Capacity Planning of Energy Hub in Multi-carrier Energy Networks: A Data-driven Robust Stochastic Programming Approach

Yang Cao[1], Wei Wei[1], Jianhui Wang[2], Shengwei Mei[1], Miadreza Shafie-khah[3], Joao P.S. Catalao[4]
[1]Department of Electrical Engineering, Tsinghua University, [2]Department of Electrical Engineering, Southern Methodist University, [3]INESC TEC, INESC TEC, [4]Faculty of Engineering, University of Porto

Cascaded utilization of natural gas, electric power, and heat could leverage synergetic effects among these energy resources, precipitating the advent of integrated energy systems. In such infrastructures, energy hub is an interface among different energy systems, playing the role of energy production, conversion and storage. The capacity of energy hub largely determines how tightly these energy systems are coupled and how flexibly the whole system would behave. This paper proposes a data-driven two-stage robust stochastic programming model for energy hub capacity planning with distributional robustness guarantee. Renewable generation and load uncertainties are modelled by a family of ambiguous probability distributions near an empirical distribution in the sense of Kullback-Leibler (KL) divergence measure. The objective is to minimize the sum of the construction cost and the expected life-cycle operating cost under the worst-case distribution restricted in the ambiguity set. Network energy flow in normal operating conditions is considered; demand supply reliability in extreme conditions is taken into account via robust chance constraints. Through duality theory and sampling average approximation, the proposed model is transformed into an equivalent convex program with a nonlinear objective and linear constraints, and is solved by an outer-approximation algorithm which entails solving only linear program. Case studies demonstrate the effectiveness of the proposed model and method.

978-1-7281-1981-6/19/$31.00 ©2019 IEEE