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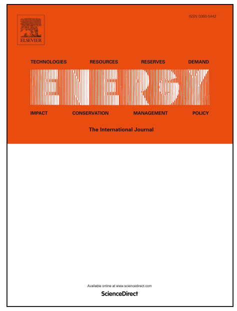

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Abstract

Multi-energy supply systems are expected to play an important role in smart grids. Today's energy supply systems are large nodes networks, and different types of energy are needed at each node to satisfy the different energy demands. These different types of energy can then be converted to each other through specific devices. How to decide the ratings of these devices at each node to make the system cost-effective is addressed in this paper. The focus is set on a gas/electricity/heat hybrid network. A hydrogen storage system (fuel cell, electrolyzer, and tanks) is used as electricity storage system, a combined heat and power device is used to produce heat and electric power, etc. A mixed integer linear programming algorithm is used to determine the optimal operation schedule of the system, where the goal is to minimize shed load. A genetic algorithm is also used to search for the best size of each component, where the goal is to minimize the total investment costs. In order to resist to contingency events, betweenness centrality (describing the relative importance of each node) is then used to find the worst case under contingency events. This worst case scenario is used to research about the influence of contingencies on the sizing results. At last, two cases (modified 13-node network and IEEE 30 + Gas 20 + Heat 14 nodes system) are tested using the proposed sizing method. The results show that the renewable energy location, investment cost of components, and the structure of the whole system influence the sizing results. When the installed capacity of photovoltaic panels is reduced by 50%, the capacity of the electrolyzer decreases by 3%, the capacity for the hydrogen tanks increases by 2%; when the investment cost of the fuel cell and electrolyzer decreases by 50%, the capacity of photovoltaic increases by 14%, the electrolyzer increases by 13%, and hydrogen tanks increase by 2%. After considering the worst case contingency event, for case I, the capacity of photovoltaic and fuel cell increase by 12% and 11%, and the electrolyzer increases by 34%; for case II, the capacity of photovoltaic and fuel cell increase by 8% and 11%, and the electrolyzer increases by 57%.

Keywords: sizing, multi-energy system, gas/electricity/heat, hydrogen storage system, optimization

Nomenclature

Acronyms

- CCHP combined cooling heat and power
- CHP combined heat and power
- DG distributed generation
- EA evolutionary algorithm
- EH energy hub
- GA genetic algorithm
- MG microgrid
- MILP mixed integer linear programming
- MINLP mixed integer nonlinear programming

Parameters

- α penalty values for load shedding of gas demands
- β penalty values for load shedding of electricity demands
- γ penalty values for load shedding of heat demands
- C_{inv} investment cost of each component
- eff_{CHP} gas utilization efficiency of CHP to consume gas
- eff_{ch} efficiency to produce H_2 through the electrolyzer
- eff_{ETH} efficiency of ETH to produce heat
- eff_{GTH} efficiency of GTH to produce heat
- eff_{heat} fuel cell efficiency to produce heat
- eff_{re} heat recovery efficiency of CHP
- $L_{el}^{i,t}$ electricity load demands at node i and time t (MW)
- $L_{gas}^{i,t}$ gas load demands at node i and time t (MW)
- $L_{heat}^{i,t}$ heat load demands at node i and time t (MW)

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