





# Transactive energy framework in fuel cell based multi-carrier energy hubs based on conditional value-at-risk

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## Abstract

The prevalence of peer-to-peer operation among industrial energy hubs is considered a promoting method to enhance local energy autonomy, efficiency, and flexibility. By conducting stochastic programming, this paper aims to minimize the operating cost of multiple industrial energy hubs that trade power and heat energies with each other and utility. Concerning the important role of hydrogen systems, fuel cell-based combined heat and power (CHP) generators are employed within the hubs to increase sustainability. The presence of electric vehicles (EVs) and shiftable loads enhances the flexibility during peer-to-peer operating mode. The trading price for power and heat energies are derived at first by solving a deterministic problem and considering average values for demands and generation. However, to address the uncertainties in renewable generation, electric and heat demands, and electricity prices under operation, scenario-based stochastic programming tries to optimize the expected objective function. Furthermore, the Conditional Value-at-Risk (CVaR) approach is proposed to provide various risk-averse scheduling tactics and measure the risk of each scenario. The results show that the proposed risk-constrained approach reduces the risk and makes cautious decisions about energy resources and trades. In this regard, the expected profit has been reduced by 75%, i.e., from 1636.78 NOK under a risk-neutral case to 414.97 NOK under a risk-averse case to reduce the expected risk in operating cost.