One of the most interesting structures in power generation is the tolling agreement. Simply defined as agreements to put a specified amount of raw material in any given period through a particular processing facility, tolling agreements are common in many industries.

In the electric industry, a power marketer or some other party pays a generator a fee or a “toll” to convert natural gas or some other fuel to electric power. In this article we briefly look at the economics of tolling agreements and point out a few of the risks associated with entering into such agreements. We start by explaining some of the fundamental concepts of tolling agreements, specifically heat rates and spark spreads and the difference between a forward toll and a reverse toll. We look at the specific terms of a tolling agreement and calculate a breakeven fuel cost for a given power-purchase price. We consider the possibility of both intrinsic and extrinsic value and demonstrate how traded financial instruments can be structured to manage risk and generate revenue opportunities for the owner of the tolling option.¹

Heat rates can be either expressed as Btu’s a kilowatt-hour or million Btu’s a megawatt-hour. Power-plant operators prefer to use the former; traded commodity markets, the latter. A generator’s incremental operating heat rate changes as the plant ages and depends on weather conditions, the percent of capacity at which the generator is operated, and other variables. For example, a generator is most efficient when running near full capacity and is less efficient when operated at minimum capacity. A plant operator will use this relationship to determine how much fuel to purchase to operate the plant. The relationship is also used in hedging, to determine how many forward contracts are needed to offset price risk.

To determine the number of million Btu’s of natural gas, coal, or oil is necessary to operate the plant, the expected output measured in megawatt-
Spark spread = Electricity price ($/MWh) – [Fuel price ($ a million Btu's) * Heat rate]

From a trader’s perspective, if you are long the spark spread, you are long the price of electricity and short the price of gas. If the price of electricity goes up relative to the price of gas, a long spark spread position will benefit the owner financially. Likewise, if the price of gas goes down relative to the price of electricity, a long spark spread position benefits financially.

It is important to note that the spark spread is tied to market prices or, more specifically, the market spread between electricity and gas prices. Spark spread is not tied to the fuel-acquisition cost or the “system lambda” marginal cost of generation. Spark spreads are traded in bilateral markets for both spot and forward time periods and are published for different heat rates in Megawatt Daily, Bloomberg Natural Gas Report, and other market publications.

Spark spreads are often used in daily dispatch decisions to determine if it makes financial sense to run existing generating units. In this case, it would be appropriate to use the generating unit economic heat rate in calculating the spark spread. A positive spark spread would indicate that it is more economical to burn the relevant fuel to generate electricity than to purchase power from the grid. A negative spark spread would indicate that it is more economical to sell the gas in the spot market and purchase the electricity from the grid. In tolling arrangements, the first condition is referred to

hours is multiplied by the appropriate heat rate in units of million Btu’s a megawatt-hour.

Required million Btu’s per month = Expected MWh generated * Heat rate

It is important to distinguish between a generator’s operating heat rate and a contractual or economic heat rate. The operating heat rate is used to calculate fuel quantities, but the economic heat rate is used to price transactions and/or establish contractual obligations. The economic heat rate is typically higher than the operating heat rate because the economic heat rate may include cost other than fuel, such as variable operating and maintenance costs, start and ramp costs, margin, and other costs.

The economic heat rate can be used to determine bid strategy and merit order. For example, if a generator has an economic heat rate of 12 million Btu’s a megawatt-hour and the cost of fuel is $8.00 a million Btu’s, the operator would bid $96.00 a megawatt-hour for the minimum price necessary to dispatch the unit.

\[
\frac{8.00}{\text{MMBtu}} \times \frac{12\text{MMBtu}}{\text{MHH}} = \frac{96.00}{\text{MWh}}
\]

In this example, the difference between the operating heat rate and the economic heat rate is the amount of the additional heat rate needed to recover the plant’s variable costs other than the cost of fuel. The additional or “grossed up” heat rate depends on the price of fuel. The incremental heat rate will drop as the price of fuel rises.

**SPARK SPREADS**

The spark spread is the price difference in equivalent units between the market price of electricity and the market price of fuel at the same or nearby locations and for the same delivery period.
as forward tolling. The second condition is referred to as a reverse toll.

Often the operators of tolling agreements will express spark spreads in terms of a prevailing market implied heat rate (MIHR). The MIHR can then be easily compared to the economic heat rate. If the economic heat rate of an electric generator is lower than the prevailing MIHR, a positive heat rate exists and it is economic to forward toll the power plant.

THE ECONOMICS OF TOLLING AGREEMENTS

A generator tolling agreement involves a marketer or some other party paying the owner of a generator a fee or a “toll” to rent the facility. The marketer is responsible for the fuel deliveries and the power sales and generally takes the full price risk for these activities. The generator is responsible to provide power at an agreed-upon heat rate, or, you could say, to provide a specified amount of electric power for a specified amount of fuel.

The tolling fee typically has two parts: (1) a fixed monthly capacity payment and (2) a variable tolling charge for each megawatt-hour of electricity produced by the generator. This type of long-term power-purchase agreement can be attractive to power-plant owners for several reasons. The fixed payments can be tied to the capital loan payments eliminating default risk. The power-plant owner is free of fuel-delivery cost and price risk.

The agreement is attractive to marketers because of the upside profit potential. However, downside risk is a real concern for the marketer. The owner of the toll will decide to either operate the plant or idle the plant depending on the spark spread. If the economic spark spread is positive, the marketer will run, or forward toll, the plant. If the economic spark spread is negative, the marketer will idle the plant, or reverse toll, and sell the gas and purchase power through the spot market. A forward toll is shown in Exhibit 2. A reverse toll is shown in Exhibit 3.

How would you decide whether or not it makes economic sense to enter into such an agreement? The positive and negative revenue potential of the tolling agreement must be fully understood, including the opportunities for hedging risk and locking in value. Using the following example term sheet proposal, we consider how a marketer may determine the value and risks of a tolling agreement over the term of the contract.

For this example, in order for the agreement to provide positive intrinsic revenue to the holder of the tolling agreement, the cost of natural gas must be less than $3.04 a million Btu’s. However, as we pointed
**Example Tolling Agreement Term Sheet Proposal**

**Term:** May 1, 2011, through September 30, 2011.
**Capacity:** 300 megawatts.
**Capacity Payment:** Buyer pays seller monthly capacity payments of $9.20/kW-month ($2.76 million/month).
**Dispatch:** Buyer shall have full dispatch rights limited only by the operational constraints of the unit. Maximum available capacity shall be achievable in one hour, assuming that the plant has not been shut down for more than 72 hours.

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<th>Minimum Available Capacity</th>
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<td>100 MW</td>
<td>300 MW</td>
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**Heat Rate:** The referenced heat rate on natural gas shall be 6,400 Btu/kWh. The seller guarantees the referenced heat rate for plant dispatch conditions between minimum and maximum plant output.

**Fuel:** Natural gas supply and transportation shall be managed by buyer.

**Tolling Charge:** $3.75 a megawatt-hour.

**Start/Shutdown Costs:** Buyer agrees to pay seller $2,500/start and $750/shutdown. Unless mutually agreed to by the parties, annual starts shall not exceed 400.

**Penalties:** Any penalties resulting from a difference in hourly scheduled and delivered megawatt-hours shall be paid from seller to buyer on a monthly basis.

**Excess Energy:** The buyer will use commercially available efforts to purchase amounts of energy generated in excess of the guaranteed capacity. The buyer will pay the tolling charge for excess energy in receives but will not be required to pay a capacity payment.

**Operations:** The seller will be responsible for performing operations and maintenance in accordance with generally accepted utility practice.

The tolling agreement specifies the terms and conditions necessary to economically evaluate the opportunity. However, the marketer additionally needs to know the prevailing price of natural gas and electricity, the operating strategy, hedging opportunities and other considerations to fully value the agreement. Both intrinsic and extrinsic value exists in a tolling agreement. In order to fully manage the risk, the marketer needs to hedge the natural gas supply and forward sell the electric power.

For this example, let us assume that we have an off-take counterparty who is willing to purchase the daily peak power for $50 a megawatt-hour and a natural gas supplier who is willing to enter into a long-term gas supply contract. What would the natural gas price need to be in order to break even given the terms of this tolling agreement?

To make the problem more interesting, let us assume that the spark spread is such that we expect to operate only on peak weekday hours for the five months May through September. There are 110 peak days in the term of this contract, or an average of 22 peak days per month.

**Start and Shutdown Costs**
- There are 22 starts: 22 * $2,500 = $55,000/month
- The unit is shut down 22 times: 22 * $750 = $16,500/month

**Capacity Payment**
- The monthly capacity payment is $2.76 million (300 MW * $9.20/kW-month)

**Tolling Charge**
- $3.75 a megawatt-hour
- 22 peak days per month * 16 peak hours = 352 peak hours per month
- Average PPA revenue potential = $3.75/MWh * 352 h * 300 MW = $396,000/month

**Revenue Potential From the Power-Purchase Agreement**
- $50 a megawatt-hour for peak weekday hours
- 22 peak days per month * 16 peak hours = 352 peak hours per month
- Average PPA revenue potential = $50/MWh * 352 h * 300 MW = $5,280,000/month

**Maximum Natural Gas Quantity**
- 6,400 Btu/kWh heat rate = 6.4 MMBtu a megawatt-hour
- Total monthly natural gas = 6.4 MMBtu a megawatt-hour * 352 h * 300 MW = 675,840 MMBtu’s

**The Breakeven Price of Natural Gas**

The expected net revenue from this tolling agreement including the $50 a megawatt-hour revenue potential from the off-take power-purchase agreement is:

- PPA Revenue – Capacity Pmt – Tolling Pmt – Start Cost – Shutdown Cost = Net Revenue
- $5,280,000 – $2,760,000 – $396,000 – $55,000 – $16,500 = $2,052,500

The marginal operating costs are included in the economic heat rate; thus, for the spark spread to remain positive, the total monthly payment for natural gas (including delivery) cannot exceed the power revenue.
- Total natural gas payment = $2,052,500
- The breakeven cost of gas = $2,052,500/675,840 MMBtu = $3.04 a million Btu’s
out earlier, the owner of the tolling agreement will have both intrinsic and extrinsic value. The intrinsic value, calculated using the economic spark spread, is tied to the forward tolling option of operating the generator, having locked in the power-purchase price and fuel cost with long-term contracts.

But additional revenue opportunities will exist from the reverse tolling option. The reverse toll represents the opportunity to unwind the gas and electricity positions when it is economically advantageous to do so—that is, when the spark spread narrows. In this example, the marketer is long a put on the spark spread with an economic strike price of zero. If the market price of electricity goes down relative to the price of gas, or if the price of gas goes up relative to the price of electricity, the option benefits the marketer financially. The revenue is extrinsic because it depends on uncertain future prices. However, the value can be hedged (and valued) using financial instruments.

**MONETIZING VALUE AND HEDGING RISK**

The owner of a tolling agreement can generate revenue in a number of ways. In the example shown here, we examined one possible structure where the marketer sells long-term forward power and buys long-term forward natural gas to hedge the intrinsic value of the forward tolling option. Having sold the electricity and purchased the gas, the marketer has entered into a short spark spread position.

However, by controlling the generator the marketer is naturally long a spark spread call option. On days when the spread is zero or higher, the marketer will run the generator, effectively exercising the option to buy the spark spread at zero. Using put-call parity, a short position together with a long call option is equivalent to a synthetic long put on the spark spread. Because put options are fungible and traded, we now have a method to fully determine the value of the tolling contract. In this example, traded financial instruments can be used to either hedge or price the intrinsic and extrinsic value component of the tolling agreement.

**NOTE**

1. For further information about the topics discussed in this article, refer to the PGS Energy Training seminar "Introduction to Heat Rates, Spark Spreads, Generation Optionality, Tolling & Heat Rate Linked Power Transactions."