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Deterministic and Probabilistic Assessment of the Impact of the Electrical Vehicles on the Power Grid

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The recent awareness about fossil fuels and the environment has arisen more sustainable alternatives regarding means of transport. Consequently, hybrid vehicles and pure electrical vehicle have become the main alternatives for green transportation. This new trend has caused market activation and it is expected that hybrid and electrical vehicles will constitute the majority in private transport. This paper analyzes the impact of the charge of EVs (Electrical Vehicles) on a power grid.

In order to analyse the impact of the EVs into the grid, a model of its charging curve is needed. From all the existing models of EV, the charging curve chosen is from the Mitsubishi I-MIEV This vehicle has an autonomy of 160 km and its batteries are made of Li-ion (50Ah 16kWh 330V). The battery is charging at full power during 2 hours and then decreases its charging power exponentially since the hour 4; at this time it is considered that the battery is completely charged.

The way of how EVs are charged from the grid has a critical influence on its impact on the voltage levels and on the saturation of the lines. Considering this fact, two modalities of charge are presented: not-controlled charge and controlled charge. In the not-controlled charge EVs start the charge as they park. In the controlled charge, EVs only can charge during a determined period of time of the day (low-load period).

During the charging process of the EV, will be charging simultaneously EV with different states of charge. Therefore, a model is needed to take this fact into account in the steady-state simulations. Eq. (1) models the superposition of the demand caused by the EV in different charging states, where *R* is penetration of EV, *Pev* is the maximum power which a car can charge, *i* is the counter associated to the actual hour, *j* is the counter associated to the previous hour, $\Delta va_{k,k-1}$ is the increase of EV between the hour *i* and the hour *j* and Cev_k is the charging state of the EV.

$$PH_i = R \cdot Pev \cdot \sum_{k=1}^{i} (\Delta va_{k,k-1} \cdot Cev_k) \qquad (1)$$

The scenario of the simulations is a part of the Danish sample grid. This grid, of 400 MW of short-circuit power, has 3 wind turbine generation units of 630 kW at busbars B013, B015 and B017. In addition, there are three combined cycle units of 3 MW each one at the busbar B005, but for purposes of the study has remained disconnected. Loads are at the busbars B005, B010, B011 and B012. Due to simplify the interpretation of the simulations and the results, EVs have been separated from the other consumptions. In order to study the most critical situation the *Winter(week)* case has been chosen from all the possible situations of electrical demand because it has the highest demand in every hour. Therefore, the wind power generation curve is from this period.

In the deterministic and in the probabilistic analysis the voltage results presented are from two busbar. The first busbar is B005 and it has been chosen because L00 is always the load with the highest power. The second busbar chosen is B014 in order to have the behavior of a closer busbar to a wind power generation unit.

Results from the simulations show that not-controlled charge amplifies the demand of the line at the hours of the higher electrical demands. On the other hand, simulations show that with the controlled charge a high penetration of EVs can be charged without investments in the switchgear.