Abstract

In this thesis, deterministic and probabilistic methods are developed for optimal planning of distribution networks with integration of WTs within a market environment.

With regards to the deterministic methods, hybrid optimization methods for optimal allocation of WTs from viewpoints of DG-owning DNOs and WTs' developers respectively for jointly minimizing annual energy losses and maximizing SW as well as maximizing NPV and SW are proposed:

(i) The method jointly minimizes the annual energy losses and maximizes the SW considering different combination of wind generations and load demands to determine the optimal locations, sizes and numbers of WTs to be allocated at candidate buses. The GA is used to select the optimal locations and sizes among different sizes of WTs while the market-based OPF is used to determine the optimal number of WTs. DNO acts as the market operator of the DNO acquisition market that estimates the market clearing price and the optimization process for the active power hourly acquisition. The stochastic nature of both load and wind is modeled by hourly time series analysis. The method is also able to model the correlation among wind resources, i.e. for each range of generation capacity of the first wind profile, a layer with the coincident hours of demand/generation can be created for the second wind power profile.

(ii) The method combines the PSO and the market-based OPF to jointly maximize the NPV associated to investment made by WTs' developers and the SW in DNO acquisition market environment. The PSO is used to select the optimal sizes among different sizes of WTs while the market-based OPF to determine the optimal number of WTs in order to maximize the SW considering network constraints. The presented case study highlighted that WTs' developers by optimally allocating WTs at buses with the highest LMPs can both improve their profits and increase consumers' benefits by energy cost reduction, power losses decrease and network constraint alleviation.

With regards to probabilistic methods, a probabilistic method to evaluate the effect of WTs integration into distribution networks within market environment was proposed. Combined MCS and market-based OPF are used to maximize the SW considering different combinations of wind generation and load demand. The method can be utilized as a simulation tool to study the probabilistic SW and the impact of wind power penetration on LMPs throughout the network. Furthermore, it characterizes how LMP changes by increasing wind power penetration. It also can be used as a tool for DNOs to approximate the amount of wind power that can be injected into the network taking into account cost reduction and consumers' benefits.

Regarding the control of distribution networks, a fuzzy controller for improving FRT capability of WTs is designed to compensate the voltage sags and swells at the PCC by controlling both the reactive and active power generated by WFs. The FRT capability improvement is investigated considering Danish grid code. The proposed method is able to simultaneously regulate active and reactive power during voltage variations. During voltage sag only the reactive power is injected by using the controller in order to improve the voltage sag effects while during a voltage swell, when the absorbed reactive power is not adequate, the active power generated by WFs is decreased by using the active power modulator that is sent by fuzzy controller to the RSC to increase the absorbed reactive power. In this case, according to both the WTs' power curve and capability curve, the WFs will not generate the maximum active power but it has positive effects on voltage regulation at the PCC, i.e. within the limited size of the DFIG converters, the reduction of active power increases the maximum reactive power absorbed by WTs.