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Hidroelektrik ve Rüzgar Enerji Santrallerin Mikro Şebekesi

Micro Grid of Hydroelectric Power Plant And Wind Power Plant

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ÖZET

Hayatın her alanında ihtiyaç duyulan elektrik enerjisi, toplumun gelişmişlik düzeyinin yükseltilmesinde önemli bir rol oynamaktadır. Enerji ihtiyacının devamlı olarak artması ve yenilenemeyen enerji kaynaklarının tükenebilir olmasından ötürü yenilenebilir enerji kaynaklarına olan talep artmıştır. Kırsal alanlarda ve şebekeden uzak alanlarda yaşanan enerji kesintilerine ve altyapı problemlerine çözüm olarak ortaya çıkan mikro şebekeler, şebekeden bağımsız ya da bağımlı olarak çalışabilen küçük enerji şebekeleridir. Bu çalışma da mikro şebekeler ve mikro şebekelerin avantajlarıyla birlikte mikro şebekeler ile sağlanan enerji üretimleri incelenmiştir. Yeni bir enerji kaynağı olması, şebekeden bağımsız olarak da çalışabilmesi mikro şebekenin en önemli özelliğidir. Bu yüzden mikro hidroelektrik enerji üretim sistemlerinin ve rüzgâr enerji sistemlerinin çalışma prensibi ve diğer sistemlerden farklı yönleri üzerinde de örnekler verilerek mikro şebekenin avantajları belirtilmiştir. MATLAB/SİMULİNK programında rüzgar ve mikro hidroelektrik hibrit güç üretim sistem modeli tasarlanıp simülasyon sonuçları belirtilmiştir.

Anahtar Kelimeler: Mikro şebeke, Rüzgar türbinleri, Mikro hidroelektrik enerji sistemleri.

ABSTRACT

Electric energy, which is needed in all areas of life, plays an important role in raising the development level of the society. The demand for renewable energy sources has increased due to the continuous increase in energy need and the exhaustion of non-renewable energy sources. Micro-grids, which emerged as a solution to energy cuts and infrastructure problems in rural areas and areas far from the grid, are small energy grids that can operate independently or independently from the grid. In this study, micro-grids and the advantages of micro-grids, together with the energy production provided by micro-grids, are examined. Being a new energy source and being able to work independently from the grid is the most important feature of the micro grid. Therefore, the working principle of micro hydroelectric power generation systems and wind energy systems and the advantages of the micro grid are indicated by giving examples on their different aspects from other systems. In the MATLAB/SIMULINK program, a wind and micro hydro-electric hybrid power generation system model was designed and the simulation results were specified.

Keywords: Micro grid, Wind turbines, micro hydroelectric power systems.

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INTRODUCTION

The ever-increasing need for energy in recent years has led to an increase in environmental emissions. The reason for this is the use of fossil fuels to meet the energy need (Ali, Kuriqi, Abubaker, & Kisi, 2019). Traditional power systems have high emissions and do not comply with the international measures taken (Bejarano, Sordo-Ward, Gabriel-Martin, & Garrote, 2019). Microgrids have emerged as an alternative option to traditional power systems (Cao et all, 2020). Microgrids increase efficiency and provide high flexibility. They also emit less environmental emissions (Zhang, Ou, & Zhang, 2006) (Rezvani, Gandomkar, Izadbakhsh, & Ahmadi, 2015).

Micro grids can be operated as dependent or independent from the grid. Micro grids are small-scale energy that have their own energy resources and productions (Kocaman, 2015). Although there are many reasons for using micro grids, the most important reasons are minimizing transmission losses, low investment cost and reliability (Hossain, Kabalci, Bayindir, & Perez, 2014) (Karavas, Kyriakarakos, Arvanitis, & Papadakis, 2015).

Micro grids are used in agricultural and forest lands, areas far from electricity grids, rural areas, hospitals and campuses, and for military purposes. Reason for use in city grids and rural feeder lines; reduction of power outages, cost reduction and wind power plant integration. In industrial areas, it is used to increase energy quality and to ensure reliability (Türkay, 2009).

A microgrid is a low voltage electricity distribution network. The load consists of distributed energy sources and energy storage systems. Microgrids were born as a solution to increasing pollution and depleting fossil fuels, as well as ensuring the efficient operation of the electricity grid. The advantages of microgrid can be listed as follows (Rajesh, Dash, & Rajagopal, 2020).

• In case of an instability that may occur in the grid, the micro grid isolates itself without affecting the loads.
• It can increase the number of distributed energy sources to increase production capacity or manage peak loads by load shedding method.
• It reduces CO2 gases.
• With 5 CHP systems, the overall efficiency of the system can be increased.

In this study, the difference and advantages of micro grid compared to all other systems have been examined. The aim of the study is to reveal that micro grids are more modern and advantageous than other systems in terms of durability, quality and cost.

MICRO GRID

Micro grids have new energy source and grid management technologies. In addition, these are electrical grids that can be independently controlled and generate power with distributed generation. Micro grids can allow renewable and purged resources to enter the grid, demand-side management and use the maximum amount of energy currently available (Kocaman, 2014).

Distributed energy resources within the micro grid can also be found as distributed generation or distributed storage energy (URL 1, 2021).

Micro Grid Design

If distributed energy resources are added to micro grids effectively, energy quality and efficiency can be increased. In a unique micro grid design (Kocaman, 2015):

a) Determination of the characteristics of distributed energy resources that should be done with priority
• Determination of the most efficient cross section (FV, wind, etc.)
• Determining the power of the unit,
• Determination of places where distributed energy resources will be placed in the grid.
b) Micro grid should be inspected for grid dependent or grid independent conditions.

Micro grid structure is shown in Figure 1 (Kocaman, 2014).

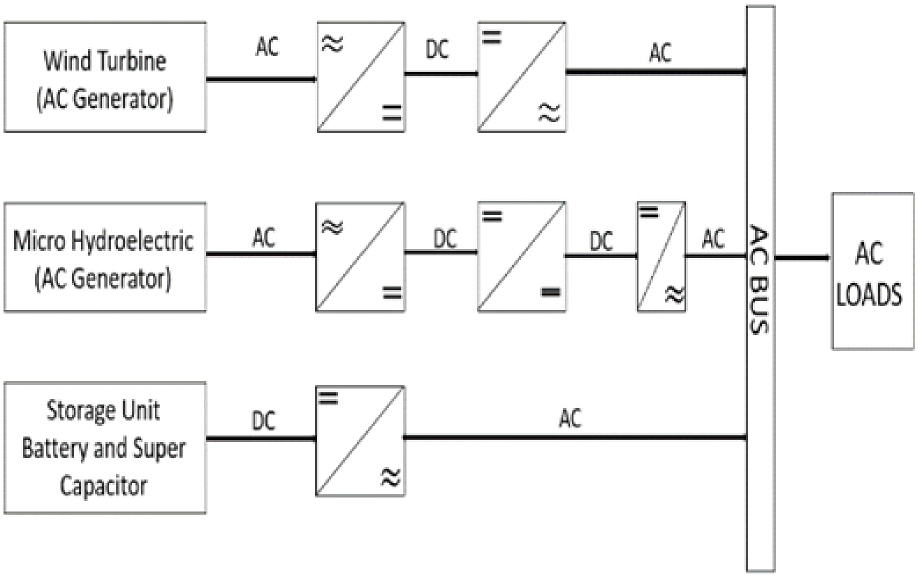

Figure 1. Micro grid structure

Economic objectives to be considered in addition to technical constraints; gains, probability of load loss, investments, operating and service costs (URL 2).

Similar to the advances in the electricity grid, micro grids are emerging as smart micro grids, taking advantage of advances in communication and information technologies. Thanks to their communication skills and intelligence, smart micro grids will be able to reach the capacity and quality to perform different tasks by creating grids in order to increase the sustainability and reliability of electrical services in the coming years (Kocaman, 2015).

HYBRID POWER SYSTEMS

Hybrid Power Systems have more than one definition. HPS according to J. Paska; Renewable and non-renewable energy sources diversified with small clusters producing electricity or both electricity and heat, and the coordination of operations takes place through the use of advanced power electronics (Paska, 2002).

As can be understood from the definition of HPS, it has emerged to provide electricity or both electricity and heat generation. HPS is mostly connected to the power grid, but it can also operate independently from the grid. They can feed individual buyers from one or more homes or small industrial workplaces to large places independently. When the HPS is connected to the grid, it provides electrical power reserves and ensures that the increased power is fed back to the grid in case of excessive power generation. HPS; They use it with little dependence on power generation, similar to various energy saving technologies, various power generation devices and advanced microprocessor control systems (Paska, Biczel, & Kłos, 2009). Hybrid systems provide more efficient energy production by combining at least two or more energy generation sources. The main purpose of these systems is to increase the efficiency obtained by using the resources together and to ensure the continuity of the energy flow in case one of the resources fails or does not exist (Demirtaş, 2008).

The hybrid power system structure is shown in Figure 2.

The hybrid power generation system has many benefits. These; Some of them are the ability to reduce costs, be quick to install, free and unlimited fuel, reduce CO_2 emissions and protect the environment (Ismail Abdel-Qader, 2008).

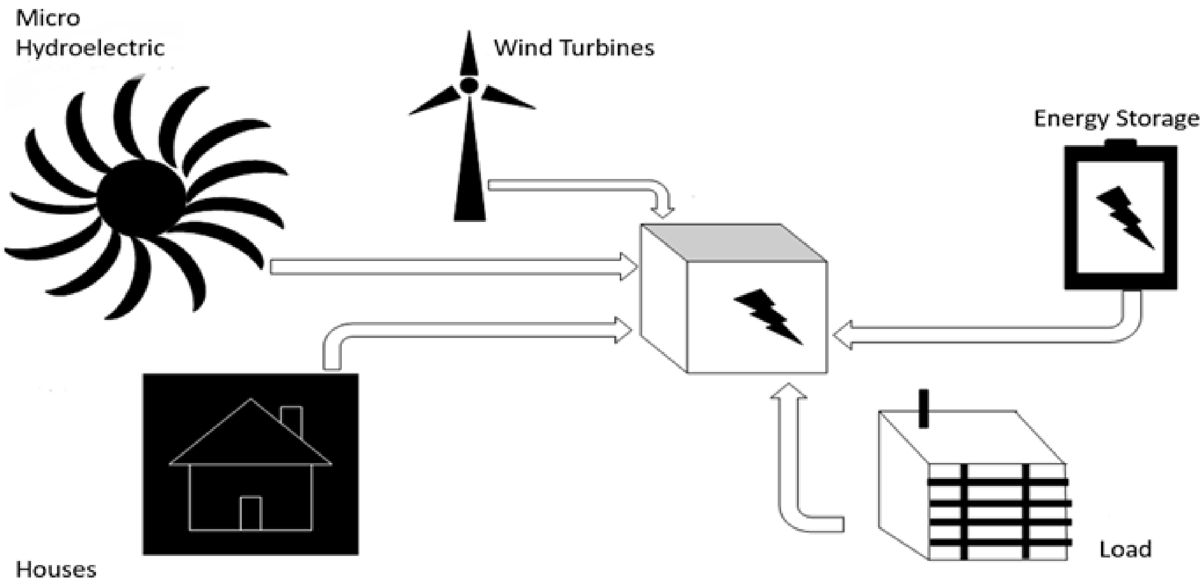

Figure 2. Hybrid power system structure

Generation Sources of the Hybrid Power System That Form the Mıcro Grid

In this article, the hybrid power system model, which is designed and controlled, consists of a wind turbine and a hydraulic turbine.

WİND POWER GENERATİON SYSTEMS

Wind is the flow of air displaced between low pressure and high pressure zone. It continuously blows from the high pressure area to the low pressure area. The air flow velocity depends on the pressure difference between the two zones. According to the average velocity of the wind turbine core, the electrical energy generated from the wind is classified as medium level at 6.5 m / s wind speed, as good level at 7.5 m / s wind speed, and high level at 8.5 m / s wind speed (Kocaman, 2014).

Wind turbines used in wind energy, which is one of the renewable energy sources, are used to generate electrical energy. The duty of the electric generator in the turbine is to convert the mechanical power into electrical power. The power of wind turbines is between 50W and 3-4 MW. The energy obtained by wind turbines depends on the effect of wind speed on the turbine (Bayır & Ozer, 2010).

There are two usage methods for the energy acquired through wind. This energy should either be offered to the consumer in the area where it is produced or it should be directed to the interconnected grid. The energy obtained from wind turbines is completely dependent on wind. So they can only be done in windy areas. The fact that production and consumption are not at the same time is one of the biggest problems of these systems. In order to solve this problem, the energy obtained must be stored. Some important storage methods are (Kocaman, 2014);

Storage method provided by batteries used in small establishments in case of necessity,
The method of storing hydrogen by separating the water by electrolysis,
The method of increasing the existing energy of the pumped water,
The method of storing energy in the air whose molecules are brought closer to each other,
Storing energy as thermal energy in water is another method.

The theoretical power of the wind with Q flow rate and V speed generated by the wind turbine (Kocaman, 2014);

$$P=0.5\times Q\times V^2 \quad (1)$$

calculated as. In this calculation, if the mass flow rate is written instead of Q = ρ * A * V, the power of the wind;

$$P=0.5\times \rho\times A\times V^3 \quad (2)$$

It is obtained as.
$A = \pi/4 \times D^2$
A: Rotor sweep area (m^2)
D: Rotor diameter (m)
V: Wind speed (m/s)
ρ: Wind turbine efficiency (taken as 59% under ideal conditions and called the Betz Limit.)
Q: : Air density (1.225 kg / m^3)
The annual amount of energy produced is;
W =P*t (kWh)

It is calculated from the equation. Here t time is taken as 8760 hours.

As can be understood from equation (1) and (2), the power supplied from the turbine is directly proportional to the square or cube of the wind speed (Kocaman, 2014).

Micro hydroelectric power generation system

Since hydraulic energy is a renewable energy, it has been used for many years. This system is based on converting the existing energy of water into electricity generation by various methods. The water stacked in the dams hits the turbine with its downward flow from the highest level, and the rotating turbine converts the existing energy of the water into kinetic energy. The generator starts to rotate the shaft thanks to the kinetic energy generated. The tension is also produced in this way (Kocaman, 2014). Figure 3 shows the schematic of a micro hydroelectric power plant.

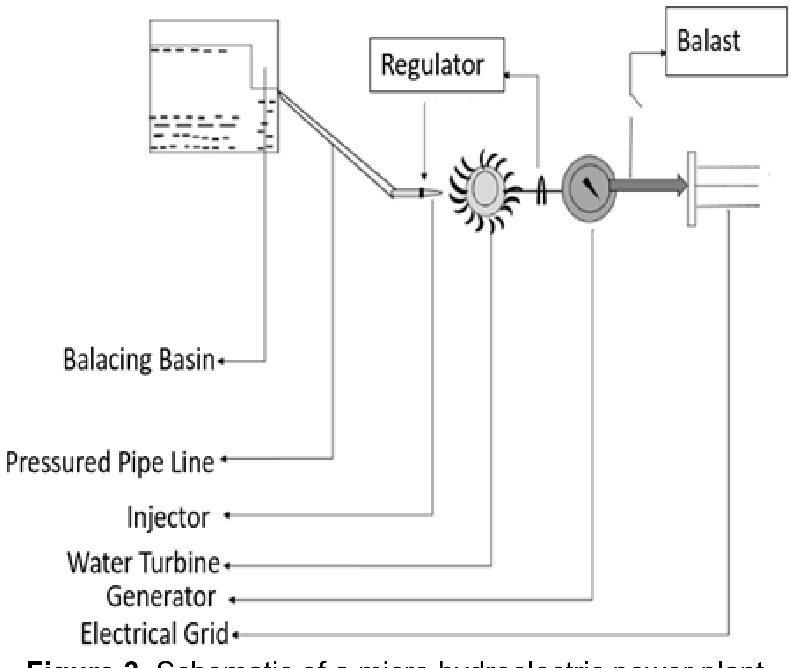

Figure 3. Schematic of a micro hydroelectric power plant.

Micro hydro is a type of hydroelectric power that generates electricity between 5 kW and 100 kW using natural water flow (Renewable Energy Technologıes: Cost Analysıs Serıes (Pdf) (Report)).

Micro hydro systems are complementary to photovoltaic power systems. Because the water flow in many regions, ie the available hydroelectric energy, is at its highest level in the winter months when the sun is at the lowest level. Micro hydro is mostly carried out with a pelton wheel for high pressure and low flow water supply. Their installation is often provided above waterfalls. Water wheels and Archimedes screws are generally used in low pressure areas (URL 1, 2021). These systems are installed in regions capable of generating electricity up to 100kW (Microhydropower Systems).

Pelton, kaplan, francis and crossflow are examples of water turbines used in hydroelectric power plants. The factors taken as basis when choosing these turbine types are the speed of the generator, flow rate and the height of the water drop.

In order to determine the most appropriate turbine and power to be used in Micro Hydroelectric Power Plants, a chart is presented in Figure 4. However, in order to be able to use this flow, the net drop height and flow rate of the dam or stream to be produced must be known (Kocaman, 2014). The equation for power generated from hydroe lectric power plants is as follows (Kocaman, 2014):

$$P=\gamma\times H\times Q\times\eta(kW) \quad (3)$$

η : ηH*ηT*ηG
H : Drop (m)
γ : Unit volume weight of water (9,81 kN/m3)
Q : Flow (m3/sec)
η : Total yield
ηH : Fall efficiency
ηT : Turbine efficiency
ηG : Generator efficiency

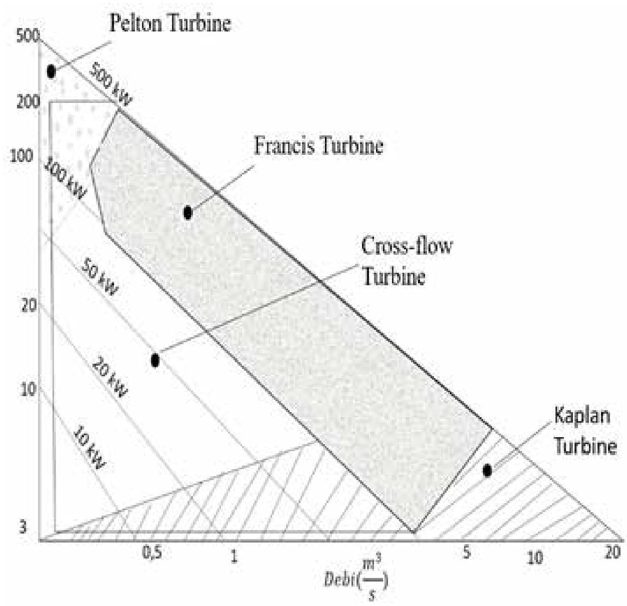

Figure 4. Net head-flow chart of micro hydro turbines (Paish, 2002)

ENERGY MANAGEMENT IN MICRO GRIDS

Energy management is a disciplined study designed for the efficient use of energy without reducing production due to the quality, safety or all environmental conditions of the product (Karavas, Kyriakarakos, Arvanitis, & Papadakis, 2015). The recent fluctuations in unpredictable energy prices, the decrease in resources, the increase of the service life of the facilities, the reduction of maintenance costs, the more effective and binding nature of energy regulations, the need to meet customer requests, the efficient management of the brand's prestige and corporate obligations, and similar reasons are effective reveals the necessity of an energy management (Kocaman, 2015).

With the energy management made in micro grids created using renewable energy resources, it enables the transfer of the electrical energy produced by hybrid connection of the production resources to the load or the storage of the energy produced in excess of the load in the storage unit and thus it is used when needed. In cases where our production resources do not produce energy and the battery is empty, some of the energy needed is met by energy management from fuel cells. In cases where the battery is full, the energy produced is either transferred to the electrolyzer to produce hydrogen to be used in the fuel cell or directly to the load (Kocaman, 2014).

Thanks to the storage unit in micro grids, the needed energy does not need to be produced immediately. The primary battery can be used for storage, but primary batteries do not have a charging feature. Batteries with charging feature are secondary batteries (Kocaman, 2014).

Fuel cell, or fuel cell, is a kind of battery. Energy in fuel cells is converted directly into heat or electrical energy. Generally, hydrogen is chosen as the fuel type. However, methane, methanol, ethanol and natural gas are also used. Recently, positive results have been obtained from fuel cells that can be used with gasoline (Solmaz, 2009).

EYS offers the opportunity to make the most appropriate sharing of distributed generation areas among themselves in a 0micro grid and to provide the least costly service to the load. Although there are small water resources in areas with small settlements, the demand for freight is high. Micro hydroelectric system structure, on the other hand, cannot meet all the demand. Therefore, the most efficient solution to this problem is to combine photovoltaic panel, micro hydroelectric and wind energy systems with a hybrid structure. The common weak point of all these systems is that they depend on meteorological factors (Kocaman, 2015).

SYSTEM SIMULATION MODELING AND DESIGN

The model of the hybrid wind and hydro power generation system under study is present in Figure 5 in detail.

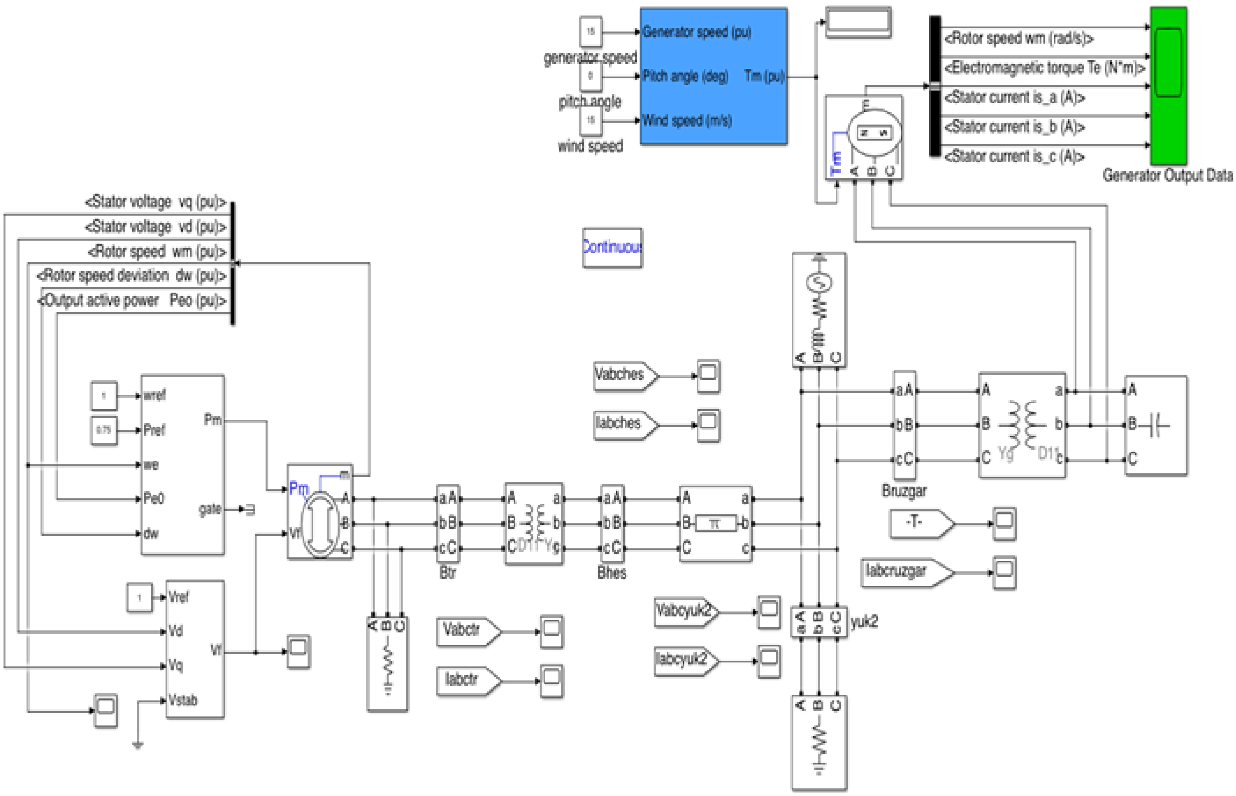

Figure 5. System simulation model

Simulation is complete with MATLAB/Simulink 'SimPowerSystem' library. The hydrolic Turbine and Governor block set was used to model the türbine. Wind speed in the system is determined as 15 m/s. The technical features of the model are presented in Table 1.

Table 1. Technical Specifications of the Model

Equipment	Technicial Specifications
Synchronous Machine	10.2 kVA, 60 Hz
Permanent Magnet Synchronous Machine	0.18 ohm
3 Phase Transformer	100 kVA, 60 Hz
Load	7500 W, 60 Hz
Wind Turbine	1500 Kw, 15 m/s

RESULTS

In this study, micro grids and energy generation systems have been examined. As a result of the researches, it has been shown that micro grids can operate as dependent-independent from the grids, and that distributed energy resources can also be found as distributed generation or storage energy. In addition, micro grids will appear in different tasks in the following years as smart micro grids.

The graphics of the simulation results are given below. Figure 6 shows the HEPP transformer output voltage time graph, Figure 7 shows the transformer output voltage time graph of the wind power plant. Figure 8 shows stator currents, rotor speed and electromagnetic torque of the Permanent Magnet Synchronous Machine fed by a wind turbine, and finally, the rotor speed of the hydraulic turbine is graphed in Figure 9. The output results waveforms are given as.

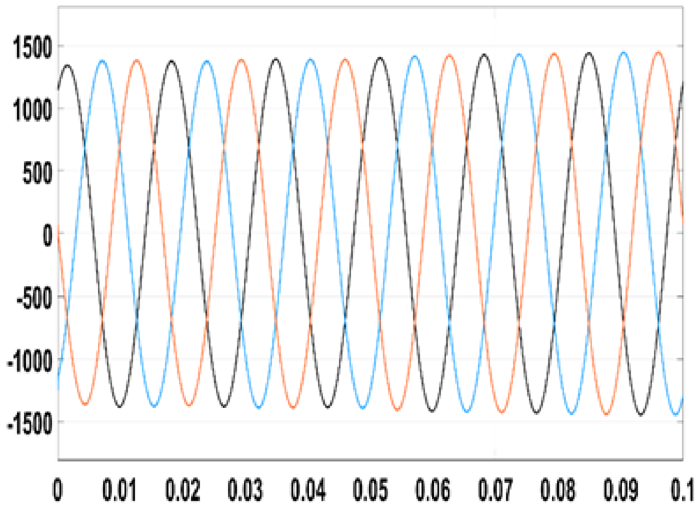

Figure 6. Transformer 1 voltage / time graph

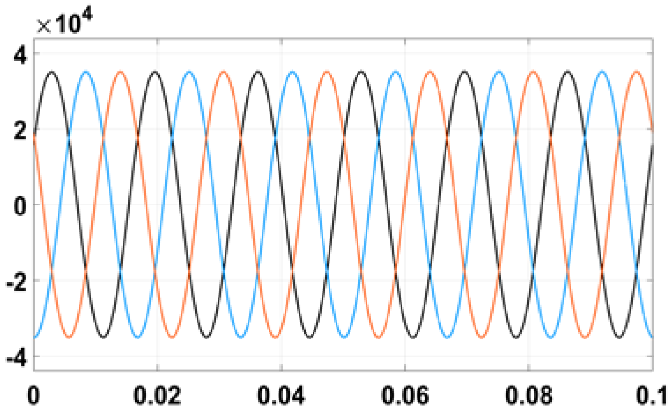

Figure 7. Transformer 2 voltage / time graph

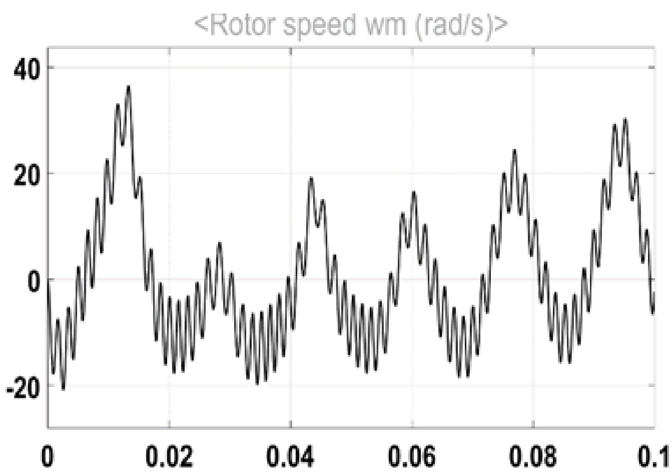

Figure 8. Rotor speed wm(rad/s)

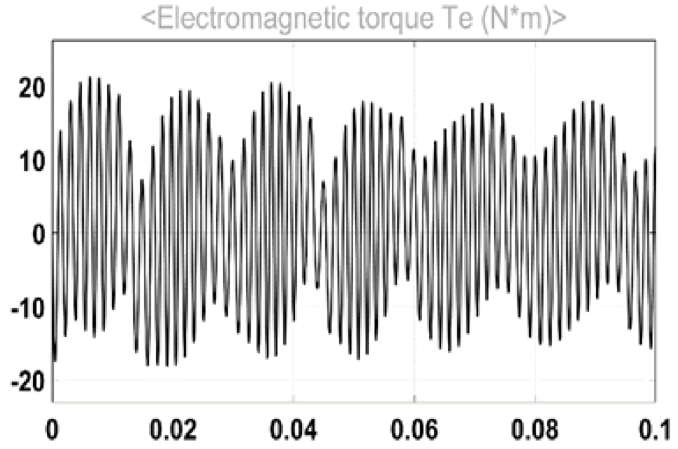

Figure 9. Electromagnetic torque Te(N*m)

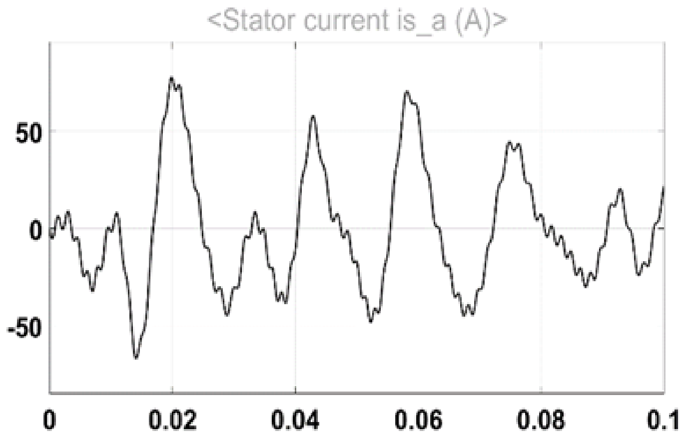

Figure 10. Stator current is_a(A)

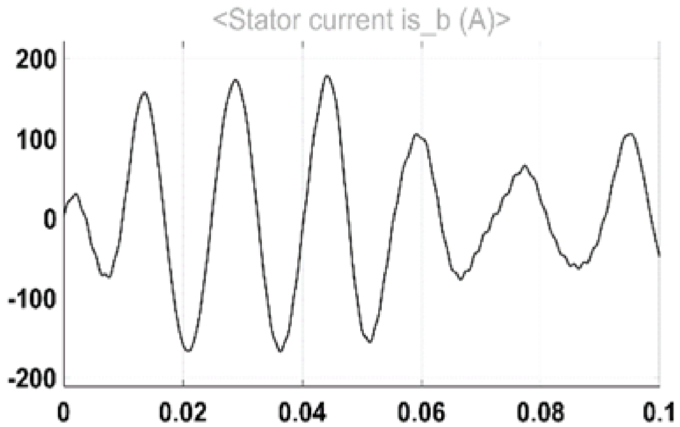

Figure 11. Stator current is_b(A)

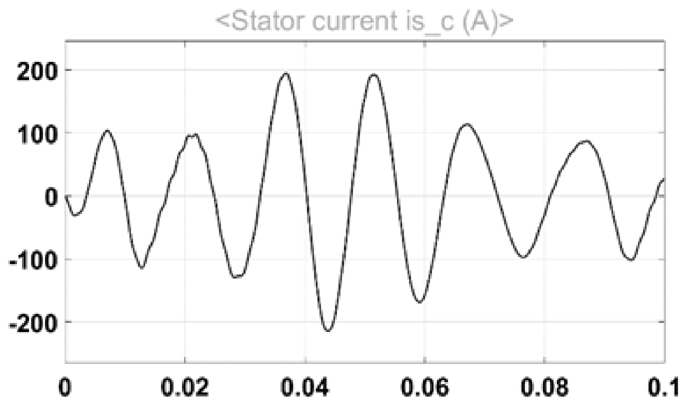

Figure 12. Stator current is_c(A)

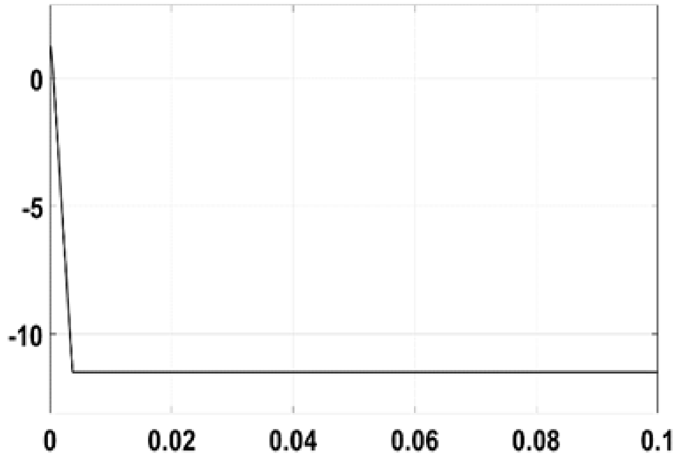

Figure 13. Hydraulic turbine rotor speed

CONCLUSION

Fossil fuel consumption will decrease with more widespread use of distributed generation in the coming years. Accordingly, there is a possibility of a decrease in the transmission and distribution phase. Energy management is a phenomenon that emerged precisely at this point. Thanks to energy management, institutions can control their energy consumption by determining their own path without compromising their own goals and objectives. In this way, a suitable environment is created for rehabilitation studies by evaluating the system.

Electric energy, which is produced by using renewable energy, provides less efficiency than standard production systems. For this reason, energy from only a renewable source may be insufficient for small residential areas. The system created by using more than one of the renewable energy sources together to provide the energy they need to the users living outside the residential areas is called hybrid power systems.

Energy management is of great importance in terms of fixing the costs of the business at the desired level. Energy cannot be obtained from the sun at night and in the morning. This demanded power is met from other production regions thanks to energy management. Thus, the importance of energy management systems in meeting the load demands in the grids comes into consideration.

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