IMPACT OF THE SMARTGRIDS CONCEPT ON FUTURE DISTRIBUTION SYSTEM INVESTMENTS IN SLOVENIA

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ABSTRACT

The paper focuses on evaluating the value of savings of the SmartGrids implementation in Slovenian distribution system network. Additional investments in the distribution system in order to connect distributed generation (DG) sources are needed for the achievement of Slovenia's environmental commitments. SmartGrids concept gives us an option to lower investment costs in the long term. However, additional investments in R&D and new equipment will be needed in the middle term of 10 years. This paper is the result of research in the Slovenian SmartGrids Roadmap (distribution network).

INTRODUCTION

The existing power system that was efficiently and reliably serving customers for over 100 years is now facing many new challenges posed by rising demand, aging infrastructure, energy efficiency, energy markets and DG. SmartGrids concept is an answer on rising problems in the system. It connects the individual elements of the system, both classical and new (DG, advanced metering infrastructure (AMI), demand side management (DSM), virtual power plants (VPP)) into an effective whole.

With existing planning and operating criteria approximately € 4 billion of new investments in the distribution network will be required in Slovenia by 2030. DSOs will not be able to carry out financial investments of such magnitude. The consequence will be that Slovenia's environmental commitments will not be achieved.

To solve the problems it is necessary to start using new technologies and control schemes that will be optimally engaged in the SmartGrids concept. Technologies that are presently technically and economically viable have to be used to achieve the future goals. The concept for Slovenia is described in the Roadmap of SmartGrids implementation in Slovenia.

The research results show that lower investments can be forseen in the next 20 years if SmartGrids technologies are used focusing on:

- Active demand and supply side management: Technologies and concepts of AMI, DSM, VPP, supported by appropriate information and communication technologies (ICT) have to be joined in a new concept of distribution system operation, which will enable a reduction of peak load. Lower load means lower future investment needs as the whole system planning is based on the peak load.
- Modern grid planning concept: ICT, advanced planning concepts, modern voltage management techniques and reactive power compensation are combined in a new planning concept, which is used to reduce the investments needed to connect DG (also enables connection of a larger share of DG).

Current situation regarding investments in the Slovenian distribution grid will be presented in the next chapter, which will be followed by presenting effects of both main SmartGrids programs. Cumulative effects of the SmartGrids plan will be presented in the last chapter.

INVESTMENTS IN THE DISTRIBUTION GRID

By year 2030 some € 4 billion new investments in the distribution grid (SmartGrids not included) will be needed [1]. Major causes, as showed in Figure 1, are aging of the infrastructure, growth of peak demand, quality of supply and DG.

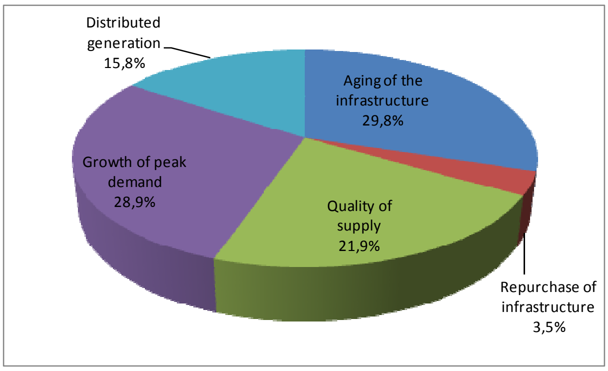

Figure 1: Investments in the distribution grid by main causes [1]

Forecasts in Slovenia predict 2,7 % average annual growth of peak demand by 2030 [2]. Almost 1.500 MW of DG will be installed in Slovenia by 2030 [3]. Combined with continuous effort for keeping the appropriate levels of quality of supply and timely replacements of aging equipment, investments costs are becoming too high for five distribution system operators in Slovenia. Financial calculations that we made show, that DSO's will be forced to finance most of the investments with debt if they will want to meet the projected needs. The situation will become uncontrollable after 2020, which is shown in Figure 2.

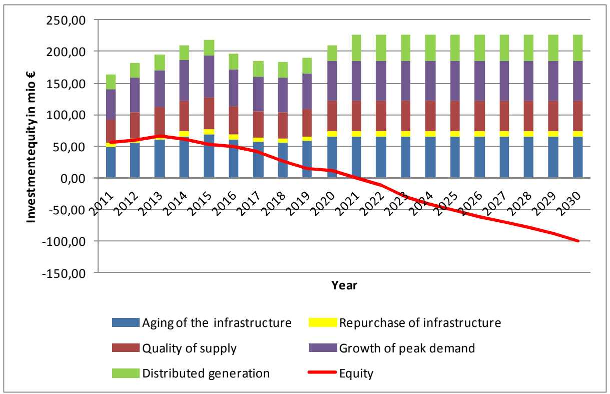

Figure 2: Structure of investments in the distribution grid from 2011 to 2030 with calculated equity of Slovenia's DSOs [4]

Since drastic increase of grid tariffs is not an option, alternative options had to be analysed. To solve the problems it is necessary to start using new technologies that will be optimally employed in the frame of the SmartGrids concept. Technologies that are presently technically and economically viable have to be used to achieve the future goals.

ACTIVE DEMAND AND SUPPLY SIDE MANAGEMENT

The concept of active demand and supply side management includes many technologies at different stages of development. ICT, Distribution Management Systems (DMS), Geographic Information System (GIS), AMI and integration platform are main elements that enable effective implementation of different demand side management programs on one and supply side management programs using virtual power plants on the other hand.

By integrating the aforementioned technologies and components in effective operation concept, the goal is to reduce peak demand by at least 5 % [4]. The goal is estimated mainly from numerous foreign pilot projects, however, additional and thorough domestic research and demonstrations will be needed to achieve the aim.

Data from previous years shows, that top 5 % hourly loads are reached in less than 100 hours per year. That is the reason we have to concentrate on these hours. Tools for advanced short term load prediction have to be developed first. Peak reduction from demand side can then be reached by using 2 different approaches:

- Direct load control and
- Critical peak tariff.

Direct load control

By using direct load control programs DSO directly controls the functioning of electricity devices. The most appropriate devices are air conditioning, water heaters, heat pumps, refrigerators, freezers and electric heating equipment. If interrupted for a limited time, customers shouldn't suffer a notable reduction in comfort. The contract should be signed with customers stating:

- maximum times in a given period a device can be shut off,
- length of a interruption period,
- minimum time between two interruptions,
- payment per interruption.

The major advantage of the program is, that DSO has direct control over the appliances and thus high reliability of response. Disadvantage of the program is, that DSO is limited by the number and types of appliances, since not every customer will be willing to participate nor every appliance is suitable for direct control.

Critical peak tariff

The main driver in the critical peak tariff is substantially higher tariff during hours with highest load. Customers are compensated with lower rates during "normal" hours. The main principle of the program is that customers electricity bills do not change, if they don't wish to adjust their consumption.

The advantage of the program is that its implementation is very simple and requires virtually no additional investment besides smart metering. The program is also not limited to only specific appliances, since customers choose on their own, which one they are willing to shut down.

The weakness of the program is mainly in the fact, that the program manager does not have reliable information on what load reduction can they count on.

Calculating the value of avoided investments

Lowering the peak load means that investments will be postponed and thus money saved. The amount of savings is estimated by marginal distribution system cost of load, which gives us an estimate on how much savings per year are reached, if peak load is reduced for 1 kW.

Marginal distribution system cost of load is estimated by dividing the total worth of the existing grid with the peak load. The calculation for Slovenia shows that additional kW of peak load costs on average around 100 € per year [5]. With estimated goal of 5 % lower peak demand, total yearly savings would be around 10 million € [4].

REDUCING GRID INVESTMENTS CAUSED BY DISTRIBUTED GENERATION

Similar to the concept of active demand and supply side management a modern planning concept also includes many different technologies and concepts. These involve ICT, DMS/GIS, integration platform, modern compensation devices and virtual power plants.

One of the first problems emerging with the rising share of DG is the increase of voltage above the levels required by the power quality standards. The expensive investments in the network infrastructure are needed to maintain the voltage within defined limits. Data from one of the Slovenian DSOs shows that additional kW of distributed generation on average means additional 450 € of grid investments due to required grid reinforcements. The value was calculated by dividing actual total additional investment costs in a given period with total additional installed power of DG.

Research projects, for example MetaPV [6] and DemoNetz [7], aim at high goals of cost reduction due to DG integration by 80 % or 90 % if compared to the grid reinforcement costs. The goal of the approach in the Slovenian case is to reduce investment costs of connecting distributed generation by 50 %. Total avoided investments with the use of advanced network-voltage control would amount to approximately 250 million € by 2030 [4].

SLOVENIAN SMARTGRIDS ROADMAP

SmartGrids represent the third major investment cycle of power system development. The first phase consisted of the construction of primary equipment. The second phase included automation of the network. The results of the first two investment cycles are reliable and cost effective supply of electricity. The cornerstone of the successful execution of the first two cycles was the clear layout of the concept.

The Plan focuses on a period to the year 2020. The main goal is to implement technologies that are already developed from technological point of view but need additional work on large – scale deployment and regulatory, economical and/or sociological field.

Main conclusions of the Plan are:

- Cost effective results from SmartGrids implementation can be achieved only by developing a concept as a whole. Partial implementations of only selected technologies will most likely result only in higher costs.
- SmartGrids doesn't mean that electricity bills of the customers will be lower in absolute values. But they will certainly be lower than without SmartGrids.
- Despite savings that can be achieved with implementation of SmartGrids, DSOs in Slovenia still need additional capital to implement all planned investments in the grid.

The final estimate of the Plan is that approximately 320 million € of investments will be needed to successfully implement main goals of the SmartGrids project. Almost 60 % of this value can be attributed to smart metering. Every technology will be implemented by a series of basic research activities, demonstration and pilot projects and finally mass implementation. Almost 90 % of all investments are planned for mass implementations, which is shown in Figure 3.

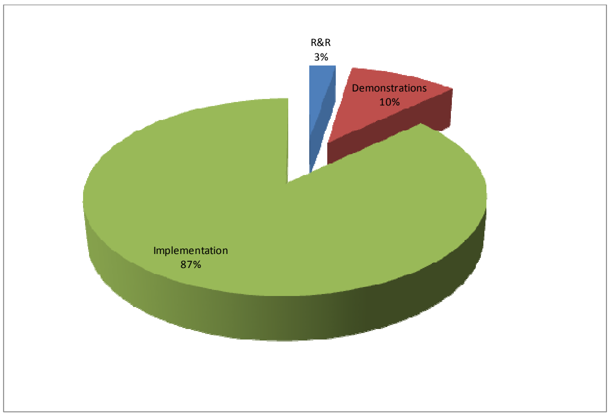

Figure 3: Shares of total investment costs of research, demonstration and pilot projects and mass implementations [4]

The final results in Figure 4 clearly show that lower total investments will be needed with the usage of the SmartGrids concept. Almost 500 million lower total investments are estimated, if the plan will be followed. However it is very important, that yearly investments in the first half of the observed period will be higher than without SmartGrids, since most of the benefits will be achieved in the second period, after the implementation of the concept.

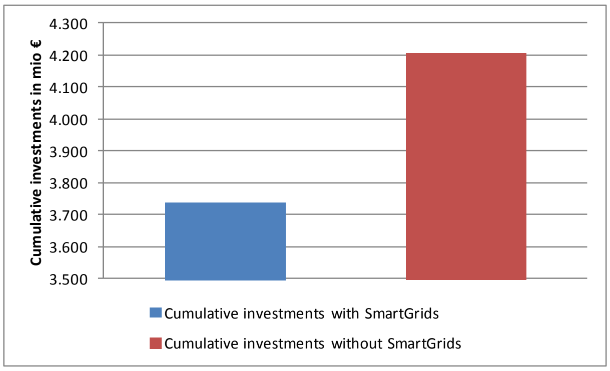

Figure 4: The difference between cumulative investments from 2012 – 2030 with or without SmartGrids [4]

CONCLUSIONS

By year 2030 some € 4 billion new investments in the distribution grid (SmartGrids not included) will be needed in Slovenia, mainly because of predicted 2,5 % annual peak load growth and additional 1.500 MW of distributed generation by 2030. Other major causes are aging of the infrastructure and quality of supply. DSO's lack the funds to carry out the investments and drastic increase of grid tariffs is not likely or desirable.

The calculation of marginal distribution system cost of load for Slovenia shows that each additional kW of peak load means average additional costs of around 100 € per year. With estimated goal of 5 % lower peak demand, total yearly savings would be around 10 million €.

Data shows that additional kW of distributed generation on average means additional 450 € of grid investments needed for network reinforcement. Total avoided investments by using alternative solutions (advanced network control and especially voltage control) in the distribution grid in Slovenia amount to approximately 250 million € by 2030.

SmartGrids doesn't mean that electricity bills of the customers will be lower. But that they will be lower than without SmartGrids.

Despite savings that can be achieved with implementation of SmartGrids, DSOs in Slovenia still needs additional capital to implement all planned investments in the grid.

Estimations show that almost 500 million lower investments in the distribution grid in Slovenia can be achieved by 2030 by using the SmartGrids concept.

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