SMART GRIDS IMPLEMENTATION PLAN IN SLOVENIAN DISTRIBUTION NETWORKS

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ABSTRACT

The paper presents a proposal for the implementation of smart grid concepts in Slovenian distribution networks. The most relevant technologies and concepts are indentified, an implementation plan is proposed and costs are evaluated. The results show, that the long-term cumulative investments in distribution grids would be lower with the introduction of smart grids when compared to the traditional approach.

INTRODUCTION

In order to have a sense of scale, some basic data describing the Slovenian electrical power system are presented. The total installed power of all power plants is 3,400 MW, the consumption in 2011 equalled to 12.7 TWh, and electricity production from distributed generation (DG) covered around 6 % of the consumption. There are five distribution companies in Slovenia and around 925,000 consumers. A distributed generator, according to the Slovenian legislation, is a power plant with an installed power of less than 10 MW that is connected to the distribution network. According to the National Energy Programme [1], annual peak consumption growth is predicted in the range of 2 - 5 % per year, and additional 1,500 MW of DG is foreseen until 2030. The installed power of DG in 2012 was approximately 470 MW.

Smart grids represent an evolution of nowadays distribution grids. The main drivers for their introduction in the Slovenian distribution system include:

- the country commitments to increase its share of renewable energy and reduce CO_2 emissions,
- the need to at least maintain the present level of power quality with rising share of DG,
- the need of the Slovenian industry in the energy and electronics sectors to acquire references at home in order to be able to sell their products abroad,
- and finally, to lower the cost of investments in distribution networks.

Based on the current distribution system operators (DSO's) investment plans for the period until 2020 [2], around 4.2 billion € of new investments will be needed in the Slovenian distribution networks without taking into account smart grids. Major reasons for investments, as shown in Figure 1, are an aging infrastructure, growth of peak demand, power quality and costs due to connection of DG. The costs for the period 2021 – 2030 were based on the extrapolated costs from the 2020 with the addition of costs due to the growth of DG share. Figure 2 shows the share of main costs in the cumulative investments in the distribution grids until 2030.

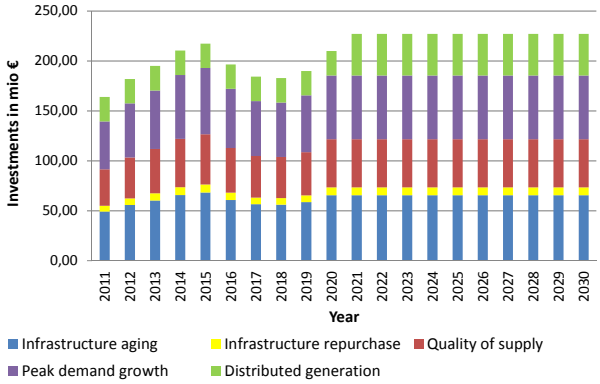

Figure 1: Structure of investments in distribution grids from 2011 to 2030

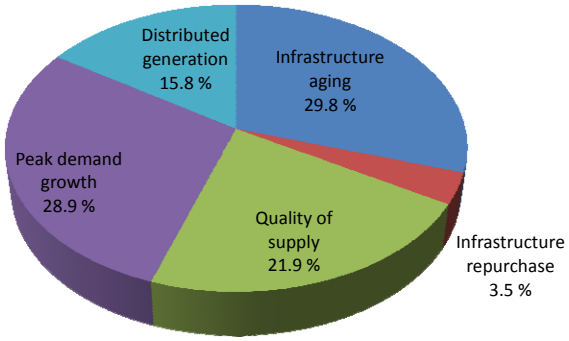

Figure 2: Share of main costs in cumulative investments in distribution grids until 2030

GOALS OF THE SMART GRIDS IMPLEMENTATION PLAN

The main goal of the Smart Grids (SG) Implementation Plan [3] is to provide a basis for the national consensus on the development of smart distribution grids. The plan should enable unification of terminology in the field, provide a specification and definition of most relevant smart grids concepts and define an implementation plan for large-scale deployment of the selected concepts.

The main criteria for the selection of relevant projects were the required investments in the network and the effect of such investments on long-term network costs. The selected projects should decrease long-term investments in distribution networks when compared to the so-called traditional solution involving network reinforcement.
One additional goal of the plan is to enable the domestic industry in the electronic and electrical sector to test the developed solutions in the network, which is required for their breakthrough on global markets.
All these goals also contribute to long-term environmental goals to which Slovenia has committed (25 % share of renewable sources in total energy consumption) and enable the long-term reliable supply of customers.

Importance for the economy

Technical solutions in the field of smart grids fit in the segment of electronic and electrical industry that is heavily represented in the Slovenian economy. The annual turnover in the sector was more than 4 billion € (before the current economic crisis), whit more than 70 % of the sum realised on international markets. The sector employed 30,000 people in 2009, which is more than 5 % of the workforce in the Slovenian industry sector.
The development and implementation of smart grids technologies may therefore have a positive influence also on the Slovenian economy, especially by means of providing a test polygon for products and solutions, and therefore providing sales references that are crucial for penetration in international markets.

METHODOLOGY

The first step Implementation Plan was to assess the state of the art in the fields of technology, sociology, economics and regulation for different smart-grid solutions (Table 1): technology focuses on the availability of technical solutions, sociology on their public acceptance, economics on business models justifying the implementation, and regulation, making the solutions legally feasible. The focus of the programme should be on readily available and accepted technologies, which would enable a relatively fast in-field implementation, of course with the benefits for the distribution network in mind. Different elements of smart grids were grouped into project clusters. As the most promising and viable, the following project clusters were identified:

- Advanced measurement of household consumers;
- Active management of consumption and generation;
- Modern concepts of interconnection and operation of DG;
- Power quality management;
- Active management of electrical vehicles (EV's) infrastructure.

Table 1 shows the selected smart-grid solutions from the viewpoint of technology, sociology, economics and regulation. As it can be seen, in our opinion, the largest gap between the state of the art and the requirements lies in the field of regulation, which is a serious drawback for smart grids implementation. A big question is also the acceptance of different technologies from the side of the society, i.e. network users, and their response to different incentives (demand-side management, different tariff systems…). Technology seems to be the most mature field in this respect.

Table 1: Maturity of smart-grid solutions

	Technology	Sociology	Economics	Regulation
Advanced measurement	✓	o	✓	o
Active management of consumption and generation	✓	o	o	×
Interconnection, operation of DG	✓	o	o	×
Power quality management	✓	o	o	×
Storage	o	×	×	×
EV infrastructure	o	×	×	×

For further evaluation, each project cluster was divided into three segments:

- research activities,
- demonstration and pilot projects and
- large-scale implementation.

For each of the project clusters and for each of the three segments, required activities were listed and their costs were assessed. For example, for the advanced measurement cluster it was considered which research activities are still needed, what demonstration projects do we need to test the equipment and what is needed for large-scale implementation. Costs were evaluated for each step. Beside that, also the time frames for each step were defined, giving a rough time-line for activities in order to reach the Plan goals.

Effects of SG on investments

For each of the project clusters also the effects on network investments were estimated. The estimations were based on national and international studies [4], [5] and are, at least to some extent, arbitrary. For each of the project clusters the following cost reductions were taken into account within calculations:

- Advanced measurement of household consumers: 50 % lower costs of meter reading, 50 % lower costs of commercial losses.
- Active management of consumption and generation: 5 % lower system peak load.
- Modern concepts of interconnection and operation of DG: 50 % lower investment costs of DG interconnection.
- Power quality management: 20 % lower investment costs for power quality assurance.

- Active management of EV infrastructure: 50 % lower peak load due to EV charging.

INVESTMENT PLAN

Based on costs and benefits evaluation, two investment plans for Slovenian distribution networks (period 2011 – 2030) were compared: one including smart-grid solutions and the other without them. The investment plan without smart grids was based on the DSO's investment plans, taking into account the foreseen growth of DG also for the period 2021 - 2030. For the calculation of the investment plan with smart grids, the required investments for smart grids solutions were taken into account, and the cost reductions that were described earlier were also evaluated. The results are shown in Fig. 3. The calculations showed that approximately 320 million € of investments will be needed to successfully implement the main smart grid projects. In the long run, from 2011 until 2030, almost 500 million € lower total investments are expected with the introduction of smart grids, which is a reduction of approximately 9 % compared to the scenario without smart grids. Cumulative investments in distribution networks with and without smart grids are shown in Fig. 4.

It is important to note that the investments in the first half of the observed period, i.e. before 2020, will be higher than without smart grids, since most of the benefits will be achieved after the implementation of the concept.

Almost 87 % of all investments are required for large-scale implementation of solutions, while the share of demonstrations and research is smaller, 10 % and 3 % respectively. The shares are shown in Figure 5. Main project groups within demonstration activities are shown in Figure 6. In the frame of large-scale implementation, 60 % of the costs are due to smart metering. Smart metering is namely an important part of smart grids and a prerequisite for many other functions, e.g. DSM, just to name one. The shares of different projects in the total costs for large-scale implementation are shown in Figure 7.

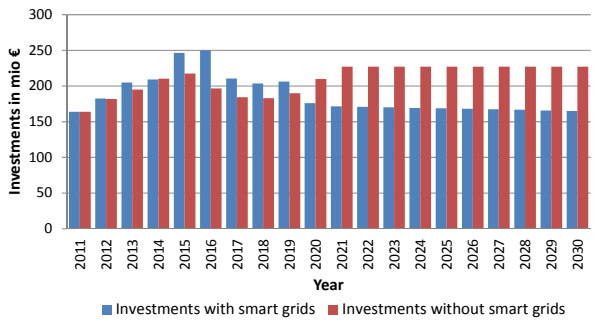

Figure 3: Required investments in Slovenian distribution grids with and without smart grid technologies

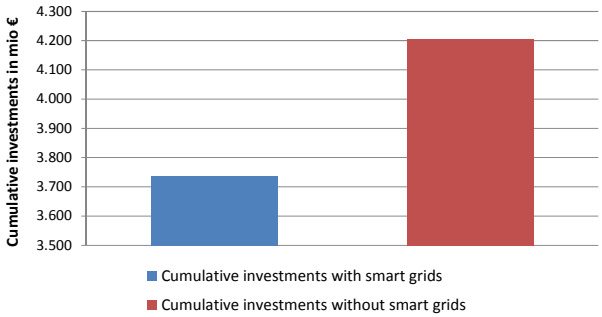

Figure 4: Cumulative investments for the period 2011 - 2030

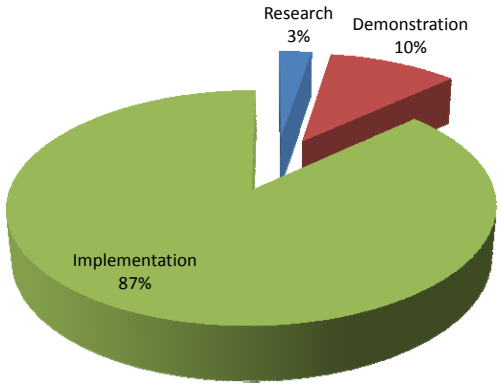

Figure 5: Share of investment in research, demonstration and implementation segments

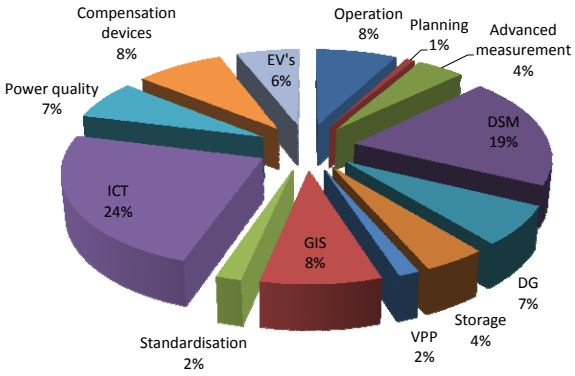

Figure 6: Main project groups within demonstration activities

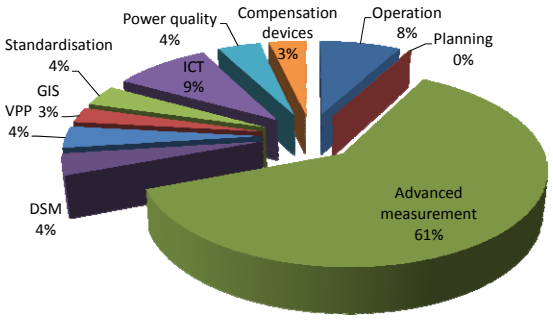

Figure 7: Costs of large-scale implementation

Financing

Within the Programme also a proposal for financing is given. For research, costs of 10 million € are expected, and the financing, in our opinion, should be provided partially by the private sector, as it will also gain from research results. The following financing scheme is proposed:

- 15 % of funds from distribution system operator and utilities and
- 85 % of funds from public-private partnership.

For demonstration projects (32 million € in total) a clear interest comes from the private sector, therefore all funds should come from public-private partnership:

- 50 % from industry,
- 50 % from state development funds.

For network large-scale implementations, with total costs around 280 million € (out of which 172 million € for advanced metering) the only solution is probably state financing through the network fee.

ADDITIONAL REQUIREMENTS FOR SMART GRIDS TASKS

Personnel requirements

For smart grids tasks, additional personnel will be required at least in the following fields:

- project management, including coordination among DSO's,
- ICT experts (measurements, network control, customer services…),
- experts from the industry and research institutions (introduction of new concepts, education, customer approach…),
- on-site workers (installation, maintenance…).

For the successful implementation of the smart grids program, a coordinated approach of distribution systems operators is essential. It is important to bear in mind that beside technical and economy knowledge also experiences from the field of sociology will be important which is due to the involvement of customers in different smart grids activities and due to the importance of public acceptance of smart grids in general.

Regulatory changes

It is clear that the regulation must accompany and actually enable the employment of smart grid concepts and include a systemic solution for financing. A special consideration of smart-grids projects is also required, covering the projects that facilitate the integration of DER and that result in lower costs compared to network reinforcement. Regulatory changes should include the fields of personal information safety, legislation for new services (e.g. virtual power plant) and the use of advanced tariff systems.

CONCLUSIONS

According to current DSO plans around 4.2 billion € new investments in the Slovenian distribution grids will be needed by 2030, which does not include investments in smart grid technologies. The Smart Grids Implementation Plan aims at a coordinated approach for smart grids introduction with the following main goals:

- Lower the required investments in distribution grids.
- Provide a test ground for the Slovenian industry.
- Enable the fulfilment of Slovenian commitments regarding the share of renewables.

Within the Plan, main project clusters were identified and the costs for each one were evaluated on the basis of the expenses for research, demonstration and large-scale implementation. The total estimated costs for all the projects amounted to 320 million €, mostly occurring in the first half of the observed period, this is until 2020.

For each project cluster, potential savings of planned network investments were assessed and an investment plan was proposed. The results showed that the implementation of smart grids could enable to lower planned network investments from 4.2 billion € to approximately 3.7 billion € (for the period from 2011 until 2030), resulting in a reduction of 500 million €.

Smart grids, however, do not mean that investments in primary equipment will not be required any more, but that the investments will be lower with smart grids than without them. It is also important that the proposed solutions are implemented in a coordinate manner. In the implementation phase, smart grids will increase network investments.

Smart grids definitely offer an opportunity for the development of the industry in the sector and form the basis for different new services. However, it is important to note, that most of the tangible benefits occur on the distribution network side.

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