The Analysis Of Local Renewable Energy Resources’ Deployment In A Smart Grid Implementation

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Key words: renewable energy resources, smart grids, smart buildings

Summary. An increasing number of smart grids’ projects around the world demonstrates a growing popularity of this solution that is perceived as a cure for many contemporary problems with traditional grids. An implementation of smart grids implicates a connection of numerous Renewable Energy Resources (RES) into a grid. This process is complex and demands fine management strategy. Many regulations, with EU energy package as one of the most important, makes the growing role of RES in the general energy-fuel balance. Numerous advantages from the implementation of RES are also an important issue in a process of their development. Nevertheless, connecting numerous RES into the electrical grid makes its instability. The aim of the paper is to present factors of RES development at a local level in a smart grid implementation.

1. INTRODUCTION

The Smart Grid Task Force defined smart grid as “the integration and application of real-time monitoring, advanced sensing, communications, analytics, and control, enabling the dynamic flow of both energy and information to accommodate existing and new forms of supply, delivery, and use in a secure, reliable, and efficient electric power system, from generation source to end-user” [4].

Smart grids are able to transform the quality of whole distribution system thanks to dispersed RES. Variable character of these sources implicates a necessity to manage the load. Local microgrids will gain a better quality of energy, a stability of supply and an energy independence. That is why a development of RES should be perceived at a local, commune level.

The development of RES is a very complex process that demands making various considerations and taking a lot of actions. The uncontrollable growth of RES’, based on wind energy, share in the electrical grid is a potential cause of its volatility. That is the reason of including social, economical, grid, legal and environmental issues into RES’ development strategy for communes and investors.

Communes in Poland have to realize the tasks on planning an energy supply thanks to the Polish Energy Law. RES’ development at a commune level takes estimations of local RES potential, identifying the possibilities of its future expansion and defining the strategy of commune’s development as a necessity.

Placing RES’ development into a local level makes an opportunity of more dynamic growth. However it takes a lot of effort from a local government, investors and even a local community. That is why the aim of that paper is to describe the crucial factors that have to be considered under the development of RES.

2. SMART GRID CHARACTERISTICS

Existing grids tend to be centralized with radial topology and one-way communication. They are prone to failures and blackouts and require manual restoration. Customers have only few possibilities of making choices and limited price information. By contrast, smart grids accommodates distributed generation (DG) and network topology. Two-way communication, monitors and numerous sensors takes effect in self-monitoring, self-healing, remote monitoring and pervasive control system. For customers, implementation of a smart grid denotes a full price information and many possibilities of making choices [14].

It is looked forward that local microgrids will progress reliability of a bulk power and distribution system and perk up energy efficiency and quality. Due to the interconnection of RES, it will reduce greenhouse emissions. What is more, demand response programmes will enable consumers to manage and control their energy usage and costs in a more aware and responsible manner.

Smart grids characteristics embrace interoperable tools enabled by expansion of ICT tools to improve monitoring, management and way of electricity usage.

3. CRUCIAL FACTORS OF RES’ OPERATION IN SMART GRIDS

Implementation of dispersed RES demands a proper management strategy and planning at a local level.
Creation of local, independent microgrids demands a consideration of five crucial factors in a planning process: social, legal, economical, ecological and grid factors.

Social factors refer to society and a single consumer. One energy consumer can have an influence on energetic in three manners: at national, local and personal level. Mapping these impacts on all society makes a national energy culture. An energy culture is a term that describes an attitude of all society: consumers, producers, grid operators, utilities to energy issues. To complete this term it is necessary to add economic and social features as i.e.: national energy resources, climate, aims of national energy policy, economic development, business and trade structure, national history and culture, level of social integration, political factors or level of energy knowledge in a society.

Poland has an East-European energy culture. Its distinctive features are: a high level of an energy consumption but lower that EU average, usage of coal as a basic resource and paternalism. Therefore, polish society is passive and accepts a coal-based energetic that became ‘transparent’. Due to this fact, building new RES usually causes social objections as people consider wind turbines or solar panels as a big change in their neighbourhood.

Polish society has a high level of national RES’ acceptance, due to the Eurobarometer research. Nevertheless, a level of a local RES’ acceptance is surprisingly low. This difference is called the NIMBY (not in my backyard) syndrome. The approval of current energy situation and coal usage, a lack of RES’ requires and a superficial knowledge of RES and energy saving determines a social resistance to any changes at a local level. The society can understand a global need of RES but will not accept its implementation in vicinity. Social resistance to a RES investment can take the shape of protests, strikes, blockades, demonstrations, petitions and, finally, to investment retention or relinquishment.

To minimize a risk of resistance, a commune and investors should take numerous actions. Firstly, a social research should be taken to define a level of possible obluction. Then, a dialogue between local society, an investor and commune authorities should begin. The feeling of participation in an investment can decrease objection and improve cooperation. A superficial knowledge of RES can be an important factor causing social protests, hence there is a strong necessity of further education. A significant part of educating is to convey reliable information about specific investment concurrently with a general information about RES. An education can be performed as training courses, dialogues, trips to locations where similar investment was completed or involving local society in Demand Response (DR) programmes. DR by which electricity users curtail usage during periods of high demand in exchange for incentive payments. That leads to change a consumer’s attitude from passive to active. An active consumer is well educated in energy saving and more willing to accept RES’ investments.

The last form of resistance mitigation is indemnity or compensation payment. Compensation payments should be also taken into consideration during analysing economical factors of a RES investment. Building a RES is a expensive process. Usually, the main part of costs accounts for an equipment, i.e. a wind turbine. But other costs that have to be incurred are: cost of preparing necessary documentation, administrative proceeding, building or adapting infrastructure, connecting RES to a grid and conceivable indemnity or compensation payments for a local society, ecc.

Incomes are reached from selling energy and property rights from ‘green certificates’. Energy prices may be stable or vary in time due to a signed contract.

An appraisal of economic efficiency of RES’ investment is a complex process that should be carried out with several methods that would effect in a comprehensive analysis. An investment’s profitability depends on numerous factors like: location, financing methods, installed power, customary manner of depreciation, price of a land, etc.

The most popular methods of analysing economic efficiency of an investment are: Net Present Value (NPV), Internal Rate of Return (IRR) or payback period. For investments in RES usually a discounting rate used in IRR amounts 10% or 12%. The biggest advantage of these methods is building in a relative worth of money in time. They show cash flows during the period of building an investment and its further exploitation.

Despite of the fact that some changes in an energy law was taken, a process of building a RES is still very complex and long-lasting. These are legal factors.

It is necessary, for an investor to gain wide documentation that includes: entitlement to property disposal, terms of spatial development, decision on existing environmental conditionings, permission to connection to the electricity grid, building permit, obtaining relevant license, concluding a contract for selling an energy from RES and property rights from ‘colour certificates’ (green, red, yellow, brown or violet). These documents are characterized by:
Implementing RES’ gains an ecological benefit that is a reduce in a greenhouse gas emission. The ecological factors embrace advantages gained from a substitution of coal-based energy with green-energy.

Producing energy from coal results in increasing an atmospheric pollution. 1 MWh got from a combustion of coal emits the following amounts of noxious substances: 850 kg of carbon dioxide (CO₂), 11 kg of carbon monoxide (CO), 10 kg of sulphur dioxide (SO₂) and 4 kg of nitrous oxides (NO₂).

A wind plant energy capability is estimated for 2 000 – 2 400 MWh/1MW per year. It means that from 1 MW of installed power it is possible to gain from 2 000 up to 2 400 MWh of electric energy every year. This value can change under numerous circumstances like weather conditions or turbine’s working time. Taking two presented above values under considerations it is possible to reduce the emission of noxious substances in a result of replacing conventional power plants with wind power plants as shown in a table below.

<table>
<thead>
<tr>
<th></th>
<th>Unit</th>
<th>2 000 MWh</th>
<th>2 400 MWh</th>
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<tbody>
<tr>
<td>CO₂</td>
<td>kg</td>
<td>1 700 000</td>
<td>2 040 000</td>
</tr>
<tr>
<td>CO</td>
<td>kg</td>
<td>22 000</td>
<td>26 400</td>
</tr>
<tr>
<td>SO₂</td>
<td>kg</td>
<td>20 000</td>
<td>24 000</td>
</tr>
<tr>
<td>NOₓ</td>
<td>kg</td>
<td>8 000</td>
<td>9 600</td>
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Source: Own elaboration.

Implementing new distributed energy resources (DER) into a grid results in enhancing power quality and reliability, reducing carbon emissions and increasing energy efficiency. However, RES that belongs to DER may cause volatility caused by i.e. changing weather conditions. That is why managing a huge number of RES becomes a challenge. Therefore there is a need for a new idea to face growing problems with operating and controlling a grid in a safe and efficient manner. This challenge could be addressed by microgrids. Microgrids can coordinate RES in a consistently more decentralized way and reduce the control burden on the grid. That permits RES to provide their full advantages.

Exemplary microgrid should consists of: RES and other DER, loads, distributed storage systems (DS), reclosers and breakers. Thanks to installed RES, i.e.: small and medium size wind farms, photovoltaic generation, small hydro generation, biomass, biogas fuelled generation or combined heat and power generation (CHP), a microgrid is able to alleviate intermittency issues and power fluctuation impacts on the national grid.

Building microgrids has numerous advantages that support growth of a grid. Firstly, microgrids allow an implementation of a huge variety of generation devices: RES and conventional, along with storage devices as well. Microgrids are also a factor that support a development of DR programmes. These programmes helps a society to become more active and conscious energy end-users, consequently leading to a society of prosumers. A prosumer is a consumer that can not only use electric energy but also produce and sell it thanks to micro RES installed in a household. Microgrids and DR programmes can also lead to benefits in economics and energy saving. Microgrids improves grids stability by dint of the control approaches based on appropriate droop in frequency and voltage at the terminals of each of its devices. The flexibility of a grid can be improved with microgrids due to the fact that they can adopt many types of generation devices as long as these devices are compatible with microgrids standards.

In other words, microgrids endorse a growth of local grids that can work in an islanding mode or in cooperation with a national grid and ensure a highly efficient energy delivery and supply system thanks to RES and other DER. End-users technology preferences and a need for improved power quality could be reached with DR programmes or other ancillary services within a microgrid. Microgrids support a secure and reliable power supply and can easily operate in an independent form in case of power outages in a main grid.

Microgrids are scalable what means that its range can fluctuate from a large-scale utility level to commercial or industrial level or small, remote microgrids for a single community. Utility microgrids are able to facilitate large-scale deployment of RES and CHP generation, DS and offer ancillary services i.e. local supply of reactive power and premium power quality as long as DR programmes. Commercial or industrial microgrids are designed for users with a demand for a high degree of power quality and reliability. Even short power outages may be critical and not tolerated. These grids are usually smaller that utilities ones and includes areas like big shopping centres, universities and their campuses, factories or other industrial installations. Remote microgrids consists of small DER for electrification of small, often isolated, communities or single premises. In a case when a remote microgrid works in an independent, isolated mode (i.e. on geographical islands or in developing areas) it is crucial to install RES that have to be sized to serve all users with an adequate level of reserve capacity for contingency management.

Designing a new microgrid also requires a strategy for RES’ development including all factors described in former sections of this paper.
8. SMART BUILDINGS’ ROLE IN MICROGRIDS DEPLOYMENT

Due to the European Union Directive on the Energy Performance of Buildings (EPBD 2002/91/EC), more than 40% of Energy consumption in Europe is due to heating and lighting operations in buildings. That is a reason for searching for a new ideas in construction to gain more energy savings.

An important foundation of microgrid is a dispersed generation of small RES. Smart buildings have micro RES implemented and that is why they can support a development of microgrid and its stability and operability. Smart building is managed by an ICT system that helps to optimize an energy usage, making a house energy independent.

A smart, passive building has to be designed with a usage of special building materials, architecture and installation but, as it is written in a European Commission Report “ICT for a Low Carbon Economy. Smart Buildings”, Information and Communication Technologies (ICT) are the engine for making this possible.

A concept of a zero-energy, smart building arises in a House2020 project performing within the scope of Bioenergy for the Region - Programme for PhD Students development. The project consists of two major parts: a concept of a single smart, passive house and a passive estate project that consist of 20 terraced houses with perfect southern exposure and 1 technical plant.

The main features of designed passive house are: superinsulation, compact shape, exposure towards the equator, right fenestration, air tightness and a Building Management System (BMS). Reduced energy demand for heating is achieved by: smart design, increased thermal insulation, air tightening the building envelope, installing high performance windows, incorporating an HRV system and BMS system that helps to optimize an energy usage.

Thanks to a superinsulation a passive house acts like a thermos. The risk deriving from thermal insulation is an excessive moisture of building partitions that causes: deterioration of the interior microclimate, a good environment for microbial growth, decrease in thermal insulation of materials plus corrosion and destruction of partitions. For that reason a good ventilation installation should be designed.

The main installation in a building are: solar hybrid system, micro-power station scheme and a recuperator. Micro CHP installation consists of: steam turbine, multifuel, evaporator, capacitor, power generator, electric pump and low boiling medium. Solar hybrid system has a photovoltaic module as a top layer and solar thermal collector as a bottom one. Photovoltaic module produces electric energy and solar thermal collector is responsible for photovoltaic module cooling and heat production. The efficiency of the integrated solar system is higher than a sum of its components as a result of providing optimal work temperature of photovoltaic module. A recuperator is responsible for a ventilation and disposal of used air. In winter warms the air from a central heating installation and in summer chills air with the usage of a absorption cooling unit.

As mentioned above, due to the European Commission Report it is clear that if smart, green buildings are to become commonplace, that this can only be facilitated by ICT. ICTs role is crucial due to the facts that: new ICT based systems would allow peer-to-peer sharing of energy produced through renewable schemes, smart meters would allow households buy and also sell energy and ICT will allow information on energy consumption of every energy-consuming appliance in a building to be provided in real-time, in a user friendly way, thereby empowering citizens to take decisions that lead to energy savings.

BMS is a solution that is already present in some buildings. Nevertheless, there is inability to centralize and manage data found within building equipment. Existing buildings are full of technology and communication devices that have been installed ad hold over time. These devices, eg.: household devices, computer and Internet connections, security devices, HVAC systems, lighting, tend to operate on different protocol standards. That is why, usually these solutions are non-integrated and managing or monitoring energy usage is difficult.

The concept of a new BMS system designed for a House 2020 project will include new challenges for BMS systems: usage of smart meters, prosumers, smart household appliances, management of energy consumption. The concept will also include the idea of microgrids, making communication among the set of buildings possible. The energy consumption user profile will be analysed and optimized in a way that maximizes the use of RES installed in a building or a set of buildings.

9. SUMMARY

Implementing new RES into a microgrid can significantly enhance power quality and reliability. Also its social, ecological and, more and more often, economical benefits are essential. Thanks to numerous advantages of RES their further development is gaining impetus. Howsoever, it is important to realize that uncontrollable growth of RES units may have a negative influence on a grid.
For that reason it is a necessity to manage a RES’ development. In this paper a number of factors crucial for RES’ development in smart grids were presented. They can stand for a strategy for managing RES’ growth. Another core issue is a fact that building RES usually takes place at a commune level. It implies a commitment of local authorities as an important partner of business model. RES’ development can be significantly improved with the microgrid concept as well as a smart building idea. Nevertheless, the role of ICT in a expansion of these both concepts is crucial.
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ANALIZA UWARUNKOWAŃ WDRAŻANIA ODNAWIALNYCH ŹRÓDEŁ ENERGII W PROCESIE IMPLEMENTACJI SIECI INTELIGENTNYCH

Słowa kluczowe: odnawialne źródła energii, sieci inteligentne, budownictwo zeroenergetyczne

Streszczenie. Wzrastająca liczba projektów dotyczących sieci inteligentnych realizowanych na całym świecie ilustruje rosnącą popularność tego rozwiązania, które postrzega się jako rozwiązanie na szereg bolączek istniejących sieci elektroenergetycznych. Implementacja sieci inteligentnych implikuje włączenie licznych odnawialnych źródeł energii (OZE) do sieci. Proces ten jest skomplikowany i wymaga odpowiedniej strategii zarządzania. Szereg regulacji, z Pakietem 3x20 na czele, warunkuje wzrost udziału OZE w ogólnym bilansie paliwowo-energetycznym. Istotne korzyści płynące z

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