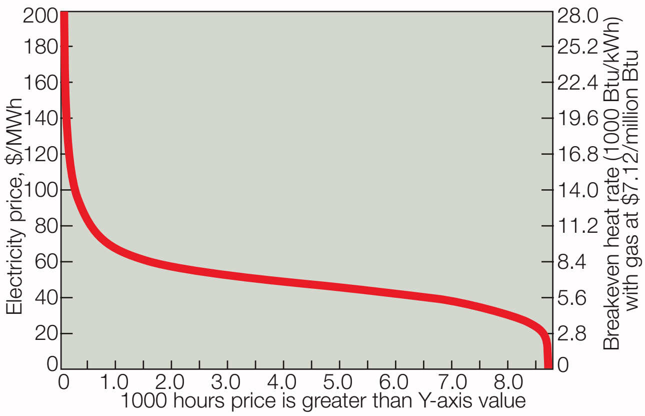
Time to reconsider the gasification option

By **Jeff Phillips,** Fern Engineering Inc

It's difficult to turn a profit with a combined-cycle (CC) plant today in many areas of the country given the high cost of natural gas and the pressures of the deregulated marketplace. Just how difficult it can be illustrated by way of example using design and operating data for two CCs, powered by state-of-the-art 501G-class gas turbines, built by Exelon Generation Co LLC, Kennett Square, Pa, in the Boston area.

You may recall that Exelon concluded last summer that these plants, located at Mystic Generating Station and at the Fore River Station, would never be able to earn enough to pay off the loans used to build the facilities. The company decided to cut its losses and simply turned the keys to the plants over to the banks. When a well-run company concludes that two of the most-efficient gas-fired powerplants in New England aren't worth owning, what does that say about less-efficient CCs?

The reason for Exelon's decision can be seen in the chart, which presents the so-called "price duration curve" for the Boston area's real-time wholesale electricity market from March 2003 through February 2004. The value of a price duration curve is that it shows how long prices for electricity exceeded various levels.



Price duration curve for ISO New England's Northeast Massachusetts market from Mar 1, 2003 through Feb 29, 2004 illustrates how difficult it is to achieve financial success when burning natural gas at the average spot price of $7.12/million Btu

The figure also graphs the heat rate that would be required to break even at the various price levels when the cost of fuel is $7.12/million Btu, which was the average spot price for natural gas in Massachusetts on a lower-heating-value (LHV) basis during the 12-month period studied. For example, at an electricity price of $40/MWh one would need a heat rate of 5600 Btu/kWh just to cover the cost of fuel.

The Mystic and Fore River CCs have heat rates of approximately 5850 Btu. This means that their variable operating costs based only on fuel are $41.65/MWh. Powerplants, of course, must cover more than just their fuel costs. Factoring typical non-fuel variable operating costs of around $3.50/MWh into the equation, the Mystic facilities need to receive at least $45.15/MWh just to break even.

Information presented in the chart shows that the ISO New England (New England Independent System Operator Inc. Holyoke, Mass) wholesale price exceeded $45.15 for only 4907 hours during the 12-month period beginning Mar 1, 2003. If the Exelon units operated at full load all that time, their capacity factors would have been 56% and gross profits (revenue minus variable operating costs) $75/kW installed. The original pro forma for those units certainly was based on much higher capacity factors and profits. The calculated $75/kW gross profit is not sufficient to pay off a loan for a plant that cost $800/kW to build, especially after factoring in payroll, property taxes, insurance premiums, and other fixed costs.

The woes of gas-fired CCs are not limited to Massachusetts. Calpine Corp, San Jose, Calif, noted in its fourth-quarter (2003) earnings report that the capacity factor of the company's base-load plants nationwide was 48.9%. Numbers less than 20% were reported in some sections of the country.

What to do? You simply cannot make money today operating heavily mortgaged natural-gas-fired CCs in deregulated New England—and in some other areas as well. Alternative solid fuels demand reconsideration as an alternative to mothballing or operating assets only during peak periods.

Referring to the figure once again, conduct a financial analysis of the Exelon facilities assuming that you can reduce the cost of fuel to $1/million Btu. The new breakeven variable costs would be $9.35/MWh (including fuel and non-fuel charges). The ISO New England real-time price exceeded that level for 8703 hours for the year analyzed, or a gross-profit potential of $359/kW installed—assuming 100% availability. Certainly no problem covering debt payments with that cash flow. The challenge, however, is finding fuel at $1/million Btu. One solution is buying petroleum coke and gasifying it. Note that pet coke currently is being delivered to a powerplant in Jacksonville, Fla, at prices as low as $0.40/million Btu.

By the numbers. A typical gasification process retains approximately 80% of the solid fuel's chemical energy in the synthetic gas (syngas) produced by the process. About three-quarters of the remainder is converted to sensible heat in the gasifier and recovered as high-pressure steam, which can be used to generate additional power in a steam turbine. Recovering this heat is important because gasification plants require significant auxiliary power to operate. An oxygen plant is the largest load. For this example, assume that the power provided by the extra steam matches the plant's auxiliary load.

A 400-MW CC powered by a 501G GT would need 2340 million Btu/hr of syngas (LHV basis); this converts to 3071 million Btu/hr of pet coke. For fuel at $0.40 million Btu, the variable operating cost (fuel only) would be $3.07/MWh, just $6.14 if the cost of pet coke doubled.

The non-fuel operating costs of an integrated gasification/combined cycle (GCC) powerplant are greater than those for a gas-fired combined cycle because it has more equipment and power production remains the same. Studies conducted by the Electric Power Research Institute (EPRI), Palo Alto, Calif, suggest that $7/MWh is a reasonable estimate of a GCC's non-fuel variable operating costs. For pet coke at $0.40/million Btu, the total variable operating cost for a 501G GCC would be $10.07/MWh. Information in the table and figure show that even a GE 7EA with solid-fuel costs similar to high-sulfur coal would be dispatched more than 8000 hr/yr.

Variable operating costs of alternative gasification/combined-cycle plants

Gas turbine model	LHV heat rate, Btu/kWh	Variable operating costs, $/MWh — Cost of solid fuel delivered, $/million Btu: 0.40	0.80	1.20	1.60	2.00
MHI 501G	5850	10.07	13.14	16.21	19.29	22.36
SW 501F	5990	10.14	13.29	16.43	19.58	22.72
Alstom GT24	6050	10.18	13.35	16.53	19.71	22.88
GE 7EA	6800	10.57	14.14	17.71	21.28	24.85

MHI, Mitsubishi Power Systems, Lake Mary, Fla; SW, Siemens Westinghouse Power Corp, Orlando, Fla; Alstom, Alstom Power Inc, Midlothian, Va; GE, GE Energy, Atlanta, Ga

The cost of a gasifier depends to a large degree on the capacity of the gasification system and its location. Economics favor large gasification plants. However, systems processing more than 2000 tons/day of solid fuel—about enough for a 250-MW CC—require multiple gasifiers operating in parallel. For GCCs smaller than 250 MW the cost of adding a gasifier would increase on a dollars-per-kilowatt basis.

Petrochemical plants are an ideal location for a gasification plant because air separation plants and sulfur-recovery units already exist, reducing equipment costs. Also, many of these facilities would permit fuel delivery by rail or barge.

Expect the price tag for adding a gasification system to an existing CC to range between about $600 and $1000 per kilowatt of output. For the Mystic CCs, which have a total capacity of 1600 MW, economies of scale and ready access to sea-going vessels should hold the capital cost near the lower end of the range, but a slightly conservative cost of $800/kW is assumed.

With a marginal operating cost of $10.07/MWh, the Mystic GCC would have generated $352/kW-yr in gross profits for the 12-month period reflected in the figure—assuming 100% availability. At a more realistic availability of 85%, annual gross profits would be $299/kW-yr, or an increase of $224 over the $75 calculated earlier for the natural-gas case. If the annual fixed costs of a gasification facility—such as property taxes, insurance, and support staff were equal to 5% of the installed cost, that would still leave $184/kW-yr to pay off the $800/kW debt. Payback would be in 4.34 years.

Other considerations. The financials are positive, what about the all-important reliability, emissions, and land-use issues? Reliability has been a mixed bag. Gasification plants are extremely complex and come in a variety of designs. Some first-of-a-kind designs operated by relatively inexperienced personnel have suffered difficulties during the first few years of service.

At the other end of the spectrum, however, one of the pioneers in gasification for power generation, Eastman Chemical, Kingsport, Tenn, has an average 98% up-time over the past 20 years at its coal gasification plant—including a first year availability of 91%, according to the company's Website. One important factor in the company's success is an operations staff with experience in hydrocarbon processing.

Emissions always are of concern when modifications are made to a powerplant. However, it appears that GCCs can meet the same emissions criteria as natural-gas-fired CCs. Achieving low emissions of NO_x and CO is not difficult because the hydrogen in the syngas provides a very stable flame—one that can be diluted with steam or nitrogen to reach low flame temperatures without encountering combustion instabilities.

Achieving low SO_2 levels is more challenging, but doable. EPRI reports that Shell has demonstrated the ability to remove up to 99.9% of the sulfur species in syngas. Such capability should be sufficient to produce a syngas with less than 11 ppm sulfur by weight, which is a typical specification for natural gas used in a CC equipped with an SCR (selective catalytic reduction) for NO_x control.

Land-use issues include access to rail or barge transportation and favorable zoning for structures that can extend up to 250 ft above grade. Many new CCs have been built in locations where a 250-ft structure would be considered an eyesore. Others have been shoehorned into small areas with no room for a gasification plant or are located far from rail and barge routes.

But there are locations where a gasification plant can fit quite well. Mystic is one of these. Demolition of boilers that are no longer in service and installation of a gasifier would have a positive impact on that neighborhood as well as on the CC's bottom line. CCJ