The minimalization of active losses in SMART network solutions

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Abstract **— Present electric networks are designed in a way that follows a certain pathway starting from production, distribution to end-users. Smart network solutions offer a different solution as the electricity flow can take up two directions. The ones consuming electricity can also produce and transmit it to the location of the production. The first chapter is devoted to distinguishing between classic and smart solutions. In the second chapter, the expression SMART GRID is explained in more detail along with renewable energy sources. The next chapters deal with the losses during the transmission process and possible methods of prevention.**

Keywords **— minimalization of losses, network reconfiguration, renewable energy sources, Smart Grid.**

I. INTRODUCTION

Nowodays it is possible to determine the electricity flow, the way it transmits itself to the households, companies and schools etc. Electricity is being produced in power stations. Power stations can be as follows:

- thermal power stations,
- nuclear power stations,
- water power stations.

After producing electricity, it transform itself to higher voltage levels to cut the losses as much as possible. In the close proximity to energy consumption it is being transformed into lower voltage levels which can be used for households. The flow of electricity is a one-way traffic at present starting from production, transmission and distribution up to the consumption [1], [2]. This flow is displayed below on Fig. 1.

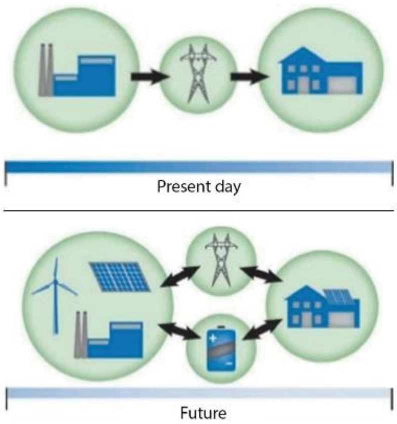

Fig. 1 Vision of the electricity system in present and the future [3]

As the renewable energy resources begin to take precedence over the classical ones, Fig. 1 captures this change as well. The big advantage of the renewable energy resources is that they can be produced for household consumption or the energy can be saved to batteries. In the future (and in the present to some extent), it will be hard to determine the electricity flow as it can be generated at home apart from the power stations. Newer technologies and processes are required to ensure communication between the elements in the system.

II. SMART NETWORKS AND RENEWABLE ENERGY RESOURCES

Smart Grids are automated systems that are supposed to use technological devices to control electricity flows in the electrical grid to achieve maximum energy efficiency. As such, intelligent systems combine traditional technologies in the system with more contemporary technology. A typical model of SMART GRID is described in Fig. 2. Where the traditional elements of the power system that are, for example, thermal power stations, transmission line or household, but new elements such as renewable energy resources, electric cars or intelligent household appliances. Of course, the most important constituents cannot be seen in Fig. 2 which tend to provide the platform for communication between individual devices. Tools like smart electrometers can be used for measuring up-to-date consumption needs and calculating the necessary parameters of electricity production based on the measurements.

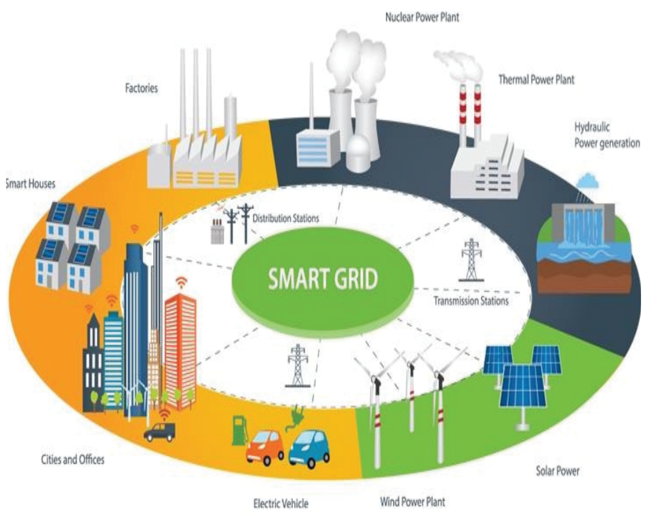

Fig. 2 SMART GRID [4]

The discussion about the intelligent networks is becoming more and more pressing issue as electricity needs to be generated as efficiently as possible. As far as the resources are concerned, the production is being dominated by fossil power plants, however, the fossil fuels are becoming harder to come by not the mention the fact that environmental standards are getting more strict as well. There is an urgent need to find a suitable replacement and ensure that this question will be tackled in the future as wall.

Renewable energy resources provide us with the best possible alternative. They have several advantages such as their inexhaustible nature being one of the most precious ones. Fig. 3 captures the flowing renewable energy resources:

- solar energy,
- wind energy,
- geothermal energy,
- water energy,
- biomass.

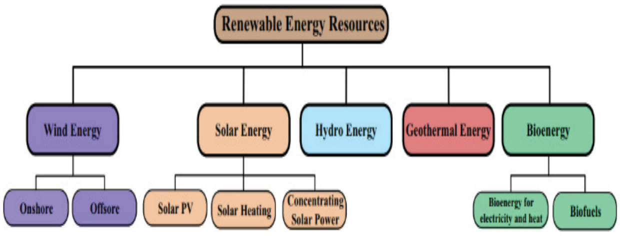

Fig. 3 Renewable energy sources [5]

The European Union set a standard of at least 20 percent of all energy production should be based on renewable energy resources by 2020. This requirement will be increased up to 27 percent by 2030 [6]. In addition, the European Commission raised the level of renewable energy resources from 27 percent to 32 percent in 2018 [7]. Each member state including the Slovak Republic has its own standards and requirements within the framework of these regulations. Some countries have already achieved these targets well in advance, on the other hand, some have to implement better methods how to achieve their share of percentage.

The share of renewables worldwide will increase gradually and therefore it is more than necessary to put an electrical system in place that can fulfil safety and reliability conditions at the same time. One of the options is to use SMART technologies which can ensure that all the right parameters are tracked and implemented. In this way the system will become intelligent enough to track and register all the ongoing procedure in the system.

The expected benefits of using intelligent networks are well-documented. The most important ones are the following:

- noticeable increase in electricity quality and reliability parameters,
- optimization of power plant production,
- increase in the capacity and efficiency of existing power lines,
- the provision of distributed generation,
- the enhancement of intrusion resistance,
- the automation of maintenance and operation,
- the possibility of using renewable energy resources in the production,
- the reduction of fossil fuels applied in the production,
- the reduction of greenhouse gas emissions levels,
- the usage of electric vehicles [8].

III. LOSS MINIMALIZATION IN NETWORKS

The available resources from fossil fuels are decreasing every year and there is an urgency to find a suitable replacement in the foreseeable future. One option would be the application of renewable energy resources to a greater extent. The second viable option can be that the generated electricity will be distributed seamlessly to the end-users. As a matter of fact, the efficiency will not be maximalized, because the losses are incurred at various contact points during the transmission process. While carrying out appropriate measures, it is viable to cut the losses by using suitable devices. There are various methods how to achieve this objective by using the following:

- redistribution of power supplies between the separate plants,
- usage of distributed generations,
- network reconfiguration.

A. Redistribution of power supplies between the separate plants

By redistributing the power between two or several different plants, performance can affect the losses which occur once the power is transmitted to the point of consumption. This distribution model is shown in Fig. 4. Two groups of the distribution can be distinguished:

- *From the perspective of minimizing* – the power distribution is solved in a way that the transmission losses are minimized although the generated electricity is more expensive.
- *In terms of minimizing losses but taking into consideration the characteristics of the power plant* – apart from tracking the losses plant characteristics and fuel cost are also assessed.

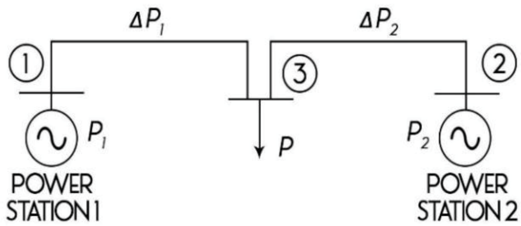

Fig. 4 Redistribution of power supplies [9]

B. Using distributed generations

The difference between this method and the one that has been described above is that the location of all the power plants in the electricity grid was predetermined, but only one power station is located. In most cases, these plants are nuclear power plants or large hydropower plants. The placement of other plants is almost arbitrary and can be calculated. The best results can be achieved once the location of the next plant is connected to the greatest power consumption so that the electricity produced does not need to be transferred to remote locations given the fact that losses are typical during the transmission process. Distributed generations described here used to place the power plant at the point of consumption [10], [11], [12], [13], [14]. Fig. 5 illustrates the characteristic scheme of this model.

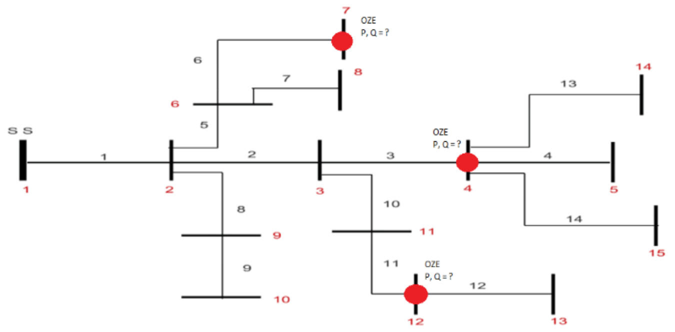

Fig. 5 Distributed generation [13]

Renewable energy resources are usually used for distributed generation, because they have a more compact size which is compatible with the nuclear power plant. They can be of varying sizes in terms of the amount of power produced. Typical values of distributed generations by plant type are as follows:

- Small hydro power plant: 25 kW – 1 MW,
- Large hydro power plant: 1 - 100 MW,
- Wind power plant: 200 W – 3 MW,
- Solar power plant: 20 W – 100 kW,
- Biomass: 100 kW – 20 MW,
- Geothermal power plant: 5 MW – 100 MW,
- Ocean power plant: 100 kW – 5 MW [11].

To reduce the loss beyond the size of the installed power value, the method has some effect on what type of generator is used. The generator can:

1. Produce only active power – P+,
2. Produce only reactive power – Q+,
3. Produce active and reactive power – P+, Q+,
4. Produce active power, but take reactive power – P+, Q- [15].

The biggest advantages of using distributed generations:

- The improvement on system reliability,
- The improvement on electricity quality,
- The reduction of transmission loss,
- The reduction of green gas emission [11].

C. Network reconfiguration

The question of network reconfiguration has come to the fore recently when new and smart technologies emerged. The term describes the process of implementing network switches which are pre-selected. The switches can be turned on and off which can cause a change in network loss [16], [17]. Using line breakers in normal operation serve to protect and isolate the networks, however, new technologies can be used to reduce network configuration losses [18]. The reconfiguration of the networks is illustrated in Fig. 6 for better visibility, the controlled sections were marked with a yellow.

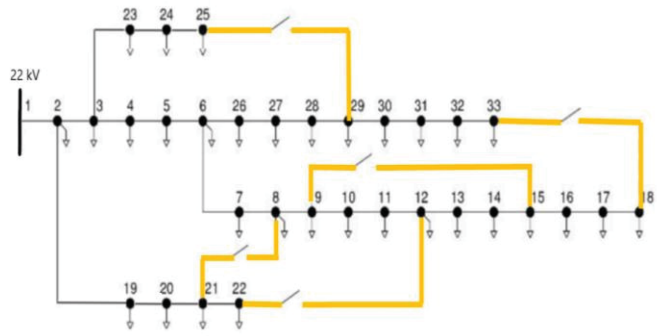

Fig. 6 Reconfiguration network [16]

It is safe to say that new technologies are better suited to reconfiguration as the current situation of the network needs to be determined. This actual status can be obtained by using smart meters indicating up-to-date P and Q value nodes. During the dispatching process, the program calculated network losses based on actual production, current consumption in nodes. The whole process can be seen in Fig. 7. Loss calculations is essential mainly because the program is required to know when the status of the line breaker is changed from off to on to change losses in the network.

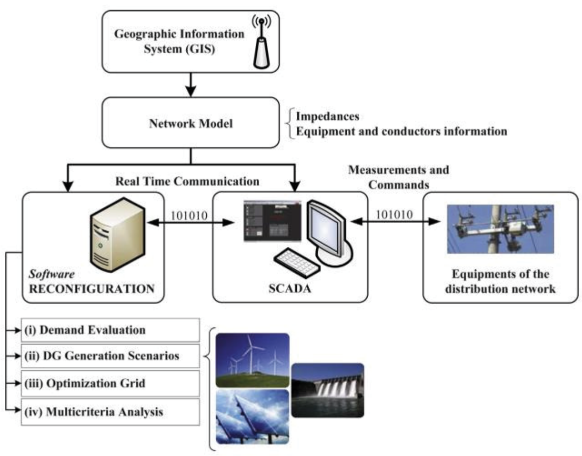

Fig. 7 The architecture of the proposed system [19]

The network reconfiguration has some other benefits besides reducing losses. It can also reduce outages, control voltage and network overload [20].

IV. FUTURE RESEARCH

Further research focuses on setting up a computer program designed to calculate network losses based on input parameters. The loss-based program should determine the location of the distributed generations in order to reduce the lossed and increase network stability.

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