Geothermal Power Brokering Using Escalator Pricing

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ABSTRACT

The paper tells how to *make a market* for geothermal power generation sales brokered into geographically disperse wholesale electricity markets.

An escalator price design provides incentives for buyer and seller. The mathematics of price determination minimizes Contract-For-Differences' and Final settlement payments. Application of a least absolute error selection criterion and a clustering algorithm to the difference between month-by-month forecast prices from Platts and magnet prices, described in the paper, forms the basis for escalator price determination. The escalator price moves up over the contract term. An initially discounted price attracts buyers to the renewable resource perceived to be not as dependable as conventional capacity. The price escalates, relative to the prevailing wholesale market price, to include a premium that allows the seller to break even or earn margin over the contract term. Success of the market-making exercise depends on sponsorship of green tags and award or distribution among market participants that varies over contract term.

The paper concludes that though market power and politics impede success for geothermal power brokering, nature, escalator prices, and green tags can make geothermal profitable and viable as a dedicated 7x24 base load resource.

Introduction

This paper uses an escalator price design, green tags, and mathematics for minimizing settlement payments to show how to make a market for geothermal power sales brokered into geographical-ly disperse wholesale electricity markets. First and foremost, power brokering with an escalator price and green tags from an interested donor are tools for arbitrage. In this market, you are likely to have a vendor or geothermal site developer with a steam-generating plant that lasts 20 years or so, requiring an investment of ~$2600/kW in overnight cost,[1] needing a payback of 10 years or less to break even in the out years. W. Michael Warwick developed an escalator price concept that this paper puts to use.[2] The escalator price compensates the seller with margin in the out years to help resolve the payback dilemma. Additionally, tinkering with the assignment and timing of green tags shortens the wait. Payback in net present value on a 15-year bilateral contract is from about 4 to 4½ years for a discount rate between 5½ and 7½ percent.

Electricity retailers participate in a deregulated, merger and acquisition market, about which surveys by CEC consultants say paybacks are one to three years maximum.[3] The escalator price gives retailers a discount over other generation sources in the early years and a green tag award in the out years when they will have to pay the margin on the geothermal power contract.

Section II describes the price design. Section III distinguishes power brokering from power marketing. Section IV describes green tag assignment and timing. Section V presents a power brokering example. Section VI uses a nomograph to tell the story of base load competition between new geothermal and combined cycle gas turbine. Section VII suggests why this market hasn't been made already. Section VIII concludes with responses to the problems raised by Section VII.

Escalator Price Design

Suppose for the moment that you think an escalator price is a good idea and consider how best to create one. It might be best if it were an information-based price rather than, say, a Monte Carlo-based price. In what follows, we consider both price derivations and give an example contrasting them. For this moment, however, imagine a particular, spatially specific, hybrid, wholesale electric price source consisting of actual prices experienced during a contract term until four months back, and Platts' Scenario[4] prices from three months back through the end of the contract term. Platts' Power Outlook Research Service uses an integrated energy market modeling methodology to issue 20-years-term, monthly forecasts of wholesale electricity price distinguished by *scenario* or *case* and revised quarterly. The scenario or case names are base, low, high, carbon tax, high hydro, low hydro, and NYMEX strip.[5]

Also imagine yourself as a visitor to the Little Shop of Horrors,[6] where the orphan Seymour has brought a strange plant with a solar eclipse legacy, named it for Audrey, the girl of his dreams, and taken *slips*. While here *and* there, think of the information-based price series as a flesh-flavored lariat that you toss (or Platts tosses) each quarter over a field of ravenous Little Audreys Seymour has planted in rows, each of which represents a month past, this month, or a month to come in the contract term. Each row has 100 plants, 97 of which are evenly spaced, one of which meanders sporadically but within its row, along the bottom land, sometimes overlapping one or more of the evenly spaced plants, and two of which occupy the highest ground, sometimes overlapping each other, sometimes overlapping one or more of the evenly spaced plants. Suppose the contract term is 180 months (15 years). Each forecast month, 180 famished Audreys (of 100 X 180 = 18,000 little carnivores) will chomp on the taste of flesh closest to them, where proximity has been predetermined by the slithering snake of the lariat toss (crossing every row). If you are astute in selecting the slithering Platts' Scenario snake best describing current market conditions, your selection will minimize CFD settlements based on actual costs incurred, absent adjustments for performance failures.

In the retrospect of a three-month lag, the Little Audreys *cluster* to actual prices they hunger for each contract month. At the end of contract life this minimizes the final settlement based on actual costs incurred by resolving the difference between them and the escalator prices formed that include the Little Audreys (as *magnet* prices), as we might expect to be predicted by Chebyshev's inequality applied to economic observations over time.[7]

Formally, let

(1) RMAG(1,t) = Platts' RLOW(t) where "R" denotes 2004 (constant) \$ and t = 1,…,T, for contract terms of T = 60, T = 120, T = 180, and T = 240, in all cases.

(2) {RMAG(2,t)…RMAG(98,t)} = {R(i,1)•g(i,t)} for -81.46% <= g(i,t) <= 81.46% over the contract term as i varies from 2 to 98, with starting values densely spaced between R(2,t) and R(98,t). Figure 1 illustrates high and low boundaries for magnet prices, and Platts' Scenario prices {RLOW, RBASE, RHIGH, RHIGH scaled to attain \$85 in 2004 constant \$ by T = 240}, circa 3rd quarter 2004, that slither as snakes do within them.

(3) RMAG(99,t) = RDIFW(t), a difficult world for wholesale electricity prices, estimated from a two-stage-least-squares structural model of worst-case natural gas and oil prices, which in turn were used to predict wholesale electricity price. To accomplish this, historical series of natural gas, oil, and coal prices as well as gross domestic product were developed from 1949 forward. Since this was done, the predicted values of explanatory variables have already been exceeded owing to China's influence on world oil price and Hurricane Katrina's and Rita's influence on natural gas prices. Nonetheless, the methodology stands intact and can easily be updated.

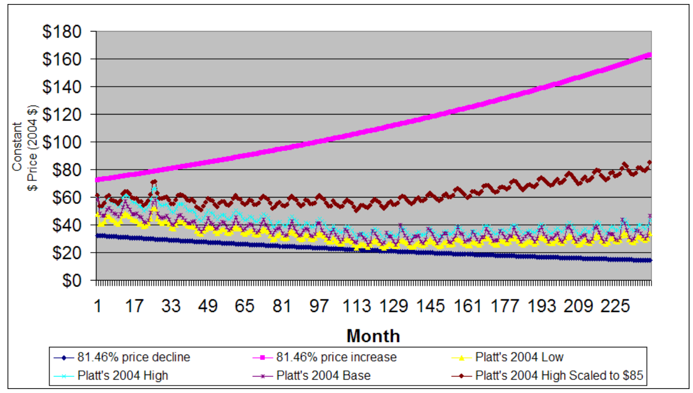

Figure 1. Price Dispersion – Platts Versus Lowest and Highest Growth Rates.

(4) RMAG(100,t) = RSPK(t), a price spike envelope intended to depict the sustained high prices for wholesale electricity entering the California market during 2000 and 2001. The envelope bounds were \$90 and \$270, within which the price spike series was created by a one-time Monte Carlo experiment conducted over a week. The experiment created a series of "clock seeds," which differ by hour on a diurnal cycle. As a result, for example, the price spikes drawn as clustering candidates at 3:44 a.m. differ from those drawn at 7:18 p.m. More precisely, there are 18,055 seeds and hence RSPK(t) magnet price drawings possible for each hour a real time or simulated contract reckoning is done. With the 100 magnet constant \$ price candidates as described, then

(5) Escalator price formation occurs for a Platts' Scenario from the set {RBASE, RHIGH, RLOHYDRO, RNYMEX[8]} for period t and Platts' geographic sub region by selecting the least absolute error RMAG(i,t(i)) – RPlatts(t), for all t = 1 to T, yielding RMAG(i,t(i))•(1 – RINDIS)•(1 + esrate(i))^$^{(t-1)}$. This is the escalator price for period t, for which RINDIS is the initial price discount fraction offered the utility (e.g., 0.1 or 10%), and escalation rates *esrate* satisfy the relationship, for t = 1 to T, Σ(escalator price(t) – RPlatts(t)) – margin) =~ 0. Solution values of esrate are determined using a "Golden Step" convergence algorithm.[9] Margin signifies the return on generation awarded the seller at contracted rates (currently, 0.0 for breaking even, 0.05, 0.07, or 0.10). Our escalator price is fixed or flat each month. This price design conforms to Richard Thaler's work on how consumers and retailers process information about purchase decisions.[10]

The Contract-For-Differences settlement reconciles the contract for the difference between Platts' Scenario price and actual market price times (1 + margin) in nominal dollars, thereby compensating buyer or seller for one month's overcharge on the contract.

The final settlement, on the other hand, compensates the buyer or seller for the difference between escalator prices and actual market prices over the life of the contract, hence disclosing the accuracy of the clustering algorithm.

(6) Alternatively, form escalator prices from Monte Carlo drawings by selecting the least absolute error RMAG(i,t(i)) – RMCS(t), for all t = 1 to T and continuing as above. The drawings are a little peculiar. For each Monte Carlo simulation three integer drawings are made with a particular integer being drawn increasingly less likely with each draw (even though *replacement* occurs). If the third drawing is 2 or 101, then RMSC(t) = RMAG(1,t) or RMAG(100,t), respectively, defined as in (1) or (4) above. If not, then if the second drawing is 3 or 100, then RMSC(t) = RMAG(2,t) or RMAG(99,t), respectively, defined as in (2) or (3) above. If also not, then RMSC(t) = RMAG(i,t), defined as in (2) above and i equals the integer drawn less 1, for integers uniformly probable from 4 to 99. Hence, Monte Carlo simulations select magnet prices (least absolute error of zero) with likelihoods chosen to reflect increasing ignorance about, or lack of confidence in, the future. Currently, 20, 50, 200, or 600 Monte Carlo simulations are possible. The final settlement payment measures the difference between revenues collected using the Monte Carlo escalator prices and the revenues collected using the Monte Carlo magnet price component of the escalator price times (1 + margin), hence depicting solely the accumulated "convergence error" in escalator price determination.

The selection of best Platts' Scenario for each month combines trial runs with the escalator price mathematics transformed into lines of computer code and our judgment of the wholesale electricity market based on current events and 30 years' experience as energy analysts. A simulated real time experiment for the Southern California wholesale electricity market, excluding Los Angeles, and a 15-year bilateral contract for 3916 MWh geothermal power from the Imperial Valley annually, reveal the difference in final settlement payments between a 600-Monte-Carlo-simulations experiment and use of favored Platts' Scenarios.[11] The experiment was conducted up to and including November 2005 for a contract beginning in March 2005. For Platts' RBASE Scenario versus Monte Carlo, the final settlement payment for the Monte Carlo simulations exceeded Platts' by $41,328 (in 2004 constant $). For Platts' RNYMEX Scenario, the final settlement payment for the Monte Carlo simulations exceeded Platts' by $28,473 (in 2004 constant $).

Power Marketing Versus Power Brokering

Escalator pricing accommodates bilateral contracts with different assignment and timing for green tags. However, some green tag distributions or assignments are not appropriate for brokerage simply because no broker is involved in transactions. Contracts like this that we have looked at with our escalator price design are ones that award all green tags to seller or buyer, and ones that award half of the green tags to the buyer and half to the seller. Contracts different from this reserve a fraction of the green tag award for a power marketing agent or a broker. A *marketed* contract must adhere to Federal Energy Regulatory Commission Market-Based Rate Authority rules for power marketing, not power brokering.[12] Power marketing rules include submission of a market-based rate schedule 60 days in advance of wholesale price changes and demonstration by the seller that it lacks monopoly power in this market. By contrast, no federal approval is needed if the *entity* will only broker power or act as an aggregator of power. Section V below shows, by example, how our escalator price and contract design not only brokers but also aggregates wholesale power moving from vendor or producer to electricity retailer.

Green Tag Assignment and Timing

Our escalator pricing methodology presumes power brokers have a free hand to implement a mutually advantageous green tag strategy:

- Issue the lion's share of green tags to the seller at the beginning of the contract, to cover dry hole risk on the next adjacent site.
- Issue the lion's share of green tags to the utility at the end of the contract, when wholesale price has ridden up the escalator (in order to provide margin to the seller).
- Issue some green tags to the broker for the duration of the contract, since he or she makes and manages this market.

Our escalator price computer code offers a fixed menu of buyer/seller/broker split options, managed through a Microsoft C# interface designed to ensure that no foreseeable combination of contract provisions would give infeasible or unreasonable escalator prices and predicted settlement payments. It does not provide a push-button-solution path to a best or optimum combination of green tag assignment and timing: Risk and reward associated with some buyer/seller/broker splits may foster adverse selection of geothermal vendors or site developers – who will default on settlement payments as the contract matures.

What appears to perform best among the five split options currently offered is a 30/60/10 split. This grants all-but-the-broker's green tags to buyer or seller as the contracted green tag timing allows. It must be this way, with the green tag timing as an option. If it were not, you would be rewarding 120 percent of the green tags to buyer or seller, respectively, for each half of the contract term. But you cannot award more green tags than you have.

Among randomly chosen options we have looked at that do not foster adverse selection,[13] the 30/60/10 split provides the site developer, owing to green tag timing and allocation, the highest reward and shortest payback in net present value terms. Someone might want to negotiate for a 25/70/5 split, which would give the seller more and the utility and broker less. Our escalator price and contract design could do this – by expanding the C# menu of options and changing a few lines of computer code. The C# shell allows us to test new contract options and terms when other things may change in unexpected ways.

A Power Brokering Example

Here, we begin by flushing out contract provisions between geothermal generation site or vendor and broker – for the 3916 MWh/year contract mentioned earlier, using the Platts' Scenario methodology that inspired more confidence than a Monte Carlo approach:

- initial discount: 10%
- return on generation (margin): 5%
- contract term: 15 years
- green tag distribution: 30/60/10 to buyer/seller/broker
- green tag timing: seller gets first

The Imperial Valley site is located in one of 13 Platts' western-state sub regions deemed eligible for geothermal power supply by our methodology. Under these provisions, the contract awards the seller 90 percent of the green tags for the first 10 years of contract term. The broker sells the electricity to a Southern California ESP under the following provisions:

- initial discount: 7%
- return on generation (margin): 7%

The contract awards the ESP 90 percent of the green tags for the last five years of contract term. We do the math for one seller and one buyer. The broker makes

- \$3,508 in margin
- \$7,832 in coupon value of green tags (valued at \$20/MWh for CO_2 displaced)
- \$11,340 total/year from less than 450 kW of geothermal capacity generating 7x24.

While this falls \$2,700 short of what the broker could make working 40-hour weeks at California's minimum wage, brokerage and our computer code allow us to manage contracts linking many sellers to a different aggregate of ESPs. Doing so, for example, returns about \$12.7 million/year in revenue from 500 MW of geothermal capacity. Ideally, as brokers, we would contract for existing or new generation adjacent to producing wells, geysers, or hot springs – with transmission/distribution accessibility. This also comports with our belief regarding dry hole risk, that production is a stronger prior foretelling success than is geologic potential.

Further, the broker can hedge risk with a commodity swap in the derivatives market.

Base Load Competition – New Geothermal Versus Combined Cycle Gas Turbine

The trading range where new combined cycle gas turbines compete against new geothermal is about \$2.75 to \$6.00/mcf for natural gas at Henry Hub. Two factors determine the range:

1. O&M cost for geothermal. If you pay about 4½ cents (or 45 mils) per kWh, you can operate geothermal all the time. If you pay only ½ cent (or 5 mils) per kWh, you can operate geothermal at about a 60 percent load factor.[14]
2. CCGT load factor. Boundary conditions are defined by operating combined cycle at its current average load factor (which is less than 50 percent) or at the geothermal load factor under consideration.

Above the range (vectored through the vendor/producer's effective tax rate), geothermal is preferred. Below the range, CCGT is preferred.

A nomograph shows the important details.[15] For a low-heat-rate gas turbine, and overnight and O&M cost data describing the Roosevelt Hot Springs Blundell geothermal plant in Utah, the nomograph discloses preferred regions for geothermal and CCGT and a trading range between the two. For data not altogether hypothetical: a 28 percent effective tax rate for sellers of natural gas through the Henry Hub, Louisiana, custody transfer point, spot gas traded 767 days between Halloween of 2002 and December 30, 2005 – with a median closing price of \$5.98/thousand cubic feet, geothermal is preferred (See Figure 2). The equilibrium price falls above and outside the hammock-shaped trading range. The median is a more conservative estimate than the average since it dampens the effect of price spikes that pull up the average price (which was \$6.59/mcf over the same period). The 767-day line connects the tax rate "price" for doing business in California and the U.S. with a natural gas price that discloses an electricity price of \$37.50/MWh. For the 241 trading days of 2005 by itself, the median price was \$7.46/mcf (electricity price approaching \$45/MWh) and the average \$8.71/mcf – showing the effects of Hurricanes Katrina and Rita, as well as indicating increased preference for geothermal in competition with new CCGT (Figure 2).

The geothermal hammock may be thought of as a hyperplane of trading options between the electricity price axis and the natural gas price line. If your line crosses the geothermal hammock, terms of trade and choice between new geothermal

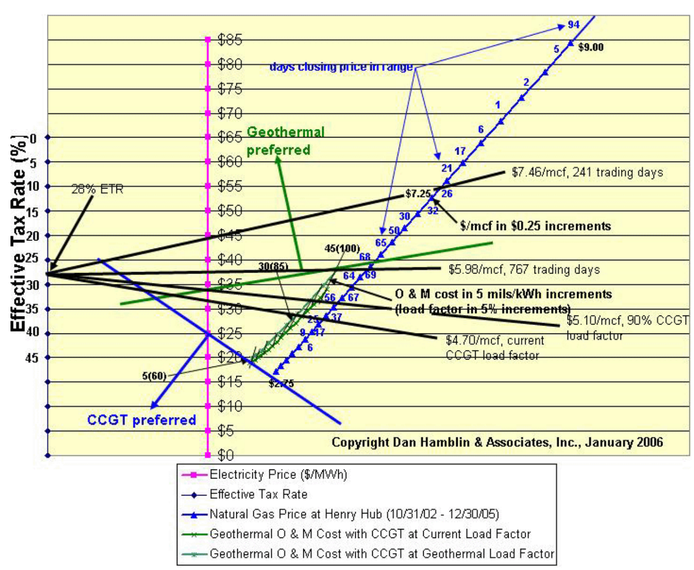

Figure 2. 6750 Btu/kWh Combined Cycle Gas Turbine Versus Geothermal – Competition & Green Hammock Trading Range.

or new CCGT depend on how you plan to operate the two options. In this regard, because of its lower overnight cost, CCGT is more versatile. You would probably want to operate it at various load factors that don't significantly sacrifice performance. If you do this, however, geothermal looks better as the 7x24 (all-hours-energy) generation source. This advantage is confirmed by the shape of the geothermal hammock. Another way of saying and seeing this is shown in Figure 2:

- Pick any given or particular geothermal load factor. Let's pick 90 percent.
- Compete along the leading edge of the hyperplane (where CCGT operates at its current load factor). Assuming the 28 percent effective tax rate, the Henry Hub natural gas price for indifference between geothermal and CCGT is about $4.70/mcf.
- Compete along the trailing edge of the hyperplane (where CCGT operates at the same load factor as geothermal). Here, the Henry Hub natural gas price for indifference between geothermal and CCGT is about $5.10/mcf.

For this example, then, if you are going to use your CCGT for peak, shoulder peak, and base load (with load factor less than 50 percent), geothermal looks just as good as CCGT fired by natural gas priced 40 cents less than if you mostly use CCGT for base load (with load factor exactly at 90 percent). Moreover, geothermal generation for wholesale electricity sales – within the green hammock trading range – returns normal profit to site developers. Above the trading range yields economic profit and/or factor rent to land. Most importantly, the nomograph results do not include benefit from green tags.

Why This Market Isn't Made Already

1. Geothermal's capital recovery factor is unfavorable for low-load-factor applications even though power generation is possible. This implies a bad opportunity cost situation relative to gas turbines. It also implies that flash geothermal isn't likely to be considered a "real" option of significance, such as natural-gas-fired combined heat and power generation – which may be valued for its "timeliness" in responding to a crisis situation.
2. 4½ cents/kWh for geothermal O&M is out of the money for California base load power supply, compared to coal-fired generation from Texas and Four Corners.
3. 4½ cents/kWh for geothermal O&M is out of the money for California base load power supply, compared to nuclear, benefiting from embedded cost recovery and load factor upgrades.

4½ cents/kWh, to pay for a 100 percent geothermal load factor, translates into electricity prices from about $34.50 to $36 per MWh on the nomograph, once you factor in the effect of the vendor/supplier's effective tax rate, and reward the geothermal site developer normal profit (and not a penny more or less). Anything much above $30/MWh is out of the money for wholesale base load electric power, although commitment to all-hours energy supply adds value. This said, green tags could pay the carbon taxes for coal-fired generators who also control geothermal resources.

4. CCGT generation companies are also geothermal generation companies (and, if they are smart, are also coal-fired generation companies).
5. Our scenario-based escalator price uses the premier energy data provision service in the world, and it charges a premium rate, even for a white sale.[16]
6. Attorneys must be involved in contract preparation and for other purposes a little bit uncertain for brokerage. Negotiating terms for performance failures is a leading example.

Responses to Issues and Problems

Geothermal generation occurs at the advantageous behest of combined cycle gas turbine and coal-fired generation companies. MidAmerican new generation site development managers cite a ceiling price that new combined cycle generation must exceed before geothermal generation is considered. Prior to the 2005 natural gas price run-up, CCGT remained comfortably under the ceiling, as did our estimates for geothermal. The ceiling price rations geothermal entry into California markets with very long-term (30-year) bilateral contracts, which are likely to undervalue the resource (although we have not been privy to these contracts).

Circa first quarter 2005, Platts' base forecast for all-hours energy (in constant $ using Platts' predicted price inflation[17]) declines by 45 percent for Southern California for the 15 years from March 2005 through February 2020. This appears to be a coal-laden scenario, perhaps foretelling continued relaxation of pollution restrictions governing coal-fired generation. Other explanations would seem to be hubris.

With our energy politics under fire at home and abroad, whether deserved or not, and with oil and gas exploration and development problems in Iraq, Nigeria, Venezuela, and the Gulf of Mexico, the time seems right, in bipartisan terms, to wake this mostly slumbering resource.

The weather supports this conclusion, with the downsides of volcanic activity (hurricanes, earthquakes, and tsunamis) making news.

A good deal of attention has been paid to improving environmental and efficiency characteristics of competing fossil and renewable technologies – some of which provide news copy more glamorous than tangible social benefit, others of which languish or hide in the circular flow of a funding cycle from year to year. By contrast, geothermal generation is smelly, noisy, and mostly not in your back yard – but can provide very significant social benefit through brokering green tags that make this market.

California's Renewable Portfolio Standard, particularly if accelerated (20 percent by 2012 rather than by 2017), and CARB-compliance requirements for distributed generation options, could make this market, perhaps with a best mix of low-emissions, high efficiency CHP meeting peak shortage demands, and a re-energized market for geothermal power generation dedicated to base load.

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