OVERVIEW OF THE SOLUTIONS DEVELOPED BY THE GRID+ PROJECT FOR SUPPORTING THE EUROPEAN SMART GRIDS PILOT PROJECTS IN ACHIEVING THE EEGI GOALS: MAIN FINDINGS AND LESSONS LEARNT

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ABSTRACT

The present paper aims at summarizing the main results and the tools that were developed in the framework of the GRID+ project1 to support the work of the European Energy Grid initiatives (EEGI) and to support smart grids pilot projects in addressing the most critical issues related to the complexity of smart grids systems: gap analysis, Key Performance Indicators (KPIs), scalability and replicability (SRA) and knowledge sharing platform. The present paper illustrates the most important tools that were developed to support distribution projects and the main indications that derive from the applications of these tools to real distribution pilot projects

INTRODUCTION

The project GRID+ was set up to give assistance to the EEGI in accomplishing its goals of coordinating the European and national smart grids initiatives to ensure the implementation of all necessary actions to demonstrate smart grids technologies and their integration in the field before their wide deployment. In order to achieve this goal different tools were developed aimed at supporting the exploitation of the results of ongoing pilot projects

GAP ANALYSIS

The gap analysis exercise aimed at the identification of the contribution that the ongoing pilot projects provided to the achievement of the priorities of the EEGI roadmap and to the identification of research priorities that the future research programs should tackle to achieve the 2020 targets of energy policy. EEGI priorities for distribution were classified into the Functional Objectives (FOs) (see Figure 1). The GRID+ team identified the "maturity categories": requirements that must be fulfilled in order to ensure the large scale deployment of the innovations. Further details about the gap analysis methodology were presented in [1] . The EEGI priorities were classified according to the maturity categories and compared to the already achieved results. Based on this comparison, the GRID+ team evaluated the current maturity level of the EEGI roadmap. The results have been presented and discussed with a broad range of external stakeholders during several interaction events organized by GRID+ project.

Cluster 1: Integration of Smart customers
- D1. Active Demand for increased network flexibility
- D2. Enabling maximum energy efficiency in new or refurbished urban districts using smart distribution grids

Cluster 2: integration of DER and new users
- D3. Integration of DER at LV
- D4. Integration of DER at MV/HV
- D5:. Integration of storage in network management
- D6: Integration of infrastructure to host Electrical Vehicles

Cluster 3: Network operation
- D7: Monitoring and control of LV networks
- D8. Automation and control of MV networks
- D9. Network management methodologies for network operation
- D10. Smart metering data utilisation

Cluster 4: network planning and asset management
- D11. New Planning approaches for distribution network
- D12. Novel approaches to asset management

Cluster 5: Market Design
- D13. Novel approaches for market designs

Figure 1 – EEGI roadmap for distribution (source: [1])

The validated results are reported in Table 1 (whose columns represent EEGI FOs, rows are the "maturity categories").

Short description	Color
Not relevant	
Ready to deploy at large scale	
Need more demonstration to validate maturity	
Need development (work with manufacturers)	
Requires more research (work with R&I institutes)	

1 GRID+ is a Coordination and Support Action which has been created for providing operational support for the development of the European Electricity Grids Initiative (EEGI).It started in November 2011 and ended in November 2014. The Project addresses the five remaining critical issues regarding the electricity system: costs, benefits, KPIs, knowledge sharing, and financing involving all stakeholders. This ensures a rational, fluid, and stable EEGI workflow in order to safely reach the 2020 European goals.

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13
Hardware													
Software tools													
Integration into the system													
Business model													
Assessment of system reliability													
Regulatory framework													
Stakeholders involvement													
Data privacy													

Table 1 - Synthetic outcome of the distribution gap analysis (source: [1])

Major gaps in domains related to: integration in the systems assessment of system reliability the FOs that require more efforts are:

- D12 Novel approaches to asset management (all red)
- D5 Integration of storage in network management and D6 Integration of infrastructure to host Electrical Vehicles (even if progress were made w.r.t the situation reported in the ERA-net report)
- D3 Integration of DER at LV
- The most advanced maturity category is HARDWARE
- In the categories "regulatory framework"; "stakeholders involvement"; "business models" level 2 have been often assigned.
  - In these categories fundamental research with the academia must be closely connected to the actual performances of the networks.
  - Pilot projects involving real networks and customers have to be realized in order to obtain realistic figures and measured performances.

KEY PERFORMANCE INDICATORS (KPIS)

Key Performance Indicators (KPIs) were developed by the GRID+ project to monitor the contribution of each single innovation project to achieving the specific objectives of the EEGI roadmap [2]. The structure of the KPIs proposed by GRID+ includes two categories of KPIs: Implementation effectiveness KPIs, which measures the completion of the EEGI R&I Roadmap and are reported in the EEGI implementation plans; and Expected Impact KPIs, which measure the benefits achieved by European R&I projects and are split into three levels: Overarching, Specific and Project KPIs.
the allocated budget.

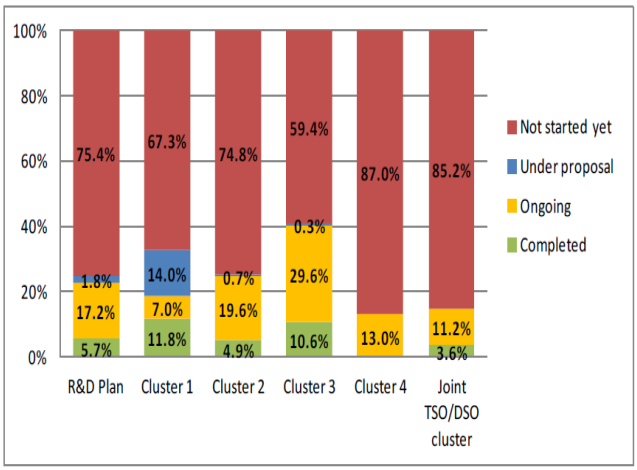

Figure 2 – EEGI Implementation effectiveness KPIs (source: [3])

The Expected Impact KPIs are structured into three levels which follow a top down approach.

- Overarching KPIs: limited set of network and system performance indicators which provide a very high level understanding of the benefits that would be achieved at a system level thanks to the contributions provided by European R&I projects and will be evaluated. These KPIs are: increased network capacity at affordable cost and increased system flexibility at affordable cost.
- Specific KPIs that determine the progress of several technical parameters relevant for network operators in order to reliably achieve their overarching goals within the different Innovation Clusters and Functional Objectives of the EEGI Roadmap
- Project KPIs that are defined by each project and assess the results of individual projects

The final list of EEGI KPIs include:

- B.1 Increased RES and DER hosting capacity.
- B.2 Reduced energy curtailment of DRES
- B.3 Power quality and quality of supply.
- B.4 Extended asset life time.
- B.5 Increased flexibility from energy players.
- B.6 Improved competitiveness of the electricity market.
- B.7 Increased hosting capacity for electric vehicles (EVs) and other new loads.

These KPIs are not intended to be used for selecting innovation projects, or for ranking project results. They intend to quantify the contribution of (R&I) results in achieving EU policy goals. The proposed KPIs can therefore be used to monitor the contribution of each single innovation project to achieving the specific objectives of the EEGI R&I Roadmap. Table 2 maps their correspondence with the pillars of European energy policy and EEGI roadmap.

EEGI Specific KPIs	Compliance with EU energy policy goals		
	Sustainability	**Market competitiveness**	**Security of supply**
B.1	X	X	X
B.2	X	X	X
B.3.	X	X	X
B.4			X
B.5.		X	X
B.6		X	
B.7.	X	X	X

Table 2 – List of EEGI KPIs and correspondence with EU energy policy goals

The indicators are currently being used by the FP7 funded IGREENGrid for evaluating the KPIs at programme level and addressing the scalability and replicability of R&I solutions related to EEGI Roadmap objectives. Moreover several feedbacks were gathered by external stakeholders about the proposed KPIs framework. The feedbacks proved the EEGI KPIs are relevant to ongoing projects and EEGI related activities. Using suggestions from other projects further recommendation on the application of the KPIs and additional examples of possible calculation methodologies were elaborated. These include recommendations on where the KPIs could be applied within a Research and Innovation (R&I) programme and what type of calculation methods could be expected. Moreover the risks to large scale deployment and representation of uncertainties were taken into account by suggesting methodologies for sensitivity analysis. Not only does this provide an approach for numerically representing uncertainty, it will also provide a mechanism for quantifying the impacts of the various uncertainties which could be shared with the relevant stakeholder to assist any decision making process. A more practical calculation approach based on network planning is also suggested for the Improved Hosting Capacity indicator.

SCALABILITY AND REPLICABILITY (SRA)

The SRA in the framework of GRID+ project aimed at assessing ex ante the scalability and replicability potential of the smart grid projects of the EEGI and to propose methods and tools for this purpose. In the first part of this work a review of the state of the art of scalability and replicability considering complex systems (nuclear, aviation, TLC etc.) and smart grid projects was conducted. The exercise resulted in the identification of inherent factors influencing scalability and replicability and of other aspects (technical and economic) making scaling-up and replication worthwhile (see the second columns of Table 3and Table 4). These elements were used to elaborate a methodology and a related questionnaire aimed at developing a tool that enables an ex ante evaluation of the scalability and replicability potential of a smart grid project. Two ad hoc questionnaires were developed (one for transmission and one for distribution) and distributed to relevant smart grids projects for assessing if the project proposals have incorporated the minimum criteria for ensure a smooth roll out of the solutions tested and for identifying the potential gaps and needs for improvements. The questionnaire was transformed into an online tool that could be used by project leaders for a self-assessment of the SRA potentials of their demos. It also serves to analyze the answers to these questionnaires. A global overview of all projects is presented by averaging the scores obtained by answering the questionnaires. The average score is compared to the ideal and the minimum score. In Figure 3 an example of outcome is reported.

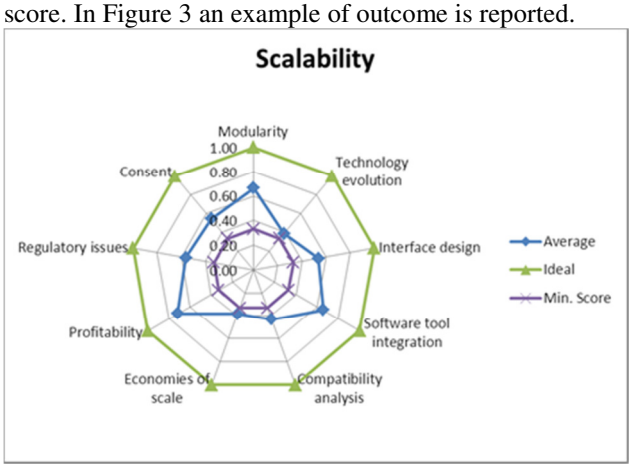

Figure 3 - Example of average scores of scalability and (source: [4])

The questionnaire was distributed to several smart grids pilot projects (e.g.: GRID4EU). The feedbacks gathered were used to identify the areas in which the future R&I activities shall focus to close the remaining gaps of SRA have been identified (see Table 3 and Table 4).

From the results reported in Table 3and Table 4 the following main barriers can be detected:

- Technical limitations: the most important barriers perceived by projects are related to:
  - equipment cost (but it is does not depend on the project itself only;
  - IT/data security and missing standardization of control signal and information flow from/to distributed generation. Advances in data handling capacities are likely. Modest score together with the uncertainty of predicting technology evolution reduces the importance of the barriers arising from the limitation of this factor.

- interface design: its impact is reduced since the factor scores modestly because certain solutions (EMS, DMS, market, etc.) prefer or require a centralized control. The factor is project and solution dependent and can be handled by the project in a rather straightforward way.

- Economic limitations: market design was indicated as a limitation. It arises from the dependency on local legal and regulatory frameworks, lack of remuneration rules and the absence of analysis to this end. The best solution for market design can be directly influenced by the project, whereas its influence on regulatory process is rather small.
- Regulatory and stakeholders related limitations. The average and high scores given to these factors, respectively, points out that despite the large estimated importance of stakeholder involvement, stakeholder involvement is expected to be a major challenge, after all regarding the scaling up of the project and its applications. However, projects expect that a positive result of a solution improves replicability. It seems important that all stakeholders can make use or are willing to use the newly proposed solutions/applications in order to be able to create the necessary societal support. Legal rules might be needed to involve stakeholders.

Limitation	Scalability	
Technical limitations	Modularity	Communication capacities
		Computation memory
	Software tool integration	Big data
	Compatibility analysis	Presence of weak elements
		Physical size
	Interface design	Depends on project nature and focus
	Technology evolution	Expected equipment costs
		IT/data security
		Missing standardization of control signal and information flow from/to DG
		Big data
Economic	Profitability	Uncertainty remuneration
		Focus on feasibility
	Economy of scale	No detailed cost-benefit analysis
Regulatory & stakeholder	Regulatory issues	Data confidentiality
		Lack of rules to provide service
		Lack of rules for interaction
	Consent	Change customer behavior
		Stakeholder opposition or hesitancy

Table 3 - Limitation and challenges with regard to scalability factors

As general conclusions, it can be said that barriers arising from technical factors can be most easily overcome by the projects; the influence on the lifting of barriers of economic and regulatory and stakeholder-related factors is limited and requires considerable efforts.
More details about the scaling up and replication methodology are reported in [4].

	Replicability	
Technical limitations	Standardization	New non-standardized services
		Proprietary standards
		Ability for standard-conform implementation
	Interoperability	Customized implementation
		Provider-specific applications
		New non-standardized services
	Network configuration	Focus/dependency on resource
		Load/generation mix and situation
		Infrastructure needs
		Demographics
Economic limitations	Business model	Uncertainty remuneration
		Lack of rules to provide service
	Macro-economic factors	Lack of analysis on macroeconomic factors
		Lack of plans to export solution
	Market design	Dependency on regulatory framework
		Uncertainty remuneration
		No corresponding analysis
Regulatory & stakeholder	Regulation issues	Non-existing or strongly varying regulatory and legal framework
	Acceptance	Change customer & operator behavior

Table 4 - Limitation and challenges with regard to replicability factors (source: [4])

Knowledge sharing platform (KSP)

The GRID+ project elaborated an online tool, the Knowledge Sharing Platform, with the aim to facilitate knowledge flows and exchanges among new, ongoing or completed R&I projects contributing to the EEGI roadmap and willing to fill in the KSP. The KSP consists in a virtual library '*Gridinnovation online*' (www.gridinnovation-on-line.eu). *Gridinnovation online* was presented at the Brussels InnoGrid2020+ meeting in March 2014. In this website new knowledge generated from innovative smart grid projects, in line with the functional objectives of the EEGI roadmap, is made available. The new knowledge is shaped in the form of articles interconnected via hyperlinks. All articles are structured in the same way in UK English. The backbone of any article remains unchangeable and systematically contains a list of paramount information.
Three main categories of articles that will be accepted in the KSP have been identified:

- State of the art article: The new knowledge is positioned within a state-of-the-art framework, in order to provide a comprehensive view of the projects and the new R&I outputs. It is assumed there will be up to as many state-of-the-art articles as functional objectives stated in the EEGI roadmap.
  - Project article : A project article is related to a specific project that addresses various challenges of a cluster. Its content provides the general description of the project and links to the related knowledge articles
  - Knowledge article : a Knowledge article is devoted to one specific R&I result. Its content

provides the general description of the research output (the new knowledge) and refers to a state-of-the art article. Each article is associated to a set of tags (hyperlinks) which allow implementing search functions and hyperlink navigation (for the knowledge seeker).

Project leaders that want to contribute to the portal are required to select one of the templates and to insert the required information. The online template represents the first step of a six-step process between knowledge provider and the reviewer illustrated in Figure 4 - .

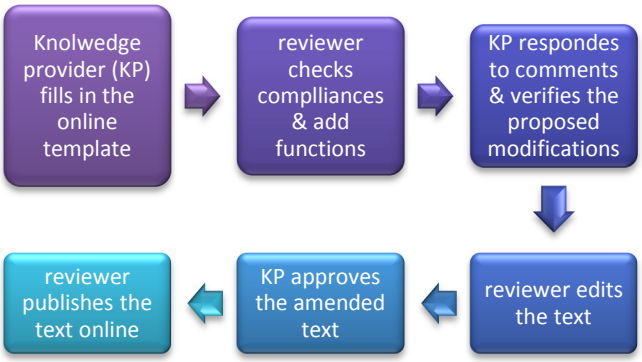

Figure 4 - Process for editing articles in the KSP (source [5])

The portal consists of three distinctive web pages:

The **Home Page**: it meets the requirement of seeking the knowledge and contains the search engine tool. The searching process consists using tags, either by performing a free or a guided search to obtain a list of relevant R&I results;

The **Knowledge Page**: it addresses knowledge and dissemination issues and hosts the data base of the KSP. This database is developed according to a "delivering template" which empowers knowledge holders to input their R&I results and the set of articles in a consistent way. The corpus of articles consists of project articles associated to state-of-the-art and knowledge articles. It represents the core of the KSP;

The **Community Page**: it enables various stakeholders to share information within a networking area.

In October 2014 64 articles (including 32 DSOs topics) were included in KSP. The articles reported the results of ongoing and pasts EU and national funded projects are reported in Figure 5-. Thanks to the contributions of several project leaders the KSP demonstrated in these months to be a powerful to that simplifies the knowledge exchanges and the dissemination of projects results by providing a standard online platform that could be easily accessed and maintained by knowledge providers and knowledge seekers.

EU supported projects	SusTainable, S3C, Meter-ON, ADVANCED, ADDRESS, evolvDSO, GRID4EU, REServices, SESAME, DISCERN, Market4RES, EcoGrid
National projects	SGMS, E-DEMA, eTelligence, MeRegio, Moma, RegModHarz, Smart Watts, MBI.
Pending projects	iGREENGrid, KIC SAGA, BestGrid

Figure 5-Projects that contributed to KSP (source [5])

Further efforts will be needed to maintain the platform alive after the end of GRID+. The support of project leaders will be in future a key element for the success of the tool.

CONCLUSIONS

The GRID+ project developed a list of toolkits that could be used by project developers and decision makers for identifying the best practices of pilot projects and bring them at European value, for identifying the R&I priorities of transmission and distribution with a coordinated and consistent approach; for mapping results of R&D projects and detecting gaps and for fostering interactions and knowledge exchange. Thanks to the contributions of stakeholders and other projects, these tools had proved to be relevant to ongoing projects and EEGI related activities. Further research is needed in order to update the already achieved results; to further develop the available tools that will enable to obtain a common vision on priority settings and will ensure an active pan European collaboration on networks, ensuring a dialogue between project leaders and Public Authorities.

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