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Risk-averse electrolyser sizing in industrial parks: an efficient stochastic-robust approach

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Abstract-

Hydrogen is called to be one of the most important energy vectors in future energy systems. Nowadays, its use in the industry sector is prominent, finding multiple applications in fertilizer production or oil refining. In this sense, some industry sectors demand a considerable amount of hydrogen for their processes. In many cases, hydrogen must be purchased externally, which supposes a challenge due to hydrogen transportation is costly and few efficient. In this context, local hydrogen production through mature electrolysis technology may suppose an attractive alternative in industrial parks. This paper focuses on this topic, in particular, a risk-averse electrolyser sizing methodology is developed. The new approach accounts for uncertainties in electricity prices as well as local renewable generation and demand through an original hybrid stochastic-robust model. The developed uncertainty modelling is integrated into a novel four-level optimization framework, whose main result is the optimal electrolyser rated power. To efficiently attain the solution, an original hybridization of the Benders' decomposition and the Column and Constraint Generation Algorithm is proposed. The developed methodology results efficient in an illustrative three-industry park, showing that installing local hydrogen generation may reduce the amount of hydrogen purchased externally (by 38%) and project costs by 2.5%. Furthermore, increasing the robustness level leads to increase the project cost by 8%, while assuming unfavourable realization of uncertainties. Moreover, the developed tool is further validated in larger parks, involving an increasing number of industries, showing that the proposed methodology scales well with the size of the park.

Index Terms- Electrolyser; Hydrogen; Industrial park; Risk-averse optimization; Robust optimization

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