# An ex post generation market power test and automatic pricing safeguards for the ERCOT wholesale electricity markets: the Peaker Entry Test and Safe Harbor Price Benchmark

**September 21, 2005**

*This discussion paper presents and describes the Peaker Entry Test (PET) and Safe Harbor Price Benchmark (SHPB), which were designed by London Economics as an ex-post market power test and safeguard mechanism. The PET, in combination with SHPB, assures regulators and market participants that potential market power abuses do not go undetected and unmitigated while also maintaining commercially reasonable arrangements in the market.*

*The PET compares the revenues earned by a hypothetical gas-fired peaker on the basis of actual market price outcomes to the full cost recovery target (levelized long-run cost) of the hypothetical gas-fired peaker. Because the test is applied by reference to actual market prices[1], it has similar traits to other market power tests employed in certain jurisdictions, such as price caps and Automated Mitigation Procedures (AMP); however, it is in fact a much more efficient and practical test than the tools employed in other jurisdictions. First and foremost, the PET is explicitly designed to recognize the need for above marginal cost bidding and scarcity rents. It corresponds to the classic definition of market power in terms of profitability and durability, and reflects the theoretical rigor of workable competition where average prices are expected to converge to long run marginal costs (LRMC). Furthermore, because the PET is benchmarked against the commercially reasonable economic profits of the marginal generator, it should not depress investment. In fact, it is likely to further incentivize the development of forward markets, which in turn would provide the necessary financial support for new investment.*

*As part of the PET's mitigation protocols, we have included an automated Safe Harbor Price Benchmark, which would act as a dynamic, temporary price ceiling once market prices have breached the full cost recovery target. The SHPB will offer protection to consumers in the instance of market failures and prevent substantial wealth transfers from consumers to generators and suppliers during those instances of possible market failure, while also providing sufficient 'headroom' for shoulder and peaking plants to remain commercially viable in the market (as the SHPB is directly based on a hypothetical peaker's variable and fixed costs, including necessary return on and return of investment).*

**Peaker Entry Test (PET):**

- ex post analysis of all market prices on a rolling basis
- market monitor examines whether over a twenty four (24)-month period market prices exceeded the level required to fully remunerate a hypothetical peaking unit by more than 20%
- if the 20% limit is exceeded for seven (7) days in a row, the market monitor imposes a temporary price cap (the SHPB) and could launch an investigation

[1] The word "price" is used deliberately; we are concerned with price outcomes, rather than bidding behavior; bidding behavior is only examined *after* an anomalous series of market prices has been observed.



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While we believe that the ERCOT market is currently in a state of workable competition, and that ex ante provisions are already in place to safeguard the market (such as the capacity-based 20% market share safe harbor), we also recognize that monitoring of participant behavior may be healthy to instill confidence in the market. As such, it is important to develop an understanding of what sort of price behavior may suggest that market power is being exercised. For electricity markets, the condition that a competitive market is one in which price equals marginal cost must be appropriately specified: over time, a workably competitive electricity market will produce prices equal to *long run* marginal costs. As such, our test of whether market power abuse has occurred examines whether prices over a twenty-four month period exceed the level required to remunerate a peaking unit operating at low load factors, allowing for an adjustment factor that incorporates forecast error and operational uncertainty.

**Key Components of PET and SHPB:**

**TANR**= Target Annual Net Revenue for a hypothetical peaker = fixed costs including commercially-reasonable return on capital and economic depreciation of capital *(denominated in $/MW per annum)*

**EPMRI**=Efficient Peaker Marginal Revenue Index = fuel times heat rate plus variable O&M, start-up costs, and any variable environmental costs *(denominated in $/MWh)*

**NM** = Net Margin =spot price minus EPMRI *(denominated in $/MWh)*

**ANM** =Annual Net Margin = sum of NM over previous 8760 hours *(denominated in $/MW per annum)*

**SHPB** = Safe Harbor Price Benchmark = EPMRI + TANR levelized over the average annual implied load factor for the previous 24 months *(denominated in $/MWh)*

**Key Building Blocks:** The Peaker Entry Test[2] involves first determining the annual fixed costs required to be recovered by a peaking unit of appropriate efficiency, including return on and return of capital. We refer to this as the Target Annual Net Revenue, or TANR. The next step involves creating an index to determine the short run marginal costs of the hypothetical peaking unit. This index, effectively fuel price multiplied by heat rate plus variable O&M costs (including estimated start up costs) plus any variable environmental costs, would be calculated daily.[3] We call this the Efficient Peaker Marginal Revenue Index, or EPMRI. Then, for any trading interval in which prices exceeded the EPMRI, the net margin (NM, or price minus the daily EPMRI) would be calculated. Once the values for TANR and the parameters for EPMRI have been established, the process for performing the PET is straightforward and transparent.

The hourly NM would be tracked and summed on a rolling twelve month basis to calculate annual net margin, or ANM. A temporary safe harbor price benchmark (SHPB) would be

[2] The rolling basis of the PET, the implicit acceptance of high prices, and the use of temporary mitigation measures is similar to the key features of the Cumulative Price Threshold (CPT) utilized successfully in Australia's National Electricity Market. The CPT is described in Appendix A to this discussion paper.

[3] Daily gas prices are currently monitored by ERCOT for Out of Merit Energy ("OOME") settlement purposes. We would suggest that this same market information be used by the IMM or ERCOT for implementing the PET. If in the future hourly spot gas markets develop, the EPMRI could be calculated on an hourly basis. Other parameters underlying the EPMRI calculation, such as thermal efficiency, variable operating & maintenance expenses, environmental costs, and start/stop costs, are also readily available on a fairly standardized, industry-wide basis.

automatically initiated if and when, after seven (7) consecutive days, the ANM over the preceding twenty-four month period exceeded TANR (the target annual revenue) by more than 20%.[4] The SHPB is the sum of each hour's implied EPMRI and the calculated TANR levelized over the average annual implied load factor over the previous 24 months. The SHPB will be removed the day that the rolling calculation of ANM/TANR falls below 120%.

Notably, the SHPB is not a fixed price cap but a dynamic price benchmark that will serve as the temporary ceiling on market-clearing prices. The SHPB explicitly follows the current market conditions in the gas market and environmental allowances markets, while also reflecting the actual historical operating profile of such a unit in this market. Moreover, the SHPB incorporates a return on capital as well as economic depreciation (return of capital) and fixed operating costs. By explicitly adjusting for market-based variable costs and commercially reasonable returns on investment for the hypothetical marginal plant, the SHPB will protect actual plant from being forced out of the market, while ensuring that inappropriate wealth transfers are avoided from consumers to producers.

In addition to the PET and temporary SHPB, if and when the SHPB is imposed, the market monitor could trigger an informal market-wide investigation. The market monitor would determine the suppliers who have been price setting over the period preceding the breach of the PET and request a dialogue with those market participants. The informal investigation will provide market participants with an opportunity to review the market outcomes with the market monitor, discuss drivers behind the recent market events, and consider whether there is a need for additional mitigation or market rule changes.

**Market definition:** In order for the PET to be truly robust, it will need to be applied over a properly defined market. We anticipate that the PET would be compatible with ERCOT's proposed nodal market design and that the ERCOT market would provide price signals adequately representing the entire market. Prior to implementing the PET, the market monitor will need to define the relevant geographic and product market using well-accepted empirical techniques and to rely on that market definition in implementing the PET and SHPB. For example, if, as expected, the market definition stage of analysis shows that there is a single ERCOT market, then the market monitor will want to use an ERCOT-wide weighted-average price as the reference point in the PET. Similarly, if, as expected, the market definition stage of analysis concludes that ancillary services are a substitute to and thus part of the energy market, then the PET applied to energy will adequately protect the ancillary services segment of the market as well. Lastly, we recommend that the test be constructed over a twenty-four month rolling-average basis and thus reflect the typical timeframe for demand-side substitution in ERCOT's wholesale power market.

**Process:** After the market has been defined properly, we would anticipate that the PET would be performed daily by the market monitor; we expect that the process could be performed in

[4] The 20% figure is designed to account for the fact that rational low load factor generators will bid to recover their fixed and variable costs, but will build in an additional premium to account for the fact that they face substantial uncertainty as to how many intervals in a given year they will be able to bid in a manner which results in fixed cost recovery.


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less than five minutes using a simple spreadsheet macro. When the rolling twenty four-month ANM/TANR ratio is greater than 1.2 for seven successive days, the Safe Harbor Price Benchmark would be temporarily imposed and the market monitor could elect to launch an informal investigation. Market-clearing prices would not be allowed to rise above the SHPB while it is in force. As soon as market prices decline sufficiently such that ANM/TANR ratio is less than 1.2, the SHPB would be lifted.

As discussed above, the SHPB is effectively composed of the EPMRI and TANR components of the PET. The EPMRI is a dollar per megawatt-hour figure based on the assumed variable operating costs, start-up costs, allowance costs, environmental cost, assumed heat rate of the hypothetical peaker multiplied by spot gas prices (inclusive of any surcharge premiums for real-time commitment). The TANR is levelized using the implied average annual load factor over the last twenty-four months for the hypothetical peaker (which, in turn, is an indirect output of the PET) in order to yield a dollar per megawatt-hour component. Depending on the frequency with which gas market conditions change, the SHPB could be calculated hourly or daily.

Any informal investigation would focus on the offer behavior of the primary price setting suppliers over the previous twenty-four months. The market monitor would first determine which participant or participants were most responsible for the offer behavior resulting in the prices that result in a breach of PET threshold, and commence a dialogue with that (those) participant(s). The informal investigation process will allow the market participants to work with the market monitor to determine what caused the price events, whether the behavior of any market participant intentionally or unintentionally contributed to the market outcomes, and what could be done to discipline any similar intentional behavior and prevent any similar unintentional behavior in the future. For example, if it can be shown that entry within the next twelve months would be likely to discipline the identified offer behavior in the future, then the market monitor would not need to pursue the informal investigation further.

It is important to reiterate that neither the PET nor the SHPB are fixed measures. In addition to being inevitably arbitrary, fixed regimes are ineffective proxies for true scarcity rents in a dynamic industry such as the wholesale power sector; scarcity rents are generally both volatile and variable. The adverse consequences of subjectively confining offers to some arbitrary figure arise because of the resulting unhealthy signals to investment, as well as consumption choices. For example, a fixed measure that is set too "low" (i.e., too restrictively) may push suppliers out of the market and distort arbitrage mechanisms that currently provide for market liquidity. Fixed measures that affect the formation of scarcity rents may also give rise to inefficient decisions on market entry and exit (or mothballing).

Rather, the PET should be viewed as a "bright line test" for supra-competitive profits and the SHPB as an automated consumer protection mechanism against wealth transfers. The PET and SHPB have the benefits of *not* being a fixed price threshold *yet* being sufficiently clearly delineated for market participants to understand them. This proposed market power test and mitigation approach is based on clear and pre-established parameters[5], such as actual hourly prices in ERCOT; it is reflective of actual market conditions; and uses a straight-forward methodology that market participants will be able to apply themselves. Because of the ease of calculation, the SHPB can be implemented effectively on an ex-ante basis — it is not an after-the-fact re-calculation of prices. Retrospective price corrections are inefficient and potentially harmful to competitive market forces — they introduce un-hedgeable regulatory risks and can create distortions in commercial decisions. With the temporary imposition of the SHPB when supra-competitive profits are detected by the PET, the possible welfare consequences of market power (such as market power-driven wealth transfers from consumers to producers) will be minimized, making price restatement unnecessary.

**Advantages of our approach:** The ability to harmfully exercise market power is expressed in terms of price in the classical definition of market power. Thus, it is essential that any test look at market prices.[6] We recommend an ex post test that directly compares market price outcomes to the economics necessary to sustain a hypothetical peaking facility — the Peaker Entry Test. Such a test, by definition, allows for prices to rise above marginal costs because it acknowledges that peakers — the price setting resources during super-peak conditions — must bid above their marginal cost in order to recover their long run costs.

It is important to note that the SHPB does not involve after-the-fact re-setting of market clearing prices, but rather a temporary cap on market prices (that is easy to approximate on an ex-ante basis). The SHPB and informal investigation components of the PET do not employ heavy-handed procedures. Indeed, the informal investigation gives affected participants an opportunity to explain their actions and mutually agree on a future course of action, if needed, with the market monitor. We believe that these characteristics of the PET and SHPB are essential to striking a balance between vigilant market surveillance and intrusive intervention.

**Case study - applying PET:**

In order to illustrate the application of the PET and SHPB, we have created a case study using actual and simulated prices, respectively. The physical market for power in ERCOT currently consists of a small balancing energy services segment and large bilateral contract segment. Several empirical analyses of market definition concluded that the relevant "market" for electricity includes both balancing energy services ("BES") and bilateral contracts, and in fact, covers the entire ERCOT footprint.[7] We have thus conducted the case study using historical

[5] The parameters associated with the test for market power should have a sound grounding, and not simply be arbitrarily selected by the regulator. We thus recommend that the gas price assumptions be marked-to-market, while other critical assumptions (such as capital costs and thermal efficiency) are reviewed periodically through an industry-wide survey.

[6] Some suggested market power tests for this industry (such as the "pivotal supplier test") have tried to infer market power from various measures of supply and demand, but without price indications. Such tests fail, in our opinion, to provide evidence of market power abuse. Moreover, such tests neither rationalize nor differentiate between market outcomes that signal scarcity rents versus those that are the result of durable market power.

[7] As commented on in Rulemaking on Definition of Wholesale Electric Market Power in the ERCOT Power Region, Project No. 29042, *Comments of TXU Wholesale Regarding the Staff's Strawman of New § 25.504* (Aug. 26, 2005).

ERCOT market outcomes coupled with bilateral price indicators, on the basis of an ERCOT-wide geographical market definition.

We first calculated an ERCOT load-weighted price index, which incorporates both BES prices and bilateral price indicators, for the 2003-2004 period.[8] We found no indication of market power abuse in ERCOT's wholesale electricity market based on our analyses. This is in fact consistent with the conclusions reached by Potomac Economics in their *State of the Market Report* (SOM) and opinions expressed in the PUCT's January 2005 report to the Texas Legislature. An analysis of the application of the PET to ERCOT-wide weighted average energy prices from 2001 to 2004 appears in Appendix C.

Clearly, on the basis of historical data, there was no need to impose the SHPB. In order to demonstrate the SHPB mechanism, we created a series of hypothetical hourly prices which would result in a breach of the PET threshold. We then illustrated the application of the PET and SHPB on those simulated prices on the basis of the assumed underlying market conditions.

**Step 1: Establishing the break-even economics of a hypothetical peaker**

The starting point for the PET is necessarily the long term costs for a hypothetical peaking facility in ERCOT (the ratio we refer to as TANR), as these estimates help us derive a benchmark price against which to compare market prices.

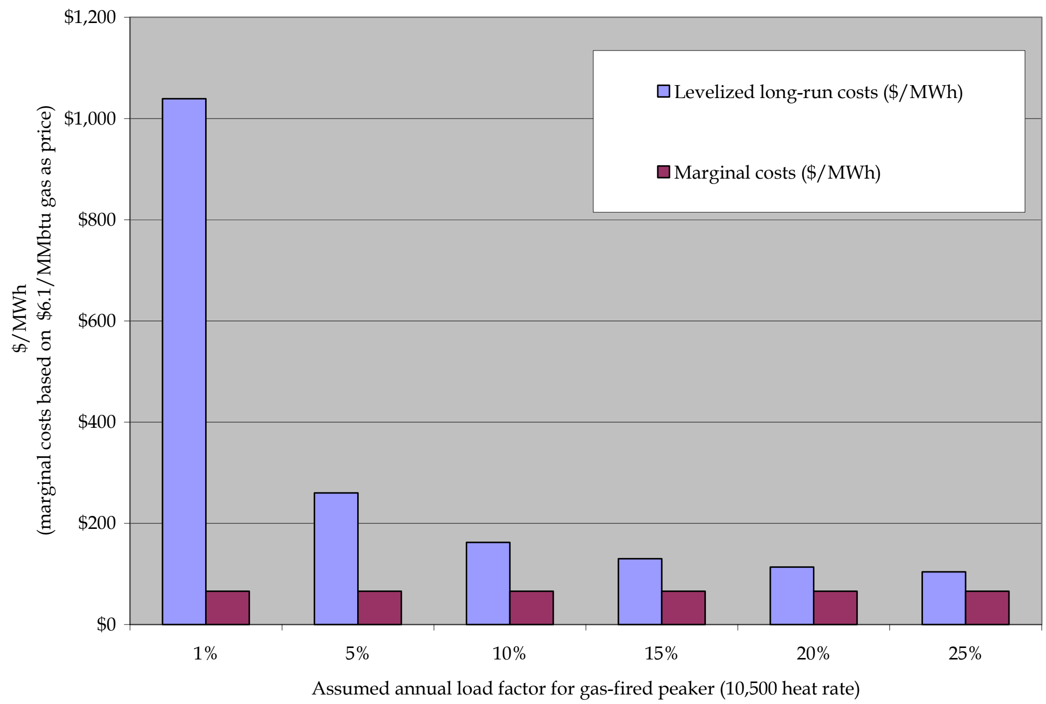
For illustrative purposes, we calculated the above-marginal cost bids necessary to remunerate a hypothetical gas-fired peaking unit operating at load factors ranging from 1% to 25% in the figure below. We then compared the difference (in $/MWh and percentage terms) between the notional marginal costs and levelized long-run costs for a hypothetical peaker under these different annual load factor assumptions. At a 5% load factor (i.e., operating 438 hours during the year), a peaker will need to bid about 293% above its marginal cost to break-even on its levelized long run costs. At a 10% annual load factor (i.e., 876 operating hours), the peaker will have to bid 146% above its short run marginal costs to assure fixed cost recovery. These results are summarized below in Figure 1 and Figure 2.

[8] The calculation of this index is detailed in Appendix D

**Figure 1. Above marginal cost bids necessary to remunerate a hypothetical gas-fired peaker[9]**

| | Assumed Load Factor | | | | | |
|---|---|---|---|---|---|---|
| | **1%** | **5%** | **10%** | **15%** | **20%** | **25%** |
| **Levelized long-run costs ($/MWh)** | $1,039.3 | $259.9 | $162.4 | $130.0 | $113.7 | $104.0 |
| **Marginal costs ($/MWh)** | $66.1 | $66.1 | $66.1 | $66.1 | $66.1 | $66.1 |
| **Difference ($/MWh)** | $973.2 | $193.8 | $96.4 | $63.9 | $47.7 | $37.9 |
| **Difference as % of Marginal costs** | 1473% | 293% | 146% | 97% | 72% | 57% |

**Figure 2. Long-run versus marginal costs for a hypothetical peaker at various load factors**




Based on the historical load-weighted price index of BES and bilateral physical sales in ERCOT and Houston Ship Channel gas prices, a peaker with a 10,500 heat rate would have operated only 4.9% of hours in 2004, earning an estimated profit, which we refer to as Annual Net Margin or ANM, of $16,053/MW above its estimated marginal costs. Based on the parameters for full cost recovery, the ANM for the hypothetical peaker in 2004 is 81% lower than the amount necessary to fully remunerate a hypothetical peaker above its marginal costs (estimated to be $86,533/MW under the assumptions detailed in Appendix B).

[9] These estimates are based on London Economics' assumptions regarding the capital costs and technical parameters of a hypothetical peaker in ERCOT, which we describe further in Appendix B. LEI's assumptions are based on independent research of current turbine costs, recent announced project costs, and equipment manufacturers' specifications for thermal efficiency on single cycle units. However, these assumptions are generally consistent with the parameters prepared and published by other third-parties.

**Figure 3. Implied operations of a hypothetical peaker (10,500 heat rate)**

| Year | Implied Load Factor (%) | Annual Net Margin (ANM) ($/MW) |
|---|---|---|
| **2002** | 0.69% | $ 10,351 |
| **2003** | 2.85% | $ 9,240 |
| **2004** | 4.86% | $ 16,053 |

**Step 2: Application of PET to load-weighted bilateral and BES price index in 2003-2004**

Finally, we applied the PET to a load-weighted price index of bilateral and BES sales in 2003-2004 (on an ERCOT-wide basis).[10] For illustrative purposes, Figure 4 summarizes the results tabulated by our spreadsheet model based on a twenty-four (24)-month cycle, consistent with the time dimension of the market. The PET would not trigger any further action by the market monitor, as the Net Margin over the twenty-four (24)-month period did not exceed 1.2 times the rolling ANM/TANR ratio necessary to fully remunerate a hypothetical peaker.

**Figure 4. Sample calculations of the PET for the recent twenty four (24)-month period**

| | | Average of ERCOT All-in Prices ($/MWh) [A] | Average monthly EPMRI ($/MWh) [B] | Count of hours where hypothetical peaker's EPMRI were less than or equal to actual pool prices | Implied Load Factor | Monthly Net Margin ($/MW) [sum of (A-B)] | Target Net Revenue (based on long-run costs of new peaker) ($/MW) [D] | Benchmark: 120% of the Target Net Revenue ($/MW) [D*1.2] |
|---|---|---|---|---|---|---|---|---|
| 2003 | January | $ 36.00 | $ 61.08 | 3 | 0.40% | $ 85.99 | $ 7,329.30 | $ 8,795.16 |
| | February | $ 63.65 | $ 81.08 | 65 | 9.67% | $ 5,891.6 | $ 6,620.01 | $ 7,944.01 |
| | March | $ 45.97 | $ 70.02 | 23 | 3.09% | $ 582.2 | $ 7,329.30 | $ 8,795.16 |
| | April | $ 35.51 | $ 60.65 | 6 | 0.83% | $ 110.2 | $ 7,092.87 | $ 8,511.44 |
| | May | $ 49.67 | $ 67.03 | 69 | 9.27% | $ 1,452.3 | $ 7,329.30 | $ 8,795.16 |
| | June | $ 42.97 | $ 66.96 | 9 | 1.25% | $ 64.6 | $ 7,092.87 | $ 8,511.44 |
| | July | $ 39.72 | $ 59.15 | 1 | 0.13% | $ 17.8 | $ 7,329.30 | $ 8,795.16 |
| | August | $ 41.04 | $ 58.43 | 54 | 7.26% | $ 876.2 | $ 7,329.30 | $ 8,795.16 |
| | September | $ 30.78 | $ 53.38 | 1 | 0.14% | $ 12.0 | $ 7,092.87 | $ 8,511.44 |
| | October | $ 31.48 | $ 54.17 | 11 | 1.48% | $ 111.1 | $ 7,329.30 | $ 8,795.16 |
| | November | $ 28.56 | $ 52.61 | 4 | 0.56% | $ 35.9 | $ 7,092.87 | $ 8,511.44 |
| | December | $ 36.90 | $ 67.94 | 1 | 0.13% | $ 0.8 | $ 7,329.30 | $ 8,795.16 |
| 2004 | January | $ 34.84 | $ 65.70 | 21 | 2.82% | $ 996.2 | $ 7,329.30 | $ 8,795.16 |
| | February | $ 32.76 | $ 60.30 | 11 | 1.58% | $ 136.0 | $ 6,856.44 | $ 8,227.73 |
| | March | $ 35.76 | $ 62.38 | 13 | 1.75% | $ 182.0 | $ 7,329.30 | $ 8,795.16 |
| | April | $ 43.03 | $ 65.17 | 38 | 5.28% | $ 696.8 | $ 7,092.87 | $ 8,511.44 |
| | May | $ 42.67 | $ 71.70 | 14 | 1.88% | $ 560.1 | $ 7,329.30 | $ 8,795.16 |
| | June | $ 45.61 | $ 70.91 | 27 | 3.75% | $ 1,360.7 | $ 7,092.87 | $ 8,511.44 |
| | July | $ 42.71 | $ 67.85 | 4 | 0.54% | $ 84.6 | $ 7,329.30 | $ 8,795.16 |
| | August | $ 42.10 | $ 62.29 | 29 | 3.90% | $ 364.4 | $ 7,329.30 | $ 8,795.16 |
| | September | $ 42.22 | $ 58.03 | 73 | 10.14% | $ 2,153.0 | $ 7,092.87 | $ 8,511.44 |
| | October | $ 49.97 | $ 70.09 | 89 | 11.96% | $ 1,880.6 | $ 7,329.30 | $ 8,795.16 |
| | November | $ 47.19 | $ 66.80 | 65 | 9.03% | $ 4,925.4 | $ 7,092.87 | $ 8,511.44 |
| | December | $ 43.84 | $ 72.45 | 42 | 5.65% | $ 2,713.6 | $ 7,329.30 | $ 8,795.16 |
| | **24-month cycle** | **$ 41.0** | **$ 64.4** | **673** | **3.85%** | **$ 25,293.9** | **$ 172,829.6** | **$ 207,395.5** |
| | | | | | | X=ANM | 2-yr TANR | Y |

**Ex-Post Market Price Test: Has Benchmark been breached? Is X > Y?** **No**

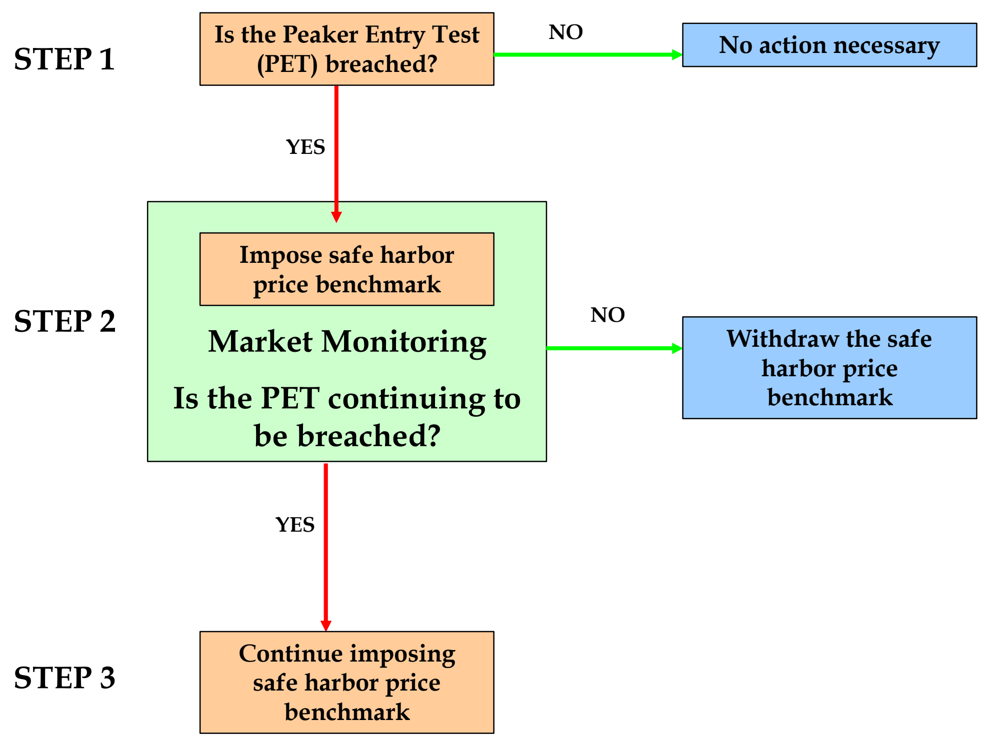
*Note: Target annual net revenue (TANR) is equivalent one year to another, which equals to $86,533/MW. 2004 is a leap year, and thus, there is a different distribution across the months due to 29 days in February in the year of 2004.*

[10]Calculations of the load-weighted price index are detailed in Appendix D

**Step 3: Stylized illustration of the Safe Harbor Price Benchmark**

The application of the Safe Harbor Price Benchmark is straightforward and is performed following three simple steps as highlighted in Figure 5: (1) detection of potential market power abuse through the PET, (2) enforcement of the SHPB, and (3) eventual removal of the Safe Harbor Price Benchmark, once market conditions permit.

**Figure 5. Safe harbor price benchmark application**




The continuous monitoring of the market for potential market power abuses is done through the peaker entry test (PET) on a rolling 24-month basis. If for seven consecutive days, the Annual Net Margin (ANM) exceeds the Target Annual Net Revenue (TANR) by 20%, the market monitor will impose the Safe Harbor Price Benchmark until such time as the PET is no longer breached, and may launch an informal investigation.

The SHPB is calculated using the same straightforward inputs as the PET. Unlike a fixed price cap, the safe harbor price benchmark would be variable and would reflect current market dynamics, such as fuel prices and implied historical load factors.[11] Highlighted on the next page in Figure 6 are examples of various SHPB levels under a variety of assumptions regarding real-time gas prices and implied historical load factors. For example, if real-time gas prices are recorded at $6/MMBtu and the implied average annual load factor over the previous 24 months

[11] The average load factors would be calculated using the same time-frame as the PET, notably a 24-month period

is 5%, the SHPB for that hour (or day, if gas prices are quoted on a daily basis only) would be $262.6 per MWh, as highlighted in the table below. Currently, spot gas prices for 2006 are expected to range in the $10 to over $12 per MMBtu based on traded futures for Henry Hub. Taking the low range of this forward outlook, $10/MMbtu, and a 5% implied load factor, we reach an estimated SHPB under such conditions of over $300/MWh. If the implied load factor over the preceding months would be lower for a hypothetical peaker, then the SHPB would need to be further increased. This dynamic is illustrated in Figure 6.

**Figure 6. Sample Safe Harbor Price Benchmark at various gas prices and load factors ($/MWh)**

| Real-time gas prices ($/MMBtu) | Implied Load Factor Over Previous 24 Months: 1% | 2% | 3% | 4% | 5% | 10% | 15% |
|---|---|---|---|---|---|---|---|
| **$4.50** | $1,026.2 | $539.1 | $376.7 | $295.5 | $246.8 | $149.4 | $116.9 |
| **$5.00** | $1,031.5 | $544.3 | $382.0 | $300.8 | $252.1 | $154.6 | $122.2 |
| **$5.50** | $1,036.7 | $549.6 | $387.2 | $306.0 | $257.3 | $159.9 | $127.4 |
| **$6.00** | $1,042.0 | $554.8 | $392.5 | $311.3 | $262.6 | $165.1 | $132.7 |
| **$6.50** | $1,047.2 | $560.1 | $397.7 | $316.5 | $267.8 | $170.4 | $137.9 |
| **$7.00** | $1,052.5 | $565.3 | $403.0 | $321.8 | $273.1 | $175.6 | $143.2 |
| **$7.50** | $1,057.7 | $570.6 | $408.2 | $327.0 | $278.3 | $180.9 | $148.4 |
| **$8.00** | $1,063.0 | $575.8 | $413.5 | $332.3 | $283.6 | $186.1 | $153.7 |
| **$8.50** | $1,068.2 | $581.1 | $418.7 | $337.5 | $288.8 | $191.4 | $158.9 |
| **$9.00** | $1,073.5 | $586.3 | $424.0 | $342.8 | $294.1 | $196.6 | $164.2 |
| **$9.50** | $1,078.7 | $591.6 | $429.2 | $348.0 | $299.3 | $201.9 | $169.4 |
| **$10.00** | $1,084.0 | $596.8 | $434.5 | $353.3 | $304.6 | $207.1 | $174.7 |
| **$10.50** | $1,089.2 | $602.1 | $439.7 | $358.5 | $309.8 | $212.4 | $179.9 |

**Real time gas prices inclusive of surcharge premiums for real-time delivery*

Below is an illustrative application of the SHPB in a hypothetical market for a week following a PET breach. As shown in Figure 7, as soon as the PET is breached the SHPB is imposed capping market prices during several intervals.

The imposition of the SHPB reduces the TANR causing the PET breach to end about 13 days sooner (303 hours) as highlighted in Figure 8 on page 12.

**Figure 7. Illustration of SHPB in a hypothetical market**

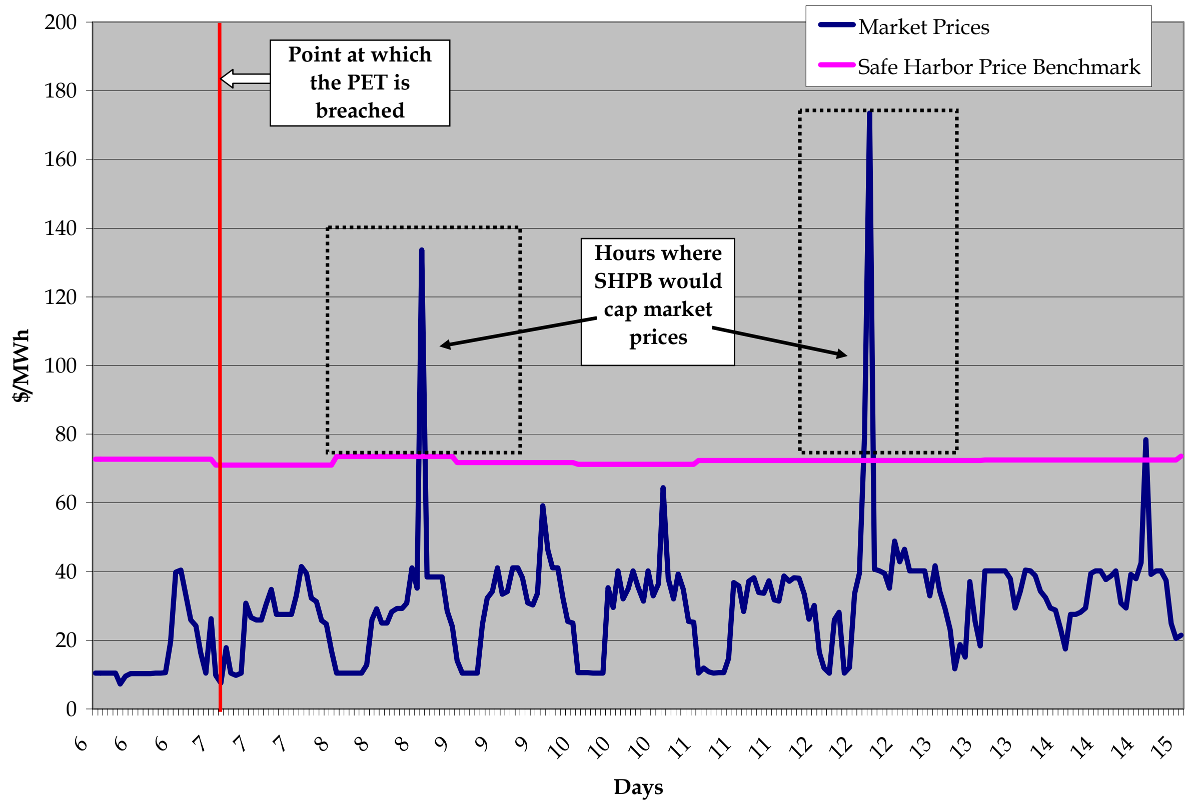
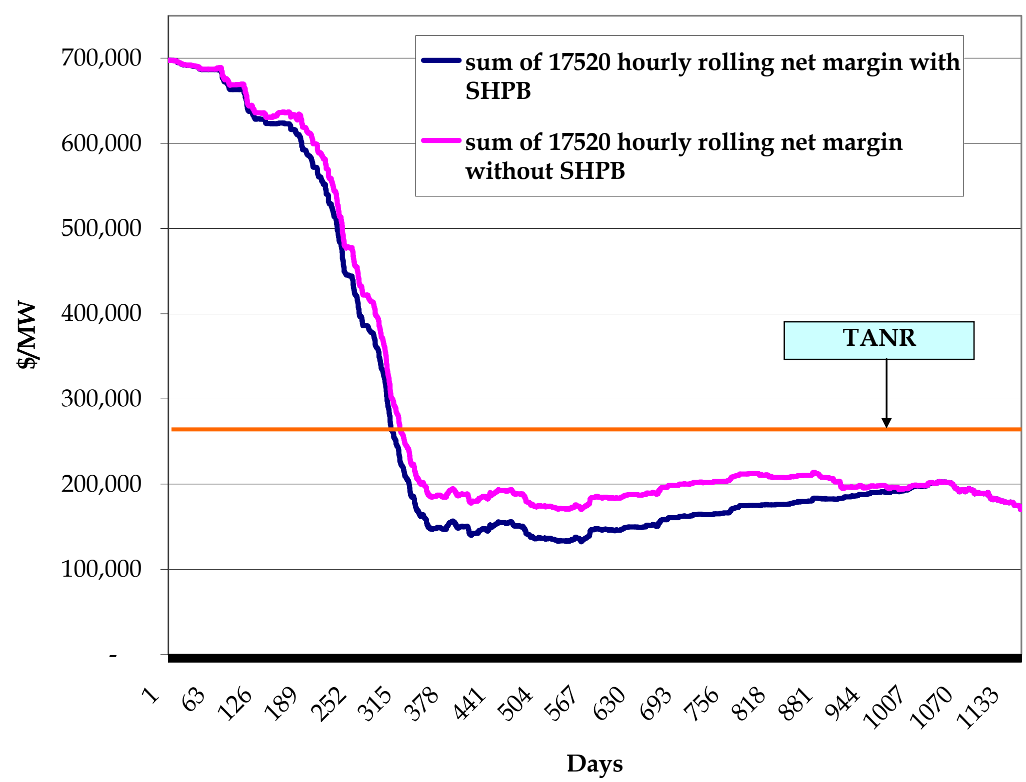


**Figure 8. Effect of the SHPB on TANR in a hypothetical market**



## Appendix A: Case Study of the CPT from Australia's NEM

Competition and fair trading in Australia is governed by the Australian Trade Practices Act, while electricity specific behavior is governed by the National Electricity Code ("the Code"). As a result of the two different pieces of governing regulations/laws, electricity market surveillance occurs as a two-part process in which the National Electricity Code Administrator (NECA) monitors the National Electricity Market (NEM) and conducts investigations, while the Australian Competition and Consumer Commission (ACCC) serves as the ultimate arbiter of violations of rules against anti-competitive behavior.

NECA undertakes investigations of anomalous market behavior or events. The investigations arise from NECA's surveillance and monitoring activities, allegations made by other parties, or a referral by the ACCC. In this regard, NECA is similar to the future Independent Market Monitor (IMM) in ERCOT. Market event investigations generally result in some recommendation regarding how the National Electricity Market Management Company (NEMMCO), the operator of the NEM, should address certain operational issues. Some investigations may call for changes in the Code, which must be authorized by the ACCC. In contrast to jurisdictions with more litigative institutional frameworks, it is not unusual for issues to be resolved through a process of negotiation between the ACCC and market participants under investigation.

NEM has also incorporated structural safeguards against market power through a price cap on spot market prices. Generally, market price caps have a negative effect on competitive market dynamics. The NEM price cap, however, is a fairly soft one in that it is short in duration and triggered during periods of extreme price volatility. The cap was not initially designed as a market power mitigation tool but more as way to contain the financial impact of major catastrophic event on the NEM and its participants. NEMMCO imposes a price cap in the national market when the sum of prices reaches the cumulative price threshold (CPT) of AUS$150,000 (approximately US $113,000) in any seven-day period. This works out to an average round the clock price of nearly AUS$900/MWh (approximately US $681/MWh). Once the seven day CPT is reached, which so far has not happened since its inception, a system of administered prices is triggered, but only for a short period of time. This administered price cap is AUS$100/MWh (approximately US $76/MWh) between 7:00 a.m. and 11:00 p.m. on business days and AUS$50/MWh (approximately US $38/MWh) at other times. The administered pricing caps, however, are effective only until the end of the trading day on which the rolling seven-day cumulative summation of uncapped prices falls below the CPT. In December 2002, the CPT threshold was nearly reached when the Queensland cumulative price reached AUS$110,769 (US $83,260).

If the CPT is not reached, the market price cap in any one hour is equal to the Value of Lost Load (VoLL)[12], which is currently set at Australian $10,000/MWh (US $7,570/MWh) and is reviewed annually by NECA's Reliability Panel. Just recently, NECA upheld the current VoLL and CPT regulations.[13]

[12] VoLL is a price cap on the spot price at the regional reference node as determined by NEMMCO.

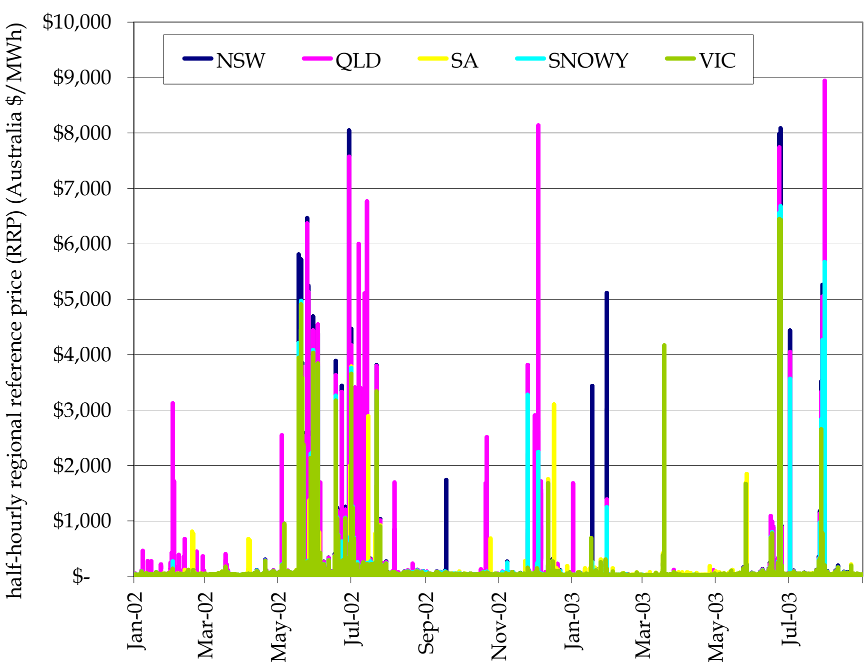
[13] "VoLL and the cumulative price threshold", NECA, March 2005.

The NEM differs substantially from North American models in that it allows offers to substantially exceed average prices. It is not unusual for prices to exceed Australian $9,000/MWh[14] (US $6,810/MWh), as seen in figure below. It could be argued that this pricing is essential because the NEM does not have specific mechanisms for the purchase of reserve. That is, the only incentive for reserve to make itself available is the prospect of earning very high prices for a short period of time when the reserve is required. It is certainly true that reserve has made itself available under this pricing regime, and that as a result, the system has operated securely. It is also the case that the market has sustained entry that has meant ongoing reliable operation.

**Figure 9. NEMMCO half-hourly Regional Reference Price (RRP) statistics, January 2002-December 2004**

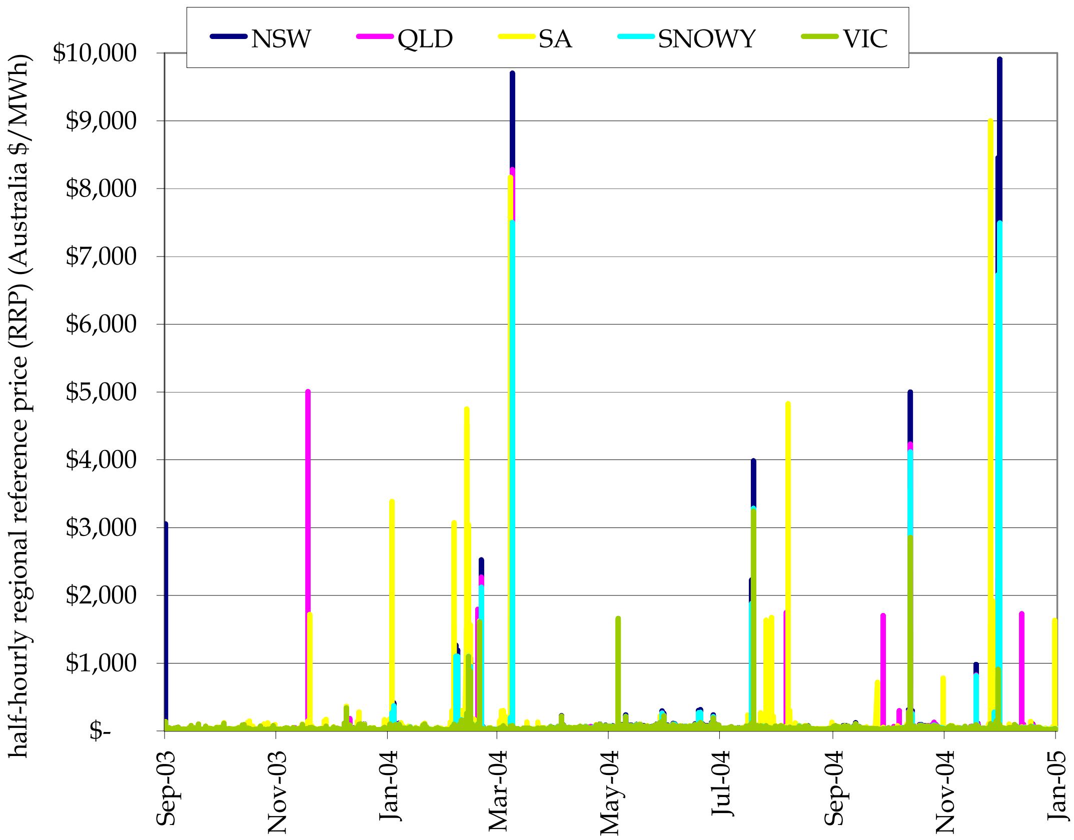
| | 2002-2004 half-hourly prices | | | | |
|---|---|---|---|---|---|
| | NSW | QLD | SA | SNOWY | VIC |
| Avg | $ 37 | $ 35 | $ 35 | $ 33 | $ 29 |
| Max | $ 9,909 | $ 8,943 | $ 9,000 | $ 7,500 | $ 6,444 |
| Min | $ 3 | $ (156) | $ (822) | $ 0 | $ (330) |
| Stdev | $ 220 | $ 186 | $ 120 | $ 155 | $ 93 |

**Figure 10. NEMMCO half-hourly Regional Reference Price (RRP), January 2002-December 2004 (part 1)**




[14] The nature of demand in Australia is that the highest prices typically occur after about four days of hot weather, after which hydro reserves tend to become depleted and air conditioning load reaches a plateau.

**Figure 11. NEMMCO half-hourly Regional Reference Price (RRP), January 2002-December 2004 (part 2)**




The threshold and price cap levels were originally determined through a consultation process with each participating jurisdiction and market participants and are intended to loosely reflect certain economic return levels and risk appetite for the industry. If any criticism of the NEM is warranted, it relates to the $100/MWh and $50/MWh caps effective after the CPT is breached; these have an element of arbitrariness. Nonetheless, the overall CPT structure is at least more likely to allow the underlying (and efficient) volatility of spot prices to be retained than simple single period offer or price caps.

## Appendix B: Assumptions for Peaker Trigger Price Model

**Table A: Summary of inputs for determining break-even costs of a hypothetical peaker**

| Peaking Unit (SCGT) | Assumptions |
|---|---|
| capital cost - $/kW | $400 |
| average heat rate - Btu/kWh | 10,500 |
| indicative load factor | 5% |
| variable O&M - $/MWh | $2.0 |
| fixed O&M - $/kW/year | $8.6 |
| leverage | 25% |
| debt rate | 9% |
| after-tax required equity return | 20% |
| corporate income tax rate | 35% |
| financing lifetime (yrs) | 15 |
| capital recovery lifetime for equity portion (yrs) | 15 |
| real-time purchase premium ($/MMBtu) | $0.40 |
| start-up costs - wear and tear ($/MW), per start | $20 |
| start-up costs - fuel consumption (MMBtu), per start | 200 |

**Table B: Calculations of the long run break-even cost and TANR for hypothetical peaker**

| | | |
|---|---|---|
| leverage | | 25% |
| debt interest rate | | 9.0% |
| after-tax required equity return | | 20.0% |
| corporate income tax rate | | 35% |
| debt financing term, years | | 15 |
| equity contribution capital recovery term, years | | 15 |
| construction time (for capitalized expenses), months | | 12 |
| carrying charge until commissioning, $/kW | $ | 23.4 |
| amortized capitalized expenses over debt term, $/kW/year | $ | 2.4 |
| **amortized carrying charge over debt term, $/MWh** | | **$5.45** |
| average annual load factor | | 5% |
| total capital cost, $/kW | $ | 400 |
| debt-financed portion, $/kW | $ | 100 |
| annual debt repayment, $/kW/year | $ | 10 |
| **annual debt repayment, $/MWh** | **$** | **23.3** |
| equity-financed portion, $/kW | $ | 300 |
| annual equity return, $/kW/year | $ | 64 |
| **annual equity return, $/MWh** | **$** | **146.5** |
| Houston Ship Channel 2004 average gas price ($/MMBtu) | $ | 5.7 |
| real-time purchase premium for gas ($/MMBtu) | $ | 0.4 |
| total delivered fuel price ($/MMBtu) | $ | 6.1 |
| heat rate, Btu/kWh | | 10,500 |
| **fuel cost, $/MWh** | **$** | **64.1** |
| **variable O&M, $/MWh** | **$** | **2.0** |
| **start-up costs - wear and tear ($/MWh)** | **$** | **0.8** |
| **start-up costs - fuel consumption ($/MWh)** | **$** | **1.9** |
| fixed O&M, $/kW/year | $ | 8.6 |
| **fixed O&M, $/MWh** | **$** | **19.6** |
| **Break-even for new peaker plant, $/MWh:** | | **$263.6** **= LRMC @5% load factor** |
| **Target Annual Net Revenue, per MW** | | **$86,533** |

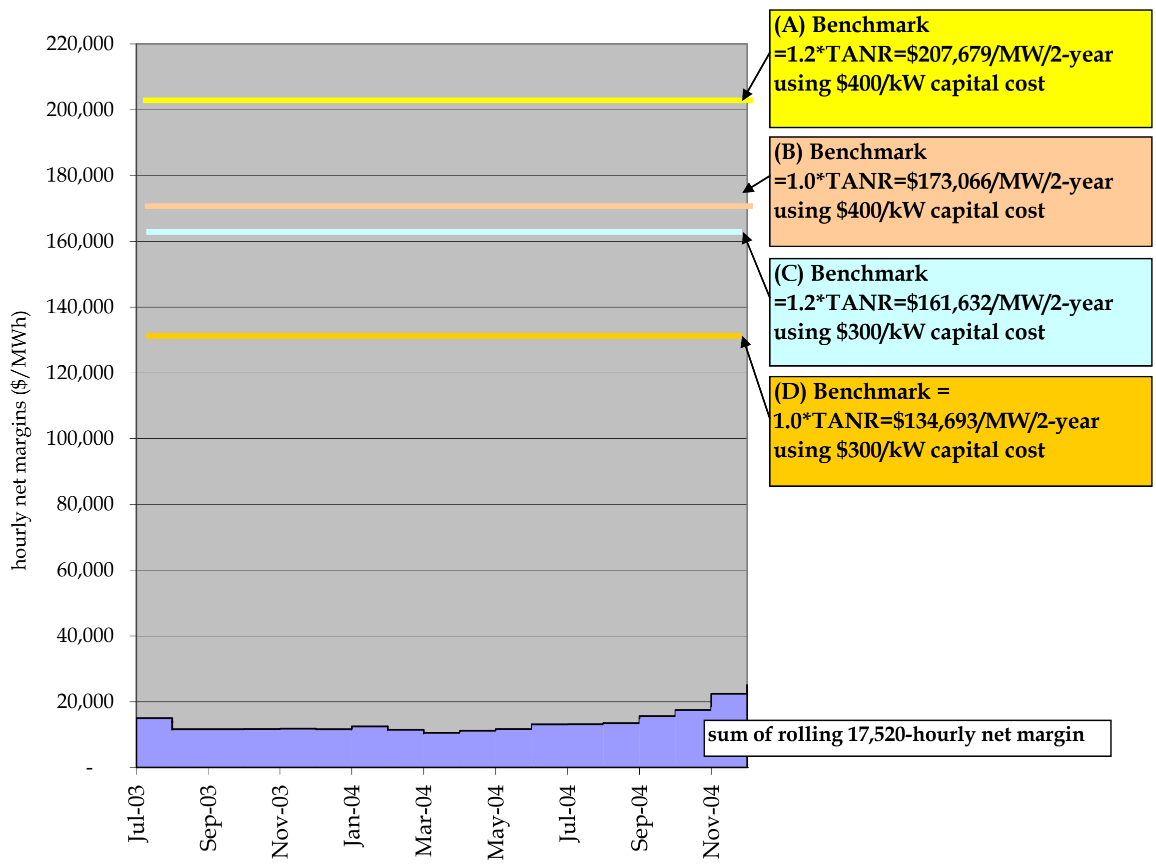
*Sources: LEI assumptions developed through independent analysis, review of region-specific publicly-available cost data and information provided by equipment manufacturers. Generally our assumptions are conservative, vis-à-vis the objectives of the PET. For example, certain industry sources estimate variable O&M as high as $4/MWh. However, our overall estimate of total fixed costs (TANR) is in-line with many industry estimates that place it in the range of $70,000 to $80,000 per MW per year.*

**Figure 12. Sensitivity table for break-even costs for a hypothetical peaker (gas prices vs. capital cost) under a 5% load factor ($/MWh)**

| Real-time gas prices ($/MMBtu) | Capital Costs for Peaker ($/kW) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **$300** | **$325** | **$350** | **$375** | **$400** | **$425** | **$450** | **$475** | **$500** |
| **$4.50** | $203.0 | $214.0 | $224.9 | $235.9 | $246.8 | $257.8 | $268.7 | $279.7 | $290.6 |
| **$4.75** | $205.6 | $216.6 | $227.5 | $238.5 | $249.4 | $260.4 | $271.3 | $282.3 | $293.2 |
| **$5.00** | $208.3 | $219.2 | $230.2 | $241.1 | $252.1 | $263.0 | $274.0 | $284.9 | $295.9 |
| **$5.25** | $210.9 | $221.8 | $232.8 | $243.7 | $254.7 | $265.6 | $276.6 | $287.5 | $298.5 |
| **$5.50** | $213.5 | $224.5 | $235.4 | $246.4 | $257.3 | $268.3 | $279.2 | $290.2 | $301.1 |
| **$5.75** | $216.1 | $227.1 | $238.0 | $249.0 | $259.9 | $270.9 | $281.8 | $292.8 | $303.7 |
| **$6.00** | $218.8 | $229.7 | $240.7 | $251.6 | $262.6 | $273.5 | $284.5 | $295.4 | $306.4 |
| **$6.25** | $221.4 | $232.3 | $243.3 | $254.2 | $265.2 | $276.1 | $287.1 | $298.0 | $309.0 |
| **$6.50** | $224.0 | $235.0 | $245.9 | $256.9 | $267.8 | $278.8 | $289.7 | $300.7 | $311.6 |
| **$6.75** | $226.6 | $237.6 | $248.5 | $259.5 | $270.4 | $281.4 | $292.3 | $303.3 | $314.2 |
| **$7.00** | $229.3 | $240.2 | $251.2 | $262.1 | $273.1 | $284.0 | $295.0 | $305.9 | $316.9 |
| **$7.25** | $231.9 | $242.8 | $253.8 | $264.7 | $275.7 | $286.6 | $297.6 | $308.5 | $319.5 |
| **$7.50** | $234.5 | $245.5 | $256.4 | $267.4 | $278.3 | $289.3 | $300.2 | $311.2 | $322.1 |
| **$7.75** | $237.1 | $248.1 | $259.0 | $270.0 | $280.9 | $291.9 | $302.8 | $313.8 | $324.7 |
| **$8.00** | $239.8 | $250.7 | $261.7 | $272.6 | $283.6 | $294.5 | $305.5 | $316.4 | $327.4 |
| **$8.25** | $242.4 | $253.3 | $264.3 | $275.2 | $286.2 | $297.1 | $308.1 | $319.0 | $330.0 |
| **$8.50** | $245.0 | $256.0 | $266.9 | $277.9 | $288.8 | $299.8 | $310.7 | $321.7 | $332.6 |
| **$8.75** | $247.6 | $258.6 | $269.5 | $280.5 | $291.4 | $302.4 | $313.3 | $324.3 | $335.2 |
| **$9.00** | $250.3 | $261.2 | $272.2 | $283.1 | $294.1 | $305.0 | $316.0 | $326.9 | $337.9 |
| **$9.25** | $252.9 | $263.8 | $274.8 | $285.7 | $296.7 | $307.6 | $318.6 | $329.5 | $340.5 |
| **$9.50** | $255.5 | $266.5 | $277.4 | $288.4 | $299.3 | $310.3 | $321.2 | $332.2 | $343.1 |
| **$9.75** | $258.1 | $269.1 | $280.0 | $291.0 | $301.9 | $312.9 | $323.8 | $334.8 | $345.7 |
| **$10.00** | $260.8 | $271.7 | $282.7 | $293.6 | $304.6 | $315.5 | $326.5 | $337.4 | $348.4 |
| **$10.25** | $263.4 | $274.3 | $285.3 | $296.2 | $307.2 | $318.1 | $329.1 | $340.0 | $351.0 |
| **$10.50** | $266.0 | $277.0 | $287.9 | $298.9 | $309.8 | $320.8 | $331.7 | $342.7 | $353.6 |
| **$10.75** | $268.6 | $279.6 | $290.5 | $301.5 | $312.4 | $323.4 | $334.3 | $345.3 | $356.2 |
| **$11.00** | $271.3 | $282.2 | $293.2 | $304.1 | $315.1 | $326.0 | $337.0 | $347.9 | $358.9 |
| **$11.25** | $273.9 | $284.8 | $295.8 | $306.7 | $317.7 | $328.6 | $339.6 | $350.5 | $361.5 |
| **$11.50** | $276.5 | $287.5 | $298.4 | $309.4 | $320.3 | $331.3 | $342.2 | $353.2 | $364.1 |
| **$11.75** | $279.1 | $290.1 | $301.0 | $312.0 | $322.9 | $333.9 | $344.8 | $355.8 | $366.7 |
| **$12.00** | $281.8 | $292.7 | $303.7 | $314.6 | $325.6 | $336.5 | $347.5 | $358.4 | $369.4 |

## Appendix C: Historical calculation of the PET using varying capital cost assumptions, July 2001 to December 2004

**Figure 13. PET calculated based on a twenty four (24)-month rolling basis, July 2001 to December 2004**



## Appendix D: Calculation of ERCOT All-in weighted prices

The ERCOT all-in prices were calculated to incorporate both BES and bilateral prices across all zones in ERCOT. We used historical data from 2001 through 2004. As shown in Figure 14, BES prices and load data (in 15-minute interval format) were obtained directly from ERCOT[15] and price indicators for bilateral contract sales (in daily format) were obtained from a third-party data provider.[16] Implicit load carried by the bilateral market was calculated by subtracting the MW deployed for BES (i.e., demand for BES) from total ERCOT load, which was also obtained directly from ERCOT.[17]

**Figure 14. Data Source**

| FORM OF PURCHASE | TYPE | SOURCE |
|---|---|---|
| BES | Market clearing price<br>Load | ERCOT<br>ERCOT |
| Bilateral Contracts | Contract price<br>Load | PLATTS / AMEREX<br>Calculated by LEI as = ERCOT load - BES load |

The next step involved formatting the data, as bilateral contract prices were only available in daily on-peak and off-peak formats.[18] These daily price levels thus needed to be converted into a 15-minute interval format by assigning the daily on-peak bilateral aggregate price index to each of the 15-minute intervals during on-peak hours of that particular day and by assigning the daily off-peak aggregate price index to each of the 15-minute intervals during off-peak hours of that particular day.[19]

As highlighted in Figure 15, we then calculated the share of load met by BES and by bilateral contracts for each zone. After the steps noted above, we then estimated the load-weighted prices for both BES and bilateral contract prices across each of the ERCOT zones. The last step involved calculating the load of each zone as a percentage of total load in ERCOT which, along with the zonal load-weighted prices, were then used to calculate an ERCOT-wide aggregate price index.

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15 See http://www.ercot.com/ercotPublicWeb/PublicMarketInformation/FileSystem.cfm?SubDir=mos/Operating_Day_Report&Title=Operating%20Day%20Reports

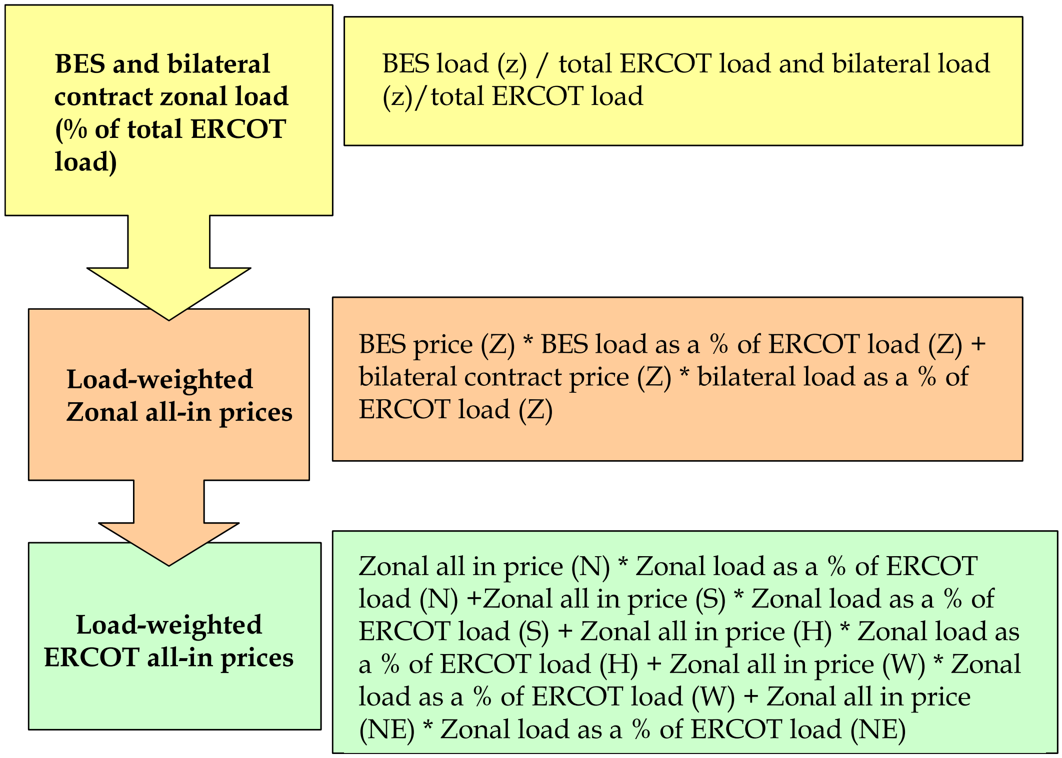
16 For the example included in this briefing memo, we have used *Platts'* next-day forwards.

17 See http://www.ercot.com/ercotPublicWeb/PublicMarketInformation/FileSystem.cfm?SubDir=mos/Load_MWh_by%20CMZONE&Title=Load%20MWh%20by%20CMZONE

18 Peak hours are defined as all hours between 7 a.m. and 11 p.m. (Monday through Friday) and off-peak hours as all hours between 7 a.m. (Monday through Friday) and all hours on weekends (Saturday and Sunday).

19 For the purposes of this example, the standard format for the data was chosen to be daily peak and off-peak. However, other formats can be used as long as the data is standardized to meet that format.

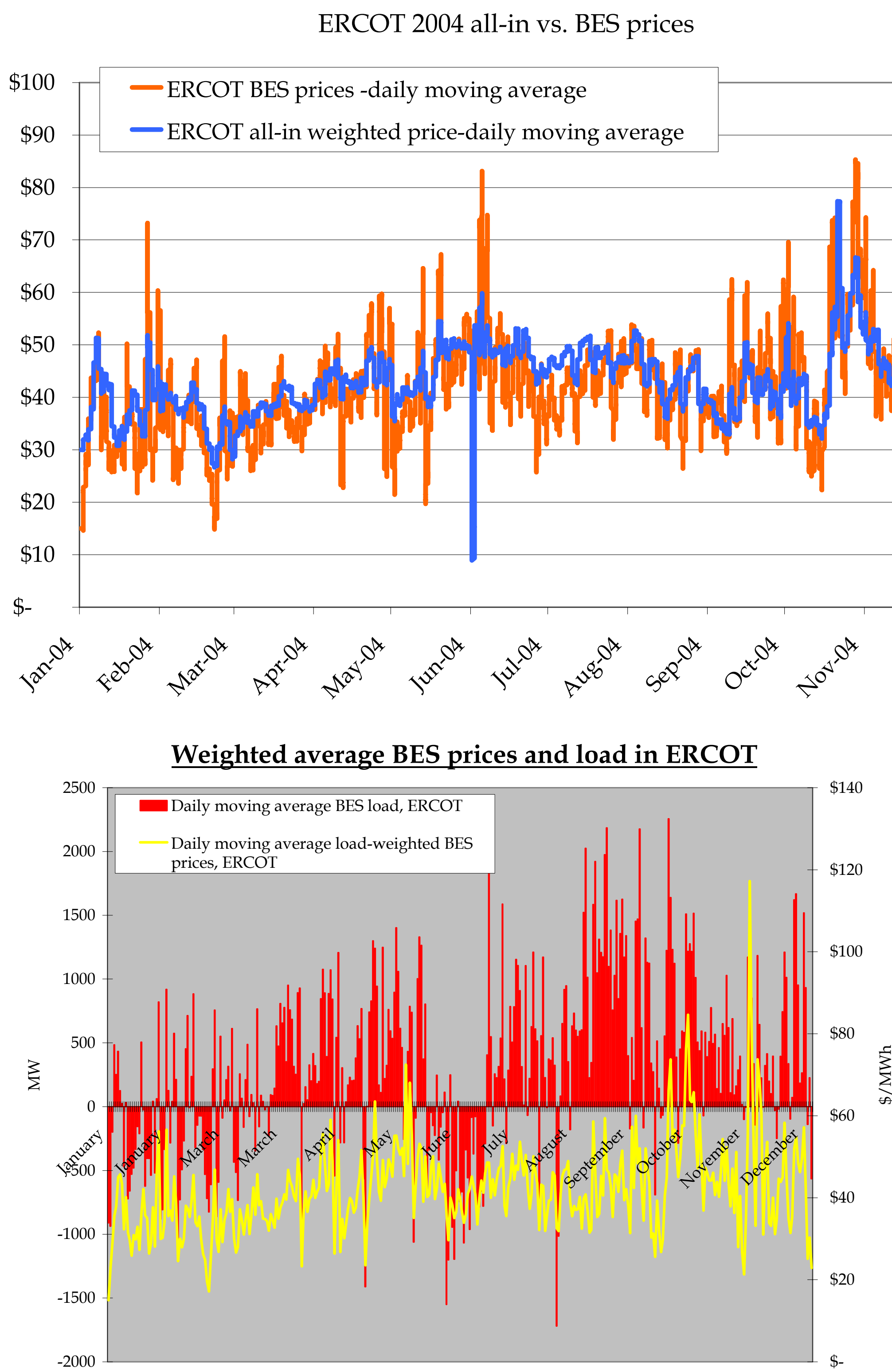
**Figure 15. ERCOT all-in prices calculation**

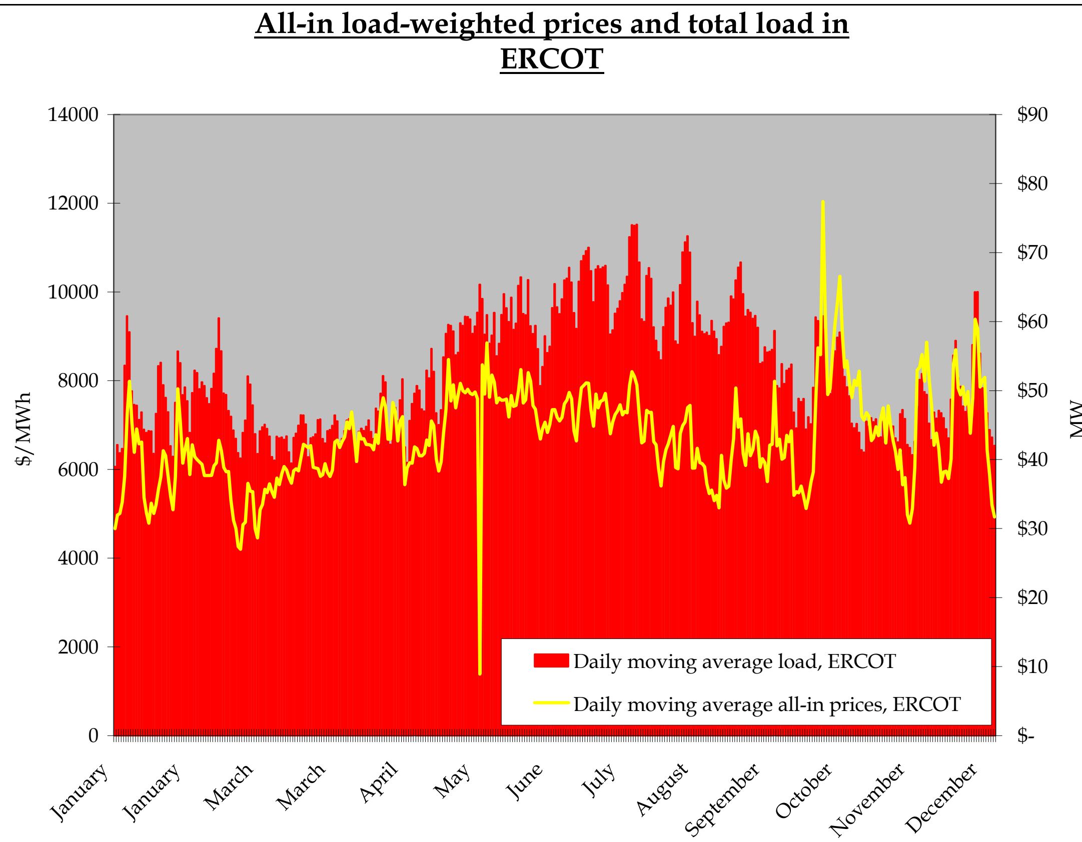



*where Z is a zone, N the North zone, S the South zone, H the Houston zone, W the West zone and NE the Northeast zone.*

Figure 16 illustrates the 2004 all-in price index contrasted against BES-only prices. For illustrative purposes, we have used *Platts* price index data for next day delivery as the price indicator for the bilateral segment.

**Figure 16. 2004 ERCOT All-in Prices and BES Prices**






## Average and 95% Confidence Interval Price Indicators by Month

| BES prices, ERCOT | Average | 5% Percentile | 95% Percentile |
|---|---|---|---|
| January | $ 34.84 | $ 12.29 | $ 56.62 |
| February | $ 32.76 | $ 12.69 | $ 52.24 |
| March | $ 35.76 | $ 13.04 | $ 52.38 |
| April | $ 43.04 | $ 14.50 | $ 68.06 |
| May | $ 42.68 | $ 12.40 | $ 64.90 |
| June | $ 45.62 | $ 14.30 | $ 66.21 |
| July | $ 42.69 | $ 17.70 | $ 59.18 |
| August | $ 42.12 | $ 18.41 | $ 62.92 |
| September | $ 42.20 | $ 17.53 | $ 71.83 |
| October | $ 49.93 | $ 14.64 | $ 87.69 |
| November | $ 47.20 | $ 13.00 | $ 84.08 |
| December | $ 43.90 | $ 12.48 | $ 75.48 |

| All-in load-weighted prices, ERCOT | Average | 5% Percentile | 95% Percentile |
|---|---|---|---|
| January | $ 38.49 | $ 20.16 | $ 50.40 |
| February | $ 36.04 | $ 20.34 | $ 44.95 |
| March | $ 37.91 | $ 24.25 | $ 46.54 |
| April | $ 43.95 | $ 30.75 | $ 53.81 |
| May | $ 44.94 | $ 24.62 | $ 58.07 |
| June | $ 47.38 | $ 34.20 | $ 58.86 |
| July | $ 47.46 | $ 33.90 | $ 58.18 |
| August | $ 43.94 | $ 28.26 | $ 57.89 |
| September | $ 39.79 | $ 24.52 | $ 54.07 |
| October | $ 47.54 | $ 23.29 | $ 73.05 |
| November | $ 44.05 | $ 23.06 | $ 58.28 |
| December | $ 46.74 | $ 20.98 | $ 62.32 |