Analysis of the on-going Research and demonstration Efforts on Smart Grids in Europe

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ABSTRACT

The present article summarizes the results of the exercise of analysis of the on-going Research, Demonstration and Deployment efforts in the field of Smart Grids in Europe, [1] produced in the framework of the European project GRID+ [2]. This exercise resulted in the definition of a new methodology for analysing and mapping the results achieved by the on-going smart grids demonstrators with respect to the priorities declared in the EEGI roadmap [3]. This analysis supports the EEGI in identifying the aspects that are already addressed by on-going projects and avoiding unnecessary duplications of work and provides the readers with clear indications for preparation of the future projects, highlighting research priorities that need to be further analysed by future large scale demonstrators. The article describes the motivations that justify this exercise; the methodology and the results of the mapping exercise and it concludes with some indications about the future steps of the gap analysis carried out by GRID+ project.

INTRODUCTION

On the way towards a low-carbon future, electricity networks are considered as an enablers and one of the critical areas to be covered under the Strategic Energy Technologies Plan (SET Plan). The first European Electricity Grid Initiative[1] (EEGI) Roadmap 2010-2018 [3] was approved by the European Commission and the Member States alongside the creation of EEGI in June 2010. The EEGI Roadmap defines the research, development and demonstration (RD&D) activities that both European transmission and distribution system operators will carry out in the next years with the aims to face the challenges connected to the evolution of power systems and to respond to different external factors. In October 2010, the project GRID+ was launched with the aim to provide operational support for the European Electricity Grids Initiative (EEGI). The Project aims at ensuring a rational, fluid, and stable EEGI workflow in order to safely reach the 2020 European goals. It provides the necessary support to the EEGI Team by bringing together and structuring a team of top level players (research centres, SMEs, universities), in coordination with the European network operators associations: ENTSO-E and EDSO4SG. However the R&D activities defined in 2010 and carried out at European and national levels need to be updated since the context is changing rapidly. In order to ensure the coordination between the RD&D projects and the EEGI priorities, the members of GRID+ team carried out an analysis aimed at understanding how such projects contribute to the EEGI Roadmap, to identify R,D&D gaps and to understand the aspects to be addressed to fulfil the EEGI research plan.

[1] The European Electricity Grid Initiative (EEGI) is one of the European Industrial Initiatives under the Strategic Energy Technologies Plan (SET-PLAN) and proposes a 9-year European RD&D programme to accelerate innovation and the development of the electricity networks of the future in Europe.

WHY THIS EXERCISE IS NEEDED

The EEGI roadmap classified the RD&D activities in a hierarchy of clusters and functional projects, for both transmission (TSO) and Distribution System Operators (DSO) (Figure 1 and Figure 3, where Tn and Dn are the projects related to transmission and distribution, respectively). A cluster is a set of functional projects dealing with common issues that need to be managed all together to avoid overlaps and guarantee the complete coverage of these issues. A functional project (FP) is a description or definition of demonstration and/or research activities needed to reach specific functional goals, and includes budget figures and expected outcomes [3].

Figure 1 – EEGI structure for the analysis of Tn projects (source: elaboration from [3])

The EEGI roadmap comprises also a cluster of joint TSO/DSO RD&D activities.

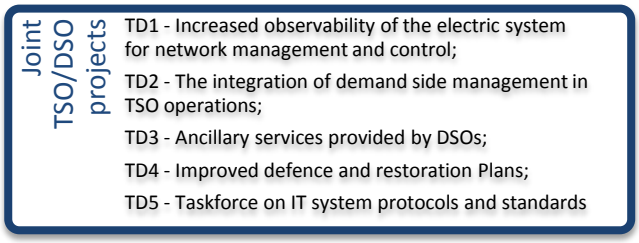

Figure 2 – EEGI structure for the analysis of Tn/Dn RD&D activities (source: elaboration from [3])

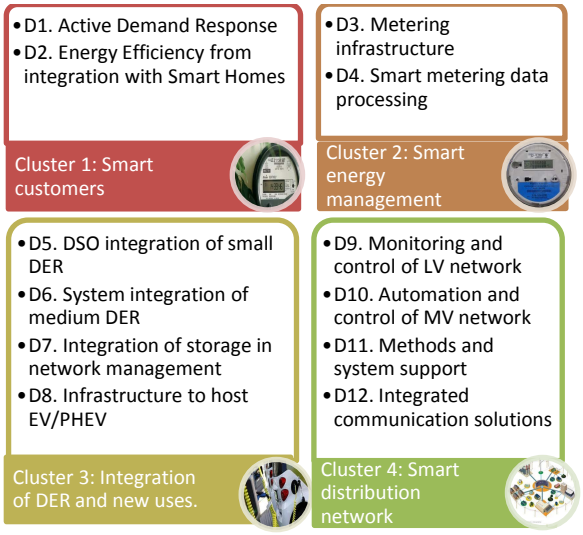

Figure 3 – EEGI structure for the analysis of Dn. projects (source: elaboration from [3])

The structure illustrated in Figure 1, Figure 4 and Figure 3 enables a clear classification of the ongoing RD&D efforts however it does not highlight the efforts that have been carried out in the different projects with respect to some common issues that are fundamental for the large scale deployment (e.g.: cost benefit analysis, system integration, reliability evaluations, etc.). The evaluation of these transversal aspects represents an important input for the quantification of the contribution provided by each local demo towards the general EEGI targets, for the assessment of the maturity level reached by each functional demo and for the identification of the research priorities that the future research programmes should tackle in order to drive the optimal exploitation of the results of local demos towards large scale deployment. In order to overcome this limitation the GRID+ consortium introduced an additional "transversal layer" composed of a number of "domains" that represent the common issues among different functional projects. These domains were introduced into the EEGI structure adopting the following methodology for classification and gap analysis.

CLASSIFICATION AND GAP ANALYSIS: METHODOLOGY AND RESULTS

The final goal of the mapping exercise is to deliver an updated map of major Research, Development, and Deployment (RD&D) activities in Europe in the field of smart grids mapped against the priorities of the EEGI roadmap. In order to achieve this goal two main tasks are required, for which an innovative methodology must be defined: the classification of the results of the EEGI projects at the light of the priorities expressed in the EEGI roadmap and the gap analysis.

Inputs for the definition and for the application of the methodology

The GRID+ consortium defined the GRID+ methodology for classification and gap analysis on the basis of the following references: the presentation "Modern Grid Strategy Overview" by the National Energy Technology Laboratory [4]; the "Smart Grid Maturity Model" by the Carnegie Mellon University and the Software Engineering Institute [5] the article "Measuring the "Smartness" of the Electricity Grid" [6]; The report "Mapping & Gap Analysis of current European Smart Grids Projects - Report by the EEGI Member States Initiative: A pathway towards FPs for distribution grids" prepared in the framework of the ERA-net initiative [7].
As for the inputs for the application of the methodology, the information about the results achieved by the on-going and past demonstrators in the transmission sector were derived from the ENTSO-E Monitoring report [8], that provides an accurate tracking of all the RD&D projects within ENTSO-E member TSOs, and by further elaborations of these results prepared internally by ENTSO-E. The information about the distribution projects were provided by the following documentation: the JRC database [9] that collects the information of 203 smart grids demonstration projects and the ERA-net report that collects and reviews the results of ongoing demonstrators [7]. The analysis carried out by GRID+ does not describe the details of each demos but aims at assessing the current maturity levels achieved by the transversal aspects that are relevant to each European project and are fundamental steps for a full smart grid deployment.

The classification exercise

The GRID+ methodology for classification consists of two activities: identification of the «domains» for a transversal analysis of transmission and distribution FPs and the definition of the topics included in each domain for each FP. For the definition of the domains, the GRID+ team have selected from the list of possible characteristics and metrics described in the literature, those aspects that fulfill the following requirements:

- They are orthogonal to the vertical structure proposed by the EEGI that includes FPs and clusters.
- They should be applicable to the vast majority of FPs (some domains might not be relevant to all the FPs).
- The number of domains should be limited, however

the final set of defined domains must allow to classify all the goals of each FP described in the EEGI roadmap and of the different RD&D projects, avoiding any redundancy.

- They contain logical groupings of incremental smart grid characteristics and capabilities that represent key elements defined in the Roadmap: grid planning, development, operation, management.

This activity resulted in the identification of a final list (illustrated in Table 1) that includes three kind of domains: commons TSO and DSO domains, DSO-specific domains and TSO-specific domains.

Domains	TSO	DSO
Hardware	x	x
Software tools	x	x
Integration into the system - technology integration/ interoperability & standardization	x	x
Market designs	x	x
Cost benefit analysis (CBA) - business models	x	x
System reliability	x	
Grid services regulation	x	
Stakeholder involvement	x	
Customer involvement		x
Privacy issues		x
Better planning of future network		x

Table 1 – List of GRID+ domains (source: [1]).

The second activity included in the classification exercise consists in the definition of the topics included in each domain for each FP. The experts from the GRID+ team have grouped the objectives that were described in the EEGI FPs according to the definitions of domains. This extensive effort resulted in the definitions of different matrices (one matrix for each FP). The rows of those matrices correspond to the domains, while in each cell of the second columns of each matrix describe the goals declared in the EEGI roadmap for the specific FP that are applicable to the specific domain. The same structure has been used also for classifying the results of the ongoing and already concluded projects. The results of these analyses have been taken as an input for the quantification of the maturity level of the EEGI goals.

The gap analysis

The GRID+ methodology for gap analysis consists of two activities: the quantification of the maturity level of each domain in each FP and the identification of the EEGI priorities not yet covered by on-going projects and the elaboration of inputs for future research programs.

Quantification of the maturity level

The GRID+ team adopted, for the gap analysis of distribution projects, the ranking scheme and the indications reported in [7] where the evaluation of the maturity level of these projects has been carried out organizing specific workshops with the leaders of the different demos and with other smart grid stakeholders that provided their feedbacks on the maturity level of the EEGI roadmap achieved with the contribution of the European demonstrators. In order to avoid unnecessary duplications of works, these indications have been reallocated according to the extended list of domains proposed by the GRID+ scheme. The assessment of the maturity level of the transmission part of the EEGI roadmap has been carried out by the experts of the working group Monitoring and Knowledge Sharing (WG MKS) of ENTSO-E. The scheme adopted for the ranking of distribution projects could not be adopted for the analysis of transmission and joint TSO/DSO projects. In fact, the "level 1" of this ranking scheme highlights those research aspects for which specific results have already been achieved by some demos, but there is still the need to foster the diffusion of these results among the smart grid stakeholders. In the transmission sector this specific requirement is already included in the mission of ENTSO-E. For this reason, an alternative scheme for the ranking of transmission projects has been adopted. The two ranking schemes are described in Table 2.

MEANING IN DISTRIBUTION ANALYSIS	MEANING IN TRANSMISSION AND TSO/DSO ANALYSIS	
Not relevant	Not relevant	
No needs identified	Ready to deploy at large scale	
Exchange of info is needed	Need demos to validate the maturity	
Objectives partially met; addressed by existing demos	Need moderate development (work with manufacturers)	
Obj. not met; included in few demos	Need more research (work with research institutes)	

Table 2 - Ranking scheme proposed for the gap analysis of distribution and transmission projects (source: [1])

Table 3 describes the result of the analysis of transmission projects: that gaps are mostly related to the domains of regulation, interaction with other stakeholders and system reliability. Future calls should finance research projects on these topics. Software tools and system integration, in several FP, are already at level 2; future calls should be focused on pilot projects investigating these domains. The FPs that require globally more efforts are related to the technologies for network flexibilities (T3) and to the T&D interface. Table 4 summarizes the results of the analysis of the distribution sector. Major research needs emerged in the technological field and on the framework needed for new structures (market mechanisms; common standards; cost-benefit analysis). On the technological side, many gaps have been identified in the low voltage grid area: (e.g. lack of monitoring data via simulation models; interaction with MV networks). Research activities on grid integration of storage and EV are limited by high costs; however recently some projects related to EV have started. More projects are needed on the integration of ICT systems into open service platforms and on the testing the latest communication technologies for system

control and automation. Many results of various projects (EV, Active demand and DSM, voltage control) will be obtained in the next years; the exchange of the knowledge and results to a broader audience should be incentivized. Research on standardization and data privacy rules should be developed and implemented at European scale. The results of these analyses have been used by the GRID+ consortium for the revision of the EEGI roadmap: e.g. the functional project D3, that includes several aspects that require only further exchange of information, has been excluded from the FPs listed in the updated EEGI roadmap. Detailed analyses of the results are reported in [1].

DOMAIN	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	TD1	TD2	TD3	TD4	TD5
Hardware																		
Software tools																		
System integration																		
Market des.																		
CBA																		
Grid services regulation																		
Stakeholder. involvement																		
System reliability																		

Table 3 -Maturity level of transmission projects (source [1])

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12
Hardware												
Software tools												
Technology integration												
Interoperab.&standard												
Market Design												
business scenario												
Custom. involvement												
privacy/data security												
Improved planning												

Table 4 - Maturity level of distribution projects (source [1])

Identification of the EEGI priorities not yet covered by on-going projects

The results of the gap analysis will be used for the elaboration other tables, that will describe the maturity levels that the members of the GRID+ project would like to achieve with the contributions of the projects launched with the calls that will be published by the European Commission in 2014. This "wish list" will then be compared with the specific EEGI priorities indicated in each FP. The GRID+ team will quantify the expected maturity level of the EEGI thank to the contribution of future projects and will prepare detailed descriptions of the priorities to be addressed in each FP and domain.

CONCLUSIONS AND OUTLOOK

The paper describes a methodology and first results of gap analysis of the EEGI Roadmap 2010-2018, an important deliverable defining RD&D activities towards smart grids. The gap analysis gives European TSOs and DSOs clear indications about the activities that should be prioritized. The results should be updated regularly and discussed with other relevant stakeholders in order to obtain a more generalized consensus on the evaluations presented in this article and to identify the next steps needed for closing the gaps. Upgraded versions of the EEGI and of JRC database will be released in 2013; the gap analyses reported in this article then will be updated. However, the results described in the present article are still valid: the updates of the EEGI roadmap keep similar structures introducing minor changes of the priorities.

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