In this dissertation, the application of the cooperative control in power system and controlling a high penetration of distributed generators (DGs) is investigated. Initially, the general form of the cooperative control is formulated to self-organize a high penetration of DGs. The primary objectives are chosen to regulate a critical point voltage and keep the active power flow from the microgrid to the main grid at a desired value. Then, the cooperative control is further developed to regulate multiple critical points voltages, to realize a more unified voltage profile. This idea is further developed by considering the case in which, each DG node in the system is considered as a critical point and it is of interest to regulate the voltage of all the nodes together.

To this end, the application of the cooperative distributed optimization is introduced. It is shown how DGs may utilize low-bandwidth, local and asynchronous communication links to perform a distributed optimization to realize a unified microgrid voltage profile. It is shown that how a unified voltage profile, also leads to the active power loss minimization. Finally, as a high level control, the interaction of the main grid and the microgrids is formulated as a Stackelberg game, in which not only the economical interests of both, the main grid and the microgrids, is optimized, but also the active power flow is improved in the sense of shaving the peak of the power.