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Operations planning with real time pricing of a primary input

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Abstract

We examine the problem of planning the operation of an air separation plant where the price of its primary production input, electricity, changes hour to hour, a situation commonly referred to as real time pricing (RTP). We present a solution approach where operating decisions are obtained from optimizing a mixed integer program embedded in a rolling horizon procedure. A simulation study is conducted to assess the effect of unreliable and finite information on the efficiency of the operations plans generated by the procedure. Results of the study suggest that the rolling horizon procedure generates robust plans. An additional simulation study is conducted to identify the conditions under which RTP is attractive vis-a-vis other selected electricity pricing schemes. Results of the study indicate that RTP is most appealing when there is substantial flexibility in the operating environment in terms of the load placed on the plant (customer demand) and with regard to ramp-up (akin to set-up) times. Although this appeal diminishes with increased loads and longer ramp-ups, it is nevertheless the case that the operational inflexibility must be significant before RTP loses its allure.

Scope and purpose:

This paper considers the plant operation problem faced by firms in the industrial gas industry with production facilities where the price of the primary production input, that is electricity, changes hour to hour, which is often referred to as real time pricing. The purpose of this work is to present an optimization based planning approach that rigorously takes into account the realities of this environment. In addition this work seeks to identify, through the use of simulation, the conditions under which real time pricing is most appealing vis-a-vis other electricity

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pricing schemes, and also the degree to which planning horizon length and uncertainty in electricity prices impact the efficiency of the operations plans generated by our planning approach.

Keywords: Operations planning; Real time pricing; Mixed integer programming; Production planning

1. Introduction

The industrial gas industry is a major consumer of electricity. According to a survey of the Energy Information Association [1], its purchases totaled 31,460 million kilowatt hours or approximately 3.5% of the total electricity bought by manufacturing industry in the USA in 1998. Not surprisingly industrial gas firms, which are producers of atmospheric and specialty gases, are continuously striving to decrease their expenditures on electricity as such outlays constitute 60–75% of their variable production costs (see [2]). Traditionally these cost reduction efforts have focused on engineering improvements of cryogenic air separation, currently the most efficient and cost effective technology for producing large quantities of atmospheric gases (see [3]), and the negotiation of 'special deals with utilities in order to obtain the lowest price possible on electricity' (see [4]). However as electric utilities have begun to make real time pricing (RTP) of electricity more readily available, a tariff where the price of electricity adjusts to reflect the actual fluctuating cost of generating it, industrial gas companies have begun to ponder whether RTP in some guise might not have a central role to play in their cost reduction efforts.

Currently industrial gas firms purchase most of their electricity under time of use (TOU) tariffs. Under TOU the price of electricity is fixed for some portion of the future for blocks of the day (e.g. on-peak, mid-peak, off-peak, etc.), days of the week (e.g. weekday and weekend) and seasons of the year (e.g. summer and winter) after being established based on a forecast of the cost of its production. While certainly popular, TOU is just one tariff or pricing scheme found in the pricing portfolio of most utilities. The specific pricing schemes found in such portfolios vary of course from utility to utility, but typically they span the risk/reward frontier. At one end of the spectrum is the tariff Guaranteed Bill which as the name implies enables a customer to obtain electricity from the utility at a fixed cost. There is little risk associated with such a tariff from the perspective of the customer, however the actual price paid by the customer for electricity is often rather high. At the other end of the spectrum is RTP, sometimes also referred to as spot pricing, which as we have already noted is a pricing scheme where the price of electricity adjusts, usually on an hourly basis, to reflect the actual fluctuating cost of generating it. No tariff in the pricing portfolio of a utility exposes a customer to greater amounts of risk, but theoretically no other tariff offers a lower price.

Although the possibility of lower electricity prices appeals to every consumer of electric power, it has been found that in order for industrial customers to take advantage of RTP at their production facilities, it is necessary for them to have the appropriate infrastructure in place (see [5]). Infrastructure in this context amounts to a firm being able to receive a price signal from its utility and then being able take that price signal along with other information and use it to automatically adjust plant operation. While such infrastructure requirements are an impediment in many industries to the adoption of RTP, in industrial gases much of the required infrastructure is already in place. This reflects that its production facilities, referred to as air separation plants, are highly automated and in fact often controllable remotely, hence