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BIOMASS/GEOTHERMAL POWER STATION ENERGY MANAGEMENT COMPUTER PROGRAM USING ARTIFICIAL NEURAL NETWORKS

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Abstract- Biomass and geothermal renewable energy sources play a crucial role in feeding the electricity grid. In this study, smart energy management algorithm in biomass and geothermal power plants was created using artificial neural networks. Biomass/geothermal power plants energy management program was created by using this algorithm, C++ programming language and Visual Studio Programs. By using this computer program, it has become possible to make daily, monthly and weekly production forecasts and load forecasts in these hybrid power plants. Electric energy produced from unstable and variable biomass and geothermal renewable energy sources, hybrid energy storage system integration has been applied to the power system. Intelligent automatic control is provided in this hybrid power plant, allowing continuous and high quality electrical energy to be produced. Possible working conditions were determined with the developed hybrid energy storage system. In these possible cases, a unique smart energy management algorithm and program has been implemented to ensure stable operation of the system. Thanks to the smart energy management algorithm, all the powers in the system are evaluated and it allows the control of the components for the desired operating conditions.

Keywords: Energy Management, Biomass/Geothermal Power Stations, Artificial Neural Networks.

1. INTRODUCTION

In recent years, with the increase in energy supply, new and renewable energy production techniques have started to be used. Some of these can be listed as wind energy, solar energy, hydroelectric energy, hydrogen energy, wave energy, tidal energy, current energy, geothermal energy and biomass energy. Considering that energy is so important and the world population is increasing, it is of great importance for both countries and the world that energy production is clean, high quality and renewable [1, 2]. It is the most important element of the energy management system in order to achieve production targets in renewable energy sources [3, 4]. With the energy management system, energy costs are reduced and it provides the opportunity to use energy efficiently.

In this study, an energy management system and a computer program were created to effectively manage energy in Biomass/Geothermal Hybrid Power Plants.

2. BIOMASS/GEOTHERMAL POWER STATIONS

Biomass power plants are power plants that produce energy using human, animal, plant and garbage wastes as sources. The biomass power generation plant is shown in Figure 1.

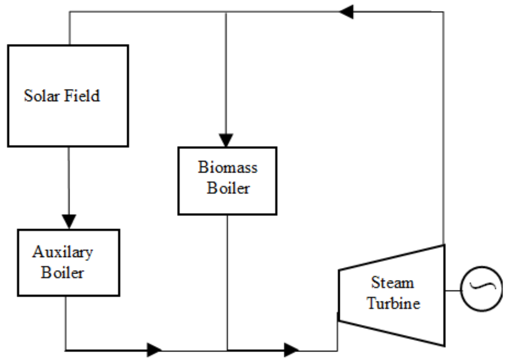

Figure 1. Biomass power generation plant

In these power plants, physical methods are applied to biomass as the first process. Biochemical and thermo chemical conversion methods are applied in these power plants. In order to separate the molecules that can be used in the biomass, physical methods are the first step of these methods. Thanks to the physical processes, it is prepared for biochemical and thermo chemical methods. Some of these studies are; water removal and drying, density increase, size reduction and separation processes. Airless decomposition is a biological process and is carried out by microorganisms living in an oxygen-free environment. This process can only occur in an oxygen-free environment. Biomass is subjected to fermentation process in an oxygen-free environment with the help of microorganisms, and then leaves manure, methane gas and carbon dioxide, which are valuable wastes.

Depending on the type of biomass and the method applied, bioethanol, biomethanol, biodiesel, biogas, syngas or biochar are obtained. Generally, heat energy is produced from the products obtained. Heat energy is also converted into electrical energy. Geothermal energy is defined as the thermal energy contained in hot water, steam, gas or hot dry rocks under pressure accumulated at various depths of the earth's crust. Figure 2 shows the geothermal power generation plant.

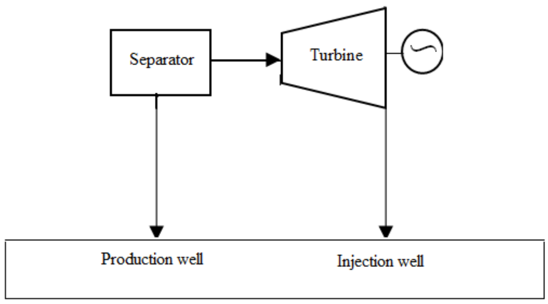

Figure 2. Biomass power generation plant

The heat source consists of the reservoir and the fluid elements that carry the heat in geothermal power plant. The heat source is high-temperature magmatic intrusions that can reach near the surface. They can also be normal temperatures, increasing with depth in low-temperature systems. Reservoirs, on the other hand, are fissured rocks in which the fluid carrying the heat can circulate. There are generally impermeable layers on the reservoirs. The geothermal fluid, on the other hand, is in most cases meteoric water. It is in vapor or liquid state depending on the temperature and pressure in the reservoir.

This water usually contains some chemicals and gases. Dry steam produced from the well is used directly to rotate the turbine in dry steam power plants. In flash steam power plants, the fluid coming from the well with high pressure is separated as water and steam in low pressure separators. The turbine is rotated with the separated steam. In binary cycle steam plants, the heat of the geothermal fluid is used and the fluid with a lower evaporation temperature than water is evaporated in the heat-exchanger. Energy is produced by rotating the turbine with this vaporized fluid.

3. ARTIFICIAL NEURAL NETWORKS

Artificial neural networks (ANN) is a system based on the working principles of the human brain. It mimics the functioning and working mechanism of the nerves in the brain. At the same time, it is an information processing system aimed at gaining abilities such as learning, comprehension, analysis and synthesis, and generalization. ANN cells come together with non-random connections to form artificial neural networks [5-7]. When neurons come together, layers are formed. There are neuron structures formed by artificial cells and the layers attached to them. These are linked to the external environment in order to receive inputs and transmit outputs. All remaining neurons are located in hidden layers. In this system in layers, different network architectures are created according to the different connection types between layers. Elements that make up a structure are layered as input, hidden, and output [8, 9]. This provides great convenience in design. A basic ANN Cell is shown in Figure 3.

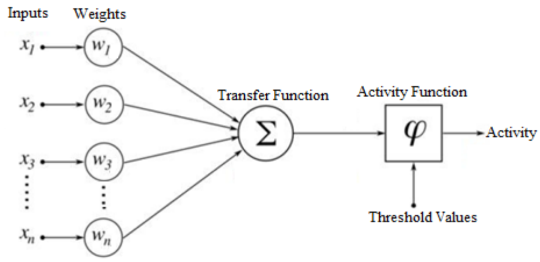

Figure 3. A basic artificial neural network cell

The activity function (*af*) calculates the net output during the process and this process also outputs the neuron as Equation (1), where, C is a constant and is the threshold value of the activation function, X is the inputs and W weights matrix as well as n is the number of entries [5].

$$af = f(\sum_{i=1}^{n} W_i . X_i + C) \quad (1)$$

The ANN is an artificial intelligence technology that enables the successful solution of complex engineering problems with artificial neural networks.

4. BIOMASS/GEOTHERMAL POWER STATION ENERGY MANAGEMENT COMPUTER PROGRAM

Energy production elements and energy consumption elements should be considered as directly interconnected. The activity should be started at the points where the consumption is more than the desired consumption rate. Standards, plans, and performance of industrial and commercial buildings must be constantly structured. Energy productions and consumptions should be updated. Institutions should be supported to reduce their costs. Effective energy management should be done to reduce greenhouse gas emissions. With effective energy management, energy-related costs are reduced and international competitiveness is increased.

In the Energy Management system, the unit energy used per output is measured. Thus, continuous improvement in energy efficiency is requested from the institution. Therefore, energy-related consumption areas should be determined correctly. Improvements should be made according to these determinations. Continuity should be prioritized in these improvements. The block diagram of the Biomass/Geothermal Power Station Energy Management System is given in Figure 4. With the designed energy management control card, all DC and AC relays in the system, reset of DC/DC amplifier circuit, reset of DC/DC bidirectional converter circuit, turbine outputs of Biomass and Geothermal power plants, pre-charge resistors of battery and ultra capacitor group are controlled. The received signals are transmitted to the control units safely and quickly. All units can be controlled manually with the switches on the control card. If the energy obtained from the turbines is less than the energy required by the load, all of it is transferred to the load. The missing energy is met from batteries and grid energy.

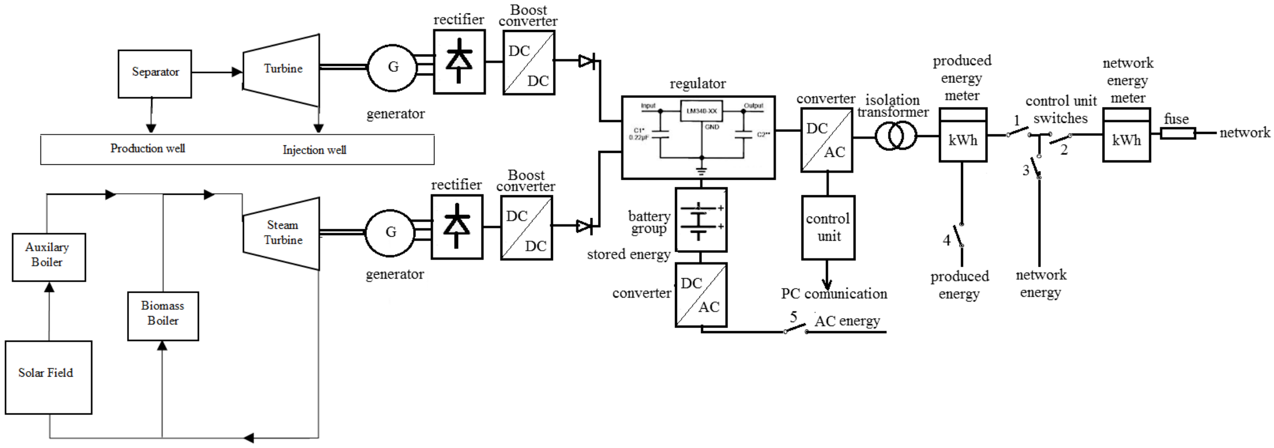

Figure 4. Biomass/geothermal power station energy management system

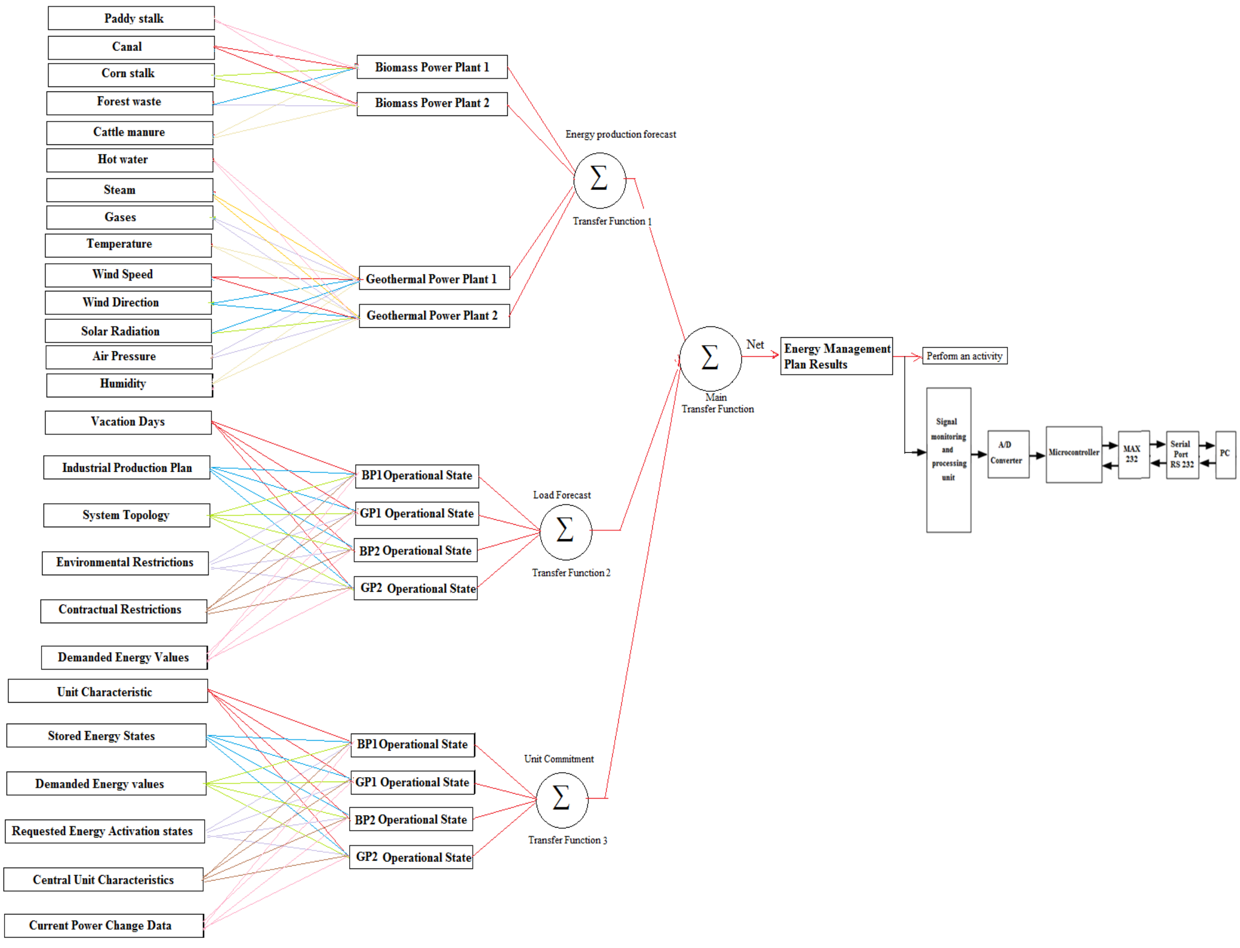

Figure 5. The intelligent energy management algorithm of the biomass/geothermal hybrid power plant

In Figure 5, the intelligent energy management algorithm of the Biomass/geothermal hybrid power plant based on artificial neural networks is given. If the energy obtained from the turbines is greater than the energy needed, the remaining energy is transferred to the charging of the batteries and to the grid energy. The energy management system of biomass/geothermal power plants created with artificial neural networks examines possible working conditions by itself. These operating conditions are determined by the current and power values of the sources and loads in the system. This created energy management system decides by itself according to these situations and controls the power flows in the system. This energy management system works by conditioning every situation. Here, it determines some limitations and band gaps for the system to work healthily and safely. It reduces the charge/discharge period of the battery by preventing the batteries from being switched on and off continuously in a small power change.

Thus, it is aimed that the battery group has a longer cycle life. At the same time, power loss is reduced by preventing continuous switching of the system. In addition, in terms of the health of the battery, the charge rate of the battery group is processed in the control system, and in case of discharge of the battery group, current is drawn up to 15% in the case of battery charge. In the charging state, when the battery group reaches 97%, the charging current is cut off and it is protected from excessive charging current.

As the current demanded by the load increases, the inverter current also increases. However, since the response time of the inverter is long, it cannot respond very quickly to instant load demands. In this case, part of the increased instantaneous load current is supplied from the network. During the sudden increase of the load, there is a common power flow from the grid and the inverter to the load for a certain period of time. Thus, voltage fluctuations that may occur on the network are reduced by reducing the amount of demand falling on the network in sudden load increases. When the power produced from Biomass/Geothermal power plants is more than the load power, the entire load is fed by the inverter and the remaining energy is transferred to the grid. Since the power demanded by the load is too much, the remaining power demand is provided from the grid. In this case, the battery pack is discharged.

The discharge current of the battery group is limited in terms of the health of the batteries, and in this case, energy is transferred with the determined maximum discharge current. Biomass/geothermal power plants energy management program was created by using this algorithm, C++ programming language and Visual Studio Programs. Created Biomass/geothermal power plants energy management program is given in Figure 6.

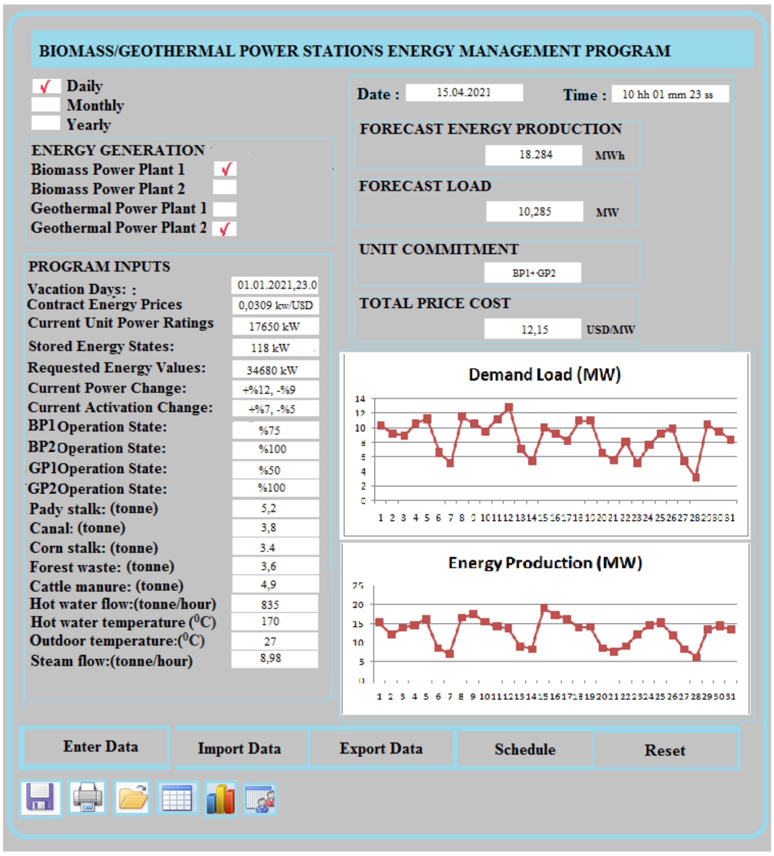

Figure 6. Biomass/geothermal power plants energy management program

By using this computer program, it has become possible to make daily, monthly and weekly production forecasts and load forecasts in these hybrid power plants.

5. CONCLUSIONS

Effective energy management should be done to reduce greenhouse gas emissions. With effective energy management, greenhouse gas emissions are reduced, it is possible to use energy efficiently, and energy costs are also reduced. Thus, international competitiveness is increased. With this study, an energy management system and a computer program have been created to manage energy in Biomass/Geothermal Hybrid Power Plants.

Biomass/geothermal power plants energy management program was created by using this algorithm, C++ programming language and visual studio programs. This computer program has made it possible to make daily, monthly and weekly production estimation and load estimation in hybrid renewable power plants. In the hybrid power plant, this study provided intelligent automatic control. Thus, it was possible to produce continuous and high quality electrical energy.

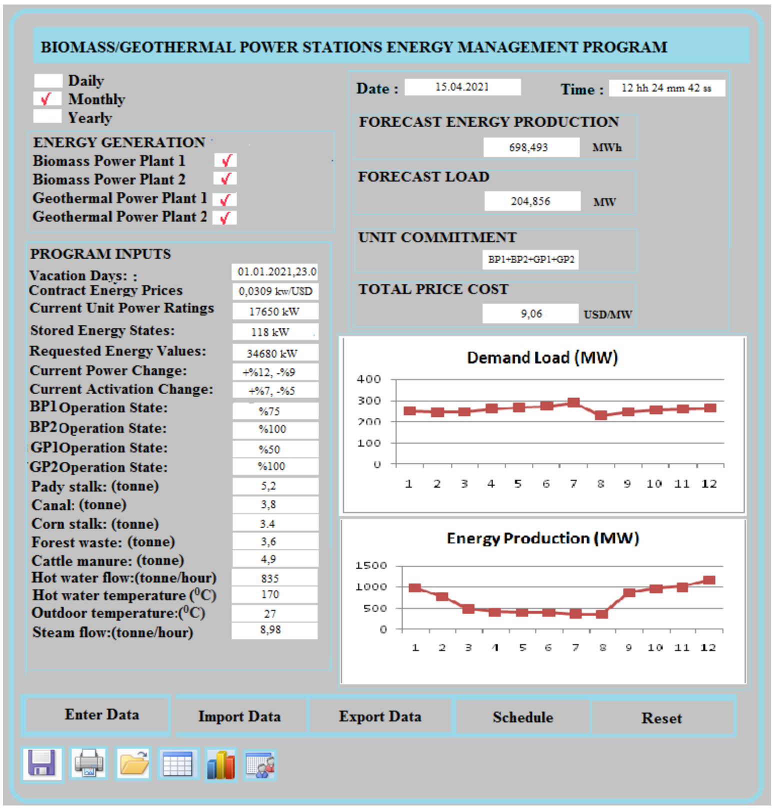

Figure 7. Biomass/geothermal power plants energy management program

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BIOGRAPHY

Mehmet Zile was born in Ankara, Turkey, 1970. He received the B.Sc. degree from University of Yildiz (Istanbul, Turkey), the M.Sc. degree from University of Gazi (Ankara, Turkey) and the Ph.D. degree from University of Yildiz (Istanbul, Turkey), all in Electrical and Electronic Engineering, in 1992, 1999 and 2004, respectively. Currently, he is an Associate Professor of UTIYO at University of Mersin (Mersin, Turkey). He is also an academic member of UTIYO at University of Mersin and teaches information systems and control systems. His research interests are in the area of control systems and electrical machines. He is a member of IEEE.