

To maximize profit, keep one eye on the market, the other on your plant

By Jason Kram and Doug Logan, PCI

A strategy aimed at maximizing profits through market-driven plant operations demands that generation asset owners simultaneously balance plant optimization against market opportunities. Though this may sound logical and relatively straightforward, the volatile nature of energy markets and the often inflexible design of some generation assets can create competing interests within generating companies (Gencos) that impact decision-making.

Traditionally, Gencos operated under cost-minimization and reliability objectives. Fulfilling native load obligations and minimizing production costs were the primary measures of their operating strategies. Flexible generators were used to accommodate changing demand, replace generators that were forced out of service, and serve peak-load obligations.

Today, Gencos must retool to operate under a profit-maximization strategy. The convergence of asset operations with energy marketing and trading has created financial opportunities for Gencos that are subject to market fluctuations. While fulfilling load obligations and minimizing production costs are still part of profit-maximization, profits from buying and selling excess generation must now be added to the equation.

When economically viable, Gencos must be prepared to fulfill obligations from the energy market and to shut down plants, remarket existing fuel contracts, and curtail plants, or bring plants online to back up energy sales. Thus flexible generators can be measured in value by their ability to capture on-peak price spikes, replace firm power obligations, and shut down under unprofitable circumstances.

The purpose of the analysis that follows is to show how market prices drive certain operational profiles in order to best capitalize on the opportu-

nities that exist. Its focus is on combined-cycle generation and how price-based commitment and dispatch, along with unit constraints, impact operational characteristics.

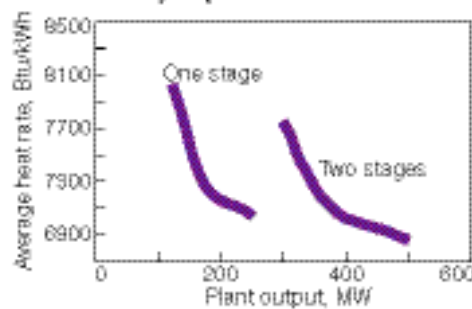
To understand some of the dynamics that occur, we will examine forward power prices, forward natural gas prices, and variable operating costs for a natural-gas-fired combined-cycle unit consisting of two gas turbine/generators (GT), two heat-recovery steam generators (HRSG), and one steam turbine/generator (ST). The plant cannot operate in the simple-cycle mode but may run in a one-on-one configuration with one GT (and its associated HRSG, together referred to as a “stage”) and the ST producing power.

As shown in Fig 1, the combined cycle’s average heat rate ranges from slightly over 8000 Btu/kWh at the lower operating limit to slightly below 7000 Btu/kWh at the higher operating limit. For this analysis, the unit was assumed to have eight-hour uptime and downtime constraints, a \$3/MWh variable operating charge, and a \$5000 startup cost hurdle for each stage of the plant. The uptime constraint means that once the plant starts operating it must continue to do so for at least eight hours. Likewise, it must remain offline a minimum of eight hours after each shutdown.

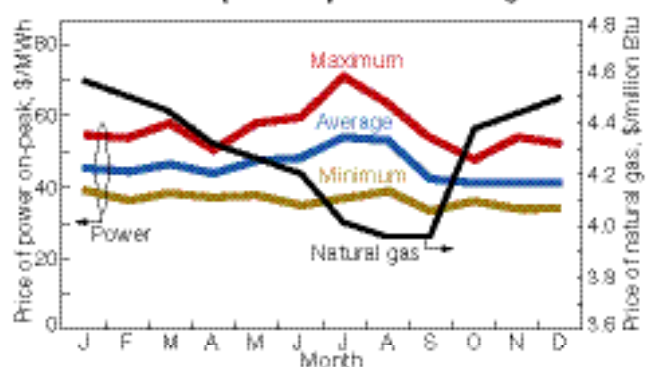
The energy price forecasts presented in Fig 2 are modeled after actual hourly power prices and monthly natural gas prices. In this example, on-peak power prices vary hourly and range from \$35 to \$70/MWh in the summer (June-September) and from \$35 to \$60/MWh in all other months. Average off-peak prices vary hourly and average around \$30/MWh for the year.

Under the assumed market conditions and unit constraints described above, we optimally commit and dispatch the unit to maximize profits. The optimization would be similar to one that an energy manager or trader would ask of a plant under the assumed market conditions. The resultant operating profile does not violate

1. Combined-cycle performance characteristics



2. Prices of power on-peak and natural gas



any of the previously mentioned unit constraints.

The number of monthly online hours and number of starts are shown in Fig 3. On an annual basis, GenCos can assess whether the forecasted number of startups and online hours are consistent with expected maintenance intervals and planned maintenance costs. For this example, the market projections yield roughly 7300 online hours and 75 startups for the year. By altering the market price forecast up and down by 20% the operational statistics can change greatly. Specifically, forecasted annual online hours can vary from 3000 to 8300 hours (Fig 4), startups from 40 to 110 (Fig 5).

Annual unit startups are of particular concern to asset owners because as that number increases, the expected life remaining in critical GT, HRSG, and ST components decreases. How rapidly components age depends in large measure on how conservatively the startup process is managed and on whether the starts are hot, warm, or cold.

Plant managers typically are assigned the responsibility for calculating the cost of a startup, a number that is influenced significantly by the actual number of starts the unit is expected to experience in a given time period—for example, one year. Obviously, the lower the startup cost the more often traders will be inclined to start the unit, taking advantage of market opportunities that may be of relatively short duration. The higher the cost, the less likely it will be started.

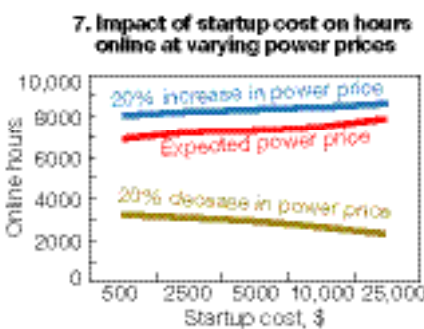
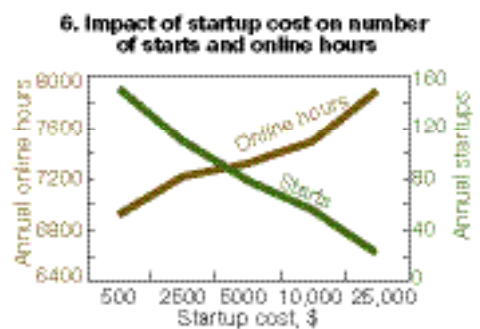
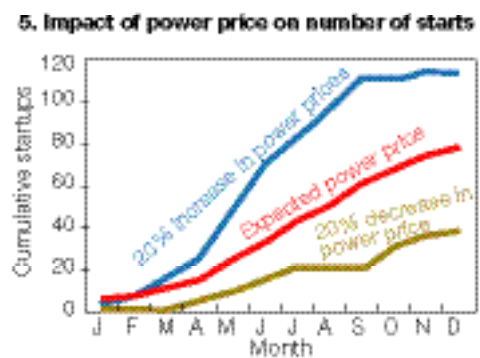
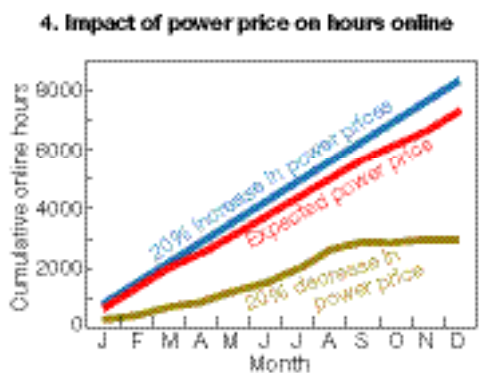
It is important to not to overlook the significance of the startup-cost calculation. It must include the obvious fuel and manpower costs prior to synchronization, as well as a realistic estimate for maintenance, repair,

GENERATION ECONOMICS

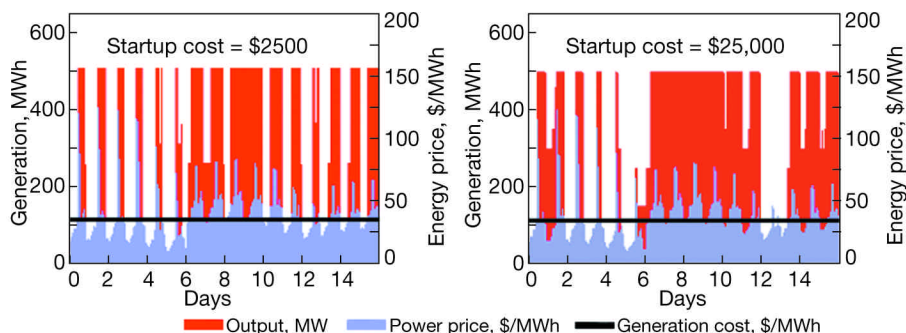
and replacement of key components. The not-so-obvious component of the calculation resides in the OEM-recommended maintenance costs (combustor inspections, hot-gas-path inspections, and so-called major inspections).

Before finalizing the number given to power marketers, the costs associated with these maintenance inspections should be built into the startup cost hurdle. The challenge in this calculation is that the startup cost depends on the number of starts *and* the number of starts depends on the startup cost. Furthermore, the startup cost will vary over time and should be recalculated periodically.

Fig 6 illustrates the effect that startup cost has on both online hours and unit starts. You can see that by increasing the startup cost hurdle, the number of unit startups decreases and the number of online hours increases. Important: This correlation depends on the market price forecast. As shown in Fig 7, an increase in the startup cost hurdle can reduce unit online hours. In some cases, when the startup cost is particularly high the unit will not run at all because it cannot clear the financial hurdle imposed on it.



8. Hourly unit commitment and economic dispatch



GENERATION ECONOMICS

To get a more granular view—down to the hourly level—of how the startup cost hurdle can drive the operational profile of a combined-cycle asset, examine the two-week commitment profile in Fig 8. The most flexible unit—defined as the one with the lowest startup cost—cycles frequently to capitalize on power price spikes. Note that the generation cost line depicts the so-called “at the money” position of the generation asset. That is, if the energy price is below the generation cost, the generation asset is “out the money” and if the energy price is above the generation cost, the generation asset is “in the money.”

The generating asset with the lowest startup cost is capable of turning on when in the money and off when out the money, with little constraint. The unit with the highest startup cost must have adequate financial justification in the market to overcome its high startup cost and must incur additional market losses since it has less flexibility. There are several times when the unit stays online even though it is out the money because of unit constraints that consist of minimum up and down times, startup profiles, ramp rates, etc.

As combined-cycle units gain operating experience, the true cost of cycling will become more apparent and drive more critical evaluation of the operating profile that market-based operations dictate. Several units that have recently gone into service were designed to run 7000 hr/yr or more.



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PCI is a leading provider of generation supply management and optimization software—including solutions critical for operations and for asset, financial, and risk management. Nearly half of all the power generation in the US is optimized with the 11-year-old company's software. The analysis presented in this article was conducted using PCI's GenTraderR.

But rising gas prices have relegated many to cyclic operation and their online hours are far fewer than planned.

The next logical step in this analysis is to combine the forecasted operational statistics with profitability for each scenario. These profitability outcomes can be measured against costs for incurring multiple startups. By balancing these outcomes both an optimal operating strategy and profit-maximizing strategy can be established. Another valuable exercise is establishing the relative certainty of projected operational statistics based on market price uncertainty. These exercises and others will be examined in future articles. CCJ

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