REPLICATION ROADMAP

WP 8 – Replicability, Scalability and Exploitation

A GUIDE TO THE IMPLEMENTATION OF INTEGRID SMART GRID FUNCTIONS IN FUTURE NETWORKS

2020 – This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731218

CONTENTS

FORWARD

BRIDGING THE GAP

Due to the significant changes in the electricity network topology necessary to meet the demands towards the drive for cleaner energy, increased technological advances and operating methodologies have become more prominent. With these new additions, system operators are experiencing challenges such as network violations, reverse power flow and increased network instability. In order to overcome these challenges, various smart grid tools and functions have been developed supporting integration of these flexibilities for the planning and operations of electrical networks while ensuring the safe and reliable supply of electricity in a cost-effective manner. Furthermore, the change in the energy paradigm also paves the way to the emergence of new actors (such as aggregators) and new behaviours (such as the active participation of prosumers or industrial customers), offering Distribution System Operators (DSO) plausible alternatives to costly network reinforcements when combined with proper operational tools. The pooling of the flexibility of loads or generators located in the distribution network through Virtual Power Plants (VPP) can also contribute significantly to the provision of new balancing services for Transmission System Operators (TSO) and Balancing Responsible Parties (BRP) which create need for the DSO to validate and coordinate such operations. This enables the DSOs to become market facilitators. Advanced forecasting algorithms, such as predictive maintenance, traffic light systems (TLS) and load/RES forecasts, are receiving increased attention such that they can be integrated in real conditions by networ k operators.

INTRODUCTION

In recent years, the electricity supply chain has experienced a paradigm shift due to the increased awareness of low carbon initiatives, the rise of renewable energy technologies due to price reductions, technology advances and new regulations which have been enforced to combat global emissions. Furthermore, the increase in flexibilities has allowed for the increase in business opportunities, where market players are able to leverage and benefit from these facilitators. However, the integration of distributed energy resources (DERs) both at the medium and low voltage level has resulted in an increase of complexities faced by the network operators in order to ensure that network operating limits are adhered to. However, the question remains, to what degree can these technologies be successful when they are integrated in larger networks, with an increased number of network devices or under different network conditions (e.g. network type, configuration or location)? Therefore, the need to conduct a scalability and replicability analysis (SRA) in order to investigate such futuristic scenarios is ever increasing in order to evaluate the impact on existing networks. The SRA allows for these scenarios to be envisioned by bridging the gap between current network conditions and possible future scenarios. In this manner, the technologies deployed can be implemented and fully utilised in a sustainable manner to ensure longevity of the networks as potential constraints, barriers and drivers are identified beforehand.

The replication road map provides stakeholders with a step by step process. Although it is acknowledged that a 'one size fits all approach' is not always feasible, it merely proposes a guideline strategy for implementation based on high-level acceptance criteria. The main drivers for a replication road map are to ensure seamless transition and integration of smart grid technologies to facilitate the objectives for a low carbon and decentralised networks. This shall serve as basis for future smart grid implementations and stakeholders to transmit all the knowledge from InteGrid and benefit from its results.

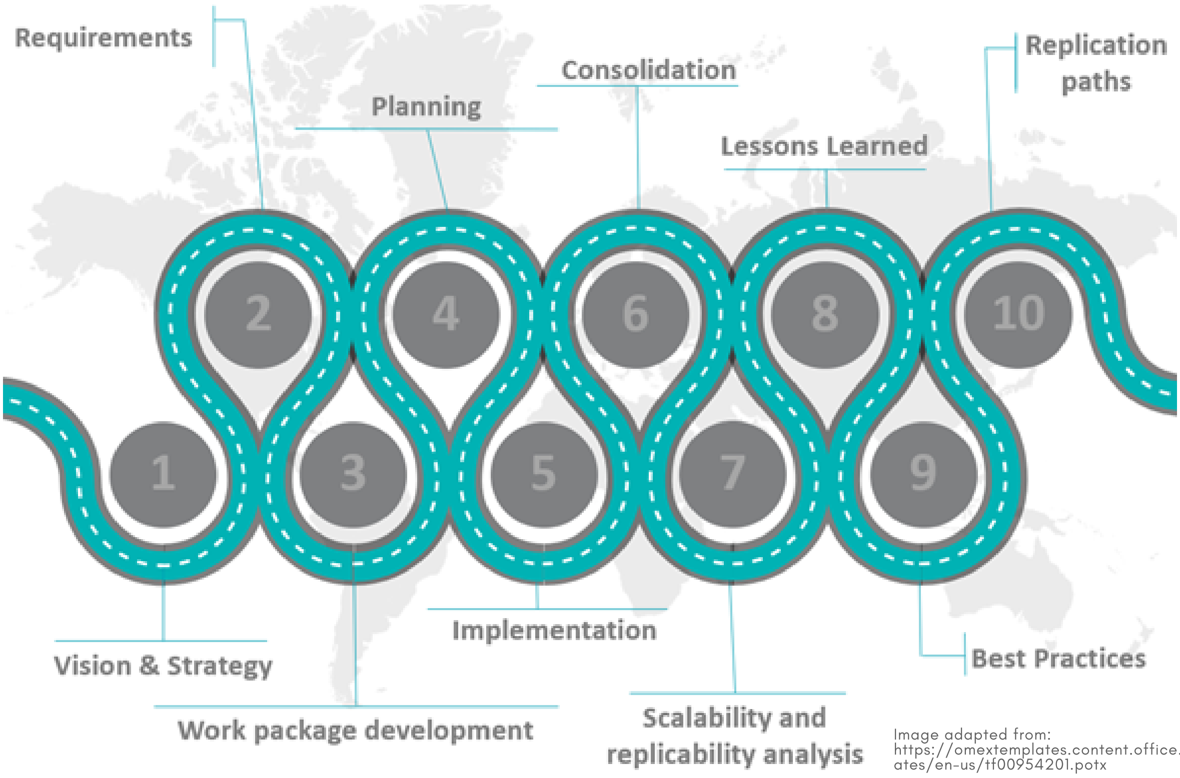


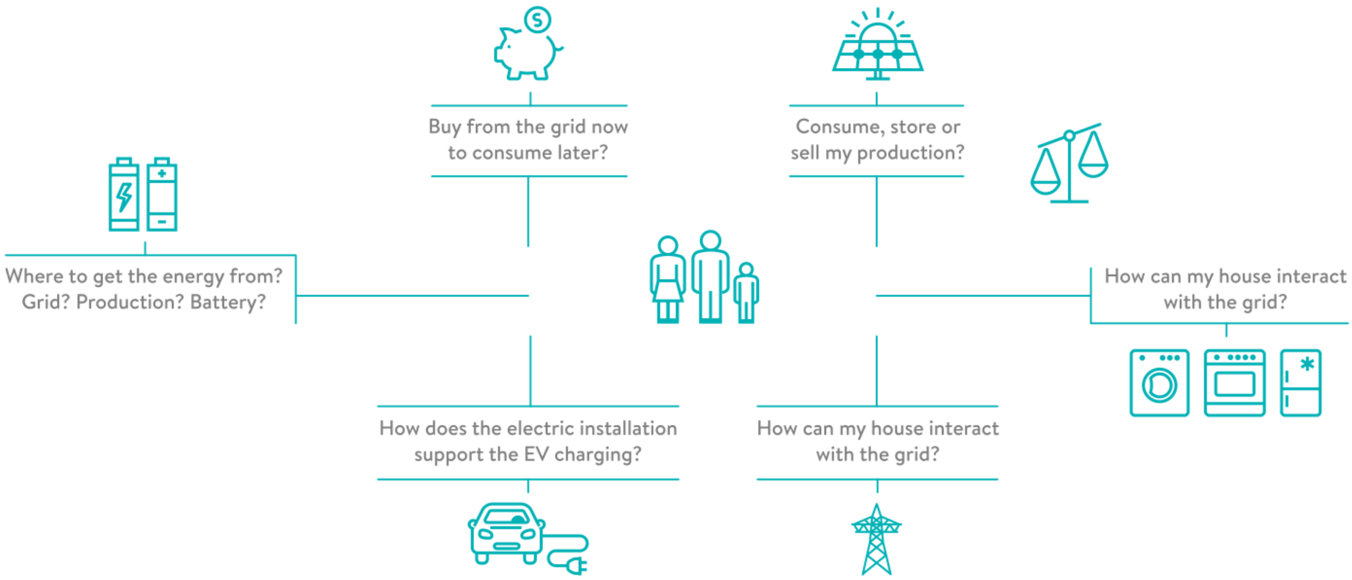
Image adapted from: https://omextemplates.content.office.net/support/templates/en-us/tf00954201.potx

The replication road map, developed within the InteGrid project, is based on the outcomes of the collaboration between system operators, service providers, regulators and customers has ensured that all stakeholders, along with each of their respective objectives, are accounted for, such that a holistic approach is achieved. The road map incorporates a set of guidelines and bests practices which are based on the outcomes of the lessons learned in order to ensure that potential risks are mitigated and that a successful endeavour is achieved. These recommendations ensure that all stakeholders are able to achieve a common objective in a fast, efficient and 'easy to follow' approach. More specifically, this road map will facilitate various stakeholders such as network owners, aggregators and flexibility owners with respect to the process required to select, plan and implement the smart grid functions and tools that have been developed within InteGrid.

VISION AND STRATEGY

InteGrid's vision is to bridge the gap between citizens and technology/solution providers such as utilities, aggregators, manufacturers and all other agents providing energy services, hence expanding from DSOs distribution and access services to active market facilitation and system optimisation services while ensuring sustainability, security and quality of supply.

integrid bridging the gap



MAIN OBJECTIVES

- To demonstrate how DSOs may enable the different stakeholders to actively participate in the energy market and to develop and implement new business models, making use of new data management and consumer involvement approaches.
- To demonstrate scalable and replicable solutions in an integrated environment that enable DSOs to plan and operate the network with a high share of DRES in a stable, secure and economic way, using flexibility inherently offered by specific technologies and by interaction with different stakeholders.

PROJECT DETAILS

Co-ordinator: EDP Distribuição

Budget: 15 Mill €

Call: LCE02

Duration: 42 months

Consortium: 14 Partners, 8 Member states

Demo locations: Sweden, Portugal, Slovenia

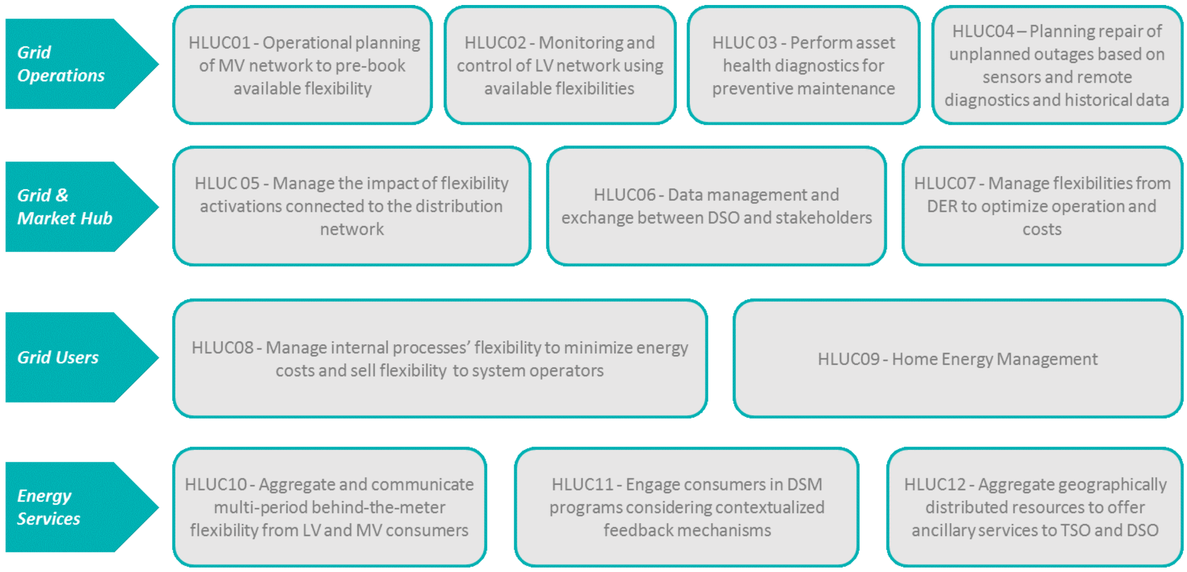
EU Commission information:

https://cordis.europa.eu/project/id/731218

PROJECT REQUIREMENTS AND DEVELOPMENT

The InteGrid project develops these requirements using the SGAM framework as a foundation to ensure the adoption of common concepts enabling scalability and replication. Through the of a technology and regulatory maturity assessment in order to obtain the current status of the network (baseline), the smart grid technology readiness level can be defined based on a technology assessment and mapping process. Furthermore, the preparation and monitoring of the demonstration activities through the use of developed KPIs is conducted in order to assess the viability of the implementation of the smart function developed within InteGrid.

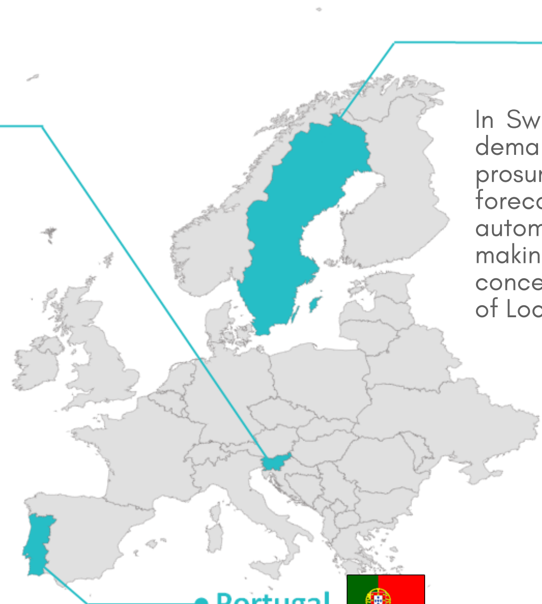
The implementation of these functions is conducted according to the project's architecture which incorporates 12 high level use cases (HLUC). These use cases are formulated within four different business domains.



PLANNING, IMPLEMENTATION AND CONSOLIDATION

Slovenia

In Slovenia, the integration of demand response, electric vehicle management, storage considerations based on a micro-grid concept was considered. The aim was to promote self-sustainability of residential and business prosumers and communities. InteGrid analysed the interaction between the DSO and energy storage through the use of a Virtual Power Plant (VPP) environment through the use of system optimization, control and forecasting algorithms and integration of a market hub for the exchange of flexibility and validation.



Sweden

In Sweden, InteGrid focused on the demand response with engaged prosumers by providing energy forecasts which facilitate home automation and informed decision making. This customer feedback concepts, was facilitated by the use of LocalLife social network.

Portugal

In Portugal, the combined operation of DER and advanced grid automation in the context of commercial and industrial customer flexibilities. Novel predictive grid management tools aimed to integrate new DER with existing assets allow for the development of an efficient and resilient distribution grid.

Image powered by Bing, GeoNames, Microsoft, TomTom

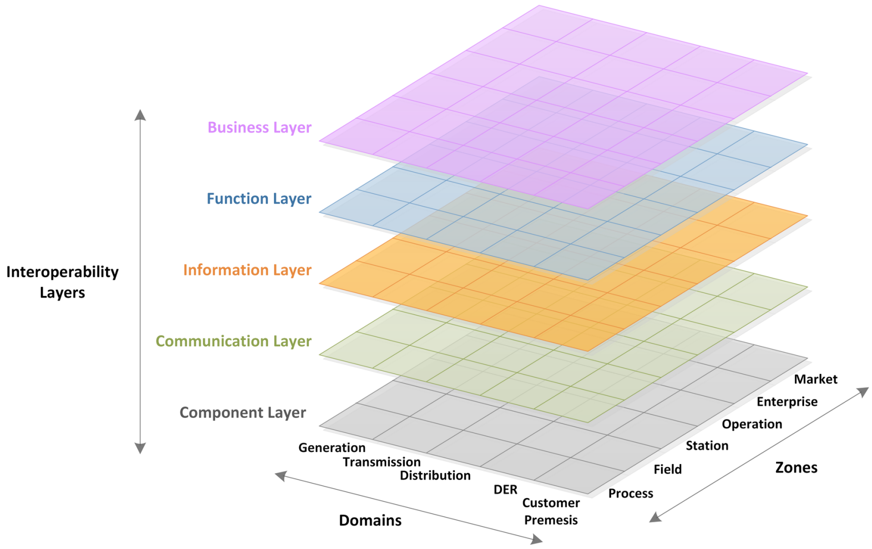
SCALABILITY AND REPLICABILITY ANALYSIS

In the case of InteGrid, scalability refers to the ability of a system, network or process to increase its size, scope and/or range to adequately meet a growth in demand. On the other hand, replicability denotes the capability of a system for being duplicated within another network, location or time. By combining these two concepts, the scalability and replicability analysis (SRA) is founded.

SGAM INTEROPERABILITY LAYERS

To capture the impact of these technologies developed with the project, it is necessary to consider several system aspects based on a multi-layer approach. These aspects can be mapped to the Smart Grid Architecture Model (SGAM) which follows the deployment of such technologies in various interoperable layers. From it, the scalability and replicability analysis considers four main focus areas for analysis, namely the functional, information and communication technology (ICT), economic and regulatory.

This enables each stakeholder to have a common reference point and develop methodologies which can be replicated along the different architectures and locations considered for the SRA. In addition, it assists the data acquisition and the data exchange internally since a common framework is used. Each of the analysis areas provides individual SRA analysis based on each of their respective objectives and methodologies. The outcomes of the SRA process, in addition to the demonstration outputs, provides the foundation for the development of a replication road map.



SGAM diagram (CEN-CENELEC-ETSI Smart Grid Coordination Group, 2012)

SRA FOCUS AREAS

FUNCTIONAL

The functional analysis focuses on the main functions and tools developed within the project. It is aimed at validating the technical integration of these technologies at the component based level. The analysis focuses on evaluating the impact of various scenarios, through simulation techniques, on various DSO networks.

ICT

The ICT analysis focuses the communication architecture using a reduced complex architecture representation provided by the SGAM in a two step analysis: a qualitative and a quantitative. The qualitative identifies potential network architecture bottlenecks and the quantitative analysis stresses them through simulations.

ECONOMIC

The economic analysis provides the cost benefit analysis based on the net present value and the initial rate of return of the implementation of the new functions and tools. The analysis provides an overview based on the economies of scale, macroeconomics and KPIs.

REGULATORY

The regulatory analysis is based on the investigation of the regulatory drivers and barriers which may be imposed within various countries in order to highlight the compatibility of these regulations during the deployment of smart grid functions.

CLUSTERING

Based on the interaction between the HLUCs, in addition to the pre-evaluation results, a total of five clusters are identified for the SRA created.

CLUSTER 01: FLEX. MANAGEMENT FOR MV

Cluster 01 incorporates the integration of a technical Virtual Power Plant (tVPP) which is used to provide the flexibility allocations from loads and renewable energy resources (RES) for the short-term management of the distribution network at the medium voltage (MV) level in order to solve network constraints (thermal or voltage based), or alternatively to provide optimised network operation (reduction of network losses). Other smart grid functions used in this cluster include the Medium Voltage Load Allocator (MVLA) and the Multi-Period Power Flow (MPOPF).

CLUSTER 02: FLEX. MANAGEMENT FOR LV

Cluster 02 considers the operation of the Low Voltage (LV) distribution network. The flexibility is achieved through the provision of the Home Energy Management Systems (HEMS) located at the customer premise. In this cluster, the DSO can book and activate these flexibilities directly, without the use of an intermediate actor such as an aggregator. The use of the Low Voltage State Estimator (LVSE) and Low Voltage Controller (LVC) is also explored as part of the tool chain.

CLUSTER 03: LARGE CUSTOMER CVPP

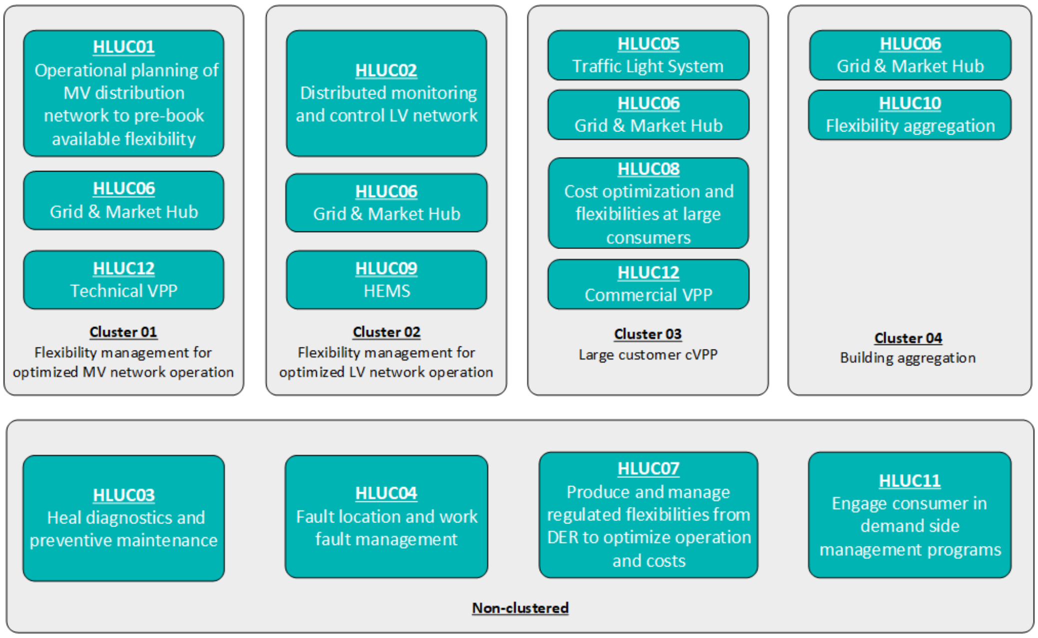
Cluster 03 embodies the use of flexibilities provided by Medium Voltage (MV) industrial customers (e.g. wastewater treatment plant) are used to facilitate balancing services such as Manual Frequency Regulation Reserve (mFRR) to the TSO through an independent commercial aggregator known as the commercial Virtual Power Plant (cVPP). The activation of these flexibilities may potentially lead to the violation of technical operational limits. To overcome this, the validation of flexibility offers, through the use of the Traffic Light System (TLS) is conducted.

CLUSTER 04: BUILDING AGGREGATION & GENERAL

Cluster 04 consists of the flexibility from commercial buildings equipped with flexible chilling systems are aggregated by a retailer in order to reduce the internal balancing cost of the portfolio or to sell it within the Automatic Frequency Regulation Reserve (aFRR) market. In this cluster the optimisation of the use of these commercial buildings is considered.

NON-CLUSTERED

Non-clustered is used to analyse the HLUC which could not form part of any other cluster. This cluster considers concepts developed for the health diagnostics and preventive maintenance planning of distribution network assets, the repair actions of unplanned outages using sensor data, historical information and remote equipment diagnostics. Additionally, the provision of a pre-qualification process which can be used by the DSO when assessing potential flexibility providers and operators is assessed and, lastly, this cluster provides an introspect into the engagement of customers which participate in demand side management (DSM) programs located at the residential level.



SRA METHODOLOGY

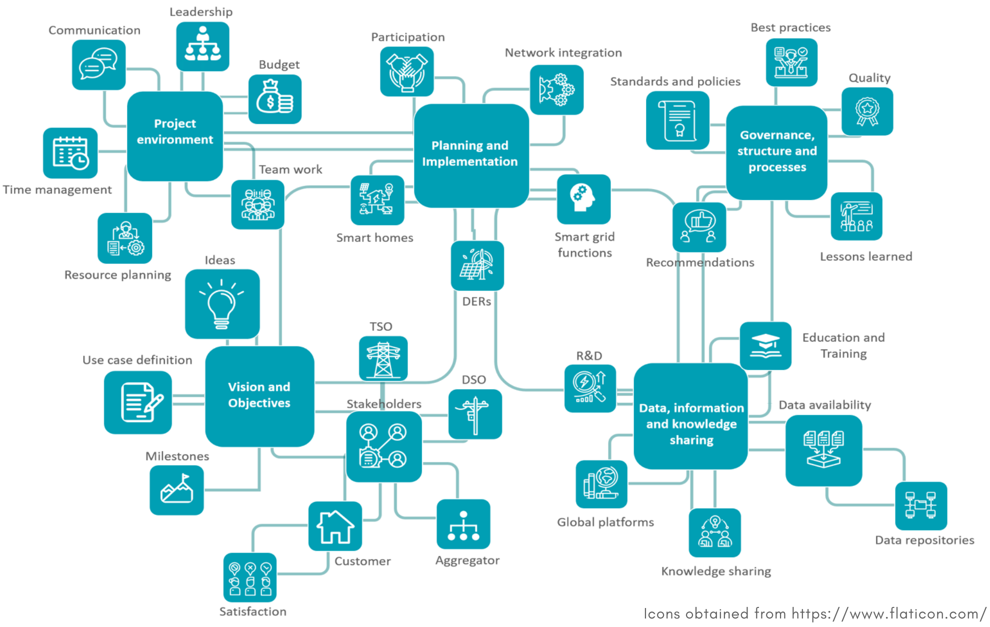
The overall SRA process adopted within the InteGrid project is based on a six-step process. Initially, the network data and inputs required for each of the focus areas are collected. In this regard, the extent of data availability and accessibility is identified. In cases where the data availability is limited, solutions based on generic generated data or alternative representative data is identified. A pre-evaluation process is performed in order to filter the requirements and identify the most relevant HLUC to be assessed based on the various areas of analysis. The definition of various scenarios to be investigated are then developed based on the main factors identified in the pre-evaluation phase by quantifying these factors with a reduced set of significant alternatives and by indicating precisely the KPIs to be considered within the analysis. The execution of the SRA is then conducted, and the results and conclusions are obtained.

LESSONS LEARNT

	CLUSTER 01	CLUSTER 02	CLUSTER 03	CLUSTER 04 AND NON-CLUSTERED
FUNCTIONAL	• OLTC helps to solve voltage problems • ESS accommodate RES in charge & discharge • Capacitor banks help mitigation • Flex. location & size is key to reduce violations • Networks are limited to a certain RES level • Lack of accuracy can lead to false activations • Need data for proper state estimation	• OLTC solves voltage violations • LVC solves voltage violations • LVC can be used • for resistive and inductive • HEMS help mitigate voltage violations • HEMS location is important • Tools computation is not a barrier • Data history is no barrier for state estimator	• Economic Optimization: Prices of flexibilities overrule their location for being activated • Current flexibilities do not cause DSO problems • Future scenarios like EV charging or higher wind penetration makes TLS necessary • Flexibilities closer to primary substation are advantaged by the TLS	• HEMS help load reduction, incentives drivers • Single households provide largest degree of flexibility • Price signal: more reliable for load reduction • Environment signal: largest load reduction potential • Accurate data for building flex. very important
ICT	• Data Storage can be seen as a driver for scaling • RTUs scheduling operation shall be kept simple • Interoperability needed specially for replication • Plug & play can help scaling speed • Security results in a more complex system • Legacy communications for RT are not suitable • Proper app. protocols increase performance	• Dedicated physical machines scale worse than cloud services • Resource optimization can help timing • Cyber security in a more complex system • Data rate is critical for RT • P2P or logic based solutions help RT scaling • PLC nodes have limits and scheduling is necessary	• Dedicated physical machines scale worse than cloud services • Resource optimization can help timing • Cyber security in a more complex system • Data rate is critical for RT • P2P or logic based solutions help RT scaling • PLC nodes have limits and scheduling is necessary	• No major scaling constraints are foreseen • Cyber security increases management complexity • Storage at field components as a long term can be an • issue or a driver for over dimension • Interoperability is needed for scaling and replicating • Microservices & cloud computing improve scaling
ECONOMIC	• Scaling is network dependent (characteristics & type) • tVPP business model not profitable as today (not enough activations) • Scaling is a driver for applications to become interesting in future as they are now just too small	• Network type (Resistive vs Inductive) importance for asset maximization of benefits • Positive results can be achieved even with moderate RES penetration • HEMS has advantages vs OLTC, however customer engagement is required • Combination HEMS + DSO assets best solution	• Positive results in SI but not in PT due to market dependency (mFRR) • SI: capacity Vs PT: only if mobilized • Number of DER & available flex extremely important, driver for scaling • PT upwards has currently high competition • Current regulation jeopardizes cVPP in PT	Secondary reserve performs better • aFRR mobilization & capacity remuneration • aFRR higher mobilization chance VS. mFRR Barriers • Pre-qualification • Bidding relation
REGULATORY	• Replicability is still limited by a strong • CAPEX-oriented regulation • Local flexibility procurement mechanisms are not in place so far • Incentives for loss reduction exist, but fail to account for the DER impact	• Conclusions from Cluster 01 also apply for Cluster 02 • Additionally, retail tariffs play an important role on HEMS adoption. So far, regulated charges and policy costs weaken flexibility incentives.	• Most mFRR markets are already open to demand participation, but practical barriers still exist • Independent aggregation faces lack of definitions in most countries • The cVPP is possible in several countries	• The aFRR market, focus of Cluster 04, is closed to demand in many countries • Product requirements for aFRR may represent a barrier for (aggregated) demand participation (e.g. prequalification, communication)

BEST PRACTICES AND RECOMMENDATIONS

The road map to reality ensures the successful deployment of smart grid technologies and is vital for the successful operation and optimization of electrical networks. In particular, the best practices attained from various SRA processes allows for the impact of such technologies, based on futuristic scenarios, to be realised prior to deployment. The best practices and recommendations are based on a high-level overview of the best practices and guidelines based on the collaboration of standard project management techniques, previous smart grid projects and stakeholder experience. These best practices are consolidated based on various categories within the project and which allow future stakeholders to become familiar with successful approaches for the implementation of smart grid technologies.



Icons obtained from https://www.flaticon.com/

FUNCTIONAL RECOMMENDATIONS

Network characteristics

- Network modularity (MV vs LV), should also be identified
- The network type, rural vs urban, resistive vs inductive etc. should be known
- The network dimension and hosting capacity should be established
- MPOPF can be used to minimise network losses by controlling the OLTC and flexibly activation

Data characteristics

- Open data among partners for tools to work and be simulated correctly and with the necessary fidelity
- Check data format to avoid tool chain problems
- Building characteristics and constraints are to be defined appropriately so ensure accurate representation

Encourage customer participation (HEMS)

- DSO shall encourage the HEMS
- Location of HEMS devices is key for flexibility provision
- Easy DSM incentives for the customer to understand and ensure active participation in the system

Establish operation priority

- Quantify of fairness: resource type, distance to node, state of charge, contract characteristics
- With dispersed network flexibilities, network losses are to be accounted for prior to flexibility activation for successful implementation of the TLS

Incorporate smart solutions & network intelligence

- OLTC should be used in combination with smart functions
- Location and availability of flexibilities are key
- Customers located at the end of the feeder in LV resistive networks are equipped with HEMS
- Dynamic pricing schemes integrated with HEMS should be implemented as far as possible to maximise load shifting
- Consideration of the capacity of the primary transformer before the activation of flexibilities via the TLS

ICT RECOMMENDATIONS

- Correct technical dimensioning of field devices
- Correct scheduling of substation devices (gateways)
- Seek interoperability (gm-Hub) & plug and play concepts
- Direct connection (P2P) links tend to scale
- Cybersecurity- check NIST and Bridge guidelines
- Check legacy systems (old meters & older technologies as 2G)
- Microservices should use virtual environment approach for cloud computing architectures

ECONOMIC RECOMENDATIONS

- Prepare a detailed list of the implementation expenditures under normal and scaling scenarios
- Perform dedicated studies to understand the best technical-economic options
- Getting to know the regulation of each country in detail to determine its fit for application
- Deploy InteGrid solutions into large-scale, since economies of scale can be generally achieved
- Considering implementing more than one cluster to the distribution business

REGULATORY RECOMMENDATIONS

- Consider the current and future publications and initiatives from the regulator.
- Consider the impact of regulatory characteristics on other focus areas of the SRA.
- Regulatory replicability may be influenced by other indirect regulatory topics such as policies and market conditions.

REPLICATION PATHS

Smart grid solutions are a collective solution which consider a wide range of fundamental aspects. Based on the SGAM framework and the identified focus areas, each offers its own replication path and key concepts for the cluster replication. However, before the replication of smart grid functions within a network, it is important to establish the current state/maturity of the network in order to assess whether their integration is feasible for both short and long-term operation. By conducting this prequalification assessment, network owners are able to establish whether there is the need for smart tool integration and identify whether their networks qualify for the replication process. In this regard, thenetwork owner can take the relevant actions required to bring their network to a reasonable state of maturity, if necessary. Therefore, two key questions identified are:

- Does the network operator/owner require the replication of the cluster in order to implement the associated tools?
- Has the network operator/owner fulfilled the necessary minimum requirements in order to ensure successful replication?

Based on these questions, the prequalification process allows for the network owner to make an informed decision whether to proceed with the replication process. In this regard, the network owner is then able to assess the condition based on a replication process which takes into consideration the specific concepts from each focus area.For each of the focus areas, a process flow is proposed, identifying the each of the respective replication paths.

This process allows for the minimum requirements for successful implementation of the smart functions and tools developed within InteGrid, to be identified. Additionally, a check list is used for the evaluation of context factors which may affect the replication process and implements a process for a mitigation strategy in order to assist in the successful replication for each cluster. An overall process flow represents the combination of each of the replication paths attained from each of the four focus areas (functional, ICT, economic and regulatory).

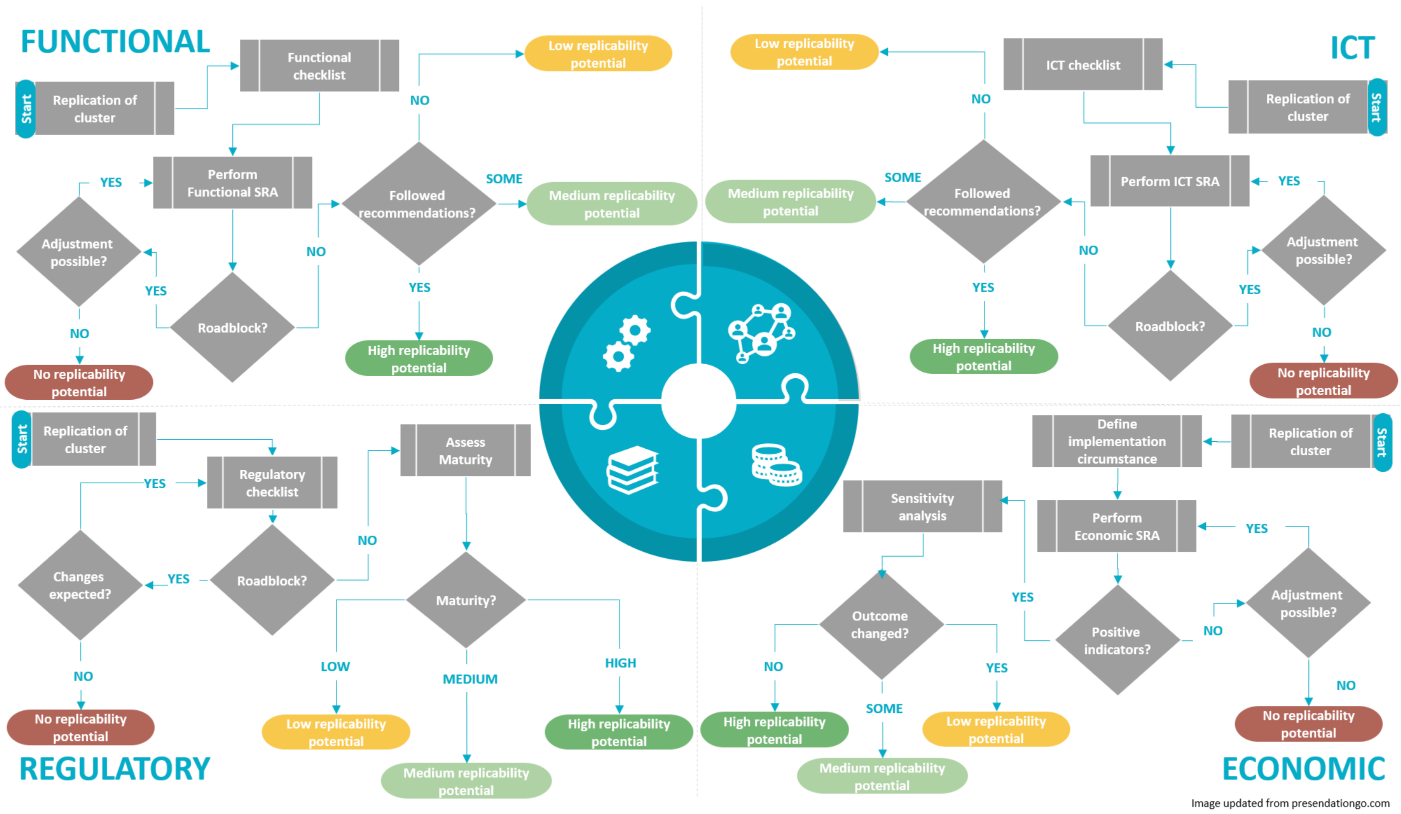


Image updated from presendationgo.com

CONTACTS

CONTRIBUTING PARTNERS

Network operators

Enablers

Aggregation

Research, Consulting & Tool developers

FOLLOW US

@integridproject

https://www.linkedin.com/company/integrid-h2020/

FIND OUT MORE

https://integrid-h2020/

https://integrid-sra.eu/

Icons made by freepik from www.flaticon.com/