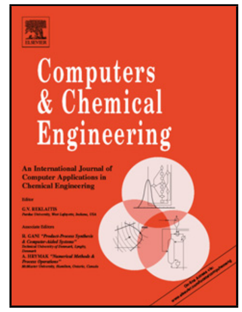

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Application of Rolling Horizon Optimization to an Integrated Solid-Oxide Fuel Cell and Compressed Air Energy Storage Plant for Zero-Emissions Peaking Power Under Uncertainty

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Abstract

In this study, the application of a rolling horizon optimization strategy to an integrated solid-oxide fuel cell/compressed air energy storage plant for load-following is investigated. A reduced-order model of the integrated plant is used to simulate and optimize each optimization interval as a mixed integer non-linear program. Forecasting uncertainties are considered through the addition of measurement noise and use of stochastic Monte Carlo simulations. The addition of rolling horizon optimization gives significant reductions to the sum-of-squared-errors between the demand and supply profiles. A sensitivity analysis is used to show that increasing the forecasting and optimization horizon improves load tracking with diminishing returns. Incorporating white Gaussian noise to demand forecasts has a marginal impact on error, even when a relatively high noise power of is used. Consistently over- or under-predicting demand has a greater impact on the plant's load-tracking error. However, even under worst-case forecasting scenarios, using a rolling horizon optimization scheme provides a more than 50% reduction in error when compared to the original system. An economic objective function is formulated to improve gross revenue using electricity spot-prices, but results in a trade-off with load-following performance. The results indicate that the rolling horizon optimization approach could potentially be applied to future municipal-scale fuel cell/compressed air storage systems to achieve power levels which closely follow real grid power cycles using existing prediction models.

1. Introduction

The electricity generation industry in North America is strongly dependent on the consumption of fossil fuels such as coal and natural gas due to their abundance and the availability of mature industrial technologies which use them. In an effort to move away from these "non-renewable" fuel sources, significant research has been invested into the conversion of energy from renewable sources (wind, solar, biofuels, etc.) in an effort to drive a more sustainable electricity generation industry. It is projected that the portion of electricity generated in the United States and Canada from renewable (non-hydroelectric) resources will be 16% and 10% by the year 2035, respectively [1]-[2]. A limitation to these technologies, however, is that they are still decades away from being implemented on the scale required to completely replace