運用・環境観点に基づくスマートグリッドの最適運用

Abstract

Worldwide power generation sectors are interested in the smart grid. Generally, a utility is introducing more renewable generations in a smart grid. There are various reasons behind for introducing more renewable energies in the smart gird. Due to growing demand for electricity, the price of fossil fuels is increasing. On the contrary, this extreme use of fossil fuels is causing global warming, and carbon dioxide emissions, as well as natural resources (fossil fuels), have been diminishing. Therefore, consumption of fossil fuels should be reduced through shifting production from fossil fuel based energy to renewable-based energy. That is why renewables based distributed generations (DGs) are getting more popularity. DGs are expected to play a vital role in the future energy demand and market. DGs consist of wind generation (WG), photovoltaic (PV) generation, concentrated solar power (CSP), biomass power generation, hydro plant, geothermal plant, smart house, energy storage system (ESS) and so on are sources of energy. These DGs can deliver a variety of benefits including improved reliability if they are operated properly. On the other hand, the problems are required a high amount of money for initial investment, and output power of renewable energies are uncertain for different weather conditions. However, power producers should consider optimization technique for reducing the operational costs and maximize the profits as well as considering the consumers benefit. As installations of renewable energy systems are expensive, so utility companies need to calculate the Break-Event Point (BEP) and Net Present Value (NPV).

First of all, the thesis describes a part of the research for introducing rooftop PV in developing countries. Most of the developing nations are facing load deficits problem as well as CO_2 emissions. Load deficits and CO_2 emissions can be reduced by installations of rooftop PV. However, there is lack of mass consciousness about initial investment. Most of the developing countries' consumers are using Instant Power Supply which is a battery storage system known as IPS. This research introduces the rooftop PV compared with IPS because IPS is a market competitor for rooftop PV.

Then, this thesis demonstrates the comparison approach of operational cost and consumer effort using multi−objective optimization for the smart grid system considering real-time pricing. This part of the thesis, optimize the consumer effort for demand response and cost of power systems. In general, more consumer efforts for demand responses can help to reduce the power system costs. However, consumers are trying to escape the demand response. Sometimes it is impossible to shift loads of a consumer. So, this research has done for reducing the consumer efforts and costs.

Furthermore, a smart house based power system for thermal unit commitment program has been introduced. The proposed power system consists of smart houses, renewable energy plants, and conventional thermal units. The transmission constraints are considered for the proposed system. The generated power of the large capacity renewable energy plant leads to the violated transmission constraints in the thermal unit commitment program. Therefore, the transmission constraint should be considered.

Additionally, this part of the thesis deals with an optimal battery energy storage capacity for the smart grid operation. Distributed renewable generators and conventional thermal generators are considered as the power generation sources for the smart grid. Usually, a battery energy storage system (BESS) is used to satisfy the transmission constraints, but installation cost of battery energy storage is very high. The proposed research, a thermal units commitment program considers the demand response system to satisfy the transmission constraints. The demand response system can reduce the BESS capacity.

Nowadays, the installations of PVs in the smart grid have been growing dramatically because the price of PVs is falling drastically. The massive penetration of PVs' power at the day-time changes the load demand of thermal generations of a smart grid which creates duck shape load curve called duck curve. This research solves the duck curve problem, increase the renewable generation, reduces CO2 emissions and usages of fossil fuels. This research introduces CSP instead of battery storage because the battery consumes grid power while charging and has efficiency loss but CSPs have own solar sources of energy. This research also considers the consumer sides, they have rooftop PV and Fuel-Cell in their smart houses so on, and consumers also get benefits through demand response scheme.

Finally, All the proposed methods are summarized. Scopes of future research have also been described.

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