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PERFORMANCE OF A COORDINATED CONTROL ALGORITHM FOR SMART GRID UNDER VARYING V2G VEHICLE POOL SIZE

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Non-conventional renewable energy sources like wind and solar are increasingly becoming popular the world over. Due to the low spatial density of these energy sources, installing numerous energy generating units over a large geographical area is inevitable. Such large penetration could be realized by installing domestic solar photovoltaic in addition to mega solar and wind power plants. However, the intermittent and random nature of these sources would destabilize the power network. Therefore the power imbalance and hence voltage fluctuation caused should be addressed to allow large penetration of these renewable energy sources.

Controllable loads and Plug-in Electric Vehicles (PEV) have high potential to balance the active power fluctuations caused by renewable energy sources. On the other hand, the reactive power capabilities of Distributed Energy Resource (DER) like solar PV and PEVs could be utilized to maintain the voltage in the distribution feeder. Hence, controlling these devices in near-real time could balance power imbalance caused by fluctuating renewable energy generation. While ensuring the power balance, the coordinated control algorithm evaluated in this study addresses the issue of harnessing maximum renewable energy while maintaining the voltage constraints of the distribution network. In this paper, the performance of this algorithm is evaluated under varying Vehicle-to-Grid pool (V2G) sizes.

Though a PEV fleet connected to electricity network has higher potential to mitigate power fluctuations, they should be used with minimal social impacts. Therefore when a PEV is connected to the grid they are charged up to 90% SoC before they are taken into the V2G pool. Only ±10% around 90% of their capacity is used in V2G operation. In this study V2G pool size is assumed to be a function of time and the total number of PEV in operation. All PEVs within a node are assumed to be controlled equally. The rated capacity of Voltage Source Inverter (VSI) in each PEV is assumed to be minimal to support the rated power of the PEV. Therefore its reactive power output is assumed to be limited by active power consumed by the inverter.

As the available number of PEVs increase, the renewable energy harvesting efficiency was observed to increase due to increased energy storage resulting from higher number of PEVs. On the other hand, as the number of PEVs increases the net power capacity of the storage increases. Hence, the algorithm tries to absorb more power from renewable sources when available. However, due to the intermittent nature of renewable energy sources the available power could drop rapidly. Even though such changes in power generation were addressed by the algorithm in the subsequent control cycle, power imbalance could occur in between the control cycles. In such situations, the power balance should be guaranteed within the distribution system. To address the above scenario the required power capacity of the storage device to provide the additional power is observed to increase as the number of PEVs increases. The algorithm studied in this paper was observed to perform better in terms of increasing renewable energy production efficiency as the V2G vehicle pool size increases.