping excel table – Part 1/3

Services	D. Better planning of future network investment			E. Improving market functioning and customer service							
Outcome	Collection and use of data to enable more accurate modelling of networks, especially at LV level, also taking into account new grid users, in order to optimise infrastructure requirements and so reduce their environmental impact. Introduction of new			Increase the performance and reliability of current market processes through improved data and data flows between market participants, and so enhance customer experience							
Functionalities	Better models of Distributed Generation, storage, flexible loads, ancillary services	Improved asset management and replacement strategies	Additional information on grid quality and consumption by metering for planning	Participation of all connected generators in the electricity market	Participation of virtual power plants and aggregators in the electricity market	Facilitate consumer participation in the electricity market	Open platform (grid infrastructure) for EV recharge purposes	Improvement to industry systems (for settlement, system balance, scheduling)	Support the adoption of intelligent home/ facilities automation and smart devices	Provide grid users with individual advance notice of planned interruptions	Improve customer level reporting in the case of interruptions
	17	18	19	20	21	22	23	24	25	26	27
WiseGRID Project Products											
WG IOP	0	0	0	0	0	0	0	0	0	0	0
WG COCKPIT	0	1	1	0	0	1	0	0	0	0	1
WiseCOOP	0	0	1	1	1	1	0	0	0	1	0
WiseCORP	0	0	0	1	0	1	0	1	1	1	0
WiseHOME	0	0	0	1	1	1	0	0	1	1	0
WISEEVP	1	0	1	0	0	1	1	0	0	0	0
WG FASTV2G	1	0	0	0	0	0	1	1	0	0	0
WG STaaS / VPP	1	0	0	1	1	1	0	0	1	0	0
WG RESCO	1	1	1	1	0	1	0	0	0	0	1
CHP	1	0	0	1	1	1	0	1	1	0	0

Figure 9 - WiseGRID products to Smart Grid functionality mapping excel table – Part 2/3

Services	F. Enabling and encouraging stronger and more direct involvement of consumers in their energy usage and management						
Outcome	Foster greater consumption awareness, taking advantage of smart metering systems and improved customer information in order to allow consumers to modify their behaviour according to price and load signals and related information.						
Functionalities	Sufficient frequency of meter readings	Remote management of meters and consumer subsystems (e.g. storage equipment)	Consumption/ injection data and price signals by different means	Improve energy usage information	Improve information on energy sources	Availability of individual continuity of supply and voltage quality indicators	**Total impact of WiseGRID assets to functionalities**
	28	29	30	31	32	33	
WiseGRID Project Products							
WG IOP	0	0	0	0	0	0	**5**
WG COCKPIT	0	0	0	0	0	0	**19**
WiseCOOP	1	1	1	0	1	1	**14**
WiseCORP	1	1	0	1	0	1	**11**
WiseHOME	1	0	1	1	1	1	**11**
WISEEVP	0	0	0	1	1	0	**13**
WG FASTV2G	0	0	0	1	0	0	**8**
WG STaaS / VPP	1	0	1	0	1	1	**18**
WG RESCO	1	1	1	1	1	1	**16**
CHP	0	0	0	0	0	0	**8**

Figure 10 - WiseGRID products to Smart Grid functionality mapping excel table – Part 3/3