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Effect of energy storage on power system stability

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Abstract

Nowadays, the difference between the amount of energy produced and the amount of energy needed is growing. However, the resources of traditional energy production methods are gradually decreasing and cause environmental pollution. Limited resources lead us to renewable energy sources. On the other hand, production with renewable energy sources brings with it the changing global climate problem. The efficient, functional and continuous use of this energy is as important as the production of energy. However, systems based on renewable energy sources such as solar and wind cannot respond quickly and reliably to fluctuating demand as they have different generation profiles seasonally and during the day. This indicates that energy storage is an important issue. It is academically important to analyze the changes in the stability of power systems by integrating storage systems into power systems. In this study, it is aimed to minimize the production-consumption imbalance by integrating energy storage systems into smart grids and the response of system stability is analyzed. In practice, development studies were carried out on the basis of the MATLAB contents applied by Hadi Saadat. For this analysis, hypothetical generation and consumption systems have been created using the IEEE 14 bus power system.

Introduction

A large part of the world's energy needs is met through centralized production systems that utilize the potential energy of water as well as fossil and nuclear fuels. Due to environmental concerns, the negative effects of dangerous gases formed during the energy production of traditional power plants on the atmosphere and global warming raise a question mark.(Kemal, 2016) Renewable energy sources are seen as a solution against adverse situations that may occur.

Renewable energy systems, especially solar and wind systems, are very important for our future, as they provide environmentally friendly and sustainable production. However, sources such as sun and wind have a production profile that is not constant during the day.

Considering that energy storage systems store energy when production is high and return it to the system, when necessary, energy storage systems are seen as a solution to balance unstable energy production and to ensure energy continuity.

Material and Method

In this study, IEEE 14 bus power system was preferred. Analyzes were made using the Matlab program. Newton-Raphson renewal method was used for stability analysis. While creating the scenarios, the load flow densities of the system were taken into account and solar generation unit, wind generation unit and energy storage system were added to the system. By creating faults in the system, the rotor angle, frequency and voltage stability of the system were examined.

In terms of high efficiency, the charging and discharging time of the battery was chosen as 3 hours.(Yilmaz vd., 2021)

Introducing the scenarios used in stability analysis

- **Scenario 1**

IEEE 14 bus system; It consists of 5 machines, 11 loads, 3 transformers and 15 transmission lines. In the current system, the bus with the highest load density is the 2nd bus. Therefore, the energy storage system is integrated into the 2nd bus and faults are created close to the 2nd bus.

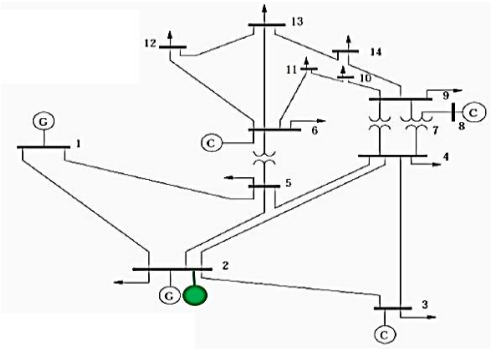

Figure 1. IEEE 14 bus system with added storage system (green circle)

The stability of the system in its current state is analyzed and the stability in the state after the energy storage system is added to the 2nd bus. The system is shown in ''Fig 1''.

- **Scenario 2**

By adding a wind generation unit to the 5th and 2nd buss and a solar generation unit to the 4th bus, it has been accepted as the current situation. In the current situation, stability has been analyzed by adding an energy storage system to the 4th bus. The test system is shown in ''Fig 2''.

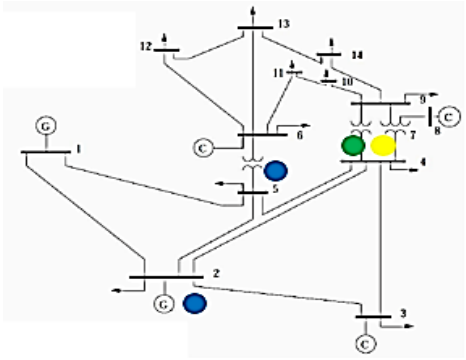

Figure 2. IEEE 14 bus system with added storage system (green circle), solar generation unit (yellow circle), wind generation unit (blue circle)

Results

The analyzes were made by taking into account the hourly consumption-production values of Turkey. The stability of the system was investigated with 0.05 seconds iteration. Since there is production at 07.00, 13.00 and 19.00, the energy storage system acts like a load, that is, it is charging. Since consumption is intense at 12:00, 15:00 and 20:00, the energy storage system acts like a generator, that is, it is discharged through the system.

Table 1. System instability times

Hour/Scenario	Scenario 1	Scenario 2
07.00	0.10	0.10
12.00	0.10	0.15
13.00	0.10	0.10
15.00	0.10	0.15
19.00	0.10	0.10
20.00	0.10	0.15

When the data in ''Table 1'' is examined, the energy storage system alone does not show a different result in case of failure in Scenario 1. However, when the energy storage system is used together with solar and wind generation units (Scenario 2), it is observed that the stability of the system is longer when the storage system gives energy to the system.

Discussion

In this study, it is aimed to see the changes in system stability with the integration of energy storage systems in power systems based on renewable energy sources. Since the energy obtained from smart grid integration renewable resources changes seasonally, annually, daily or even hourly, the importance of energy storage systems emerges to ensure the continuity of this energy.

However, it will be an academically important study to examine the effect of energy storage systems on system stability in their work with the existing power system, solar and wind generation units.

Conclusion

According to the results of the analysis, it is seen that the energy storage system has a positive effect on the stability of the system in case of a possible failure, while providing energy to the system, that is, in case of discharge. It has been observed that while storing energy from the system, that is, in the charging state, it behaves like a load and does not have a serious deterioration effect on the stability of the system.

It is predicted that the use of IEEE's 9, 30 and 39 bus power systems as a test system will also have positive effects on the literature.

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