POWER GRIDS AS A PREREQUISITE FOR EFFICIENT ENERGY MARKETS

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Abstract

Smart grids and management of demand are primarily envisioned as a huge jump in development communication and information technologies with aim to increase grid reliability and to allow integration of production of various smart grid resources of electricity such as renewable resources, demand response, electricity storage and electricity transportation. Based on many researches aimed at of the reliability impacts of these resources, it is concluded that an ideal mix of the smart grid resources leads to a flatter net demand that developed reliability issues further. An architectural approach of this smart grid net is essential to the transformation of the grid to a "smarter grid" similarly as was, for example, with the iPhone architectural.

Key words:
Smart grid, management of demand, liberalized electricity market.

JEL Classification: O12, O25, O44

Introduction

Energy management plays a crucial role in securing the necessary system flexibility for dealing the ongoing integration of simple energy market in EU. Demand Response (hereinafter DR) programs are the important flexibility tool for market price volatility to the end-consumers. In such conditions, this energy management system helps in using of flexible end-equipment's, which make possible the individual consumer's personal preferences and beliefs. We apply the one of the first large scale natural experiments, with multiple dynamic pricing schemes for the end consumers. The energy sector is going through many of quick and radical transformations to meet the growing energy demands. The future of the energy sector will be formed by a transformation in the electricity and natural gas sectors, which will be as challenges for traditional electrical and gas power systems. This movement of changes have a complex nature, but it requires a great support of the transition of the electricity grid faces decentralized production from renewable sources, electric mobility, and related innovations. These are at opposite from traditional power systems, where central large-scale generation of electricity faced inelastic consumer demand. (Cullen, J, M. Allwood , J.M.2009). The European Union's efforts to create an integrated single market for electricity using the market coupling method as a basic mechanism for distribution transfer interconnection capacity.

Objective and Methodology

The aim of paper is to demonstrate the impact of market coupling on the convergence of prices in related markets and the effects on the energy sector. Market coupling achieves the highest efficiency in the allocation of transfer capacity when the single market. Negative feature of electricity energy is it´s the non-storability and volatile aspect to provide of sustainable energy sources. The future requests the shift from a demand-driven to a supply-driven market. On the retail side, end-consumers can offer demand flexibility on the grid by shifting their energy consumption to other times of the day, not on moments of peak demand.

SWOT analyse of Slovak energy sector

EU member states have already approved investments to key infrastructure projects in the energy sector, so-called Projects of Common Interest (hereinafter PCI), and the funds will come from the Connecting Europe Facility (hereinafter CEF). "The CEF is the one of important instrument, by which shows that the Energy Union could become a more efficient and greener community," stated Maroš Šefčovič.EU for improving electricity markets and building of smart grids EU has about 500 million Euros. The whole package will support 14 different projects - seven in the electricity sector, three in the gas sector, two in smart grids, and two project for reducing CO_2 emissions. EU in its evaluating Slovak energy sector stated increasing of interconnection capacity with neighbouring countries, market coupling with the Czech Republic, Hungary and Romania, as positive feature, which improved the stability of electricity prices. At same time EU shoved on reducing greenhouse gas emissions and increasing the share of renewables (RES) in line with targets set for 2020.

But on the other hand, EU as weakness stated a high share gas, oil and coal imports, as well as a high carbon intensity of the economy, especially in industry. Negatively evaluates the regulated final prices of electricity and gas for households and small businesses, what are still barriers for creating more competitive markets.

The EC states as opportunities in SR the building various north-south pipeline projects for example - Eustream, putting into operation reverse natural gas flow from the Czech Republic, Hungary, Poland and Austria, what will contribute to the increase energy safety. As well as a wide ranges of cost-effective investments in buildings with aim reduce energy intensity. As opportunities are listed RES programs, which can reduce import of energy sources from almost the only one gas source - from Russia. Positive feature are developing the transparency and predictability of the regulatory framework and increasing the attractiveness of the Slovak energy sector for investors, namely in gas storage capacity.

In addition to positive reports, the EU has critical views, especially on increasing electricity consumption in the summer months or unplanned circular flows. These facts can have a negative impact on the security of the transmission system. The heat affects the electricity transmission system and even the control of the electricity system by several ways. Weather with high temperatures is usually accompanied by an increase in electricity consumption due increased use of air conditioners. Some power plants have subsequently great problems with drought and heat, what cause the negative effect of reducing their production. In summer, at the same time, due to law of physics the conductors and cables, are stretched and subsequently fall near to the ground. The Slovak Energy and Transmission System (hereinafter SETS) constantly monitored and data are collected in a central management information system (CIS) to ensure it ´s safety and ability to distribute electricity to all consumers.

In a liberalized electricity market, it is necessary to create contracts for the supplies of electricity, which companies in grid will then provide. This is often not a problem in the single market, as the network is designed with sufficient capacity and there is usually no risk of congestion. In the case of two interconnected countries, at least two their transmission system operators shall be involved in the transmission line management. The electricity lines in the network consists of a fixed transport capacity through which electrical energy can be exchanged. Double congestion can occur on these lines:

- Physical overload, when it is technically impossible to meet energy demand. There are insufficient funds available for the production of electricity or its transmission, which leads to outages in the short term. However, the problem of outages can only be solved in the long term by investing in generation or transmission capacity.
- Economic congestion, is a situation when it is technically possible to satisfy the demand for electricity everywhere, but the planned financial transactions are not sufficient to protect load on the network, which in one place of the network will exceed its capacity. In order to meet the demand, the volume of electricity have to be sent by the generator must be adjusted, according to the required market conditions. The management of such congestion consists of operational interventions regulating the volume of electricity production. (Kurzidem, M. J. 2010).

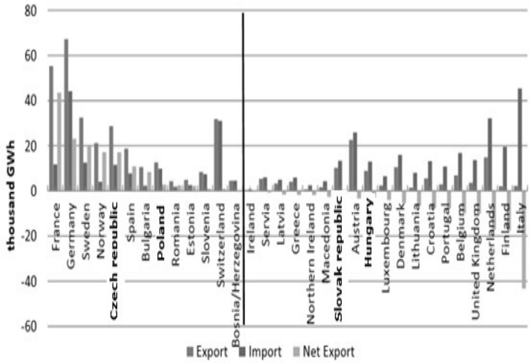
The flow of electricity from the producer to the final consumer passes through a number of parallel routes. In a highly interconnected European network, the transactions between interconnected countries do not necessarily flow directly among countries, but the transfer of electricity will follow through different route. Transfer processes are controlled through individual methods to avoid overload. This problems with management of demand and flows of electricity are another negative problems, so called the circular flows of electricity, this a phenomenon is caused by the insufficient infrastructure within the interconnected system. This problems is caused by the common German-Austrian trade zone, where the capacity is allocated automatically, regardless of the impact on the surrounding, neighbouring countries, which are suffered with this problems. **(**Bryce, R. (2010).)**.** Agency for Cooperation of Energy Regulators (hereinafter ACER) has already proposed the division of these zone. In countries of V4 countries have gradually put into operation phase shift transformers (hereinafter PST), that divert part of the electricity power.

1. Management of Demand

Management of demand allows consumers to reduce their high prices conditions in the electricity grid, mainly during peak load or congested operation. If a part of their consumption could be "consumed" at a more appropriate time, so we have a flatter, less risky load**.** (Koolen, 2017)

In Europe, the cross border electricity trade is deferent among regional interconnected markets. This diversity is shown in the chart below. Providing an overview of the amount of electricity in GW / h that is exported and imported in countries across Europe. The chart is a summary of monthly data for 2016 and its focus is on the physical, real flows of energy. European Network Of Transmission System Operators For Electricity (hereinafter ENTSO-E) defines the physical flow of energy as the real movement of electricity between neighbouring countries on foreign routes.(European Network Of Transmission System Operators For Electricity, 2015).

Figure 1: Import and export of electricity in EU



Source: (Entso-E. 2015)

The chart shows that the largest exporters of electricity in Europe are France (net exports around 43.516 GW / h), the source of production is mainly nuclear power plants. In second place is Germany (net exports of approximately 23,096 GW / h) from Eastern European countries, the Czech Republic is a major exporter.

The electricity supply chain begins with its production. The methods of electricity generation are highly dependent on the geographical location, mineral wealth but also on the legislative - political framework. Energy policy, as part of national economic policy, can dampen certain energy sectors (fossil fuels) or support the development of new advanced ways of producing clean, green energy in line with the Europe 20-20-20 strategy. Energy sources we obviously divide fossil fuel sources (coal, oil, gas), nuclear power plants, hydroelectric power plants, renewable sources including hydropower, wind, photovoltaic systems, solar and thermal, and some others such as geothermal or tidal energy.

Countries with access to the sea, such as France, Germany and Denmark, have a high proportion of offshore wind farms. Their share in the total volume of energy produced - the energy mix - has rapidly increased in recent years. Due to the electricity cannot be stored, the remaining energy is diverted through regional interconnected markets. Germany and Switzerland have already stopped production of nuclear power plants. In contrast, in France, nuclear energy still accounts for a significant share of energy production. There is a unique energy mix for each country.

The market coupling method brings more efficiently complementary methods for energy generation. If, for example, a storm occurs in Germany during the night and more electricity is produced than is necessary, this electricity has to be rerouted to power plants in the Alps or in Norway or it is an opportunity to move this electricity to a place where volume of electricity is insufficient.

In most countries, thanks to the liberalization of energy markets, energy is produced by a wide range of companies of different sizes.

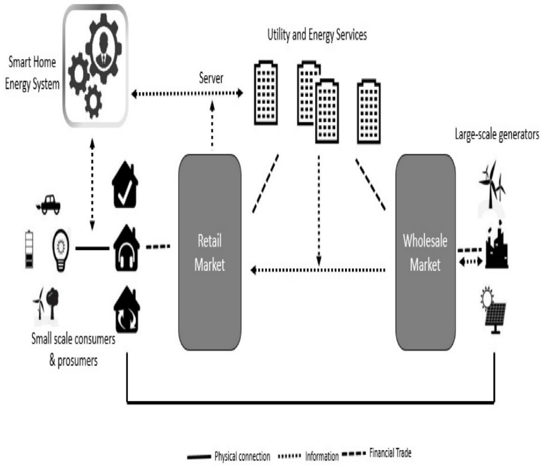
The markets coupling method and the development towards a single integrated market affects the situation of producers towards to increasing competition in the energy market. (Mirza, F. M., & Bergland, O. 2012) . Management of demand and supply has not been widely adopted yet, because contract based participation has been typically below 5% of peak load. Due this fact there is a network load, as we mentioned above. (Baltagi, 2013).

Map 1: Management of Demand

Source: (Geleen, D., Reinders, A. , Keyson, D., 2013)

In a smart grid, management of demand is implemented automatic or manual response through price signals, or through a bidding process based on direct communications between the consumer and the market. (Ketter, W.; Collins, J.; Reddy, P. 2013). The demand can serve to flatten the load or it´s can serve as an additional resource and it ´s management provides such schemes, which could improve reliability in smart grid.

Figure 2: Management of demand in smart grid

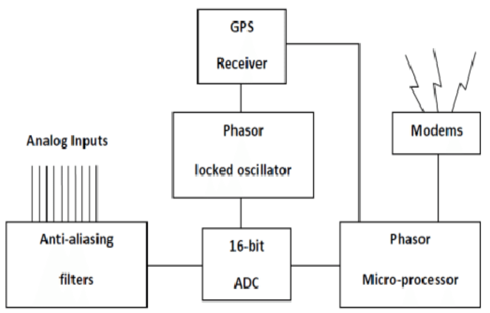


Source: (Gottwalt, S.; Ketter, W.; Block, C.; Collins, J.; Weinhardt, C. 2010)

Realization of the smart grid vision requires meeting goals with increasing reliability challenges by reliability of modern communication and information technologies to enable an advanced IT infrastructure. IT infrastructure provides coordinated monitoring and control of demand in smart grid.

Such IT infrastructure should be able to provide bidirectional communications among the individual loads in the grid-wide control centres including all important equipment at the distribution and transmission levels. Such system is able to solve almost all failures or interruption of electricity supply, so called black outs. This involves processing a great number of data transactions, whit a high performance IT infrastructure capable provides fast intelligent local responses to prevent of rapidly evolving adverse events, above mentioned blackouts. (Greene, 2008). A smart-grid can connect the high performance infrastructure with local intelligent grid using modern IT technologies based on answer in second. (Dorsey, P.2018). This technology is utilizing phasor measurement (hereinafter PMU) for faster time-stamped, higher accuracy, sub-second scanning to enable timely grid-wide situational awareness.

Figure 3: PMU technology



Source: (Alcott, H. 2011)

Time synchronization is usually ensured by GPS or IEEE 1588 Precision Time Protocol, which make possible synchronized real-time measurements of multiple distant points in the grid. These time synchronized measurements in grid are very important because the grid's supply and demand are not perfectly matched and frequency imbalances could cause stress in the grid, which is a potential cause for power outages. PMUs can be used to measure the frequency in the power grid, what helps to engineers in their analysing dynamic events. Such measures could not be possible to realize with traditional SCADA measurements, because those realised one measurement each 2 or 4 seconds, what is not enough quick. (Phadke, 2002).

Thus, the PMUs are equipped with monitoring and control capacities and are considered as the one of the most important measuring instruments in the future of power systems - smart grids. (Kassakian, J. G. - Schmalensee, R. 2011).

There are several negatives of above described system, too, (LaCommare, K.H. and Joseph H. Eto,J.H.(2006).

- Overload of smart grid is driven by uncertainty, diversity and distribution of energy supplies due to environmental and sustainability concerns. The power flow patterns in real-time can be significantly different from those considered in the design PMU,
- More numerous and larger distributions on longer distances are increasing volatility and reducing reliability,
- The smart grid, which is being operated at its "edge" of more locations, we mean in several places of grid, at the same time is not so safe and reliable due insufficient investment of infrastructure,
- Still increasing energy consumption and demand in peak creates limited transfer capacity,
- Aging infrastructure.

Conclusion

It was not due of a few specific applications that "smarter grid" revolutionized the "grid" but for its architecture that led to an explosion of functionality. (Bichler, Gupta, Ketter, 2002).

This approach "Demand Response I or Management of Demand" is using a spectral clustering approach to show distinct groups of households with using the most dynamic pricing schemes: Time-Of-Use and Real-Time Pricing. The results indicate that a more effective design of smart home energy management systems can lead to a better fit between customer and electricity tariffs to reduce costs, to increase predictability and stability of demand flexibility by such systems.

Energy Management Systems (EMS), used in energy grids, can control the use of end-appliances and optimize the flexible range, based on the end consumer's personal preferences. Demand Response builds on the behavioural features of energy consumers through their communication through home energy systems. The effectiveness of such programs is largely affected by the willingness of end-users to be involved in such programs. Implementing customers to this system requires systematic communication and interaction between the energy provider and the people it serves, with the intent of building trust, respect, and achieving optimal **energy usage**[1]. It was not due of a few specific applications that "smarter grid" revolutionized the "grid" but for its architecture that led to an explosion of functionality.

In Smart grid is possible to manage Demand Response is using a spectral clustering approach to show distinct groups of consumers with using the most dynamic pricing schemes: Time-Of-Use and Real-Time Pricing. The results indicate that a more effective conception of smart home energy management systems can lead to a better match between customers and electricity grids, which brings reduction of costs, led to increase predictability and stability of demand flexibility by such systems.

Energy Management Systems (EMS), which are used in energy grids, can control the use of end-equipment's and thus to optimize the flexible range, based upon the end consumer's personal preferences Demand Response is built on the behavioural features of energy customers through their home energy systems. (Darby, S., 2010). The effectiveness of such processes is mostly affected by the willingness of end-users - customers to be involved in such programs**.** (Victor, Pugh, T., 2013).

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The Single European Market should be to involve the contracts on the price of electricity and the transfer contracts in order to increase the efficiency of the overall process. Market coupling leads to increased competition in the electricity markets as it facilitates the entry of new competitors on the market. After the introduction electricity grid the market power of producers can be reduced, price level declines and will improve the social situation of the population and other customers.

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