Offering the New Control Method for Performance Analysis Of Biomass System in the Smart Grids

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Abstract

In this article we tried to control electrical loads in a small scales and a distributed generation with fuzzy logic controller. In this article the distributed generationis considered biomass power plant. The distributed generationis provides the power for electrical loads. In this simulation , the fuzzy system has the role of controling electrical loads connected to biomass power plant and when increasing electrical loads and biomass power plant not being able to provide the power, it separates the loads from the power plant and connects it to power network. The simulation in this paper was implemented on an IEEE standard 14 base load system and a fuzzy system operates between a small scale power plant and a throughout power network and controls the electrical loads .

Keyword : *biomass power plants ,smart grids ,fuzzy logic controller*

1. Introduction

Biogas is a kind of newly found energy in the area of sustainable energy. Environmental protection and the economic factor are two important factors here. This growing segment of this particular economy is nearly 5 % per year. Furthermore, private households demand almost 23 % of electrical energy of this source. Generally speaking, if this energy is used in the correct manner, the economy will grow and this energy industry will be able to be a part of climate protection. Nevertheless, additional income is obtained

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from energy production from renewable resources. Great investments are expected in agricultural and other industries leading to higher tax revenues. Several intermediates are originated during fermentation and the final product is biogas. It consists of roundabout 60% methane, 30% CO_2 and residuum gases [1]. Smart grids are of those grids which are used to increase biomass power plants efficiency in the energy distribution cycle.

Smart grids are important topics in engineering research. The building block in the field is that mathematical analysis and "smart meters" could be used to induce users to reschedule their electricity use, thus creating a more efficient power grid [2]. Much existing work has been done on smart grids, including pricing [3], [4], integration of home production of electricity into the grid[5],[6], and dynamic load rescheduling [4].

A power grid involves physical components, which generate and transmit power, and cyber components, which transmit data and control signals. Currently, operation and control of bulk power generation and transmission network occurs at centralized control centers and relies mostly on operator in the loop control and analysis. For example, operators will review results from state estimation and contingency analysis and system operators make adjustments system operation accordingly. This control loop relies on human intervention and the time scale is on the order of minutes. In addition, some automatic wide area control, such as automatic generation control (AGC), has been implemented and relies on a slow response. More specifically, "AGC acts slowly and deliberately over less than a second or a few minutes [7].

These power plants have obvious effects in power generation so a precise controller is needed to control the power plant and its effects on the grid. Nowadays various controllers are used to control diverse kinds of power plant, which fuzzy controller is of the most important of the kind [8]. According to the position of these power plants in the field, different studies and simulations have done. For instance, operation of biogas power plants with a network of fuzzy nerves was simulated [9], but there hasn't been any quantified study with a new controller and its effect on smart grids.

2. Biogas Power Plant

Every year, about hundreds of tons of biomass in various forms is produced in the world since it is a popular source of energy after coal, oil and natural gas. The most obvious benefit of biomass-based energy is its renewability and it is also environmental friendly. Worldwide biomass has the fourth rank as an energy resource, providing approximately 14% of the world's energy. It can be as high as 35% of the primar energy supply in developing countries like Bangladesh [10]. The country enjoys an electricity distribution of 42%. In the present era, a major section (81.43%) of the power generation capacity of the country is gas-based . As a result, Bangladesh is practicing a lack of power generation comparing with its demand, which causes load shedding [11] Agricultural biogas production has several environmental benefits. Electricity and heat can be produced from a renewable energy source. Standardized guide lines on the buildings and the operations of agricultural biogas plants guarantee a cost effective building and also save operation. Biomass has retained its position as a renewable energy source derived from plants that use solar energy during the process of photosynthesis. By being a source of renewable gas, biogas originates biomass through anaerobic digestion. In the past two decades, it has been adopted as one of the best alternatives for conventional fuels. Anaerobic digestion (AD) is a waste-to-energy technology biological process that produces biogas by bacteria under poor or no oxygen conditions. It is a colorless, flammable gas produced from a variety of substrates, such as animal manure, plant, human, energy crops, industrial and municipal wastes amongst others, to give mainly methane (5070%), carbon dioxide (20-40%) and traces of other gases such as nitrogen, hydrogen, ammonia, hydrogen sulphide, ater vapor etc. [12] It is smokeless, hygienic and more convenient to use than other solid fuels. The digesters are incubated at mesophilic (25–35) or thermophiles (45–60) conditions for a certain period of time. It is a multi-step biological process where the organic carbon is mainly converted to carbon dioxide and methane. The process can be divide into several steps. hydrolysis/liquefaction, acid genesis, acetogenesis and methanogens. Fig. 1 shows the pathway for the mechanism of anaerobic digestion process.

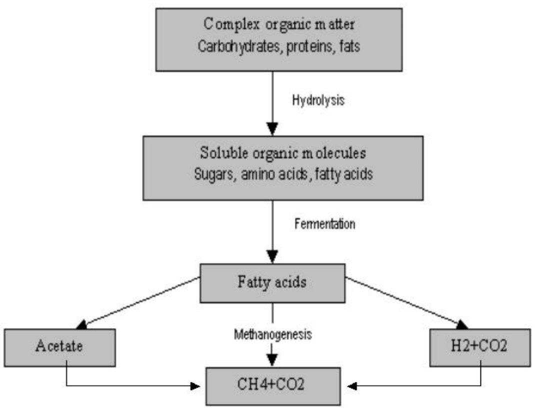

Fig.1. pathway for the mechanism of anaerobic digestion process.

Co-digestion of agricultural organic wastes is regulated. It also helps to enhance the implementation of biogas technology on farms, anaerobic digestion of farmyard manure as well. The aim of agricultural biogas production in any country is about 20% of farmyard and, 40% of cattle waste. Biogas has a wide variety of applications with many different purposes. In small scale installations, the gas is primarily utilized for heating and cooking (e.g., gas cookers/stoves) for and lighting (e.g., biogas lamps), and using as a potential fuel of a burning system for tea processing, fruit storing, hatching chickens, and household energy. In larger units, CHP's are fueled with biogas. In some cases, the driving force for utilizing gas is economizing fossil fuels or wood like in developing countries.

3. Smart Grids

3.1 Smart Grids

There's been several years that electrical infrastructure has remained unchanged. The components of the hierarchical grid approach their death-line. While the electrical grid has been ageing, the demand for electricity gradually increases. According to the U.S. Department of Energy report, the demand and consumption for electricity in the U.S. have increased annually by 2.5% over the last 20 years [13]. Today's electric power distribution network is very complex and inappropriate to the needs of the current century. There is a lack of automated analysis and poor visibility among the

deficiencies, mechanical switches causing slow response times, lack of situational awareness, etc. [14]. These have contributed to the blackouts happening over the past 40 years. Some additional inhibiting factors are the growing population and demand for energy, the global climate change, equipment failures, energy storage problems, the capacity limitations of electricity generation, one-way communication, decrease in fossil fuels, and resilience problems [15]. Also, the greenhouse gas emissions on Earth have been a significant threat that has caused by the electricity and transportation industries [16]. Consequently, a new grid infrastructure is urgently needed to address these challenges.
Various emerging technologies within the transmission and distribution networks can contribute towards improving system operation and management [17]. The distribution system is very important because it used to be a passive network with less automated functions than the transmission system. In this vein, the fundamental objective of any smart grid implementation on the distribution system should enable all infrastructures to allow all desirable functions of optimizing the operation of the distribution system to achieve maximum benefits to utilities and end users alike[18],[19] .

These goals can only be obtained by a system that will enable accurate and regular monitoring of the distribution system. Lack of communication capabilities is the existing grid while a smart power grid infrastructure is full of enhanced sensing and advanced communication and computing abilities, as illustrated in Fig. 2. Different components of the system are linked together with communication paths and sensor nodes to provide interoperability between them, e.g., distribution, transmission and other substations, such as residential, commercial, and industrial sites.

Fig. 2. Smart grid architecture increases the capacity and flexibility of the network and provides advanced sensing and control through modern communications technologies.

Indeed, there are some energy-related advantageous from deploying the SGTs in the distribution network. Nonetheless, it requires further development of the SGTs and integrating them into the grid structure. This could allow the self-healing functionality of the grid and makes the integration of distributed generation (DG) technologies easier [20].

3.2 Smart Grids Simulated

Smart grid and its characteristics, which is used in this article, is the standard model of grid 14 bus bar IEEE. Figure 3 shows a smart grid 14 bus bar IEEE.

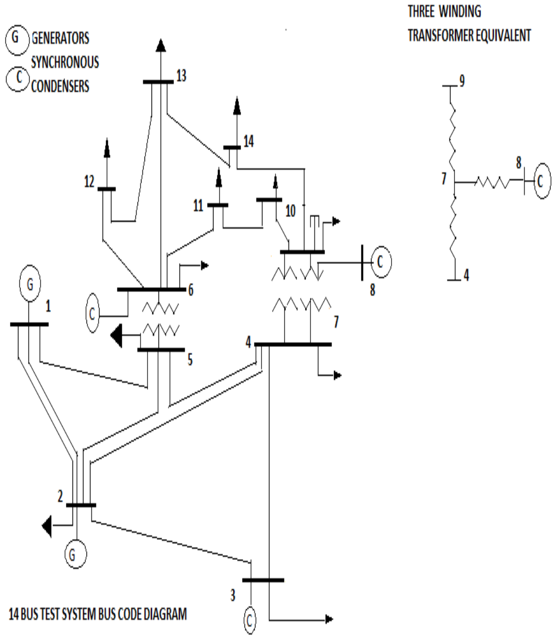

Fig.3. smart grid 14 bus bar IEEE

In this simulation 5 power plants connected to network and a distributed generation power plant were used with following generating capacitances :

- 1 power plant generating 615 MW scale
- 2 power plants generating 65 MW scale
- 1 power plant generating 25 MW scale
- 1 distributed generation power plant 25 MW scale.

In this simulation we connected considered loads to a DG power plant with 25 MW scale and these loads, from one side, are connected to a power network and from another side, to a distributed generating biomass power plant. Electrical loads are connected to power networks when are in peak amount and when distributed generation power plant has not the ability of providing needed electronic load. This biomass power plant can be established near agricultural farms or ranchering farms where we can find lots of animals garbages and agricultural wastages . Also in these places we can use Methan gas resulted from these wastages for generating power.

4. Fuzzy Controller Inference:

Fuzzy Inference Systems (FIS) have been applied comprehensively in the field of control, data classification, modeling problems and computer vision. FIS, using fuzzy logic, is the way of mapping a given input to an output. Fuzzy inference has two methods: indirect and direct. Direct method are the simplest and it categorizes in Mamdani type FIS [21] and Takagi and Sugeno FIS [22]. In 1975, Ibrahim Mamdani used fuzzy set theory and proposed the first control system using the theory. In this article, also used Mamdani kind of a fuzzy inference system in which P and Q capacitances are system entrances and a biomass power plant controlling and load's switching to throughout network, are system outlets. Figure 4 shows the fuzzy inference system, entrances and outlets.

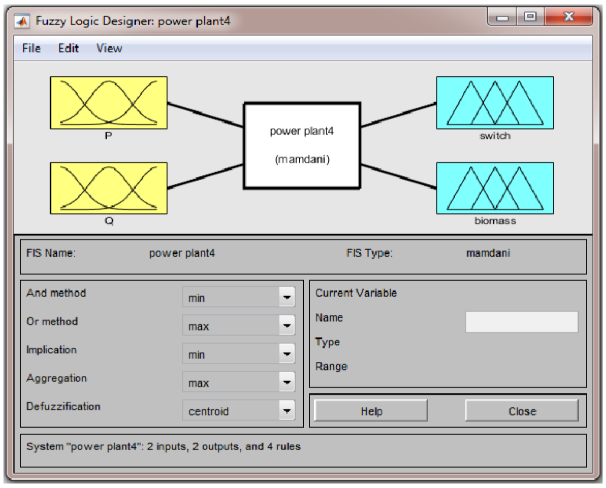

Figure 4. Mamdani's fuzzy inference set and its available inputs and outputs.

fuzzy system operating is in this way : it receives P and Q entrances and when increasing capacitances more than identified limits , the system switching the throughout network for the electrical load and lessen the biomass power plant production . took the values of P and Q from the charactristics of IEEE 14 base load standard system .

In this simulation used two input’s and two output’s that figure’s 5 to 8 shows the membership function’s :

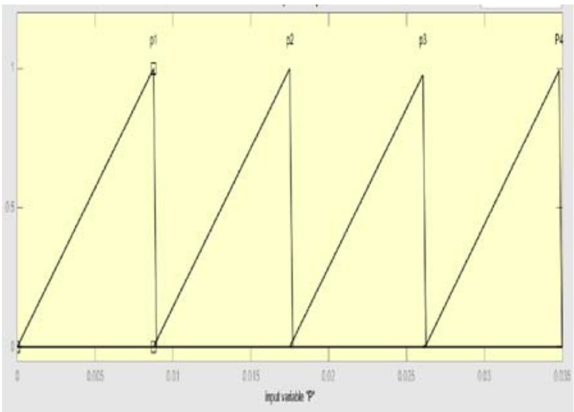

Figure 5. shows the membership function of input P

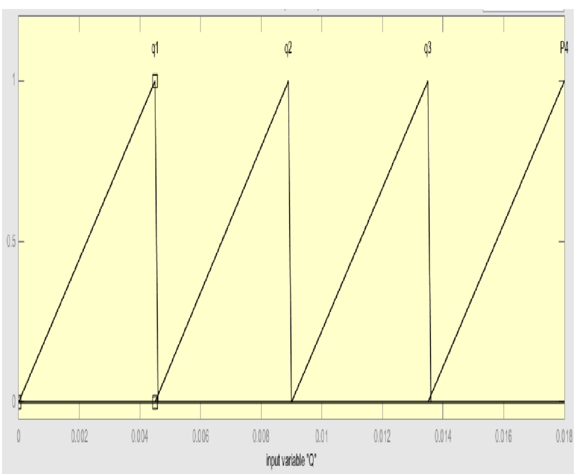

Figure 6. membership function of input Q

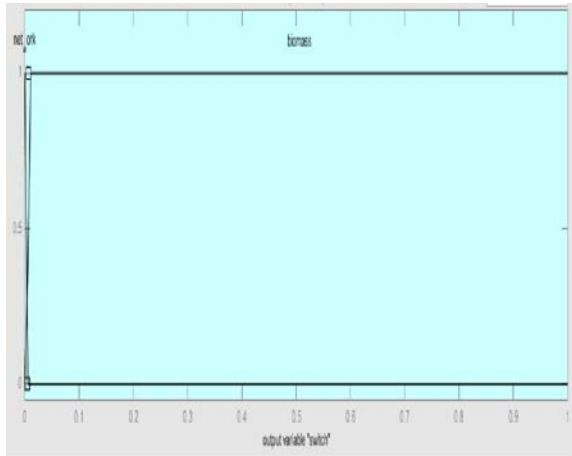

Figure7. membership function of switching output

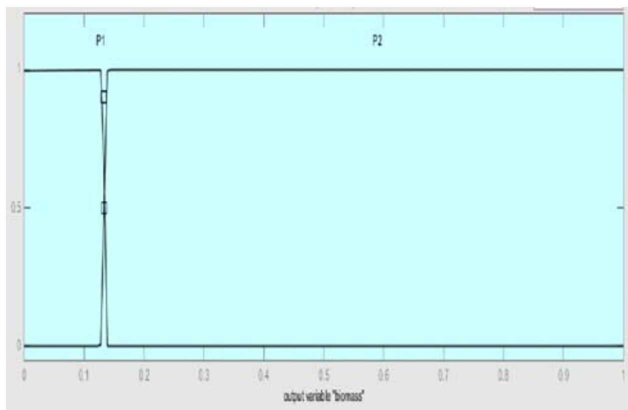

Figure 8. membership function of biomass power plant control output

5. Results

Figure 9 shows the diagram of biomass power plant operation that connected to power network. This diagram shows the

Overall power output behavior of power plant in 39 days. In this 39 days can be see that power plant about 5 times logged of circuit thoroughly and occurred the blackout that this status can be damages to power plant, network and will follow all of the client that connected to biomass power plant.[23]

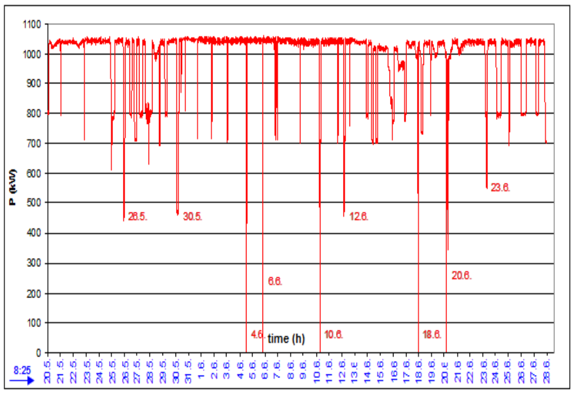

Figure 9. Overall power output behavior

In this simulation the fuzzy system so that designed that with increase the P and Q power's amounts of a specified range , reduce the biomass power plant production and in the same time contact the load's of other side to throughout network than be compensated the lack of electric power's and will reduce the biomass power plant production to minimum amount itself and until that do not come down the P and Q power's of the same desired limit the fuzzy system does not allow to increase the electrical production of biomass power plant. Figure 10 shows an overview of the implemented simulations and we can find out from it the controlling role of fuzzy system on biomass power plant and electronic load.

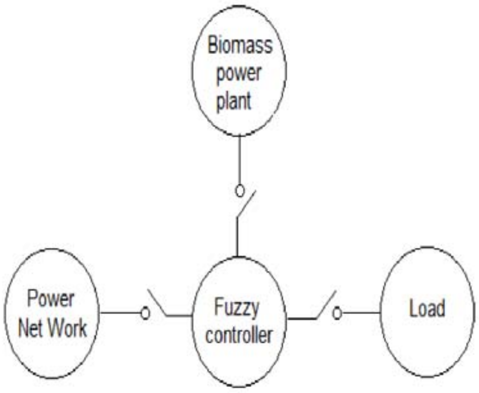

Figure 10. an overview of the implemented simulations .

Figure 11 shows the results of simulation for increasing P and Q capacitances which the fuzzy controller lessen the biomass power plant production and connects it to the power network.

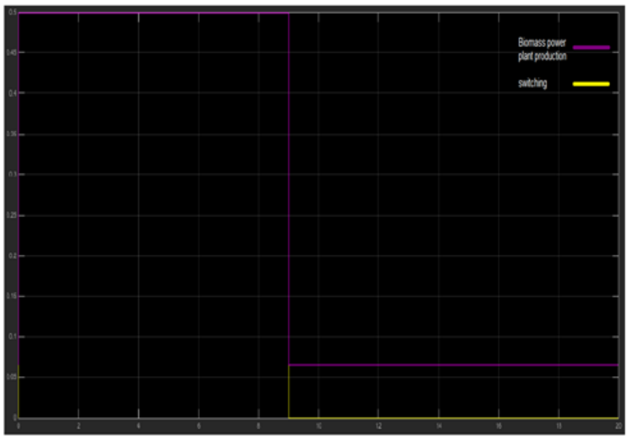

Figure 11. the operation of fuzzy system .

From figure 11 it can be found out that fuzzy system connected electrical load to power network in 9th second and reduces the biomass power plant production to minimum amount itself and after 9th second, the amount of capacitance generating of biomass power plant is decreased.

Figure 12 shows that with increasing electrical load, in the 9th second , fuzzy system operates and connects the load to the power network and we will see increasing power.

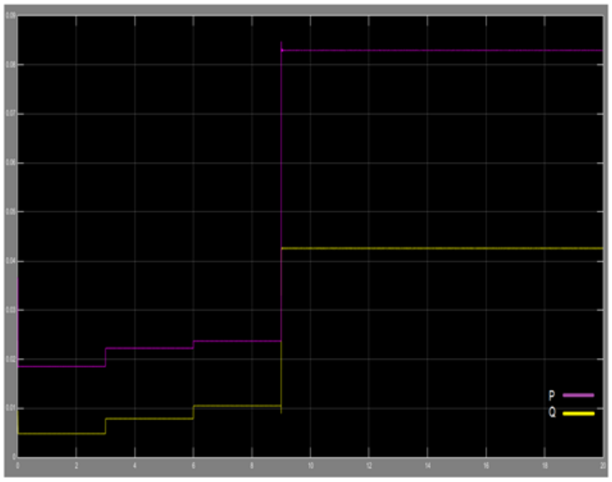

Figure 12. increasing electrical load in the 9th second

In this simulation increased load in 4 phases and in the last phase , we observe that load increasing is happened in 9th second and simultaneously, fuzzy system operates and connects electrical load to the power network.

7. Conclusion

In this simulation due to used of fuzzy system and control the biomass power plant and connected load's to biomass power plant with fuzzy system, during the sudden load's increase or decrease the fuzzy system will present the appropriate response to the same status of load's which makes removed the blackout situation, that this appropriate response can be connect the electrical load's to power network or can be reduce or increase biomass power plant production.

Also whenever power electrical amounts increase of specified limits the fuzzy controller will reduce the biomass power plant production which makes removed the again switching status of power plant

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