

Smart Grid Ready Concept as an Enabler for Demand Response and Distributed Generation

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Abstract - The need for advanced technological solutions in the energy sector has become more important during the past few years. Many players are hoping that smart grids will revolutionize the energy sector and bring significant benefits to energy companies and customers. There is also a belief that smart energy infrastructure will support demand response solutions and rollout of distributed generation. All these will lead to increase of energy efficiency and will support achievement of 3x20 goals defined by European Union. The key for the success is the mitigation of regulatory, technology and social risks.

The Smart Grid Ready concept structures smart metering investments so that the final solutions are resistant to technological, regulatory and customer acceptance uncertainties. It is also a concept enabling emergence of demand response services and supporting investment in distributed generation assets. This paper presents a concept for shaping investments in advanced metering infrastructure to ease implementation of more advanced smart grid solutions.

Keywords—Global Production, Intelligence Operator, Advanced TPS, V-MICS-VM, Visual Manual, Toyota

I. INTRODUCTION

Smart Grid technologies have recently become a hot topic among utilities around the world. According to studies based on real power-consumption data for more than 800,000 U.S. utility customers [1], smart grids could cut as much as 115,145 MW off-the-peak, translating to approximate savings of \$120 billion. Reducing peak consumption is just the tip of the iceberg in terms of the possible overall benefits. If we consider all the possibilities related to creation of new products and emergence of new business models then only the sky is the limit for calculation of benefits. If we focus on more tangible benefits then we should consider reductions of grid losses, reduction of operational cost and optimization of expenditures related to new investments and modernization of assets.

Investors are struggling however with several uncertainties related to larger smart grid roll-outs. Technological, regulatory and social uncertainties are stopping utilities from taking decisions on spending large CAPEX amounts on investments in smart grid technologies. Therefore, mentioned benefits are not realized even though technology companies are coming up with more and more intelligent solutions.

Smart Grid Ready concept is a deployment approach that supports risk mitigation for smart grid investors. It makes smart grid investments “smart” by ensuring that when built, they can accommodate changing technological, regulatory and social conditions.

II. NEED FOR EMERGENCE OF INTELLIGENT SOLUTIONS FOR MANAGEMENT OF DEMAND AND SUPPLY

The need for development of solutions supporting flexible management of electricity demand and supply results from growing overall demand for electricity in the peak of power system operation. It translates into a need to manage power systems in the following situations [11]:

- limitations in supply of production capacity (emergency or planned units withdrawal, old power units decommissioning, instability of wind sources),
- limitations in power transmission in the networks of System Operators (transmission and distribution),
- limitations in the area of power reserves accessible for balancing the electricity system.
- daily and seasonal variability in demand for power and energy.
- fluctuations in electricity prices in the peak of demand (including changes in consumption profiles, instability of generation from renewable resources), and
- increase in pollution, in connection with the need for increased power generation from conventional sources covering the peaks of demand.

Competent system operators, responsible for system balancing, implement different types of emergency programs in real time, allowing the use of distributed power resources potential and the potential of end users reductions. These programs may be launched considering various markets: system services market, balancing market, spot market, day-ahead market or power market (Figure 1).

These include stimulus programs used in USA and in Europe [13] like direct load control, interruptible curtailable rates, demand bidding programs, emergency demand response programs and ancillary service programs.

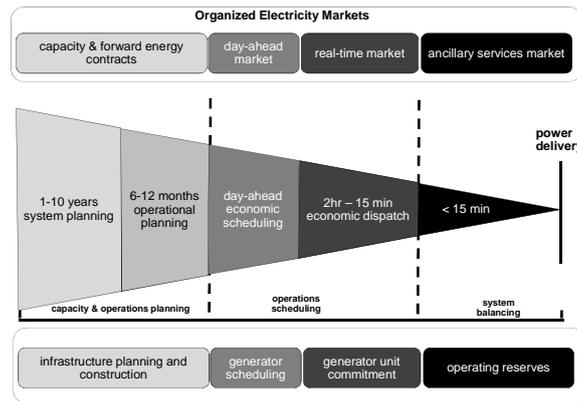


Fig 1: Electric system Planning and Scheduling: Timescales and Decision Mechanisms [12]

Depending on reduction potential of end users and distributed sources, it may be necessary to aggregate demand and supply, possible to use within electricity system management. In practice, this could mean splitting the customers, with low demand side response potential connected to medium and low voltage electricity networks, into groups with significant potential in relation to large end-users and generations connected to extra-high voltage networks. The use of distributed generation and distributed energy storages, together with demand-side reduction create distributed energy resources. Efficiency of resources utilization notably depends on coverage of the power system infrastructure by smart metering infrastructure, capable of generating real-time information for system balancing.

III. SMART GRID TECHNOLOGICAL ADVANCES AND ITS IMPACT ON MARKET CONVERGENCE

Smart grid may help manage electricity demand and supply in a flexible way. Therefore, more and more focus is being put on the development of “smart” technologies. Smart grids enable convergence of technologies from many areas: utilities, telecommunications, transport, home automation and others. Taking into consideration the fact that “smart” technologies require connecting grid appliances to the communications network, it is clear that distribution system operators (DSO) will either build their own telecommunication infrastructure or cooperate with existing companies. In both cases, utilities and ICT providers will have common interests, which in the future may lead to the convergence of services from both markets.

TABLE I EXAMPLES OF SMART GRID MARKET CONVERGENCE

Selected Fortune 500 companies involved in Smart Grid		
Company	Sector	Overview
Apple	Electronics	Home energy management system, which is be able to share video, music and data over a high-speed power-line network. The system will be able to seamlessly monitor energy usage of each electric device within its range [2].
Boeing	Aerospace & Defense	Boeing announced that it would develop a smart-grid enabled, secure SCADA system for ConEdison [3].
BT	Telecommunications	BT plans to take part in creating a national network for smart meter communications in the United Kingdom. The company formed an alliance with Arqiva and Detica to provide a nationwide low RF network to reach the more than 26 million smart meters that will be installed in the U.K. by 2020 [4].
Deutsche Telekom	Telecommunications	Deutsche Telekom prepared an IP-based communications solution for smart metering and smart-home applications. The platform is based on an open standard of communication and is compatible with meters of 20 producers 错误!未找到引用源。 .
Intel	Electronics	Intel plans to enter the Smart Grid market by building a wide range of devices, including control systems for substations, wind turbines and HAN devices such as IPTV-integrated energy controllers [6].
Microsoft	IT	Microsoft launched its Hohm Web application, which allows customers to analyze data acquired from smart meters [7].
Volkswagen	Automotive	Volkswagen and German electricity supplier LichtBlick plan to build small distributed generation sources based on VW's gas engines [8].

Many Fortune 500 companies put efforts to find their place in the smart grid arena – these companies realize that the success of their products and services will be strictly dependent on introduction of partnership models. Taking into consideration the current market and regulatory models, DSOs may have little interest in investing in areas not directly connected to electricity distribution infrastructure. However, energy retailers may be more apt to cooperate with companies in other markets, because together they could develop unique products and services and create a real competitive advantage over other players.

According to a survey conducted in 2009 in Poland [9], many end-customers are still reluctant to change their electricity retailers. Such a customer behavior is mostly driven by two factors: firstly, many of them do not know about their right to change the retailer; secondly, retailers rarely stand out from their competition—apart from small price differences, the products they offer are very similar. In such situations, only by offering new services can retailers differentiate from each other.

Customers would change retailers not because of price, but rather because of new services such as access to real-time electricity data on the internet, which would help assess the true impact of a particular device on their electric bill, or optimize electricity usage by moving energy-consuming tasks to periods when prices are lower.

Moving forward, utilities may also play a significant role in the transportation sector, as the smart grid infrastructure may be the backbone of the modern transportation system in the era of electric vehicles. Taking into consideration how much power electric cars need (a single charge for the Tesla Roadster requires about 60 kWh [10]) and the unpredictability of consumption patterns, only fast and automated grid steering will be able to maintain a stable electrical system when electric cars become more popular.

IV. CUSTOMERS EXPECT RELIABLE ENERGY DELIVERIES AT COMPETITIVE COST

At first, few customers are expected to be receptive to smart grids. During the deployment phase, with utilities investing heavily as full benefits are not yet achieved, the price of energy distribution will rise. It will not be a major factor for price increases, and certainly not the only one, but customers may oppose them. Considering market research that shows that even before smart grids and smart meters, 55 percent of households are dissatisfied with pricing [9], utilities will need to do some work not just to adjust their offerings to bring added value, but also to communicate the added value clearly to consumers.

In the medium term, customers will be paying more for energy distribution and, therefore, will expect something in return. Analysis of household customers indicates that their expectations are primarily related to the reduction of their electricity expenditures [9]. Additional value arises for different groups of customers: 1) those with “intelligent homes” in which smart meters become a steering unit to manage home appliances, and 2) those with electric vehicles and need a way to reduce costs and avoid too many internal installations.

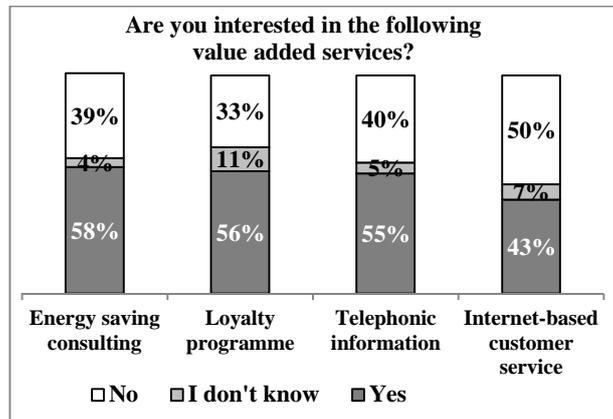


Fig 2: Customer preferences for various value added services (percentage of customers interested in value added services for the energy market)

Smart meters leave a positive impact not only on long-term electricity costs but also on supply security and specifically the speedier identification of sources of network failures. In fact, most customers indicate security of the electricity supply as the most important value they expect from their electricity suppliers [9].

The key to the success of AMI implementation is the communication of benefits to customers and proper risk management. If this task is not done properly then investors may face a challenge like Duke Energy who attracted only 20 out of 10,000 customers to its variable-rate program [14].

V. KEY RISKS IN SMART GRID PROJECTS

When considering large-scale implementation of smart grid solutions, DSOs must address a long list of risk areas that, in general, can be grouped into three classes.

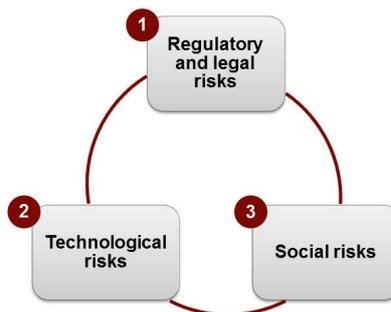


Fig 3: Three classes of risks related to Smart Grid implementation

A. Regulatory Risk

In lack of right regulations, utilities may find it difficult to invest in smart grid solutions. Significant investments in the modernization of the grid should guarantee a proper return to utilities, so that the risk of investment is covered. Considering the regulatory frameworks of most European countries [15], DSOs do not currently have enough incentives to invest in projects to increase their operational effectiveness. This is especially true for the most modern and efficient companies, which already have costs close to or below targets set by regulators. Moreover, in the current market framework there are few incentives that would drive DSOs to invest in some smart grid functionalities, such as demand management. As a result, because DSOs revenues are often fully dependent on past investments and cost levels agreed to by regulators, there is little pressure on them to change consumer behavior. Similar mechanisms apply as utilities are considering convergence with other markets. In the current regulatory framework, DSOs have little interest in selling additional services using the smart grids they are implementing. In many countries, there are no incentives for DSOs to sell services other than those related to distributing energy, because regulators limit revenues so that any non-core activities of DSOs are not profitable. Previously, this framework did not collide with the best interest of DSOs and customers, but when smart grids are widely introduced, this situation may change. The natural inclination will be to use DSOs' infrastructure to provide services to end customers based on the telecommunications infrastructure, but this is not profitable given current regulations.

On the other hand, regulators that seek to minimize price pressures on customers will want to be confident that the ample investments made into smart grid projects are beneficial to everyone in the energy market and that they pave the way to future price reductions.

Because DSOs, transmission companies, energy producers, customers and regulators have different agendas and goals, the smart grid rollout may slow down, or its scope will be narrowed.

B. Technological Risk

The most critical technological risk is the lack of interoperability and commonly agreed standards. As a consequence of high level of investments needed in metering and telecommunications devices, DSOs expect that the devices provided by different vendors can communicate and cooperate seamlessly. Unfortunately, standardization is still a work in progress, and DSOs must address interoperability in different ways. Another technology risk lies in the fact that it is not sure which technology will dominate in the future, especially in telecommunications.

As a result, utilities face serious technological risks from investing significant amounts of money in modernization projects that may not be "modern" any more when they're finished.

C. Social Risk

Even though many studies find that smart grid solutions offer benefits to customers, the awareness of these benefits is rather low. Moreover, smart grids, and especially smart metering, may be seen by customers as a threat to customer privacy. While consumer privacy is limited when using mobile phones and credit cards, in those cases it is the client's decision to buy those services.

Today, the lack of wide acceptance of smart grid technologies is also a significant risk for utilities that are planning to modernize their networks. In California, Pacific Gas and Electric Company (PG&E) faced a problem when customers rejected smart meters, citing privacy issues, high installation costs and even the potentially higher presence of electromagnetic radiation [16].

Utilities know that wide customer acceptance is absolutely necessary to achieving the maximum benefits of the smart grid. Therefore, addressing these social risks is critical in every major smart grid investment.

VI. APPROACH FOR INSTALLATION OF ADVANCED METERING INFRASTRUCTURE

Apart of risks that have to be considered at the strategic level, at the operational level deployment of a Smart Grid Ready concept is a complex and long program. Utilities have to perform detailed analysis, deal with complicated public procurement procedures and need to solve several emerging technical problems.

The first step that must be taken into consideration by DSOs, before starting a broad roll-out of a smart grid ready project, is a detailed feasibility study. Preparing such an analysis helps the investor identify and quantify costs and benefits, and take a deep dive in technologies and suppliers active on the market.

Another important prerequisite for broad smart grid deployment is a detailed stock-taking of all grid appliances, in particular types of substations and quantities of different meter types installed in different geographical regions. This step will help plan both the installation process and supply chain management.

Procurement strategy is an important project element to be considered. As the process is publicly watched and is often audited afterwards, RFP documents must be prepared very carefully – DSOs must ensure that the technical specifications do not favor any of the suppliers. Experience shows that utilities would need up to 15 months before appliances are delivered:

preparation of tender documentation may take 1-3 months, the procedure itself takes usually 3-6 months (the latter takes into consideration appeals to arbitration courts which are often the case in big public procurement tenders) and finally the production and delivery of devices takes 3-6 months (the shorter the time of delivery and production, the higher the price of delivered devices).

DSOs must also consider and solve detailed technical problems during the process of preparation for installation of smart grid devices, from the development of a common standard for modernization of substations, to the choice and fine tuning of communication protocols.

Moreover, implementation of a smart metering solution changes a significant part of DSOs processes. Detailed mapping of these processes can be performed during the implementation phase of an IT system supporting management and acquisition of metering data. In particular, DSOs should align its processes and organizational structure in such a way that secures achieving promised benefits.

Experience shows that the preparatory phase before implementation of a smart grid system may last about 2 years.

VII. CONCLUSIONS

Further development of smart grid technologies and implementation of larger projects are unavoidable. It is still unclear who will benefit from these projects and how much return companies spending money on the intelligent grid infrastructure will earn. The Smart Grid Ready approach is helping investors to ensure that the distribution of benefits is fair and investors are awarded accordingly to their efforts and capital expenditures.

It is not possible to eliminate all risks from smart grid projects, thus investors should additionally introduce proper project management methodologies and approaches for project risk management.

It is also critical to ensure that the investments will empower energy market players to take more active position on the energy market. This empowerment will ensure that objectives related to energy security and sustainable development will be realized.

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BIOGRAPHIES

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Robert Masiąg received his Master's degree in electrotechnics and applied computer science from Lublin University of Technology. Presently he holds the post of Board Representative at ENERGA OPERATOR S.A. and is responsible for management of the biggest Polish implementation of an Advanced Metering Infrastructure project, covering approximately 25% of the area of the country. He has over 20 years of experience in management of complex technological projects, design of architecture of complex IT systems and consolidation of IT systems. Previously he worked for a leading Polish telecommunications company, where he was responsible for implementation and integration of IT systems