Microgrid model with electric car charging

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***Abstract* — The micro grid or the lower level smart grid is in these days very popular topic. In order to verify the reliability and safety of the grid operation, it is necessary to model the anticipated states. Based on these findings, it is then possible to ascertain the effectiveness and reliability of the future network. In the microgrid model are used a diesel generator, a wind farm, a photovoltaic farm as a source of production and on the other side, a source of consumption is a simulation of a smaller village and an electric car charger.**

***Keywords* — smart grid, microgrid, renewable energy source, electric car charging.**

I. Introduction

In these years "Smart" is as a very often mentioned term. It usually refers to special products with an increasing degree of computing power and intelligence. We know smart products such as smart phone, smart TV or other smart electronics with a variety of features and applications. Electrical energy is currently a strategic "raw material" and its importance in the future years is clearly growing. For this reason, increasing emphasis is placed on the stability, safety and security of the electricity supply to end customers. Therefore, the computerization is increasingly being introduced into the electricity system during the time. Very popular is also the new term “Smart Grid”.

The many of projects, articles and publications focus on theme of Smart Grid, as well as foreign and domestic conferences. Despite the great popularity, there is a wide inconsistency in the definition of this term. Nevertheless, Smart Grid is often referred also to as the network capable of using more renewable energy sources and distributed production than the current network.

Comprehension of the current Smart Grid network is rather difficult and from costs perspective expensive. It is a long-term process that binds capital over many years. Therefore, it requires a strong commitment from all stakeholders. In addition, it is still not fully verified how the individual technologies within Smart Grid will work together.

II. Implementation of the smart grid

Smart Grid networks have the following features and benefits over classic networks. The biggest difference is the different network topology due to the inclusion of distributed production that causes different energy flow directions. The change is also thanks to the new technologies, two-way communication and the presence of active elements and sensors throughout the system, self-monitoring as well as rapid detection and localization of failures.

Thanks to new technologies, higher reliability, better security, greater convenience for customers and higher efficiency in the use of electricity are expected. Intelligent systems also envisage semi-automatic renewal and auto-regeneration as well as adaptive protection and isolation of a potential problem. Customers are thus provided with the integration and provision of new services. From the distribution point of view, it is the use of centralized resources along with decentralized resources.

Decentralized sources of small capacities deployed across Europe are in line with the European Union's commitment and commitment to increase its share of renewable energy production to 20% by 2020. There is expected reducing system losses and the associated increase in ecology, economy and operational efficiency as well as support for scattered production along with the development and research of new management methods results.

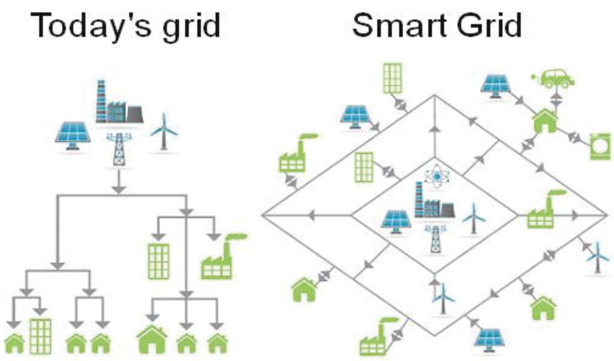

Fig. 1 Comparation of today's grid and the smart grid.

III. MODELLING MICROGRID

Modelling and using of modelling software are a very good method for making designs thanks to computer calculating performance, especially taking in account complexity of the environment. Of course, in the background of every software there is a set of mathematical formulas that we can use to make modifications more efficiently while changing a constant. So, it is not necessary to repeat the entire calculation.

The necessary part of creating an electrical network is adequate preparation which is needed to ensure that the network's functionality is properly verified to avoid unnecessary investment costs. Without suitable training it would not even be possible. At the same time, the software tools create the right conditions for laboratory testing as well as back-up verification of the functionality of the already implemented project. The basis of the modelling must be precise as possible in order to ensure the accuracy of the results is also close as possible to the reality.

Simulink is a MATLAB extension for simulation and modelling of dynamic systems. It provides the user with the ability to quickly and easily create dynamic system models in the form of block diagrams. Models can be described by equations or can be assembled from blocks representing real system elements. Besides models of physical systems, it is possible to model also control system algorithms including their automatic tuning, signal processing systems, communication and image processing.

The microgrid is divided into four important parts: A diesel generator (15MW), acting as the base power generator; A PV farm (8 MW) combined with a wind farm (4,5 MW), to produce renewable energy; a vehicle to grid system installed next to the last part of the topology which is the load (10 MW) of the grid. The size of the microgrid represents approximately a community of a thousand households during a low consumption day in spring or fall. There are 100 electric vehicles in the base model which means that there is a 1:10 ratio between the cars and the households. This is a possible scenario in a foreseeable future.

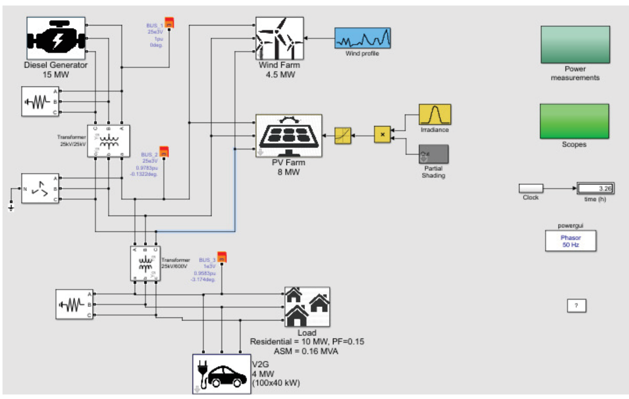

Fig. 2 Model of micro grid in Matlab - Simulink

The diesel generator balances the power consumed and the power produced. We can determine the frequency deviation of the grid by looking at the rotor speed of its synchronous machine.

The load consists of a residential load and an asynchronous machine that is used to express the impact of an industrial inductive load (such as a ventilation system) on a microgrid. Residential load monitors the consumption profile with a given power factor. The asynchronous machine is controlled by a square relationship between rotor speed and mechanical torque.

The photovoltaic power plant produces three energy factors: the size of the area covered by the photovoltaic power plant, the efficiency of solar panels and irradiation data. The simplified model of a wind farm produces electricity after a linear relationship with the wind. When the wind reaches the nominal value, the wind farm produces nominal power. The wind power plant emerges from the grid when the wind speed exceeds the maximum wind speed until the wind returns to its nominal value.

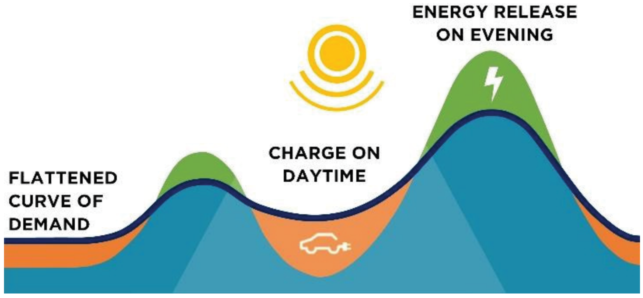

Fig. 3 Optimal plan of charging EV [15]

The V2G has two functions: Controls the charge of the batteries connected to it and uses the available power to regulate the grid when an event occurs during the day. With an increased number of electric vehicles, there will be a situation that can significantly affect the daily load diagram of the power grid. From this point of view, there are several EV charging scenarios. These scenarios consider target variables such as the car owner's working time as well as whether they have the option to recharge their e-car at work or not. The block implements five different car-user profiles:

Profile #1: People going to work with a possibility to charge their car at work.

Profile #2: People going to work with no possibility to charge their car at work.

Profile #3: People going to work with a possibility to charge their car at work but with a longer ride

Profile #4: People staying at home.

Profile #5: People working on a night shift.

The diagram below shows the graphs of charging the car. The graphs are only approximate, but better illustrate the flow of energy in car batteries.

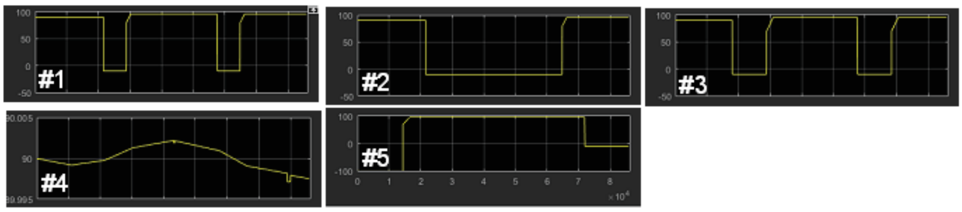

Fig. 4 Comparison of the apparent and active power of a photovoltaic power plant, a wind power plant and a diesel generator.

Run the model and observe the various range signals inside of it. It is possible to monitor rotor speed behaviour in the range above the model.

Click on the Scopes and Power measurements subsystem to access information from different nodes. The charging status of each vehicle profile is also available in this subsystem. Negative charge state means the car is on the road or not connected.

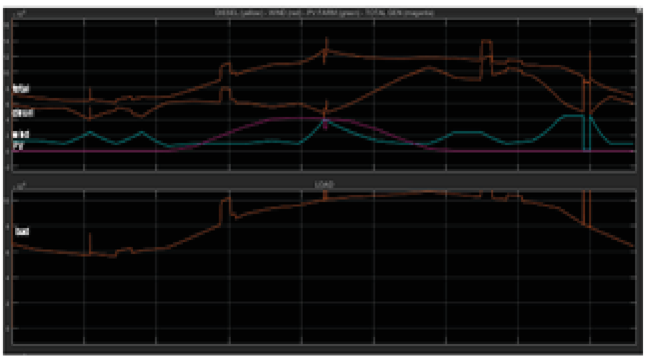

Fig. 4 Processes of production performance (upper graph) and consumption (lower graph)

Simulation takes 24 hours. The intensity of sunlight is controlled by the normal distribution where the highest intensity is reached at noon. In figure it has magenta colour. The wind (blue) changes significantly during the day and has several peaks and minima. Diesel generator (red) holds frequency and naturally regulates electricity generation. Residential load has a typical formula similar to normal household consumption. It is low during the day, increases to the peak during the evening and decreases slowly at night. Three events affect network frequency during the day:

-the start of the asynchronous machine in the third hour

-a partial cloudiness at midday affecting the production of solar energy

-a wind farms cut off in 22 hours when the wind exceeds the permitted maximum permitted wind energy.

IV. Conclusion

This paper describes a simulation that includes power sources like diesel generator, a photovoltaic and wind power plant, electricity consumption and a model of electric vehicle charging as reserve electricity in case of network drops or surpluses. The system also includes unpredictable sources that in combination with the diesel generator and the electric car system keep the network running.

Because of the model is the off-grid system it is not connected to a larger system, it depends on the reliable operation of the largest source. The base is a diesel generator that is not dependent on wind and solar power but provides the maximum space for energy from renewable energy sources. Several measurements have been performed within the model, demonstrating the functionality of the model and its stability under the given conditions. On a given model, it would still be appropriate to monitor the quality of electrical energy, especially the frequency, since large frequency fluctuations have an undue influence on the functionality of the elements in the network.

The theme of microsite and smart grid modeling is highly up to date due to the speed of this time. Electricity plays a significant role in society, and a small one is aware of its daily needs. Model testing improves network reliability and reduces downtime.

Acknowledgment

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