MICROGRIDS CAN STRENGTHEN GRID RESILIENCE

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ABSTRACT

The purpose of this paper is to analyse solutions of microgrids implementation, to ensure the continuity of electricity supply in order to minimize the risks of electricity network outages. It is necessary to identify the alternative supply options to reduce the vulnerabilities and to implement multiple provisioning possibilities that will guarantee energy redundancy.

INTRODUCTION

Distributie Energie Oltenia (DEO) is the distribution operator of CEZ Group Romania and in the same time is one of the main distribution operators in Romania. It provides electricity supply to more than 1.5 mil. customers, in seven counties of the south - west of Romania (Fig.1).

One of the ambitious projects of DEO is to create for the beginning a microgrid able to operate independently from the main power grid or in synchronization with it.

Fig. 1 – Area served by DEO in Romania

The target is to achieve an electrical scheme that can be disconnected from the national network if the situation requires and that can operate autonomously.

Microgrids can strengthen grid resilience and help mitigate grid disturbances as well as function as a grid resource for faster system response and recovery [1].

MICROGRID DESIGN

A microgrid comes in a variety of designs and sizes. It must be located in a clearly defined area.
It has the potential to bring savings and benefits to consumers, without foreclosing the competition in the new activities.

Why microgrids ?

People need secure and sustainable energy at affordable prices. Our way of life depends largely on energy to provide everyday services that are indispensable for both citizens and businesses.

In order to improve the services for its customers, DEO is looking for flexible solutions in operating distribution network through the creation of microgrids.

Besides of the main purpose for which a microgrid is created, namely to ensure continuity and safety in the electricity supply of an area, in situations where disturbances / interruptions may occur in national networks, a distribution operator wishes to make microgrids from the following reasons [2]:

- A microgrid can produce secure, reliable and affordable energy for entire community,
- Provides power quality for end users,
- Enhances the integration of distributed and renewable energy sources,
- Enables smart grid technology integration,
- Increased the final customer participation.

Choosing the microgrid

Three areas were analysed for choosing the microgrid, respectively, zone A – in Arges county, zone B – in Dolj county and zone C – in Gorj county. All of these counties are in the distribution licensing area of DEO.

The operation of microgrids offers distinct advantages to customers and utilities, i.e. improves energy efficiency, minimization of overall energy consumption, reduce environmental impact, improves reliability of supply, it assures network operational benefits such as loss reduction, congestion relief, voltage control, or security of supply and cost efficient electricity infrastructure replacement. [3]

Zone A – in Arges county

The Microgrid 1 is intended to be created in Curtea de Arges town and surroundings, in the west of Arges county (Fig. 2). Here is a touristic zone, with many sights of great historical importance.

Curtea de Arges was the first capital of Wallachia and preserves the most important Byzantine buildings on the Romanian territory, as well as monuments of art and architecture of high artistic value of international

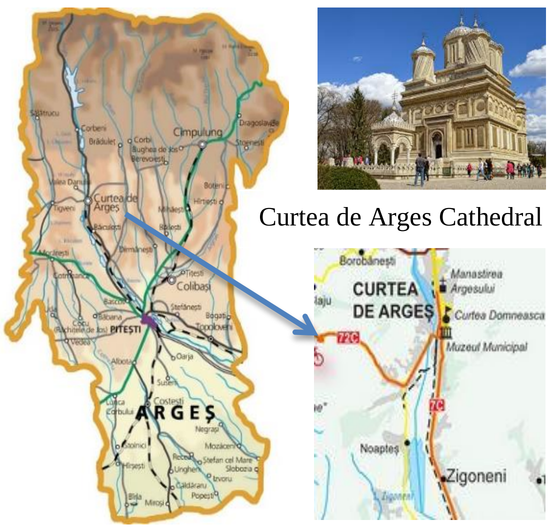
interest such as Curtea de Arges Cathedral.
As sources of electricity generation, Microgrid 1 incorporates the hydropower plant named CHE Noaptes (2X7.7 MW) and as a reserve source is another hydropower plant named CHE Zigoneni (2X7.7MW).

The point of common coupling (PCC), respectively the point in the electric circuit where Microgrid 1 is connected to a main grid, is located at the separator of the OHL 110 kV Arges Sud - Valea Danului that connects with national power grid.

In the present the annual electricity consumption of the area is approx. 21,000 MWh, so it can be covered from the local generation plants.

The electrical networks of Microgrid 1 are: a sub-station 110 / 20kV, 72 secondary substation, 62 km OHL 20 kV and 22 km cables 20 kV.

In this area, there are 7,451 electricity consumers.



Source: http://pe-harta.ro/arges
Fig.2-Arges county with Microgrid 1 - Curtea de Arges

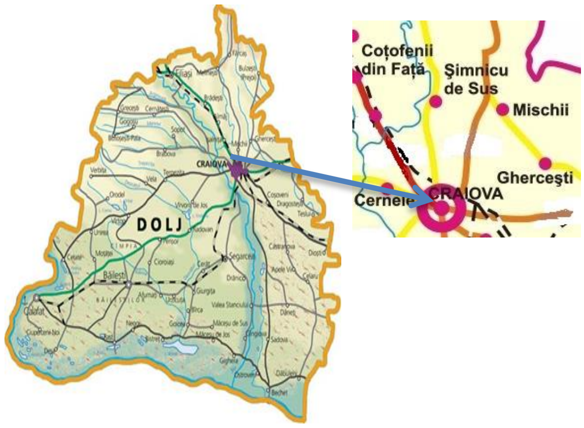
In the future, it is expected that the Microgrid 1 will also incorporate biomass power plants, with the advantage that their electricity production is predictable.

DEO will provide to users, charge stations for electric vehicles, included in this microgrid.

The plan is also to integrate the energy storage technologies. In microgrid, energy storage is required to ensure energy quality, frequency and voltage adjusting, and last but not least to provide the system's energy reserve.

Zone B – in Dolj county

The Microgrid number 2 could be located in a well-defined area, in the east of Craiova city, Dolj county (Fig. 3).
The zone has an economic and social importance, where the users of electrical networks are large industrial consumers, household consumers and small non-



Source: http://www.cjdolj.ro
Fig. 3 – Dolj county with Microgrid 2 North Craiova

household consumers of high importance (egg. children's homes, schools, elderly homes, etc.).

The source of electricity generation in the Microgrid 2 is the power station named CHP Craiova II using solid classical fuel (coal). This power plant is the main source for the thermal energy supply to consumers both in the Microgrid 2 area and in the entire city of Craiova in a centralized system, by:
- 2 cogeneration steam turbines (2 × 150/120 MW) - on coal with gas, flame support;
- 2 hot water boilers (2X100 Gcal / h) - on coal with oil, flame support;
- a boiler of 50 Gcal / h and a boiler of 30 Gcal / h.

The PCC where Microgrid 2 is connected to a main grid, is located at the separator of the OHL 110 kV Simnic - DIF that connects with national power grid.

The electrical networks of Microgrid 2 are: a sub-station 110 / 20kV, 91 secondary substation, 51.7 km OHL 20 kV.

In this area, there are 20,917 electricity consumers.
The annual electricity consumption of the this zone is approx. 100,000 MWh.

Zone C – in Gorj county

The Microgrid number 3 could be located in a clearly defined area, zone Tismana – Godinesti, in the north - west of Gorj county (Fig. 4).

The zone is a symbol of the Romanian traditional art craft and in the same time Tismana and Godinesti are among the oldest localities in Romania.

Source: http://pe-harta.ro/judete/Gorj.jpg
Fig. 4 Gorj county with Microgrid 3 Tismana - Godinesti

Tismana Monastery is the oldest monastic settlement in Wallachia. Nearby there is the Memorial House Constantin Brancusi, famous Romanian sculptor.

The sources of electricity generation for Microgrid 3 are Hydroelectric plant Clocotis (10 MW) and Hydroelectric plant Tismana Aval (4 MW), because Gorj county is located in a hydrographical basin with inner resources superior to the country averages.

The PCC for Microgrid 3 is located at the separator of the OHL 110 kV Godinesti – V. Mare, OHL that connects with national power grid.

The annual electricity consumption of the proposed area is 30,000 MWh, which can be covered by the production of the two power plants if it would operate at a minimum of 25% of the installed capacity.

The electrical networks of Microgrid 3 are: the sub-station 110 / 20kV named Godinesti, 164 secondary substation, 208 km OHL 20 kV. In this zone, there are 16,031 electricity consumers.

By analysing this area, there is an impediment for take a decision in order to disconnect temporarily the electrical installations related of Microgrid 3 from the national power grid.
The Godinesti sub-station that is part of the installations of Microgrid 3 is also a very important node for national power grid. There are therefore risks to be isolated from it. In Godinesti sub-station are connected many electrical lines, which provide electricity for the entire region.

The assessment criteria for establishing microgrid

The zones A, B and C were analysed in accordance with the criteria listed below.
In order to establish the microgrid area, the following criteria were considered:

- The sources of electricity generation in that area,
- Electricity consumption in the area,
- Possibility to achieve an electrical scheme that can be disconnected from the national network and that can operate autonomously,
- The performance indicators for distribution service (SAIDI, SAIFI),
- The network losses.

The results of the analysis are shown in Table no.1.

Table no. 1

The criteria for analysis	**Zone A**	**Zone B**	**Zone C**
Local generation capacity [MW]	30.8	300	14
Annual electricity consumption of the zone [MWh]	21,000	100,000	30,000
Possibility to achieve an electrical scheme that can be disconnected from the national network and that can operate autonomously	Yes	Yes	No
Values for SAIDI, on LV [min/year/client]	69.13	68.51	58.31
Value for SAIFI On LV [no/year/client]	0.31	0.30	0.32
Network losses [%]	13.19	12.24	6.01

Continuity in electricity supply is one of the main parameters of the quality of transmission and distribution services.
Ensuring the level of security in supply is an important condition for the distribution operator to provide efficient services and for the proper functioning of the market itself.
Microgrids support a flexible and efficient electric grid by enabling the integration of growing deployments of distributed energy resources such as renewables. In addition, the use of local sources of energy to serve local loads helps to reduce energy network losses, further increasing efficiency of the electric delivery system.[4]

The establishment of the microgrid

The technical analysis of the zones A, B and C with the calculations of the related electrical network volumes, will lead to the establishment of the microgrid.

So,
Zones A - the source of electricity generation is a hydropower plant with a reserve source another hydropower plant. These sources are ecological and cover the area's electricity consumption needs.
Moreover, in case of there would be some difficulties in the national system, zone A could be isolated and would function safely, ensuring the supply of electricity for this touristic zone, which attracts numerous tourists who need to provide the best services and comfort.

Zone B - The electricity source is a power plant in cogeneration, named CHP Craiova II. It is one of the largest cogeneration plants in Romania.
At present, in Craiova city, CHP Craiova II provides, in a centralized system, thermal energy for 123 thermal points, out of which 104 urban (household consumers and small non-household consumers) and 19 economic agents and public institutions.

Decoupling Zone B from national power system would have implications because:

- In the normal scheme, CHP Craiova II supplies the electricity through 6 OHL 110 kV connected in its own sub-station, named Simnic;
- The insulation of Microgrid 2 requires a scheme in the Simnic sub-station, with only one OHL 110 kV on a bar section, which would supply all consumers in the Craiova East. Plus, for an efficient operation of a power plant that generates electricity and heat in cogeneration, there must be a ratio between the amount of electricity and the amount of thermal energy generated. This ratio is correlated with the season. In Romania are considerable variations from summer to winter and the temperature differences are high. That's why such a power plant must evacuate the power in a looped network not radial network. So, it is not advisable to limit in generating a kind of energy (electricity or thermal) in favour of the other because would cause a low performance.

Zone C - The sources of electricity generation are hydroelectric plants, which ensure the electricity consumption of this zone. The sub-station that should be isolated from the national system to be part of the Microgrid 3 is a very important node for the national power grid. The isolation of this sub-station from the national system could cause risks in the functioning of the national power grid.

Considering the above, ***the option in order to achieve a microgrid is Zone A - in Arges county***, ***respectively Microgrid 1***

In order to meet all the conditions related to the safe and efficient operation of the classical power plants that provide the power sources in Microgrid 1, it is necessary to complete the automation equipments (control and regulation) of the plants. The main purpose in this reason is to make the desired regulation: frequency - active power, ensuring the operation of the equipments to the nominal parameters, meeting the performance criteria imposed on the entire system.[5]

A microgrid not only provides backup for the grid in case of emergencies, but can also be used to cut costs, or connect to a local resource that is too small or unreliable for traditional grid use. A microgrid allows communities to be more energy independent and, in some cases, more environmentally friendly.[6]

Conclusions

Microgrid is contributing to network consolidation, increasing flexibility and the improved efficiency, allowing integration of classical growing developments and above all, renewable energy distributed resources.

In this reason, DEO will increase the number of micrograms in its license area, respecting the criteria mentioned above. Previously, the cost-benefit analysis will be done and will include also the results of the monitoring of the Microgrid 1.

The improving of the reliability and the resilience of the network means smart grid preparing.

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