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USING COMPUTER SIMULATION TO MITIGATE RISK IN ELECTRICITY GENERATION/CONSUMPTION COLLABORATION POLICIES

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ABSTRACT

The electric utility industry has undergone fundamental change in the last decade. Foremost of these changes have been numerous deregulation attempts. Producers and large consumers have built business models based upon large volume transactions, which lead to smooth production and volume discounting. The risks associated with using these traditional business models in deregulated markets are many. This paper describes the development of a computer simulation environment that models a novel collaborative strategy proposed by a local electricity utility to mitigate highly varying load situations demanded by the largest steel-producing region in the United States. Through the use of this model, collaborative strategies for effective electricity generation and usage are developed and analyzed.

1 INTRODUCTION

Throughout the last decade, many attempts have been made to restructure the electricity generation environment. So far, no single type of restructuring has proven to be best for all parties. The main objective from a national point of view is to have a secure, reliable power network. In free market environments, the objective is to foster a sufficient level of competition that provides for producer efficiencies and user economies.

During the last decade, electricity demand has steadily increased while the construction of new electricity generation capacity has remained steady. This mismatch of demand and supply has put electricity producers and large industrial electricity users in risky operations and financial environments. Historically there has always been enough electricity. Numerous events over the last five years, including rolling blackouts and the bankruptcy of the largest energy company in the United States lend to a future, uncertain environment.

The electric utility industry serves two distinct types of customers; household consumers and industry. Household use of electricity is generally stable and small. Industrial users consume large amounts of energy in a highly varying fashion. It is not uncommon for the peak electricity demand of a large industrial user to represent twenty percent or more of the serving utilities generation capacity. The generation of electricity is a capital-intensive process and more importantly one in which carrying an "inventory" is not possible. Thus, serving a highly varying load is difficult at best. With the demand for electricity approaching generation capacity, the ability for a utility to serve highly varying industrial loads at peak demand periods is uncertain. Thus, the development and implementation of rationing and collaborative efforts between producers and consumers is a critical area to be investigated.

Traditional analysis methodologies of regulated electric economies involved cost minimizations of operational costs and capital investments as in Boucher and Smeers (2002). With the advent of deregulated electric markets, the development of single optimization models becomes a much more difficult process. Agent-based models have been developed that represent the behavior of multiple producers, consumers, and service providers. These types of models search for equilibrium conditions, where production and consumption achieve a balance.

In previous work, Brady (2001) reports on the development of a computer simulation model to analyze the effects of collaborative electricity rationing policies between a utility and a single piece of equipment in a steel mill. The main feature of the simulation model was the control of rolling mill operational logic according to the projected near term availability of electricity. The near term availability of electricity is represented in a concept similar to a traffic light. The traffic light feature signals the near term availability of electricity and is used as a signal to control the flow of material through the rolling mill. Operational decisions on whether to introduce slabs into the rolling mill process are made based upon the projected electricity availability position. This decision-making occurs continuously. The objective of the simulation model was to examine operating strategies that evaluate electricity usage requirements of the rolling mill and the allocation of electricity from the utility. The electricity supply state of the utility is represented by a status indicator of the supply position for the next ten minutes. The indicator represented three states. State one represents the maximum supply situation and puts no restriction on electricity usage. State two represents a cautionary supply situation where usage should be minimized if possible. State three represents a negative supply situation, one in which usage should be avoided.

In this paper, we extend the stoplight concept to investigate the potential of a collaborative electricity use policy between an electric utility, the United States energy market, and a region of steel mills. Steel mills represent one of the largest energy using industries and exhibit the most difficult demand form. When peak electricity demands on a utility exceed generation capability, it may not be able to supply the instantaneous power requirements of industrial customers. Thus, some type of collaborative arrangement must be developed to mitigate this undesirable situation. Potential solutions include collaboration strategies and purchase of power from external suppliers.

The extension of this paper from a single mill to a regional, multi-company area focuses on the concept of the traffic light, i.e. the signal of conditions for electricity usage. In developing the single mill concept, it was always assumed that there will be many other concurrent 'users' of electricity, all who might or might not be seeing the same conditions. These 'users' have one thing in common; they are all competitors in the same industry. As human nature and the desire to make a dollar takes over, some of the system users will gain reputations for never exercising caution and yielding electricity demand during peak and close to peak time periods. Conceptually, comments such as "so when we need the power, Company X might be in a down turn and we can take all we want and vice versa" seem reasonable. In practice, there will always be situations in which one user might be forced to sacrifice perfect condition capacity at the expense of a competitor who is either more adept at using the system to their advantage or simply ignores it. What needs to be considered is some type of 'scorecard' that can effectively keep track of who has been cooperating with the system and who has been abusing the system.

This type of dynamic scorecard system is ideally modeled with simulation and is described by the terms adaptation and complexity. In essence, it is a real-time, adaptive behavioral system. Essential elements include rules, conditions, credit assignment, and adaptation. If modeled correctly, a robust, efficient set of rules can be developed that will define AND govern any type of collaborative sharing system that is made up of competitors. The scope of the model is an entire region of steel mills. The focus of the model is a macro perspective of the stop light concept on the decision making process of the individual steel mills and its impact on the reliability of the electric grid and the profits of the participating companies. The decision-making process is modeled as a set of rules that interact within the simulation model.

2 THE SIMULATION MODEL

The steel industry is an extremely competitive, capital-intensive business, characterized by high utility costs and intense foreign competition. The industry consists of two distinct types of companies. Integrated companies make steel from raw materials and produce coils and plates while mini-mill companies melt scrap steel and produce coils, bars, and structural shapes. Integrated steelmakers have large facilities and consume large amounts of energy. The state of Indiana is the largest steel producing state in the United States, with four integrated mills and one mini-mill existing within a thirty-mile stretch in the northern part of the state. This area is served by a local utility whose generation requirements are significantly influenced by the highly varying loads of these large industrial customers.

The simulation model was constructed to model the behavior of this large steel region with respect to the stop light concept and includes three integrated steel mills, one mini-mill, the local utility, and the external electricity market. Figure 1 shows a representation of the model.

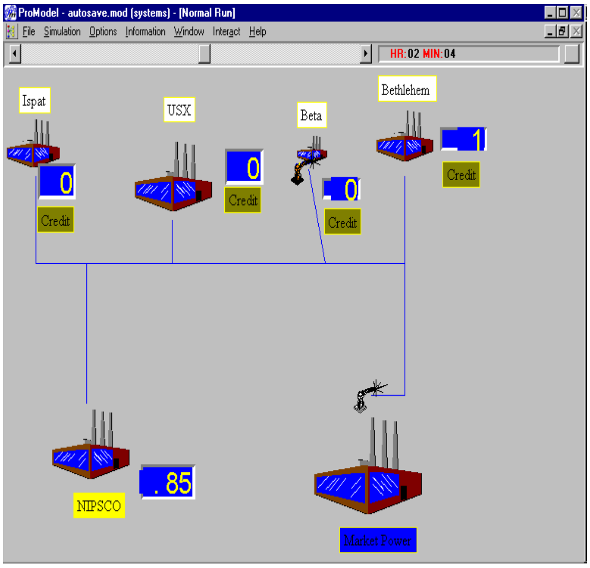

Figure 1: Simulation Model Environment

There are four distinct elements in the model. These elements include generators, consumers, the system operator, and transmission operators. Generators are the companies that produce electric power. Consumers consist of the steel mills. The system operator is responsible for governing the behavior of the model. It consists of a set of rules that enforce governmental regulations that exist in the electrical network. The transmission operators are responsible for the transmission lines that connect consumers and generators. These operators have fixed capacities. Each steel mill in the model is described by three parameters. These parameters include a yearly production volume, a cooperation value, and an external purchase value. The yearly production volume defines the pace and volume of production and the electricity requirements of the mill. The cooperation value defines the level at which the mill follows the signals from the utility. This value can be set at three levels; full, partial, and random cooperation. Full cooperation involves using the local utility power exclusively while adhering to the stoplight at all times. Partial cooperation involves using the local utility power exclusively, but adhering to the stoplight a given percent of the time. Random cooperation allows the mill to use either power source and, when using the local utility, follow the stoplight randomly.

During the simulation, each steel mill possesses a credit value. This value is earned or lost by following the stoplight. Adherence to the stoplight signal builds credit, while ignoring the stoplight decrements credit. When mills possess credit, they are allowed to deviate from following the stoplight without penalty. Thus, mill operating strategies can involve building credit during low production periods, or by not using power during utility shortage periods, etc.

The local utility generates power and sends out stoplight values to each mill. The market power element also offers power at various credit levels. The main performance measure for the local utility is standard deviation of generated load. While the utility attempts to service all load, it attempts to smooth the component load requirements by sending appropriate stoplight signals to the mills.

3 CONCLUSIONS

The combination of steel mill production strategies, the credit concept, and the stoplight concept present an environment to develop and test collaborative policies seeking to obtain equilibrium conditions in a given electric consuming region. This simulation modeling environment addresses risky production and economic situations faced by electric generators and large industrial customers through the use of adaptive behavior. Policies that encourage and reward collaborative efforts between electricity users and producers can be developed to effectively and efficiently balance electricity generation and consumption. Because of the highly variable nature of steel production and resulting electricity demand, computer simulation is an ideal analysis tool. Using this model, electric utilities and high use industrial customers can tailor collaborative usage policies that maximize the use of productive resources within a select region.

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