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Analiza potencijala za uvođenje sistema pametnih mreža u Bosni i Hercegovini

Analysis of the Potential for the Introduction of Smart Grid Systems in Bosnia and Herzegovina

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Rezime - U radu je prikazana analiza postojećeg stanja u pogledu razvoja elektrodistributivne mreže i potencijala za razvoj pametne mreže u odabranoj pilot regiji Bosne i Hercegovine. Osim procjene okvira politike, u opseg analize uključeno je nekoliko kriterija zasnovanih na indikatorima: udio obnovljive energije i obnovljive energije kao distribuiranog energijskog resursa, ukupan udio distribuiranih energijskih resursa, broj instalisanih pametnih brojila za mjerenje potrošnje električne energije, broj stanica za punjenje električnih vozila, kapaciteti za skladištenje energije i tehnološki razvoj. Ukupna analiza procjene urađena je normalizacijom izračunatih vrijednosti indikatora na skali od 1-5. Indikatori su pokazali da je sektor pametnih mreža u Regiji trenutno nedovoljno razvijen.

Ključne riječi - pametna mreža, energijska sigurnost, obnovljivi izvori energije, pametna brojila, distribuirani energijski resursi.

Abstract - The paper presents an analysis of the current situation regarding the development of an electricity distribution network and potential for a smart grid development in the selected pilot region of Bosnia and Herzegovina. Apart from the policy framework assessment, several indicator based criteria were included in the scope of analysis: share of renewable energy and renewable energy as distributed energy resource, total share of distributed energy resources, a number of installed smart meters for measuring electricity consumption, a number of charging stations for electric vehicles, energy storage capacities and technological development. The overall analysis of the assessment has been done by normalization of the calculated values of the indicators on a scale of 1-5. The indicators have showed that the smart grid sector in the Region is currently underdeveloped.

Index Terms - smart grid, energy security, renewable energy source, smart meters, distributed energy resources.

I Introduction

The concept of smart grids has been developed in order to ensure efficient distribution of electricity, security of electricity supply, and also to maintain low losses and high level of quality. The concept enables a small, individual scale to generate electricity and sell it to the grid [1]. Smart grids are considered to present the modern, innovative electric power grid infrastructure for the enhancement of the energy efficiency, security and reliability through automated and smart control, modern communications infrastructure, smart metering technologies, renewable energy systems (RES) integration, and modern energy management techniques, enabling of the electricity customers to become active participants [2]. Smart grids promote the greater use of renewable and unused energy and contribute to the improvement of energy self-sufficiency rates and reduction of CO_2 emissions [3]. Since the integration of RES to conventional electricity grid is very difficult to manage, smart grid technologies will significantly reduce barriers to the integration of renewable resources and allow power grids to support a greater percentage of variable and intermittent renewable resources [4]. Integration of distributed energy resources (DERs) into conventional grid at distribution level poses a number of technical challenges such as reverse power flow, grid stability, frequency variation, power quality issues. However, these challenges can be adequately taken care of in the smart grid system, as it can effectively sustain and absolve great percentage of locally available DERs especially renewable energy sources for stable, reliable and affordable electricity [5]. Smart grids will allow networks to adapt to meet higher levels of demand at lower total costs in comparison to the traditional networks, and some of the resulting financial benefits should be passed on to the consumer through incentives and lower prices [6].

One of the most important benefits of smart grids is the improvement of the consumer capacity to use more, but cheaper electricity to enhance the standard-of-living [7]. Also, with the integration of the devices which provide electricity consumption data, utility providers can benefit from balanced utilization of energy by achieving a higher level of efficiency in provision of electricity [8].

Around the world, smart grid technology is growing steadily; between 2017 and 2023, the global market is expected to triple in size reaching some 61 billion U.S. dollars. The key regions incorporating smart grid technology includes North America,

Europe and Asia Pacific [9]. Smart grid development is currently still tied closely to the economic development of countries. Most smart grid development so far has been focused in countries with high renewable energy targets, as they are starting to face problems with the stability of their power supply due to more intermittent generation. However, the potential for applying smart grid technology in developing countries is increasingly being explored [10].

Bosnia and Herzegovina (BiH) adopted the Energy Framework Strategy 2018-2035, which defines a direction of the country's energy development. A long-term energy-related vision of Bosnia and Herzegovina is to create a competitive and long-term sustainable energy system including security of supply. The Framework Energy Strategy aims to balance the following aspects: a) security of supply, b) price competitiveness and c) decarbonized energy supply [11].

The paper presents an analysis of the current situation regarding the development of the electricity distribution network in the region of Central Bosnia and Herzegovina and the level of efforts for the introduction of smart grid systems in the Region. The Region covers the geographical area of two cantons in BiH: Zenica-Doboj and Central Bosnia Canton with population of 619,119 inhabitants. Both Cantons are very industrialized but at the same time have potential for tourism development. The electricity consumption in Central Bosnia Canton in 2019 amounted to 538.71 MWh, while for Canton Zenica-Doboj the consumption amounted to 724,889 MWh.

II METHOD

We have applied an electricity market analysis that provides an overview of energy production by conventional and renewable energy capacities and distributed energy resources (DER). The analysis of the existing electricity market and electricity network includes the integration of new technologies, opportunities and resources.

As policy support is key for the adoption of smart grid technologies, we conducted a gap analyses of existing policy framework in BiH focusing on smart grid related objectives and measures. Apart from the policy framework assessment, several indicators were included in the scope of the analysis: share of renewable energy and renewable energy as distributed energy resource, total share of distributed energy resources. A share of installed smart meters for measuring electricity consumption, number of charging stations for electric vehicles and energy storage capacities are presented and analysed under the new technologies.

Qualitative and quantitative research methods were used during data collection and market analysis. An aggregated evaluation has been done by normalization of the calculated values of the indicators on a scale of 1-5. The scale refers to a level of implementation of the criterion:

- “1” correspond to “no measures set/ potential unused” ,
- “2” correspond to “measures unclear or unrelated to the objectives / underutilized potential“,
- “3” correspond to “fewer measures contribute to the objectives / potential partially used”,
- “4” correspond to “significant number of measures contribute to the objectives / potential significantly used”,
- “5” which correspond to “fully developed/ potential fully used” (this is defined as a target value).

III POLICY FRAMEWORK

Bosnia and Herzegovina has two policy documents setting a basis for the smart greed development:

- BiH Energy Framework Strategy for 2018- 2035,
- National energy efficiency action plan 2016-2018

Besides national policy documents, public institutions in energy sector prepare their own development plans, such as Long-term development plan of the Public Enterprise “Elektroprivreda” BiH until 2030 with the Strategic Plan.
The Energy Framework Strategy sets the midterm objectives to modernize and develop infrastructure and introduce new technologies with the distribution system operators (DSO). Focus should be put on the infrastructure digitalisation, smart meter/grid roll out, technical and IT integration activities, and adjustment of fieldwork processes, predominantly in the operations (dispatching) and maintenance segments. The Strategy calls for intensified integration of sources of distributed energy [11].

National energy efficiency action plan identifies two main challenges in terms of integration of distributed power generation which is mostly of variable character (wind power, photovoltaic solar):

- Their integration into the electricity network infrastructure, because integration of a large number of distributed producers increases the technical requirements for ancillary services; and
- Their integration into the electricity market, because with large volumes of variable production capacities it is much more difficult to balance supply and demand.

The necessary technical condition for implementation of this requirement is therefore the introduction of smart grids, whose development should enable the electricity distribution sector to address all challenges presented by the liberalised electricity market [14].

The long-term development plan confirms the strategic commitment to ensure technical preconditions for smart metering, introduction of information and communication technologies and smart grids. It has been planned to: install the modern metering devices with a possibility of two-way communication at the billing metering points of the distribution network users; make structural changes in the network for increased acceptance of distributed generation and invest in new technological solutions of network elements and plants (smart grid) [15].

IV CONVENTIONAL SYSTEMS FOR ELECTRICITY GENERATION

In the Region, electricity production is dominant from the Kakanj thermal power plant, Jajce I and Jajce II hydropower plants. Thermal power plant (TPP) "Kakanj" with an installed capacity of 450 MW, produces electricity from brown coal and is currently the second largest producer of electricity in all of BiH.

The realized production in TPP Kakanj for 2019 amounted to 1,768.42 GWh.

A significant producer of electricity in the Region is HPP Jajce I, which has an installed capacity of 60 MW. HPP Jajce II has a total installed capacity of 30 MW. Electricity production from large hydropower plants, i.e. from Jajce I and Jajce II, amounted to 390 GWh in 2019. The ratio of electricity production from a thermal power plant is significantly higher compared to the production from two hydropower plants (Figure 1).

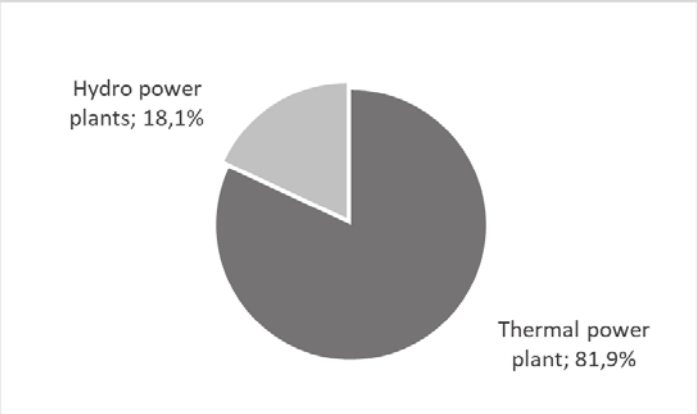

Figure 1. Primary electricity production from conventional systems

V NEW TECHNOLOGIES THAT INCLUDE RES AND DER

A significant number of small hydropower plants have been installed in the Region, of which a total of 42, as well as small solar photovoltaic power plants, of which there are 49. Also, one wind power plant (one 250kW wind turbine) has been registered in the Region, but the value of electricity produced from this system is slightly small. The company Natron-Hayat produces the electricity from biomass and the company has the status of an independent producer.

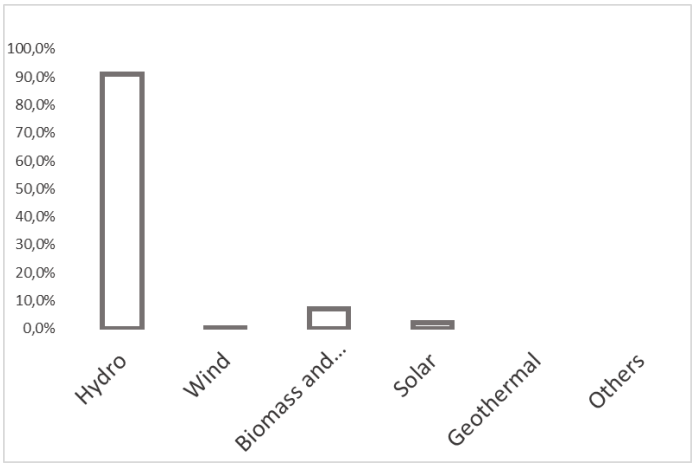

Figure 2. Share of renewable electricity generation by type of technology in 2019 (%)

Electricity production from small-hydropower plants in 2019 amounted to 95 GWh. The electricity produced from solar power plants and wind power plants is small and amounted to 2.1 GWh for solar power plants and 0.011 GWh for wind power plants (Figure 3). The Natron-Hayat company produces 7.3 GWh.

The consumption of electricity from RES in the industry and service sector accounted for 80.3% and in the household 19.69%, of the total consumption, while the consumption in the transport sector was negligible (0.01 %).

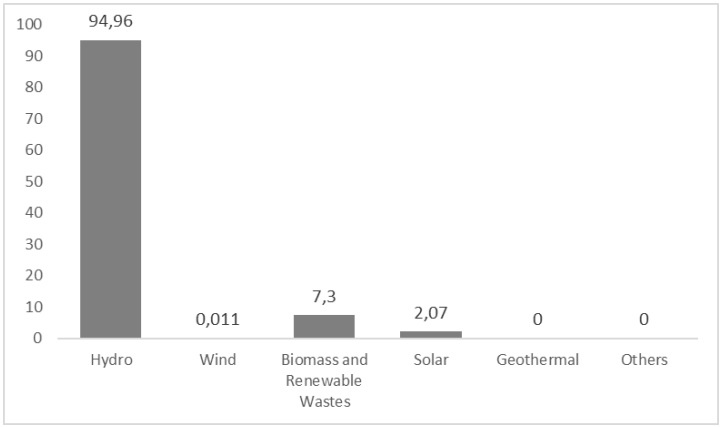

Figure 3. Electricity production from renewable energy systems in 2019 (GWh)

The share of renewable energy sources in the total regional gross final electricity consumption amounted to 22.6% in 2019. Based on Long-term development plan, Public Enterprise Elektroprivreda BiH is planning the development of 12 RES projects until 2030 (Table 1). This will increase the share of renewable energy sources to 60.2%.

Table 1. Installed capacity of planned RES projects

Type of project	HPP	WPP	SPP	TPP-biomass cogeneration	Total
GWh	218	480	116	179.4	814
Number of projects	3	4	4	1	12

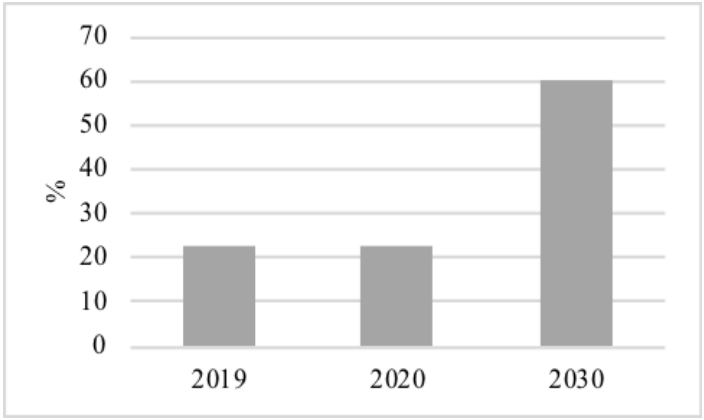

Figure 4. The target to increase the share of RES for 2030

The share of DER in the production of electricity from renewable sources is 21.09%, mainly from small HPPs and solar. The

Region has significant potential for distributed electricity generation especially in small HPPs, wind power plants and biomass cogeneration systems [13].

The share of DER in the total regional gross final electricity consumption in 2019 and 2020 was 4.78% (Figure 5). Based on Long-term development plan, Public Enterprise Elektroprivreda BiH is planning the installation of new distributed energy systems, which will increase the share of distributed sources in the total regional gross final electricity consumption to 6.88%.

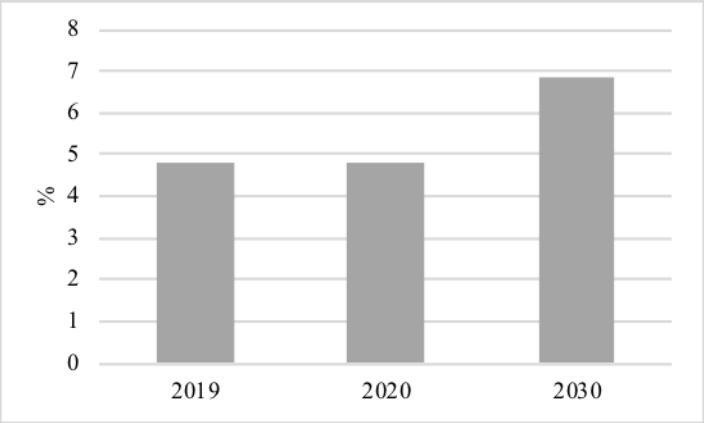

Figure 5. The target to increase the share of DER in 2030

The current share of DER in the gross final electricity consumption is unsatisfactory due to its low value, and also the value of the targeted share of DER for 2030 is not very ambitious.

The increase in the share of DER in the total electricity production causes a number of technical consequences that depend on the size and number of DERs as well as their distribution on the one hand, and on the other hand on the structure of the power system.

Initial experiences in the implementation of distributed electricity generation also raise some issues regarding the constraints to be addressed by market participants, regulators and energy policy makers in the Region with the maximum involvement of research activity according to the following aspects [13]:

- Regulation of the power system with regard to the integration of distributed generation;
- The impact of distributed electricity sources on the planning of distribution and transmission networks;
- Integration of distributed electricity sources in the distribution and transmission network management system;
- Distributed sources of electricity and their impact on the quality of electricity supplied to customers.

The development of the use of DER will require additional automation and construction of advanced networks in the distribution system.

VI Research Results

According to data from the Public enterprise Eelektroptivreda BiH, a total of 26,024 smart meters have been installed in the Region. Considering the fact that there are 199,469 households and 20,057 industrial consumers, this number is rather small. The potential of e-mobility in the Region has only just begun to develop, with the electromobility sector recognized as one of the strategic development directions. It is planned to continue with the construction of charging stations for electric vehicles and procurement of these vehicles. So far, a total of 4 charging stations for electric vehicles have been installed in the Region and only 3 electric vehicles are currently in use. However, the use of electric vehicles in BiH has not been legally regulated, yet. The Association for Electromobility advocates for adoption of a regulatory framework and policy framework for electromobility, with special attention to defining conditions for providing charging services for electric vehicles, technical requirements for charging stations, technical conditions for connecting charging stations to the electricity grid.

Currently, there are no capacities for electricity storage in the Region.

VII Discussion

According to the assessments of the possibilities and conditions for the development of the electricity network, it is evident that the smart grid sector in the Region, as well as in the entire BiH, is currently underdeveloped, and certain shortcomings have been identified. Existing national policy strategically supports the development of smart grids, but there is no support on the level of operative planning and implementation. Policy documents lacks specific, measurable, relevant and time- orientated goals and set of concrete action to support the goals achievement. With the current level of investments in innovative technologies the strategic goals and ambitions cannot be reached. In comparison to 2019, no progress has been made in the share of RES and the share of DER. Out of 4.78% of the share of DER, only 1% is from RES. Therefore, both DER and RES criteria have the same scoring. Only smart meter deployment is better scored since 11.8% of the total meters are smart meters. The values of the criteria, which are shown in Figure 6, refer to the current situation regarding the development of the smart grid sector, where the values of 5 represent the target value for the full implementation of the smart grid sector.

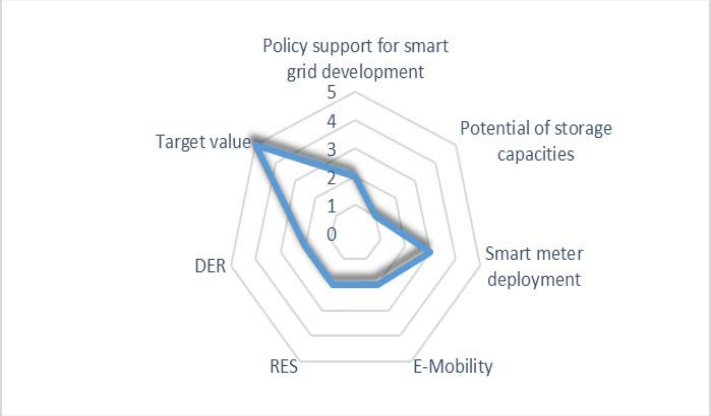

Figure 6. Aggregated evaluation of analysed criteria

VIII CONCLUSION

The market analysis has been performed using indicator-based criteria. We have included a policy framework assessment, share of renewable energy and renewable energy as distributed energy resource, total share of distributed energy resources and new technologies. The selected set of criteria and indicators proved to be a good initial framework for analysis but should be expanded in the future research. Aggregated evaluation, based on normalized values, helps decision makers to better understand the result of the analysis. The selected five-point scale, in course of further research, can be improved and adapted to the level of knowledge and way of thinking of the decision makers. In this research, the opinion of decision makers was not taken into account.

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LITERATURA/ REFERENCES

[1] Agung A.A.G., Handayani R. Blockchain for smart grid, *Journal of King Saud University – Computer and Information Sciences*, (In Press) https://doi.org/10.1016/j.jksuci.2020.01.002

[2] Sun Q., Ge X., Liu L., Xu X., Zhang Y., Niu R., Zeng Y. Review of Smart Grid Comprehensive Assessment Systems, *Energy Procedia*, Vol. 12, pp. 219–229, 2011. https://doi.org/10.1016/j.egypro.2011.10.031

[3] Elzinga D. Electricity system development: a Focus on Smart Grids, UNECE, 2015. https://unece.org/fileadmin/DAM/energy/se/pdfs/geee/News/Smart_Grids_Overview_05-19-15.pdf [pristupljeno 20.01.2021]

[4] Jain A., Mandloi T. Integration of Renewable Energy Sources in Smart Grid Systems and their Constraints, *International Journal of Modern Trends in Engineering and Research*, Vol. 2, Issue. 03, 2015.

[5] Johnson D.O., Petinrin J.O., Oyelekan S.F. Integration of Distributed Energy Resources in Smart Grid System, in Proc. *International Conference of Science, Engineering & Environmental Technology (ICONSEET)*, Vol. 2, Issue 6, pp. 38-47, 2017.

[6] McNamara R., Marshall A. *Smart grid: A great consumer opportunity*, 2013. https://d346xxcyottdqx.cloudfront.net/wp-content/uploads/2013/10/Smartgrid-consumer-opportunity.pdf

[7] Anderson R.N., Ghafurian R., Gharavi H. *Smart Grid: The Future of the Electric Energy System*, 2018.

[8] Dimitriou T., Awad M. K. Secure and Scalable Aggregation in the Smart Grid Resilient against Malicious Entities. *Ad Hoc Networks*, Vol 50, pp. 58-67, 2016. https://doi.org/10.1016/j.adhoc.2016.06.014

[9] Jaganmohan M. Global smart grid market size by region 2017-2023, 2021. https://www.statista.com/statistics/246154/global-smart-grid-market-size-by-region/ [pristupljeno 20.01.2021]

[10] Álvarez, Ó., Ghanbari, A., Marken, J. A Comparative Study of Smart Grid Development, in Proc. *7th CMI Conference 2014: Mobile Communications in Developing Countries*, 17 - 18 November 2014,Copenhagen, Denmark, 2014.

[11] Framework Energy Strategy of Bosnia and Herzegovina until 2035, http://www.mvteo.gov.ba/data/Home/Dokumenti/Energetika/Framework_Energy_Strategy_of_Bosnia_and_Herzegovina_until_2035_ENG_FINAL....pdf [pristupljeno 20.01.2021]

[12] Energy needs balance of Central Bosnia Canton for 2020

[13] Strategic Plan and Program for the Development of the Energy Sector of the Federation of BiH, Sarajevo, September 2008

[14] National energy efficiency action plan 2016-2018, https://www.iea.org/policies/2365-national-energy-efficiency-action-plan-2016-2018 [pristupljeno 20.01.2021]

[15] Long-term development plan of public enterprise "Elektroprivreda" BiH until 2030 with the Strategic Plan, Sarajevo, 2014

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