IMPACT OF CONNECTION POINT OF ALTERNATIVE ENERGY SOURCES TO THE SIZE OF SHORT CIRCUIT CURRENT IN THE DISTRIBUTION NETWORK

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ABSTRACT

Nowadays it is effort to use as much as possible renewable (alternative) sources of electricity based on the sun radiation (biomass, hydro, wind or solar power). These plants are environmentally friendly and do not pollute the environment as much as it was in traditional coal power plants. These sources are at present in a large number were connected to the existing distribution network. Due to the increase of these sources in distribution networks is necessary to examine their impact on the overall operation of the network as in normal operation as well as a fault condition. The aim of this paper is to point out of impact location of connection newly built alternative energy sources, especially biomass power plants (BPP) to the size of short-circuit current during fault in the distribution network. This paper describes possible connection of these sources into power system, short theoretical knowledge for short circuit calculation in distribution network and simulation in program Matlab / Simulink.

1. INTRODUCTION

In Renewable energy is biogas power plant one of the vital sources to meet partially the global energy demand. In developing countries in the world, where the people's occupation is predominantly agriculture and most of the population lives in villages is one of the best ways to generate electricity and heat use of biogas power plant. Many of these villages are remotely located and their connectivity with the grid is very difficult resulting in their being not electrified at all or lack of continuous supply. For the development of the region, there is every need to utilize energy efficient techniques and potential of available renewable energy resources. An economic solution can be achieved by proper energy management making the village self-sustained in its energy requirement. By employing existing but well proven energy conversion techniques, these resources can be used for various energy requirements for basic needs like electricity, cooking, water heating etc. The aim is to generate electric power, produce cooking gas and other forms of energy locally and distribute them within the village effectively.

In promotion of the new energy policy in the world, there is the large-scale expansion of constructions of renewable energy sources. Renewable energy sources based on biogas has seen rapid growth in the last years also in Slovakia where the connection of these sources can led to considerable changes in the structure and subsequently cause changes in short-circuit ratios in our large distribution network. Therefore, it is really necessary to examine the impact of connecting these sources in distribution network in consideration of improve the reliability of electricity supply.

2. BIOGAS POWER PLANT DESIGN AND CONSTRUCTION

A BPP uses the process of biological fermentation to generate renewable electricity and heat. It ferments natural waste products and energy crops to generate green energy. BPP have an important place in a sustainable energy policy. This is because they have some important advantages that other alternative forms of energy such as solar power and wind power do not have.

- Highest energy efficiency: Biogas is converted in a combined heat-& power coupling (CHP), with an efficiency of 85%.
- Continuous operation: The anaerobic fermentation is a biological process that occurs continuously
- Waste: Various wet waste flows can be processed into energy
- Flexibility: Flows from different sources can be processed together

The starting point for each project is always based on the input flows that are available on-site and in the region. There are many different input flows that can be fermented:

- Energy crops such as corn, beet, ...
- Manure from pigs, chickens, ...
- Organic Biological Secondary flows and products
- Organic sludge

After fermentation the biogas plant generates electricity, heat and digestate [1].

3. CONNECTIVITY BIOGAS POWER PLANT TO THE POWER SYSTEM

Voltage level, location of connection and method biogas power plant connection to the power system determines the relevant system operator based on technical and economic criteria.

Voltage levels for connection:

Depending summary of installed power BPP can be determined voltage level and point of connections as follows:

- **0.05 to 5 MW** - Medium voltage (MV) network level, point of connection is made (depending mainly distance from the power supply point substation 110/22 kV) either to the existing 22kV line or in the worst case directly to the MV transformer busbar 110/22 kV,
- **5 to 20 MW** - If you fulfil the technical criteria connected point may be in busbar 110/22kV transformer station at the earliest. Otherwise, the required connection point on the high voltage (HV) level by loop or directly connected to the HV busbar.
- **over 20 MW** - HV network level

Connectivity BPP to the 22 kV network can be carried out either loop (T- connection) to the existing HV lines through the entrance HV substation BPP or connection to the MV busbar substation at the transformation 110/22kV [2].

4. THEORETICAL KNOWLEDGE FOR SHORT CIRCUIT CALCULATION IN DISTRIBUTION NETWORK

Given that faults in the distribution network causes asymmetry in the system calculation of fault currents or voltage is determined by the calculation of symmetrical components. For this purpose can be used for decomposition of an unbalanced system to the symmetric components one of the most used methods namely DTF - The Discrete Fourier Transform. Since this is a three-phase system, it is necessary to make decomposition into three symmetrical components - positive, negative and zero sequence.

Electrical equipment are being dimensioned to the largest short-circuit current in the 22 kV network, either single-phase or three-phase short-circuit current whichever of them will be greater. In the following procedure will be described and in the next chapter simulated easier way to calculate fault current for three-phase short circuit where sufficient to determine the positive sequence impedance of each individual electricity network elements. Solution for three-phase short circuit is solved as follows:

- draw up the equivalent circuit for positive sequence, where individual electricity network elements are replaced by their impedances and recalculated to the base voltage (voltage at the point of short circuit),
- calculate the resulting impedance which is given by series parallel combinations all impedance between the place of all short circuits and all sources in the system
- the resulting size of the three-phase short-circuit current is then determined by the voltage at the point of short circuit and the resulting positive impedance.

Above were mentioned briefly theoretical procedures for solving of short circuits where detailed procedures and formulas we can find in [4]. In the next chapter it is shown modern solutions of short circuits by means of computer technology specifically in the program Matlab / Simulink [2][4].

5. IMPACT OF CONNECTION POINT OF BIOGAS POWER PLANT TO THE SIZE OF SHORT CIRCUIT CURRENT IN THE DISTRIBUTION NETWORK

In this chapter will be specified the results of the three-phase short circuit simulation, placed at three different locations, with and without BPP connected to the network. For connection to the network BPP were placed to three different positions whereas at one time will always connect only one BPP. These positions are equivalent to the point of connection BPP to the network in real conditions. Based on these possible variations, there was examined which location of BBP in the network most affects the size of short circuit current.

Network model (fig.1) is part of the 22 kV network located in Slovakia. Values of transformers, lines and power source were entered according to the data, which we have obtained. Values of individual loads are determined on the basis of the optimum load in operation. The network has nine points of loads, each point has its switch to connect / disconnection load or common switch which is used to disconnect the entire section (S1 and S5).

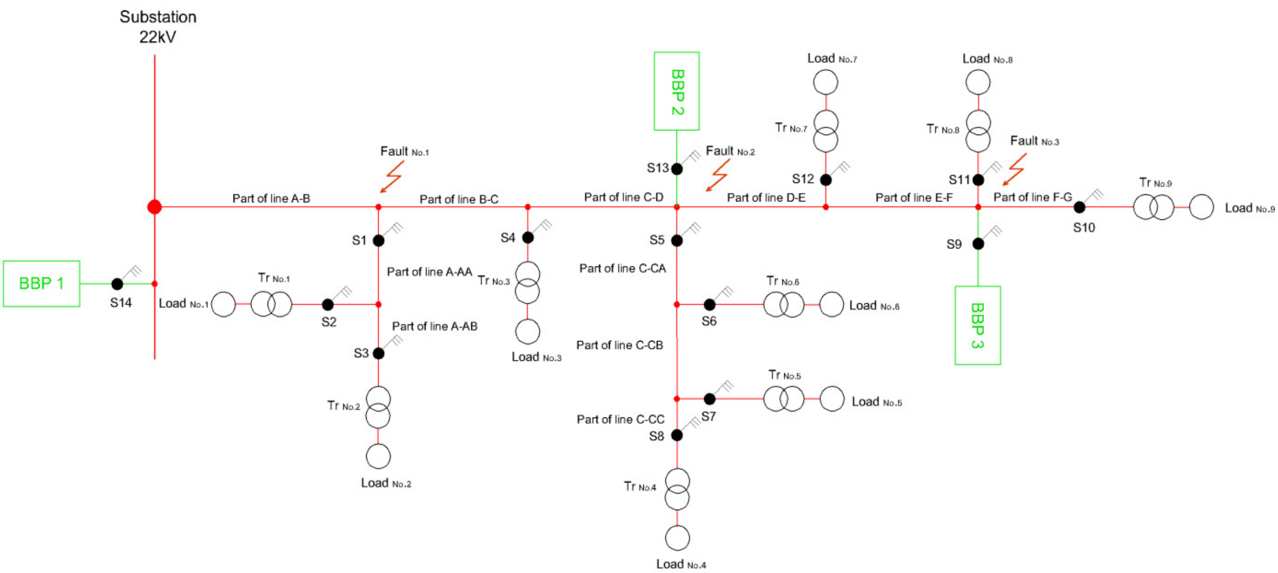


Figure 1 - Scheme of selected distribution network section

Figure 2 shows a model of selected distribution network section created in Matlab /Simulink. The entire network is composed of lines which together have a length of 31.3 km while the main line has 16.6 km. Transformers in load points transformed voltage from 22 kV to 420 V. Values of necessary quantities, specified in the settings of models elements have been specified based on available technical parameters. In the case of BPP is a source which provides power 5MW. This source is shown in Figure 2 as a block composed of the generator which is connected through a transformer to the 22kV network [3].

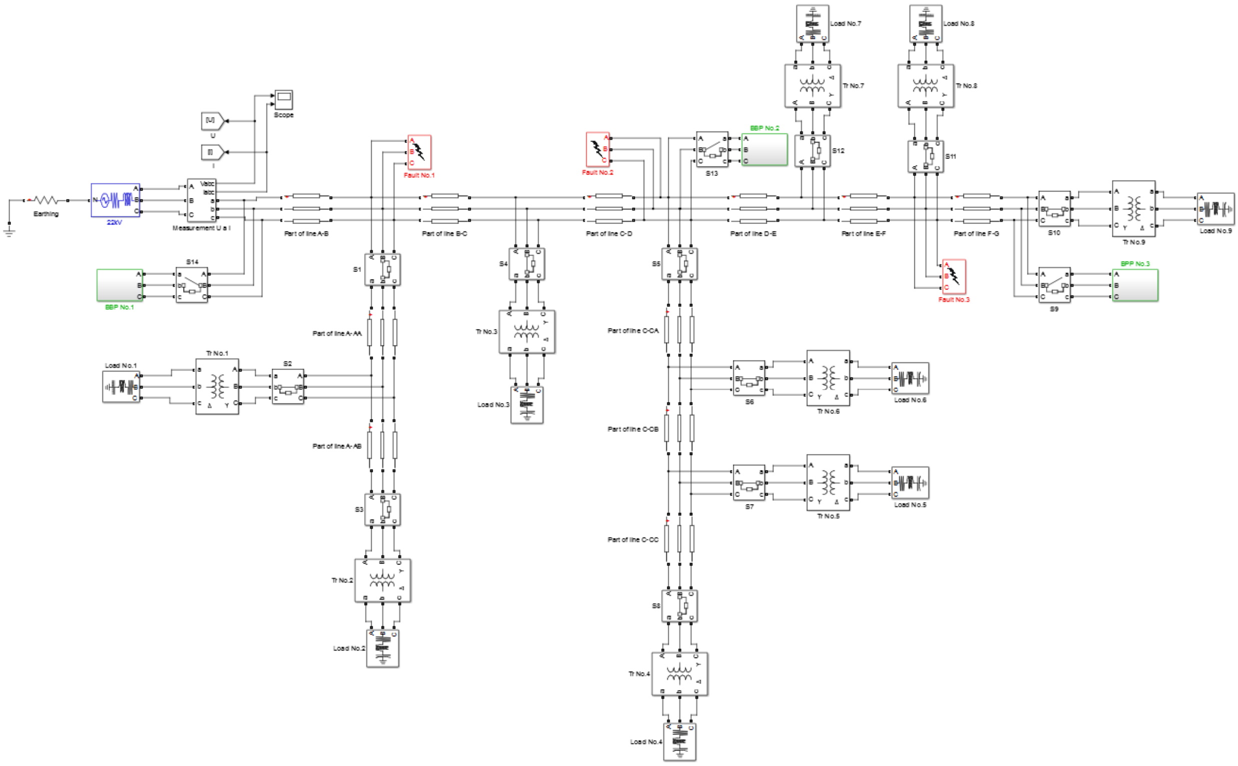
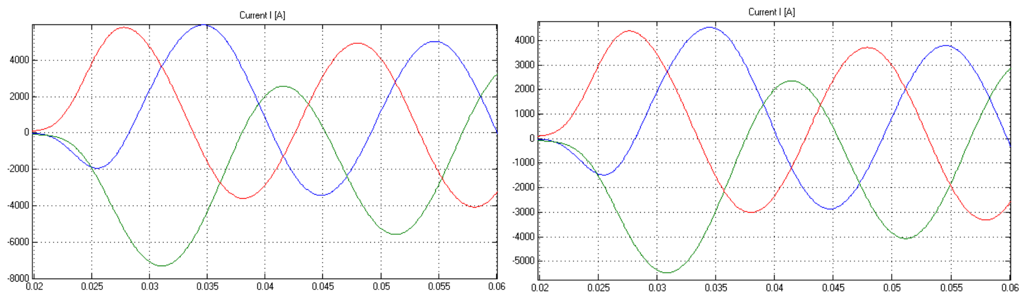


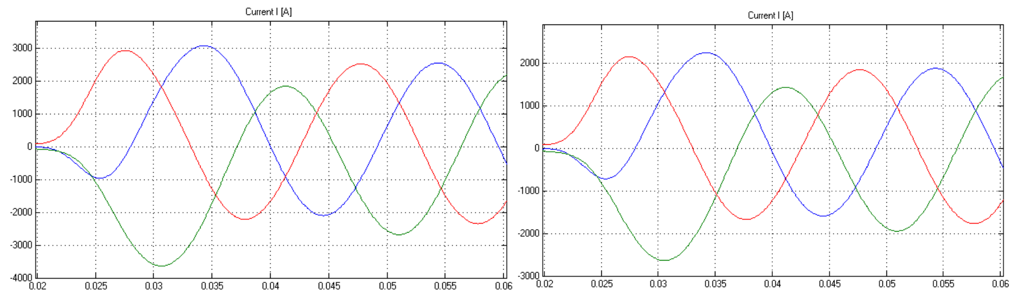
Figure 2 - Model of selected distribution network section created in Matlab /Simulink

In the first case, as shown in fig. 1, short circuits were simulated at three different locations in the network without connection BPP (that is the S14, S13 - S9 are opened). In this case, the size of the three-phase short circuit current flowing through the line was decisive impedance of line participating in short circuit, mainly given its length. In addition, the worst case of short-circuit (without BPP connected) was also simulated. In this case the largest value of short-circuit current was I''_{K3} = 6.550 kA, this fault occur on busbar at 22 kV substation (fig. 3a), subsequently the current levels gradually decreased with increasing line length (fig. 3 b, c and d). Exact values of these currents are given in Table 1.



a) b)

Figure 3 - Instantaneous values of three-phase short circuit current without connecting BPP
a) on busbar substation, b) Fault No.1



c) d)

Figure 3 - Instantaneous values of three-phase short circuit current without connecting BPP c) Fault No.2, d) Fault No.3,

In the second case, short circuits were simulated at three different locations in the network with connection only BPP 1 (S14 is closed, S13 - S9 are opened), as shown in fig. 1. From the scheme follows that during connections BPP 1 to substation busbar, BPP 1 will be directly involved in the increase short-circuit current in the network. As in the first case, the size of current will depend on the distance of a short circuit from the source (directly from the line impedance participating in the short circuit). The largest current value in this case was during a short circuit at Fault point NO.1 namely, $I''_{K3} = 5.7$ kA, where the contribution from the source BPP 1 constitutes the 789 A. The current value gradually decreased with increasing line length.

Table 1 – Changes of transformers taps

Connected Sources	Point of fault	I''_{k3} [A] (from 22kV)	I''_{k3} [A] (from BPP)	Connected Sources	Point of fault	I''_{k3} [A] (from 22kV)	I''_{k3} [A] (from BPP)
Without BPP (only 22kV substation)	No.1	4987		BPP 2 + 22kV Sub.	No.1	4812	689
	No.2	3875			No.2	3854	1040
	No.3	2863			No.3	2661	714
BPP 1 + 22kV Sub.	No.1	4965	789	BPP 3 + 22kV Sub.	No.1	4823	670
	No.2	3619	512		No.2	3875	830
	No.3	2624	371		No.3	2861	998

In the third case, short circuits were simulated at three different locations in the network with connection only BPP 2 (S13 is closed, S14 - S9 are opened), as shown in fig. 1. The scheme shows, if there is a short circuit between the 22kV substation and point of connection BPP 2, then current will flow from two sides to the point of short circuit, for other cases it will supply from only one side. The size of short-circuits currents of individual sources in this case, is determined by the distance of the short circuit from these sources.

In the last case, circuits were simulated at three different locations in the network with connection only BPP 3 (S9 is closed, S13 - S14 are opened), as shown in fig. 1. In this case we can see that if there is a short circuit at any point, to a point of short circuit will always flow current from both sides. The size of short-circuits currents of individual sources in this case, is determined by the distance of the short circuit from these sources.

Exact values of BPP 1, BPP 2 or BPP 3 and 22kV substation currents are given in Table 1.

6. CONCLUSIONS

This article describes influence of three-phase fault currents size, depending on the location of a short circuit and BPP connection points in the network. For connection to the network BPP were placed to three different positions whereas at one time will always connect only one BPP. We can conclude from each recovered values of simulation that the worst case is when both sources are connected to the same busbar. Short-circuit current can reach the highest value (approx. 7.6 kA) and if there is a short circuit on the busbar or in the near distance whole 22kV line must be switched off. As the best aspect to improving the reliability of electricity supply appears to be the third and fourth case. When fault occur on the busbar 22kV substation in the third case, only part of the network and the fourth whole 22 kV network (according to the performance of BPP and extensiveness of network) may still be supplied. However, in these cases, it should be recalled extreme caution in repairing fault on the line with respect to two-sided power supply.

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