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A three-level model for integration of hydrogen refuelling stations in interconnected power-gas networks considering vehicle-to-infrastructure (V2I) technology

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Abstract-

The coupling with natural gas networks creates an excellent opportunity for renewable-rich power systems to facilitate the utilisation of renewable energy resources; on the other hand, with the increase in employment of fuel cell vehicles (FCVs), the number of hydrogen refuelling stations (HRSs) is increasing. The integration of HRSs in electric distribution systems may impact the operation of electric distribution systems. Through vehicle-to-infrastructure (V2I) technology, vehicles may exchange information with HRSs and know hydrogen prices. The operation of the coupled power and natural gas networks with integration of green HRSs, considering the model of FCVs has not been investigated in the literature, so, it has been set as the goal of this paper. To avoid the challenges of nonlinear gas flow model, they are linearized through piecewise linearisation. The case study is a 33-bus electric distribution system, coupled with a 14-node gas distribution network; each HRS includes a battery, a hydrogen tank, an electrolyzer, a PV and a wind turbine. MILP models have been used for FCVs, HRSs and power-gas networks. CPLEX solver is used for solving the developed MILP models. The results show that the total cost of the coupled electricity-gas network is $760.37 and the refuelling cost of each FCV is $17.30. The results indicate that both electric and hydrogen storage systems enhance the flexibility of HRSs, enabling efficient utilisation of PV modules and wind turbines, so, only in few hours, HRSs need to purchase electricity from electric distribution system; that is why each HRS makes a considerable profit of $519 per day. The achieved results also indicate that the pressure of all gas nodes and gas flow of all pipelines fall within their prespecified range.

Index Terms- Renewable energy; Power-gas nexus; Hydrogen refuelling stations; Fuel cell vehicles; Transportation electrification; Distribution systems

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