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Operational, short and long term profile optimization (economic dispatch) of distributed energy resources in Microgrid

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In this article we define, decompose and describe the basic principles of the optimal control synthesis for a microgrid (namely three levels of distributed energy resources (DER) usage optimization: operational, short- and long-term). Such strategy allows you to apply coordinated management for each DER unit available, reduce fuel costs, minimize amount of the necessary external energy purchases from the power market; equipment maintenance costs can also be reduced. Additionally, increase in revenue from energy sales and ancillary services (demand response mechanism realization, frequency and voltage regulation) can be achieved.

Microgrid consisting of numerous units which generate, store, consume and transmit electrical power, has been considered. Every such unit has it's own operational cost, technical limitations, and all of them should be controlled in a way to provide power balance in the system. Microgrid also usually contains several renewables, and their power output generally should be maximized (thus saving energy resources such as fuel). Multi-objective optimization problem arises, as we need to simultaneously control slow changing parameters like generators' technical state, perform economical optimization with 1-day horizon and constantly enforce power balance in the system. The proposed solution is to decompose the multi-objective optimization problem into three consequently solved smaller problems mentioned before: operational, short- and long-term.

Long-term optimization is needed mainly to achieve balanced equipment usage, e.g. to ensure that all the generators have approximately the same operational life hours. Every relevant equipment unit would get a "rating", which should be used when performing lower level optimization. The procedure of the long-term optimization does not need to be carried out too often, day or several days should be enough.

Short-term optimization is the core of the whole microgrid control problem. It's essentially the unit commitment problem (UCP), solved for the 24-hours time horizon with the 15-

minutes grid step. To solve it we also need to perform load forecast, renewables output forecast. It is done using statistical data and regression algorithms. The fact that we have energy storages and some units can be switched on/off (for a price) does not allow us to just solve the problem in every time point, we instead need to solve the problem as a whole. There is also need to build strategies for the external network and storages control. This nonlinear mixed-integer problem has been solved using the dynamic programming method (DP), also linearized problem has been solved using branch-and-bound algorithm.

Operational optimization uses the solution of short-term optimization as a base and refines it, using the newly received measurements data. This allows system to adapt to irregular and random events. The second task is to perform reactive power optimization (short-term optimization only takes active power into account).

The algorithms and methods, described above, have been implemented in the AMIGO software solution. Proposed optimization methods have proven to be effective, energy resources economy at the level of 7-12% has been achieved.