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AES GR068
March 2011

# Economic Valuation of a Power Plant (Conventional or Renewable) and Demand Response Programs in a Utility Portfolio

Prepared By

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Prepared For

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# PURPOSE OF THIS REPORT

At the request of the Power Company (the Company), Intertek APTECH conducted a comprehensive study to assess the economic value of the energy and capacity of Beagle Dam and, in particular, the value of having scheduling rights to use AnyState's share of Beagle generation for meeting dynamic load conditions and ancillary services. The value of the Beagle energy as a hedge against natural gas price volatility was also analyzed, and variations in accounting for certain power plant cycling-related maintenance costs that Beagle availability avoids were explored.

The primary focus was on the economic benefits to the Scheduling Entity that the Company has contracted to schedule Beagle power on behalf of all Company customers. Several models were developed to study the economic benefit of the availability of Beagle power to the Scheduling Entity, which at present is GenCo X. For this study, estimating the energy benefits of Beagle power to GenCo X was approached directly by calculating GenCo X's total production costs both "with" and "without" the dispatchable Beagle power and associated Dynamic Signal. To ensure that the projections were realistic, the inputs were extensively researched and actual MW generation, market environments, and operating costs from Calendar Year 2008 were used for the models. Moreover, to offset the uncertainty of the lack of comprehensive market transaction data and GenCo X's future resources, care was taken to ensure that all inputs and results either were conservative or had their uncertainties included within several modeled scenarios. Finally, the impact of volatility in market conditions and costs and the benefits that GenCo X or the Company customers receive from Beagle power under such conditions were also quantified in the various scenarios.

Based on the analysis conducted in this report, Intertek APTECH has reached the following conclusions:

- The total annual value of Beagle generation to GenCo X can be classified into its capacity and energy components as follows:
  - Net Capacity Value: $XX million to $XX million
  - Net Energy Value: $XX million to $XX million
  - Total Net Value: $XX million to $XX million

- GenCo X has 15% targets for renewable integration (by 2025)[1]. This renewable portfolio will primarily consist of variable resources such as wind and solar, both of which add considerable cycling-related maintenance costs on fossil plant cycling and other related operations. The availability of Beagle power helps GenCo X to mitigate these effects and keep operational costs lower.

- Intertek APTECH developed three base cases (Cases A, B, and C) and further expanded this analysis with four scenarios based on Base Case B. The most applicable results of this study are summarized in the table below:

| Case | Net Energy Savings for ($ Millions) |
|---|---|
| Base Case B | |
| Scenario 1 B - Reduced Near Term Gas Prices (26% reduced) | |
| Scenario 2 - Raised Natural Gas and Coal Prices ($1 per MMBtu). | |
| Scenario 3 - Increased SRP Demand (2.5%) | |
| Scenario 4-21 - Reduced Hoover Availability to SRP (21% reduced) | |
| Scenario 4-43 - Reduced Hoover Availability to SRP (43% reduced) | |

The results summarized in the table above indicate that there is not a substantial change in the savings for potential changes in economic conditions. Capacity savings also would not change under the terms of the first three scenarios. Scenarios 4-21 and 4-43 give the impact on energy savings if the amount of Beagle capacity and energy allocated to GenCo X for dynamic control was reduced by 21% or 43%, respectively. It is interesting to note that when the Beagle capacity and energy are reduced by 21%, the

[1] Source: GenCo X Website: http://www.GenCo Xnet.com/environment/renewable.aspx

resulting savings are reduced by 22%; and when the amount of Beagle is reduced by 43%, the savings go down by 43%.

- Hence, dramatic changes in GenCo X fossil production costs (due to fuel price, load growth, etc.) had very small impact on the value of Beagle power. This adds credibility and defensibility to this analysis and validates its assumptions.

With expected increases in fuel prices, environmental regulations, increased renewable integration (and variability), and load growth, the economic benefits of Beagle power to the Company and its customers are of substantial value. The analysis summarized above is fully developed and explained in the body of this report.

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# EXECUTIVE SUMMARY

This report was prepared by Intertek APTECH to assess the Power Company's (Company) share of Beagle Dam capacity and energy with the specific purpose of evaluating this resource in light of the Company's ability to schedule Beagle dynamically to meet varying load conditions and to provide ancillary services. This study also evaluates Beagle's energy benefits as a function of changes in natural gas prices, load growth, and additional cycling expenses.

The Company has the responsibility of acquiring and marketing AnyState's share of Beagle Dam power. In the past and currently, the Company has accomplished power delivery through a contract with GenCo X to function as the Company's Scheduling Entity. To control synchronized generation "for regulation, ramping (from zero to full scheduled synchronous generation and reverse), and reserves" at Beagle Dam, the Company is authorized to use a Dynamic Signal. The Dynamic Signal allows the Company to change its share of the Beagle generation on a 4-second basis. GenCo X pays the Company a fixed annual fee for the control of this signal, which allows GenCo X to schedule Beagle power on behalf of the Company's customers, including itself. GenCo X has instantaneous generation scheduling responsibility for meeting load requirements and is charged with dispatching the Company's Beagle power to GenCo X's best advantage. In Calendar Year (CY) 2008, GenCo X as a customer of the Company was entitled to about 15% of the available Beagle energy that it scheduled on behalf of the Company.

As a Company customer itself, GenCo X receives benefits of controlling the scheduling rights to Beagle power. In evaluating Beagle power for this study, Intertek APTECH focused on valuing Beagle power specifically for the GenCo X system. It should be recognized that GenCo X is fairly representative of a typical utility in the region, and valuing Beagle power against GenCo X's system provides a reasonable estimate of the value of Beagle power used elsewhere.

Intertek APTECH analyzed the economic benefits to GenCo X from Beagle power in the areas of:

- Energy Benefits, including:
  - Fuel Cost
  - Variable O&M
  - Automatic Generation Control
    - Effective Capacity Reduction
    - Heat Rate Increases
  - Power Plant Damage Reduction
  - Reduced Cycling of Fossil Plants
  - Emissions Cost
- Capacity Benefits

In addition, the value of the "energy bank" that Company customers (and GenCo X) accumulate every month was estimated. Energy is "banked" when the allotted Beagle power (for GenCo X's use) is greater than the scheduled Beagle power (on behalf of Company customers). This banked energy is depleted in the summer months, when the Company customers schedule more than the allotted Beagle power that GenCo X uses to satisfy its own generation needs. The net energy bank at the end of each operating year (September 30) is expected to be zero, and this is assumed in all of the study's analyses. In reality, any difference is carried forward to the next operating year. However, because GenCo X must "pay back" more energy than it is allotted from Beagle when the prices are highest in the summer, the net annual effect of the banking is to reduce the Beagle power's value to GenCo X. This reduction is also accounted for in the study's evaluations.

For this study, estimating the energy benefits of Beagle power to GenCo X was approached directly by calculating GenCo X's total production costs both "with" and "without" the dispatchable Beagle power and associated Dynamic Signal.

It should be noted that the analysis reflects the economic conditions in CY 2008. While the broader economic conditions and the specific electricity markets have been rapidly changing, it is Intertek APTECH's opinion that the general conclusions identified in this report are still valid. Moreover, scenario simulations included a near-term natural gas price of $X/MMBtu, a higher

($X/MMBtu) future price, and several other variations were evaluated to account for volatility in the natural gas price and other uncertainties.

## APPROACH

Intertek APTECH modeled GenCo X's thermal generation portfolio for a base case (CY 2008) and four scenarios (base case +):

1. Near-Term Fuel Price (natural gas = $6/MMBtu)
2. Long-Term, High Fuel Price (natural gas = $9/MMBtu) and Higher Emissions Cost
3. Higher Demand
4. Beagle Dynamic Signal Split between GenCo X and another Scheduling Entity

Intertek APTECH's Unit Commitment and Economic Dispatch program (Cycling⬍ Advisor™) was employed to simulate GenCo X's system by modeling GenCo X's fossil fuel generation hourly dispatch and AGC in 2008. We accomplished this by running 12 monthly, hour-to-hour unit commitment runs for three base cases and four scenarios[2]. Runs with- and without-Beagle power were made for the base cases and each of the scenarios.

Cycling costs are maintenance-related costs that are the result of a power plant providing dynamic load following and on/off operation. Each time a thermal power plant turns on/off it goes through unavoidable thermal cycles that lead to fatigue damage and eventually to component failure. This failure of components contributes to the increase in cycling-related maintenance costs.

It is important to understand that utilities like GenCo X, with control area responsibility, change the output of each of their generators (to meet their load responsibility) on a continuous basis to minimize the cost of energy generated. They do this with computer systems generally known as automatic generation control (AGC). Intertek APTECH has found through its extensive studies of cycling and units providing AGC services that the heat rates and, thus fuel costs, increase significantly when thermal units must provide cycling and AGC. We have accounted for these effects on heat rates in our analysis.

[2] Cycling⬍ Advisor offers all the capabilities of standard unit commitment programs and contains special capabilities to model fossil unit cycling damage and resulting costs.

Since it is unclear how certain cycling costs (low-load fuel expense and increased maintenance) would be accounted for in GenCo X's (or any other typical utility's) unit commitment decisions, additional models were executed to account for various levels of these cycling costs. Under the base case and Scenario 1, the runs modeled 0%, 50%, and 100% of what Intertek APTECH estimates are GenCo X's cycling costs (Scenarios 2 through 4 include only the 50% cycling costs case). To keep our estimates of the value of Beagle power conservative, we configured Cycling⬍Advisorto minimize GenCo X's total production cost with input cycling-related costs that were a reduced percent of the actual cycling costs associated with low-load fuel expense and increased maintenance. The program output includes both the calculated minimized cycling costs and the total "actual" cycling costs.

For the remainder of this report, we will only refer to the input cycling costs as the costs associated with power plant cycling and the resultant increased maintenance and wear and tear costs. Wherever necessary, we will clearly point out the higher "actual" cycling costs.

To corroborate the validity of the results, the 0% cycling cost simulations (i.e., fuel costs only, no power plant damage modeling) were run on another proprietary model, similar to market standard models such as PROSYM or PROMOD. The annual production costs estimated from these runs were found to closely approximate the results from Cycling⬍Advisor.

To determine the full value of Beagle power, the study also evaluated cycling costs for a large thermal generation fleet, such as GenCo X's[3], and analyzed the positive benefits of using dispatchable hydro energy to mitigate cycling costs. Assumptions identified in the analysis are conservative in nature, thus the benefits identified are the lower bounds.

## RESULTS

The study estimates a $XX million-plus total annual benefit of Beagle power to GenCo X (or comparable Scheduling Entity). About 55% to 60% of this total comes from energy benefits and the remainder from capacity benefits.

[3] GenCo X has utilized Intertek APTECH in the past for mitigating the effects of cycling, and such mitigation is accounted for in the range of simulated cycling costs.

## Capacity Benefits

The capacity benefits bestowed by use of Beagle power were estimated to be $XX.X million to $XX.X million annually. This range was calculated by assuming that Beagle Dam could be replaced by a new 300 MW gas turbine. It is Intertek APTECH's opinion that this assumption is conservative because, while such a gas turbine would nearly match available Beagle capacity, it could not nearly duplicate the high ramp rates or produce the range of MW generation achievable with Beagle power. It is recognized that, in the current depressed economy, replacing all lost Beagle capacity may not be an immediate requirement. However, the results indicate that eventually the full annual capacity benefits will rise to this $XX million to $XX million range.

## Energy Benefits

The annual energy benefits of Beagle were estimated to be $XX million to $XX million for CY 2008 and nearly the same thereafter. All but about $X million[4] of these annual energy benefits are summarized in Tables ES-1 through ES-5, which provide the Cycling⬍Advisor output summary of each of the with- and without-Beagle simulations run under this project. The estimates[5] in these tables include the energy benefits (and banking obligations) of Beagle under all of the different assumptions and scenarios discussed above.

Table ES-1 shows the results from the base case (CY 2008), which evaluates GenCo X's total production cost with and without Beagle power, and accounting for varying levels of power plant cycling costs. The table lists total CY 2008 costs, along with three of its six[6] components: the dominant baseload fuel costs and the two much smaller indirect cycling cost components, wear and tear and low-load fuel costs.

Beagle's energy benefits are calculated by subtracting the total with-Beagle costs from total without-Beagle costs. For example, for Case B, which utilizes half the cycling costs, Cycling⬍Advisor's optimum dispatch strategy with Beagle resulted in a total cost of $XXX.XX million and $XXX.XX million in actual costs. Without Beagle, the total costs were $XXX.XX

[4] The added $X million energy benefit of Beagle not included in the Cycling⬍Advisor-rurtables is due to avoiding heat rate increases in coal units with increased automatic generation control.
[5] Due to uncertainties and dependencies in Cycling⬍Advisor's numerical optimization procedures, the total production cost estimates in these tables have an approximate numerical error of less than ±$X.X million, while the Beagle energy benefits are believed to be accurate to within 3% (see the demonstration in Appendix D).
[6] The three unlisted cost components are tabulated in the main report. These are energy purchases, energy sales, and direct startup costs (combined cost of auxiliary power and startup fuel).

million and $XXX.XX million actual. So Beagle's energy benefits are XXX.XX - XXX.XX = $XX.XX million for this case (ignoring rounding error) and the actual energy benefits are XXX.XX - XXX.XX = $XX.XX million.

Note the insensitivity of Beagle's minimized output total costs or the actual values, which range narrowly from $XX million to $XX million, to cycling cost assumptions. Note also that with or without Beagle power, there is nearly a $XX million penalty for ignoring all power plant cycling costs. To see this, compare Cases A and C in Table ES-1. For example, the with-Beagle runs indicate that, if all cycling costs are considered, actual production costs total $XXX.X million, but if all cycling costs are ignored, the actual costs soar to $XXX.X million. Conversely, if true cycling costs are underestimated by a factor of two (Case B in Table ES-1), there is very little penalty. The actual total costs for Cases B and C are essentially identical.

Table ES-2 shows the results of the first scenario, in which the natural gas price (with emissions cost) of the base case is reduced from $X.XX/MMBtu to $X.XX/MMBtu to partially reflect recent gas price fluctuations. Note that the total production cost to GenCo X has reduced dramatically and by well over $XXX million compared to the base case. However, the value of Beagle power to GenCo X changes only slightly from the base case, decreasing by less than $X million in most cases.

Tables ES-3 and ES-4 show the results for Scenario 2 and Scenario 3, respectively. Scenario 2 modifies Base Case B (50% of cycling costs) inputs to reflect a higher fuel price and emissions price, along with higher market prices. The total production cost of GenCo X in Scenario 2 rises by $XXX million above the base case shown in Table ES-1, with little effect on Beagle's energy value to GenCo X ($XX.XX million).

In Scenario 3, with a higher MW demand on GenCo X system and without modifying any other input to Base Case B (50% of cycling costs), a $40 million increase in the total production cost is seen, again with negligible impact on estimates of Beagle energy value to GenCo X ($XX.XX million).

Finally, Table ES-5 shows the results from Scenario 4, where the Beagle Dynamic Signal is split between GenCo X and another Scheduling Entity. This scenario was evaluated by running two separate simulations. Under the first, the available Beagle capacity to GenCo X is reduced by 21% and under the second it is reduced by 43%. The table compares the with- and without-

Beagle power results for Base Case B (50% of cycling costs) against two cases in which the Beagle capacity available to GenCo X is reduced. A fairly linear reduction in the value of Beagle to GenCo X can be seen. With 21%-reduced available capacity to GenCo X, the value of Beagle to GenCo X reduces from $XX.X million to $XX.X million (22% reduction in savings). When the available Beagle capacity to GenCo X is reduced by 43%, the value of Beagle to GenCo X reduces further, to about $XX.X million (43% reduction in savings).

## CONCLUSIONS

Intertek APTECH concludes that GenCo X receives significant benefits from controlling the Beagle Dynamic Signal. The estimates of these benefits (listed below) are quite insensitive to significant changes in fuel price, power demand, and cycling costs. While current economic conditions deflate the gross margins at utilities such as GenCo X, future increases in emissions regulations, highly variable renewable energy sources, and typical load growth are likely to increase the value of hydro electric power plants such as Beagle.

The key conclusions of this study are that:

- The total annual value of Beagle generation to GenCo X exceeds $XX million.
- In 2008, Beagle generation provided $XX million to $XX million energy benefits to GenCo X.
- Annual "capacity" cost savings of GenCo X due to Beagle availability are approximately $XX million to $XX million. While these savings may not be realized immediately in the currently depressed economy, with growing demand and variable renewable generation, firm capacity needs of GenCo X will support these cost estimates.
- Gas price reductions from about $X/MMBtu to $X/MMBtu decreased total production costs by about $XXX million, but decreased Beagle value only slightly, by about $X million to $X million annually. Clearly, the reduction in the total (fuel + emission) natural gas price, does not have an important impact on the Beagle value to GenCo X or the Company customers.
- Coal and gas price increases of $X/MMBtu greatly increased production costs by about $XXX million, but had small impact on Beagle value estimates.

- Hence, dramatic changes in GenCo X fossil production costs had very small impact on the value of Beagle power. This adds credibility and defensibility to this analysis and validates its assumptions.
- Ignoring all indirect cycling costs for with- or without-Beagle scenarios, GenCo X's total production cost is much greater, resulting in an actual loss of about $XX million.
- However, there is a relatively small penalty for underestimating the true cost of cycling by half.
- Benefits of available Beagle capacity to GenCo X are almost linear. For example, a 21% loss of Beagle availability to GenCo X results in about 22% loss in Beagle energy value to GenCo X.
- The highly responsive Beagle generation signal produces benefits far beyond simple Gigawatt-hour (GWhr) value, most notably the ability to avoid AGC in most GenCo X coal units.

In its Fiscal Year 2010, third-quarter report, GenCo X has suggested that it was not immune to the economic conditions prevalent in 2009 – 2010. There were significant reductions in the operating expense due to lower fuel costs and market prices. However, these are short-term signals and eventually both demand and fuel and market prices are expected to rise.

In general, increased demand and higher fuel prices result in considerable increase in total operating costs. While total Beagle energy benefit is not particularly sensitive to these variations, the capacity benefits of Beagle would increase to the $XX million to $XX million range estimated herein. In fact, Intertek APTECH has used a conservative approach to value the costs, and a utility like GenCo X could take many additional significant benefits from having the approximately 300 MW of firm capacity that the Company's share of Beagle power represents. For example, Beagle allows GenCo X to ramp from 0 to maximum load within seconds. Also, with a growing percentage of GenCo X's capacity being non-dispatchable renewable wind and solar energy, the need for flexible generation, such as that offered by Beagle power, to mitigate the inherent variability of these new resources will be greater.

## Table ES-1

## BASE CASE (CY 2008) SUMMARY OF CYLING◆ ADVISOR RESULTS

| Base Case - 2008 Cycling Advisor Output Summary | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Fuel Type | Total Fuel Cost with Emissions ($/MMBTU) | | | | | | | | | | | |
| Coal | 2.33 | | | | | | | | | | | |
| Gas | 8.14 | | | | | | | | | | | |
| Case | With | % Actual cycling costs considered | Conservative Estimate Minimized (optimal) Costs ($M) | | | | | Total Actual Costs* ($M) | | | | |
| | | | Base Load Fuel | Wear and Tear | Low-Load Fuel | Total | Value | Base Load Fuel | Wear and tear | Low-Load Fuel | Total | Value |
| A | Yes | 0% | INTENTIONALLY DELETED | | | | | | | | | |
| | No | 0% | | | | | | | | | | |
| B | Yes | 50% | | | | | | | | | | |
| | No | 50% | | | | | | | | | | |
| C | Yes | 100% | | | | | | | | | | |
| | No | 100% | | | | | | | | | | |

* See Note Below

## Table ES-2

## SCENARIO 1: NEAR-TERM GAS PRICE, SUMMARY OF CYLING◆ ADVISOR RESULTS

| Scenario Case 1 - "Near Term Gas Price" Cycling Advisor Output Summary | | | | | | |
|---|---|---|---|---|---|---|
| Fuel Type | Total Fuel Cost with Emissions ($/MMBTU) | | | | | |
| Coal | 2.33 | | | | | |
| Gas | 6.02 | | | | | |
| Case | With | % Actual cycling costs considered | Conservative Estimate Minimized (optimal) Costs ($M) | | Total Actual Costs ($M) | |
| | | | Total | Value | Total | Value |
| A | Yes | 0% | INTENTIONALLY DELETED | | | |
| | No | 0% | | | | |
| B | Yes | 50% | | | | |
| | No | 50% | | | | |
| C | Yes | 100% | | | | |
| | No | 100% | | | | |

## Table ES-3

## SCENARIO 2: HIGH FUEL PRICE, EMISSIONS, AND MARKET PRICE, SUMMARY OF CYLING◆ ADVISOR RESULTS

| Scenario Case 2 - "High Fuel Price, Emiss. and Market Prices" Cycling Advisor Output Summary | | | | | | |
|---|---|---|---|---|---|---|
| Fuel Type | Total Fuel Cost with Emissions ($/MMBTU) | | | | | |
| Coal | 3.33 | | | | | |
| Gas | 9.14 | | | | | |
| Case | With | % Actual cycling costs considered | Conservative Estimate Minimized (optimal) Costs ($M) | | Total Actual Costs ($M) | |
| | | | Total | Value | Total | Value |
| B | Yes | 50% | INTENTIONALLY DELETED | | | |
| | No | 50% | | | | |

**Note:** Actual cycling costs include: (1) direct cycling costs such as startup fuel, auxiliary power, and additional fuel costs related to degradation of heat rate; and, (2) indirect cycling costs associated with additional maintenance, forced outage costs due to wear and tear on equipment, and reduced equipment life.

## Table ES-4

## SCENARIO 3: HIGH DEMAND
## SUMMARY OF CYLING◆ ADVISOR RESULTS

| Scenario Case 3 - "High Demand" Cycling Advisor Output Summary | | | | | | |
|---|---|---|---|---|---|---|
| Fuel Type | Total Fuel Cost with Emissions ($/MMBTU) | | | | | |
| Coal | 2.33 | | | | | |
| Gas | 8.14 | | | | | |
| Case | With | % Actual cycling costs considered | Conservative Estimate Minimized (optimal) Costs ($M) | | Total Actual Costs ($M) | |
| | | | Total | Value | Total | Value |
| B | Yes | 50% | | | | |
| | No | 50% | | | | |

INTENTIONALLY DELETED

## Table ES-5

## SCENARIO 4: DYNAMIC SIGNAL SPLIT
## SUMMARY OF CYLING◆ ADVISOR RESULTS

| Scenario Case 4 - "Dynamic Signal Split" Cycling Advisor Output Summary | | | | | | |
|---|---|---|---|---|---|---|
| Fuel Type | Total Fuel Cost with Emissions ($/MMBTU) | | | | | |
| Coal | 2.33 | | | | | |
| Gas | 8.14 | | | | | |
| Case | With | % Actual cycling costs considered | Conservative Estimate Minimized (optimal) Costs ($M) | | Total Actual Costs ($M) | |
| | | | Total | Value | Total | Value |
| Base Case (B) | Yes | 50% | | | | |
| | No | 50% | | | | |
| B 21 | Reduced | 50% | | | | |
| | No | 50% | | | | |
| B 43 | Reduced | 50% | | | | |
| | No | 50% | | | | |

INTENTIONALLY DELETED



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# Section 1
# INTRODUCTION

The Power Company (Company), a body corporate and politic of AnyState, was formed as a result of federal legislation (AnyState Act of 1928) that allocated a portion of power produced from the ____________________ (Beagle Dam and Power Plant) to AnyState. The AnyState State Legislature created the Power Company and charged it with the responsibility of acquiring and marketing AnyState's share of Beagle power. The Company presently has an Electric Service Contract dated June 1987 with Area Power Administration (AREA) to receive AnyState's allocation of Schedule A and B power and C energy from Beagle Dam. The Company markets and schedules this entitlement to 30 power customers in the state of AnyState. These power customers include cities and towns, irrigation, power, water conservation, and electrical supply districts. The contract with AREA allowed the Company to purchase 377 megawatts (MW) of the capacity and energy generated at Beagle Dam at approximately 25% capacity factor. However, drought conditions in the River Basin in recent years have resulted in reduced available energy. For instance, the expected available maximum capacity and energy to the Company for operating year 2009–2010 is 327 MW and 705,000 MW hours (MWhr), respectively.

The Company has a Scheduling Entity Agreement with GenCo X for that entity to schedule the Beagle power on behalf of the Company's customers. GenCo X has the right to schedule the Company's entitled Beagle power share within the constraints of outages, river operations, reservoir drawdown, and emergencies.

Section 5.6.2 of the Electric Service Contract between the Company and AREA allows the Company to use a Dynamic Signal to control Beagle Dam's synchronized generation "for regulation, ramping (from zero to full scheduled synchronous generation and reverse), and reserves". Under its contract with the Company, GenCo X is authorized to use this Dynamic Signal to schedule Beagle power. While GenCo X schedules the Company's Beagle power on behalf of all the Company's customers, GenCo X itself is a customer of the Company. In

Calendar Year (CY) 2008, GenCo X was entitled to about 15% of the available Beagle energy that it scheduled on behalf of the Company.

As the Scheduling Entity, GenCo X has instantaneous generation scheduling responsibility to dispatch the Company's Beagle power to the best advantage of GenCo X. GenCo X pays the Company a fixed price (currently $X.X million) annually for the rights to use the Dynamic Signal and to schedule the Company's Beagle power, with a considerable benefit to itself.

## 1.1 PURPOSE

The Company has entered into past and current contracts with GenCo X for the Company's scheduling rights to power from Beagle. Past contracts have sold the scheduling rights of Beagle power at what some believe may have offered very favorable (i.e., low) costs to GenCo X. The Company believes that GenCo X's payments for the scheduling of the Beagle power may not reflect the true value of the available Beagle firm capacity, energy, and ancillary services, as well as the avoided power plant cycling-related "damage costs", that GenCo X derives from the rights to schedule Beagle power.

Thus, the Company contracted with Intertek APTECH to undertake an independent assessment of the value of these Beagle energy and capacity services for future contract negotiations with GenCo X or other utilities that seek to schedule the Beagle power through the Company.

Without Beagle power's dynamic load responses, GenCo X would increasingly ramp MW output up and down the load ranges of many of its large fossil units. These fossil plants would endure increased startups, load follows, automatic generation control (AGC) requirements, and other fast cycling requirements due to the unavailability of Beagle power. This extra ramping and cycling causes unavoidable fatigue cycles and resultant damage in the power plants, which lead to significantly increased repairs and refurbishment maintenance and forced outage costs, increased fuel use resulting from higher unit heat rates, and increased plant startups and associated shutdowns. These starts and shutdowns require additional cycling-related startup fuel, manpower, chemicals, water, and power. In addition, the need to use the most economical baseloaded (usually coal) units to support AGC often keeps them well below their dependable and economical MW rating. This effectively reduces the coal units' capacity to cope with periods of high system demand and necessitates increased and more expensive gas-fired unit generation and high-cost energy purchases.

The primary goal of the Intertek APTECH's study is to determine the value to the Scheduling Entity (in this case, GenCo X) of using the Company's Beagle generation entitlement for ancillary services, with specific focus on dynamic control (using the Beagle Dynamic Signal) to meet load conditions as they vary. The study included a detailed evaluation of the anticipated value that a utility that has instantaneous generation scheduling responsibility might expect to receive if that utility had control of the Dynamic Signal. The study also evaluated the value to the Company's customers of "banking" energy with the Scheduling Entity (GenCo X) during the fall, winter, and spring months for later use during the summer months. An overview of the main project components is presented in Figure 1-1.

This report presents a sound, reasonable, and defensible cost analysis of the value of Beagle energy and capacity to a Scheduling Entity, as typified by GenCo X. The cost analysis is intended to inform and, thereby, help the Company negotiate with GenCo X, and other potential Beagle generation Scheduling Entities that serve load in AnyState, to achieve a fair and reasonable Scheduling Entity Agreement for itself and its customers through competitive bidding and/or negotiations.

## 1.2 Intertek APTECH'S APPROACH

The Company seeks to provide Beagle power to AnyState utilities in accordance with Company-AREA Contract MM-XXXX-XXXXXXXXX, which notes in Section 8, page 54, "Resale of Electric Energy":

> **RESALE OF ELECTRIC ENERGY**:
>
> 8.1 Distribution Principles: The purpose of making low-cost, Federally-generated power available is to encourage the most widespread use thereof, and therefore:
>
> 8.1.1 The benefits of Federally-generated power shall be made available at fair and reasonable terms to all of the Contractor's customers at the lowest possible rates consistent with sound business principles;

Based on the assumption that fair price should relate closely to a fair and reasonable value, Intertek APTECH undertook to provide an accurate estimate of this value.

This report provides the Company with a best estimate of the value of the Beagle power it controls and sells and a description of the analyses undertaken to arrive at this result. The estimate should be useful for internal planning, as well as for negotiating fair and reasonable prices and rates consistent with sound business principles, as delineated above.

Indications are that, for the near future, most or all of the Beagle Dynamic Signal may continue to be sold to and used by GenCo X. Thus, it was decided that the most practical approach would be to determine the value of Beagle power specifically to GenCo X system, rather than to a hypothetical Scheduling Entity. The analysis, therefore, focused on GenCo X. However, GenCo X does represent a typical utility in the state of AnyState and, thus, the analysis in this report is valid for any other similar Scheduling Entity that the Company decides to negotiate with (e.g., AnyState Public Service, Electric Power Company, or AnyState Electric Power Cooperative, Inc.).

Intertek APTECH approached the study by evaluating both the energy and capacity benefits that a Scheduling Entity such as GenCo X gets from using the Beagle power. To evaluate energy benefits, Intertek APTECH's proprietary unit commitment and economic dispatch program called Cycling⬍Advisor™was used to model GenCo X's thermal portfolio to evaluate the total annual production cost "with and without" Beagle power for CY 2008[7].

The energy-benefit value of Beagle power to GenCo X can be evaluated directly by calculating the reduction of GenCo X total generation costs that results from its use of the Beagle Dynamic Signal. The best way to estimate this reduction is to calculate GenCo X's system production costs with and without Beagle power. The difference in these two calculated costs is the desired estimate of the Beagle energy value (benefit) to GenCo X for CY 2008. So, Cycling⬍Advisorwas used to sum the results of hourly, 12-month unit commitment runs with and without Beagle power for several variations of a base case and four alternative scenario cases:

- Base Case:
  - CY 2008 GenCo X thermal portfolio — with and without Beagle power
- Scenario Cases:
  - Scenario 1: Near-Term Gas Price ($X/MMBtu)

[7] The only portion of the Beagle energy benefit not modeled in the Cycling⬍Advisor analyses is the beneficial effect on heat rate that Beagle creates by reducing the need for minute-by-minute fast cycling (e.g., AGC) of fossil units. This heat rate benefit is analyzed separately.

- Scenario 2: High Fuel Price and Emissions ($X/MMBtu, effects of carbon regulation)
- Scenario 3: Moderate Load Growth (demand increase of 2.5%)
- Scenario 4: Splitting of Beagle Dynamic Signal (between GenCo X and another Scheduling Entity).

### 1.2.1 Benefits for Scheduling Entity

GenCo X has the advantage of utilizing the Beagle Dynamic Signal. Many of the benefits that GenCo X can realize from Beagle power are straightforward to determine and very large. It should be understood that, if GenCo X doesn't take the benefits described below and evaluated in detail in this report, it is to GenCo X's disadvantage. Any utility that has the ability to control in real time Beagle power can seek to have the following advantages:

- Energy Benefits
  - Reduced Fuel Cost and Variable Operations and Maintenance (O&M) Costs: GenCo X's thermal plants (especially coal-fired power plants) would generate less in the presence of Beagle. For GenCo X, this displaced MWhr generation comes mostly from gas-fired plants with relatively high energy generation costs.
  - Automatic Generation Control: Intertek APTECH has found through its extensive studies of cycling and units providing AGC service that heat rates and, thus, fuel costs, increase significantly when thermal units must provide AGC and cycling. Moreover, units performing AGC (typically coal) cannot operate at their maximum capacity, resulting in an effective capacity reduction for the units and the overall fossil system. The benefit to GenCo X of reduced need for AGC on its fossil power plants is corroborated by the North American Electric Reliability Corporation (NERC)[8] audit in 2004, which states: "GenCo X often carries more than the minimum spinning reserve requirement as it uses the Beagle hydroelectric plant for most of its spinning reserve." Without Beagle, GenCo X would have to commit several expensive gas-fired units to provide spinning reserves. These units would have to often remain on-line at an inefficient minimum MW load, incurring excess fuel costs.

[8] NERC 2004 Control Area Readiness Audit – GenCo X.

- Damage Reduction: Availability of Beagle power allows GenCo X units to cycle less to control MW demand, resulting in fewer power plant forced outages now and in the future. Benefits include avoided future maintenance, capital, and forced outage cost benefits due to reduced cycling in hourly/daily dispatch and second-by-second AGC dispatch.

- Reduced Emissions or Credits: With Beagle power, GenCo X generates less from its gas and coal units and also improves power plant heat rates and efficiency. This reduced need for gas/coal unit generation and increased efficiency leads to reductions in SOx and NOx emissions from these thermal plants. Future benefits from carbon credits can be received if such regulation is put into place.

■ Capacity Benefits

- Reserve Capacity: GenCo X considers the available Beagle power as a firm contract. So GenCo X gets the advantage of not purchasing capacity or building a substitute power plant. Planned and existing wind and solar power plants are not considered firm capacity and, hence, availability of Beagle capacity provides significant current and future capacity benefits to GenCo X. It may take 2 to 3 simple-cycle gas turbines to meet the 200 to 300 MW/min load cycling capability of Beagle Dam.

### 1.2.2 Basis for Technical Approach

Intertek APTECH's technical approach and all of the scenarios investigated revolve around the primary goal of modeling accurately GenCo X thermal system with and without the Company's Beagle power to estimate its value. Intertek APTECH is an industry leader in studying the cost of cycling power plants, and its Cycling⬍Advisor program allows a traditional unit commitment model to incorporate a sophisticated damage model to determine the production cost not only in terms of fuel and variable O&M costs, but also in terms of cycling and damage costs.

Cycling⬍Advisor was utilized to model GenCo X's thermal portfolio to simulate annual 12-month, hourly dispatch of GenCo X's portfolio with and without Beagle power (for CY 2008). The analysis considered various levels of cycling costs, as well as scenarios wherein Beagle energy would be used as a hedge against natural gas price volatility. The simulations that were run for this economic analysis are listed below (also see Figure 1-2):

- **Base Case**: GenCo X Portfolio – with and without Beagle for CY 2008.
  - A: Fuel Only, indirect (i.e., wear and tear and low-load heat rate increase) cycling costs = 0
  - B: Assumed 50% of indirect cycling costs to dispatch
  - C: Assumed 100% of indirect cycling costs to dispatch
- **Scenario 1**: GenCo X Portfolio – with and without Beagle for a near-term natural gas price ($X/MMBtu).
  - A: Fuel Only, indirect cycling costs = 0
  - B: Assumed 50% of indirect cycling costs to dispatch
  - C: Assumed 100% of indirect cycling costs to dispatch
- **Scenario 2**: GenCo X Portfolio – with and without Beagle for high natural gas price ($9/MMBtu) and higher emissions cost.
  - B: Assumed 50% of indirect cycling costs to dispatch
- **Scenario 3**: GenCo X Portfolio – with and without Beagle with higher demand (2.5% higher than CY 2008).
  - B: Assumed 50% of indirect cycling costs to dispatch
- **Scenario 4**: GenCo X Portfolio – with and without Beagle with a split in the Beagle Dynamic Signal. Available Beagle capacity to GenCo X (in CY 2008) reduced by 21% and 43%, while the remaining capacity was available to another Scheduling Entity.
  - B21: Assumed 50% of indirect cycling costs to dispatch, Beagle capacity available to GenCo X reduced by approximately 21%
  - B43: Assumed 50% of indirect cycling costs to dispatch, Beagle capacity available to GenCo X reduced by approximately 43%.

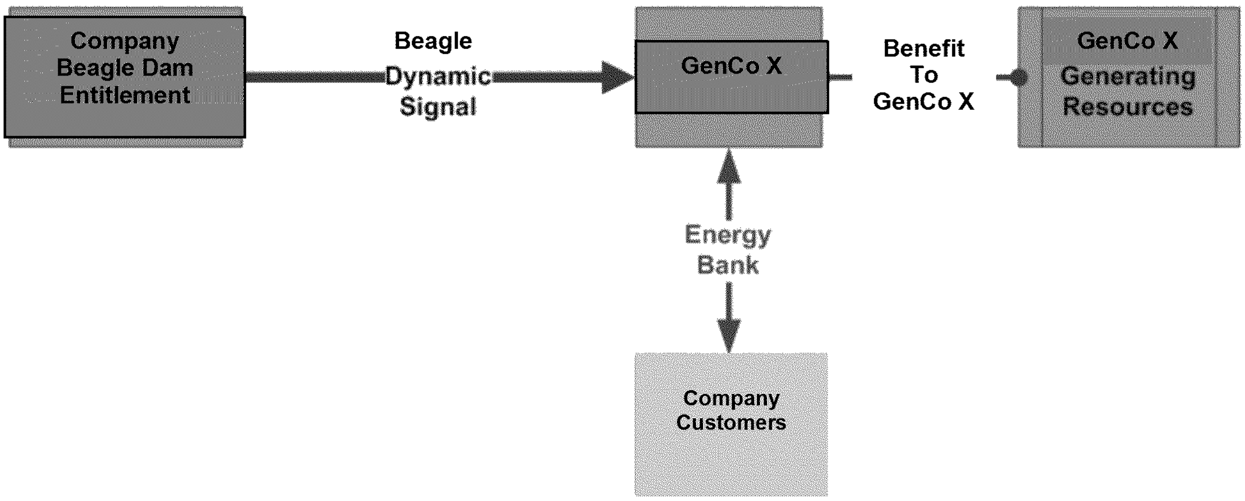


Figure 1-1 — First Level Overview of GenCo X Components.

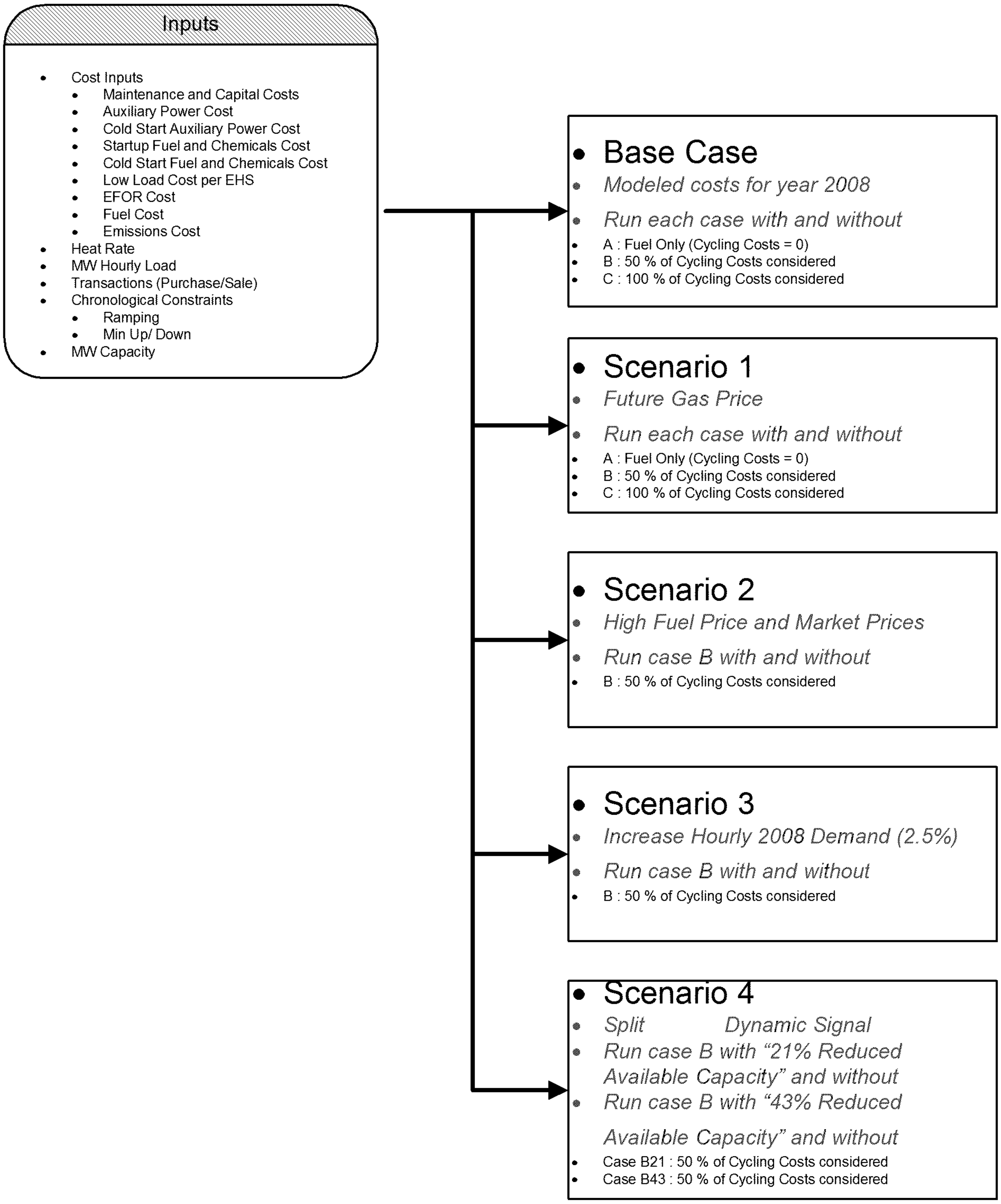


Figure 1-2 — Simulation Runs – Base Case and Scenarios.

# Section 2
# MODELING APPROACH – INPUTS AND CONSTRAINTS

Intertek APTECH analyzed the value of Beagle power from the perspective of the benefit to GenCo X and the value to Company customers of the Scheduling Entity Agreement that the Company has with GenCo X. All analyses assume that GenCo X takes advantage of the Beagle Dynamic Signal by attempting to best use the Beagle resource, along with its thermal portfolio.

In this section, background, modeling inputs, and assumptions are described for the following:

- GenCo X – An overview is provided of the utility, its generating capacity, etc., and the sources Intertek APTECH used to gather input data (Section 2.1)
- Company Customers – The Company's customers and the basic procedures used to schedule Beagle power, including energy banking, are described (Section 2.2)
- Cycling⬍Advisor – Modeling inputs and constraints are discussed (Section 2.3)
- Modeling assumptions are defined (Section 2.4)

## 2.1 GENCO X OVERVIEW AND GENERATING RESOURCES

GenCo X is one of the largest government-owned utilities in the US. The GenCo X Agricultural Improvement and Power District, a political subdivision of the State of AnyState, provides electricity and has a current generating capacity of 8,094 MW[9] and distributes power to about 934,000 homes and businesses. GenCo X dispatches its own generation assets and procures power in the wholesale market to serve its customers at the least possible cost.

[9] Peak MW generation, 2010. Source: GenCo X Website

The "base case" analysis in this report is based on CY 2008. Intertek APTECH utilized publicly available information regarding GenCo X's portfolio and the market conditions to develop the system topology within Cycling⬍ Advisor.

GenCo X's peak generation capacity in 2008 was 7,794 MW[10]. GenCo X's installed capacity is shown, by fuel type, in Figure 2-1. Baseload coal and nuclear capacity account for 32%, hydro generators (including pumped storage) represent 5%, and natural gas accounts for 38% of installed capacity.

Data specific to GenCo X system were gathered from publicly available sources, primarily the Environmental Protection Agency (EPA) database[11]. Every significant active GenCo X fossil unit in CY 2008 was explicitly included in each model. However, some units, such as the nuclear Citrus Plant unit, small hydro, and other renewable units were not included in the model. With or without Beagle, it was assumed that these non-fossil units would be used similarly. For example, they would either run baseloaded (Citrus Plant) and have little to no effect on our analysis, or would be 5 to10 MW units of small run of the river hydro or renewable units that do not dramatically impact the production cost of GenCo X system. Another reason for not including these units in the model was their lack of publicly available information.

To improve accuracy and realism, and at the Company's request, available actual data for 2008 were utilized throughout the modeling, although data from prior years were studied to understand operational characteristics. The list of units modeled in Cycling⬍ Advisoris shown in Table 2-1 and the portfolio for these, by fuel type, is shown in Figure 2-2.

## 2.2 COMPANY CUSTOMERS AND ENERGY BANK

The Company has 30 customers, consisting primarily of public power, water conservation, irrigation and electrical districts, and municipalities in AnyState. These customers are in the control area of various utilities, namely:

- AREA Power Administration (AREA)
- AnyState Public Services Company

[10] Peak MW generation, 2008. Source: ACC Summer 2008 Energy Preparedness Meeting - March 19, 2008.
[11] EPA FTP site. Hourly MW Generation, Fuel and Emissions Data - Source: ftp://ftp.epa.gov/dmdnload/emissions/hourly/.

- Electric Power Company
- AnyState Electric Power Cooperative
- GenCo X

The workflow of the energy schedule and the "energy bank" for a given month (Jan 2008) can be seen in Figure 2-3. Essentially this workflow has the following major steps:

1. AREA (not as Control Area) publishes the Beagle target schedule for energy available to Company customers.
   - AREA is designated by the Bureau of Reclamation to provide this schedule to the Company.
2. GenCo X, as the Scheduling Entity of the Company and with the control of the Beagle Dynamic Signal, receives this published energy target schedule on a periodic basis.
3. Company provides its customers' scheduling requirements to GenCo X to schedule on their behalf.
4. GenCo X submits its own scheduling requirements for Beagle to AREA.
   - GenCo X uses the Beagle Dynamic Signal to meet its own system requirements, which includes that of the Company customers' requirements.
5. Any difference between the Beagle target schedule "published" by AREA and the "requested" schedule of the Company customers to GenCo X (energy target) creates an energy bank.
   - GenCo X has a negative energy bank when the Company customers schedule more power (typically for irrigation needs) than is available from Beagle; this occurs primarily in summer months. GenCo X has to serve these customers as if they were its own load.
   - GenCo X has a positive energy bank in all other months. This positive energy bank can be used by GenCo X to its advantage.

The "net" energy bank at the end of each operating year should be zero. Hence, all of the positive energy banked power has to be paid back by GenCo X to the Company customers by the end of the operating year. Moreover, GenCo X must follow guidelines set up for the efficient operation of Beagle Dam. Hence, in most hours, GenCo X is obligated to take the minimum generation from Beagle Dam and has to adequately plan for this. GenCo X uses this generation to meet its system requirements and has to credit the Company and its customers for the energy on an end-of-month basis.

Therefore, GenCo X uses Beagle generation like its own generating resource. GenCo X also serves the Company customer load as if that load were its own in the times of energy bank "payback". Intertek APTECH determined the value of Beagle power to GenCo X, as well as the value of this energy bank to Company customers. The usage of Beagle generation and the payback by GenCo X was modeled within Cycling⬍Advisor, including the monthly generation exchanges and the monthly purchase prices.

## 2.3 CYCLING ADVISOR INPUTS AND CONSTRAINTS

GenCo X's generation assets to meet the load and ancillary service requirements were modeled and optimized using Cycling⬍Advisor (see key inputs in Tables 2-1, 2-2, and 2-3). The application produces a generation schedule that minimizes the cost of meeting these requirements, and maximizes the profit from energy sales, considering the portfolio constraints and the market depth. The base case configuration and base data were configured to model GenCo X's portfolio for CY 2008, considering all fundamental asset and portfolio characteristics, including:

- Chronological constraints:
  - Minimum up/down time (hours)
  - Ramp rates (MW/hour)
- Unit characteristics
  - Minimum/maximum capacity (MW)
  - Unit heat rate characteristics (MMBtu/MWhr)

- Fuel characteristics
  - Fuel costs ($/MMBtu) (annual average)
- Energy market price forecast
  - Purchase/sale price functions ($/MWhr)
- Other costs
  - Low- and variable-load cycling costs ($/EHS[12])
  - Equivalent forced outage rate (EFOR) cost ($/EHS)
  - Maintenance and capital costs ($/EHS); these include equipment wear and tear costs associated with all steady loading and all cycling transients as a function of their load swings, ramp rates, and for startups the prior down time (e.g., hot vs. warm vs. cold starts).
  - Startup and auxiliary power costs ($/Start)
    - Cold start (fuel + chemicals)
    - Hot\warm start (fuel + chemicals)
  - Ramp rate cost curve
- System constraints
  - Hourly MW load demand
  - Ancillary services requirements (e.g., 3% spinning reserve requirement)

Note that the inputs, analysis, and results are presented in constant 2008 dollars, unless otherwise stated.

[12] EHS is an acronym for "Equivalent Hot Start," which is Intertek APTECH's unit of cycling intensity. One normal (gentle) hot start and shutdown cycle would produce about one EHS. One abrupt hot start with especially damaging ramp rates and other load range characteristics would produce well over 1 EHS, as would most warm starts and all cold starts. The usually more numerous load follow cycles each typically produce a small fraction of an EHS.

The primary objective of this project was to simulate operational and market constraints of CY 2008, for the base case. To keep the analysis as realistic as possible, the majority of the input data described above were gathered from published publicly available sources. "Actual" CY 2008 hourly MW generation data for GenCo X units and Beagle were used in the analysis. To account for unavoidable outages, a thorough analysis of the actual past MW data was conducted and was modeled in each of the simulations.

Intertek APTECH also looked at CY 2008 market conditions and fuel prices to determine inputs for the model. Since GenCo X does not publish any of its wholesale transaction data, the market transaction prices were based on the Citrus Plant power index. Monthly nonlinear curves (price as a function of hourly demand) were modeled into Cycling⬍Advisor to capture CY 2008 purchase and sale prices for the base case and most scenarios. However, for Scenario 2, High Fuel Price and Emission Costs, these market prices were inflated to adequately account for the increase in price due to fuel cost. For Scenario 1, Near-Term Gas Price, the model accounted only for a lower natural gas price without changing any market conditions or demand.

For the majority of on-peak hours, GenCo X's gas-fired generators were the marginal units[13]. Economic efficiency dictates that generating resources be ordered from lowest cost to highest required to serve load. Cycling⬍Advisor ensures that the simulated GenCo X runs its plants per the least-cost dispatch principle. Since the price an electric generator pays for fuel is a variable cost of dispatch, a generator needs to recover this cost from the prevailing electric power market, and Cycling⬍Advisor accurately accounts for the market conditions and fuel costs.

## 2.4 MODELING ASSUMPTIONS

One of the constraints of this study was having only publicly available data to use as inputs to the models. Moreover, GenCo X does not report its wholesale purchase/sale transactions to the Federal Energy Regulatory Commission (FERC) and, hence, transaction inputs had to be based on the Citrus Plant power price index and other public information. The following subsections outline the assumptions made to model GenCo X system to evaluate value of Beagle power.

[13] The offer price to an electricity market in $/MWh of the last power plant ("marginal power plant") required to satisfy the demand determines the market price for all the other power stations.

### 2.4.1 General Assumptions

- To determine the value of Beagle power to reduce 2008 GenCo X generation costs, GenCo X's fossil units were modeled in Cycling⇕Advisor as follows:

  - First, GenCo X fossil system with Beagle power was modeled.

  - Next, the model was repeated without Beagle power; that is, assuming no Beagle signal or generation was available to GenCo X.

  - The cost differences between the with- and without-Beagle GenCo X fossil fleet models provide the estimated Beagle energy benefits to reduce production costs of the hourly dispatch for all of 2008.

  - All results reported relied mainly on 12 full-month unit commitment runs. Other simulations run with varying granularity gave similar results for the Beagle energy benefit estimate:

    - One full-year run

    - Four quarterly runs

    - Four 10-day periods, scaled up to all of 2008 (as originally proposed to the Company).

  - Other proprietary Unit Commitment models (such as PROSYM and PROMOD) resulted in comparable Beagle value when indirect cycling costs were ignored.

- It was assumed that the usage of the non-fossil GenCo X generation units (such as nuclear generation, other hydro generation, wind and solar power, and other renewable energy, etc.) would be unaffected by the presence or absence of Beagle power.

### 2.4.2 System Demand and Market Transactions

- Using hourly EPA MW data, with-Beagle and without-Beagle demand was calculated using the equations in Appendix A, which also shows several results of the demand calculation.

- A case of uniform around-the-clock GenCo X energy banking "payback" was assumed, as described in Appendix A.

- Net MW power plant capacity (rating) was used to model demand and fossil unit capacity.

  - From other studies, it was estimated that net MW is 6.6% lower than gross MW for coal units and 3.5% lower for gas ones.

  - To ensure accuracy, the net MW power plant capacity used in Cycling⬍ Advisor modeling was verified with GenCo X Integrated Resource Plan provided by the Company.

- It was assumed GenCo X fossil system required a spinning reserve of 3%.

- GenCo X's purchase price for every hour in 2008 was estimated using regression of the Citrus Plant power price index data for all monthly peak and off-peak periods.

- The market clearing prices were analyzed with respect to the market transaction data of other utilities in the region that are GenCo X counterparties. These utilities report this information to FERC.

- Several sales price assumptions were input into the model; however, they did not materially impact the Beagle value results. The simulations reported herein assumed a 15% difference between marketplace sales and purchase prices each hour.

### 2.4.3 Fuel and Auxiliary Power Costs

- Fuel costs are dominated by baseload operation at or near full unit capacity.

- Primarily[14], GenCo X's fuel costs are based on the heat rate analysis in Appendix B.

- Cycling generally increases fuel and power costs, starting with startup fuel and auxiliary power consumption.

[14] The exception being the effects of AGC operation on heat rate and fuel costs, as discussed in Section 2.4.5.

- There are also significant low-load and variable-load cycling extra fuel costs, and these were estimated using a cycling heat rate analysis of GenCo X's actual fuel usage and generation data (see Appendix B).

- Fuel and emission costs are summed and documented in Appendix B. Table 2-3 shows the total costs used in the various cases.

- Sensitivity runs are included to explore significant deviations from the CY 2008 averages.

### 2.4.4 Cycling Costs

- Cycling costs (excluding the low-load and variable-load heat rate effects above) were estimated for each GenCo X power plant using Intertek APTECH's benchmark methodology against appropriate units.

    - The method used for benchmarking power plant maintenance and other cycling costs is analogous to that used by an appraiser estimating the value of a home (i.e., making heavy use of reliable data on comparable homes and then accounting for differences between comparable and target homes).

### 2.4.5 Unit Operation

- GenCo X fossil unit loading capabilities (specifically their capacities, maximum ramp rates, minimum loads, and minimum shutdown and online periods) were estimated from context (EPA hourly MW data) and experience with similar units.

- AGC data on a large coal unit similar to those at GenCo X were used to estimate how much the Beagle signal reduces GenCo X's need for AGC.

    - It was calculated that the Beagle Dynamic Signal reduces the need for AGC in at least three large coal units with a total capacity of 1,600 MW (see Figure 2-4).

- Analysis of a similar large coal power plant under AGC showed a 6% reduction in effective capacity compared with operation with no AGC. It was conservatively assumed that GenCo X's units under AGC would have 5% capacity reductions.
- For conservatism, it was also assumed that units totaling about 1,400 MW capacity, rather than 1,600 MW, would need to use AGC in Beagle's absence.

■ The AGC analysis considered only two, key, avoided-cost components (whose significance is discussed in Prowse, et al.[15]):

- The extra fuel costs due to rapid AGC load variations
- The costs associated with reduced capacity of any units under AGC

■ AGC extra fuel costs were analyzed separately from the Cycling⬍ Advisor runs and are documented in detail in Appendix C (AGC Fuel Cost Effects).

■ The cost of reduced capacity due to use of Beagle generation to avoid AGC was estimated several ways. Specifically, several different combinations of units that would add AGC in Beagle's absence were assumed.

■ All reasonable alternatives produced large and similar economic results.

[15] Prowse, D. C. H., P. Koskela, T. A. Grove, and L. R. Larson, "Experience With Joint AGC Regulation", *IEEE Transactions on Power Systems*, Vol. 9, No. 4, November 1994, pp. 1974–1979.

## Table 2-1

## GenCo X THERMAL PORTFOLIO

| Thermal Generation System - 2008 | | | | | |
|---|---|---|---|---|---|
| PLANT | NUMBER OF UNITS | TOTAL CAPACITY ( GROSS MW) | [redacted] SHARE OF CAPACITY (%) | [redacted] CAPACITY (MW) | FUEL TYPE |
| Intentionally Deleted | 3 | 410 | 100 | 410 | Gas |
| | 1 | 593 | 100 | 593 | GAS |
| | 1 | 264 | 100 | 264 | GAS |
| | 2 | 593 | 100 | 593 | GAS |
| | 1 | 292 | 100 | 292 | GAS |
| | 2 | 877 | 100 | 877 | COAL |
| | 2 | 1640 | 10 | 164 | COAL |
| | 1 | 262 | 50 | 131 | COAL |
| | 3 | 2250 | 21.7 | 488.25 | COAL |
| | 3 | 1283 | 29 | 372.07 | COAL |
| | | | Total Capacity (modeled) = | **4184.32** | |

## Table 2-2

### CYCLING◆ ADVISOR COST INPUTS

| Unit(s) | % Own | Maintenance and Capital Cost per EHS | Auxiliary Power Cost | Cold Start Auxiliary Power Cost | Startup Fuel + Chemicals per Start | Cold Start Fuel + Chemicals | Varying & Low-load cost per EHS | EFOR Cost per EHS | Base Load heat rate |
|---|---|---|---|---|---|---|---|---|---|
| s4 | 10% | | | | | | | Confidential | 10395 |
| s5 | 10% | | | | | | | Confidential | 10395 |
| =1 | 100% | | | | | | | Confidential | 10291 |
| =2 | 100% | | | | | | | Confidential | 10291 |
| =3 | 100% | | | | | | | Confidential | 10291 |
| ɔ1 | 100% | | | | | | | Confidential | 10500 |
| ɔ2 | 100% | | | | | | | Confidential | 10500 |
| 31 | 100% | | | Intentionally Deleted | | | | Confidential | 10291 |
| 32 | 100% | | | | | | | Confidential | 10291 |
| ə7 | 100% | | | | | | | Confidential | 10291 |
| ɔ1 | 22% | | | | | | | Confidential | 9975 |
| ɔ2 | 22% | | | | | | | Confidential | 9975 |
| ɔ3 | 22% | | | | | | | Confidential | 9975 |
| 5A | 100% | | | | | | | Confidential | 10291 |
| 5B | 100% | | | | | | | Confidential | 10291 |
| 5A | 100% | | | | | | | Confidential | 10291 |
| j1 | 29% | | | | | | | Confidential | 10395 |
| j2 | 29% | | | | | | | Confidential | 10395 |
| j3 | 29% | | | | | | | Confidential | 10395 |
| Hayden2 | 50% | | | | | | | Confidential | 10395 |

## Table 2-3

### TOTAL FUEL AND EMISSION COST INPUTS

| | Coal Cost ($/MMBTU) | Emissions Cost ($/MMBTU) | Total Fuel Cost - Coal | NG Cost ($/MMBTU) | Emissions Cost ($/MMBTU) | Total Fuel Cost |
|---|---|---|---|---|---|---|
| Base Case | | | | | | |
| Scenario 1 | | | | | | |
| Scenario 2 | | | Intentionally Deleted | | | |
| Scenario 3 | | | | | | |
| Scenario 4 | | | | | | |

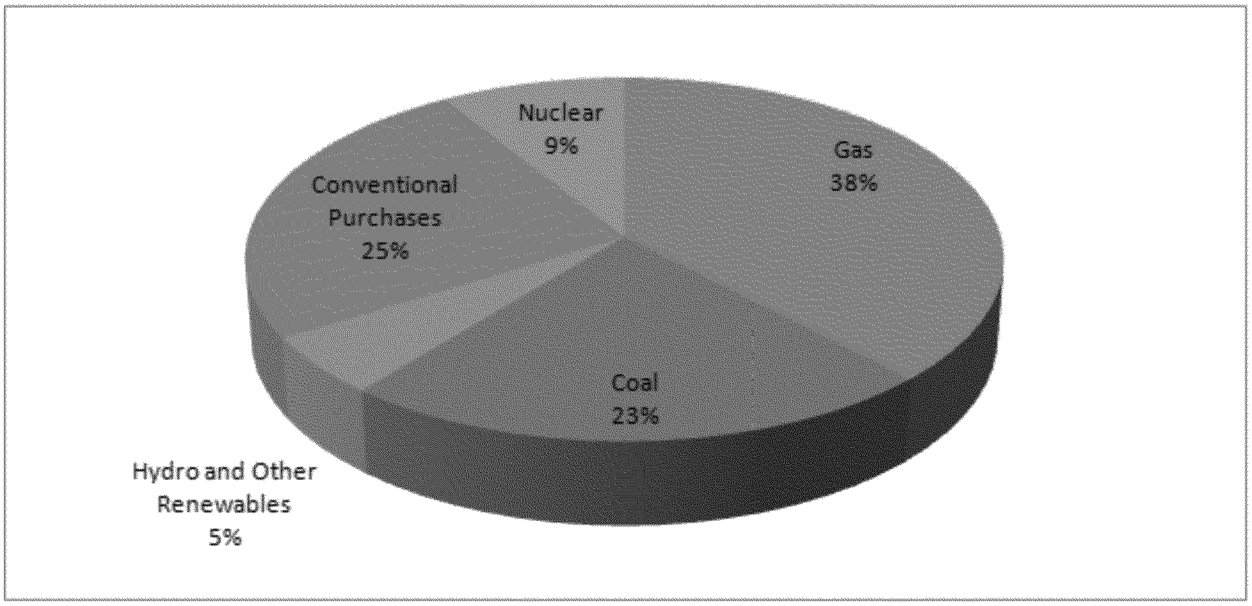


Figure 2-1 — GenCo X Total Portfolio (2008, Actual Total Installed Capacity[16]).

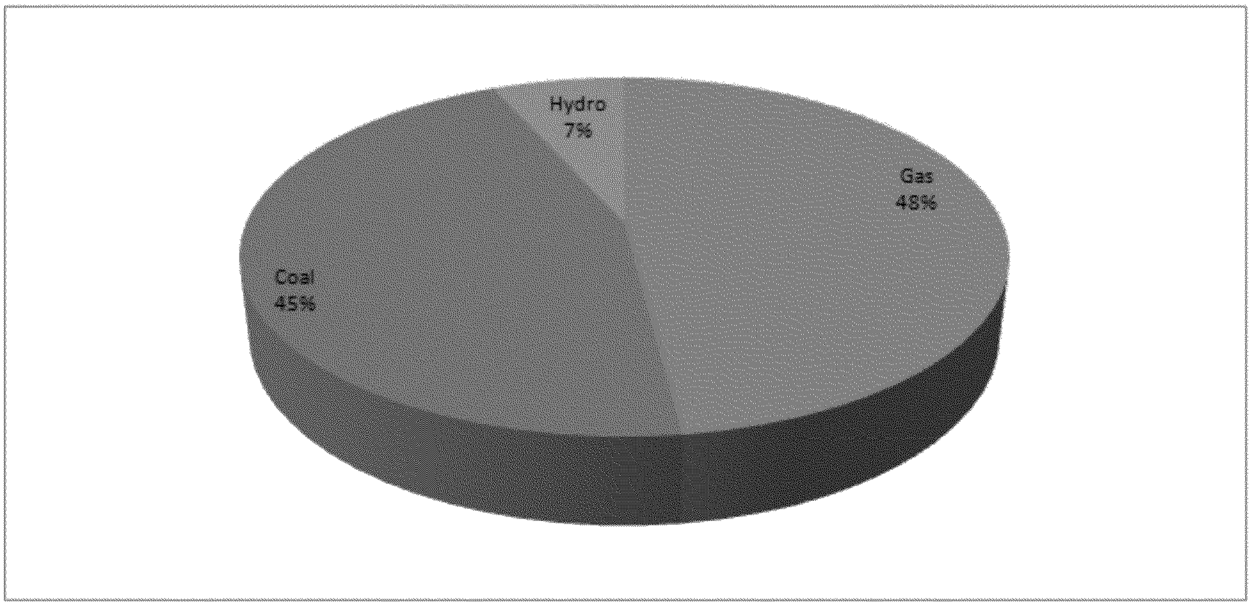


Figure 2-2 — GenCo X Portfolio, as Modeled (2008, Percent Installed Capacity for Units Modeled).

[16] SRP Summer Preparedness presentation to Arizona Corporation Commission (2008).

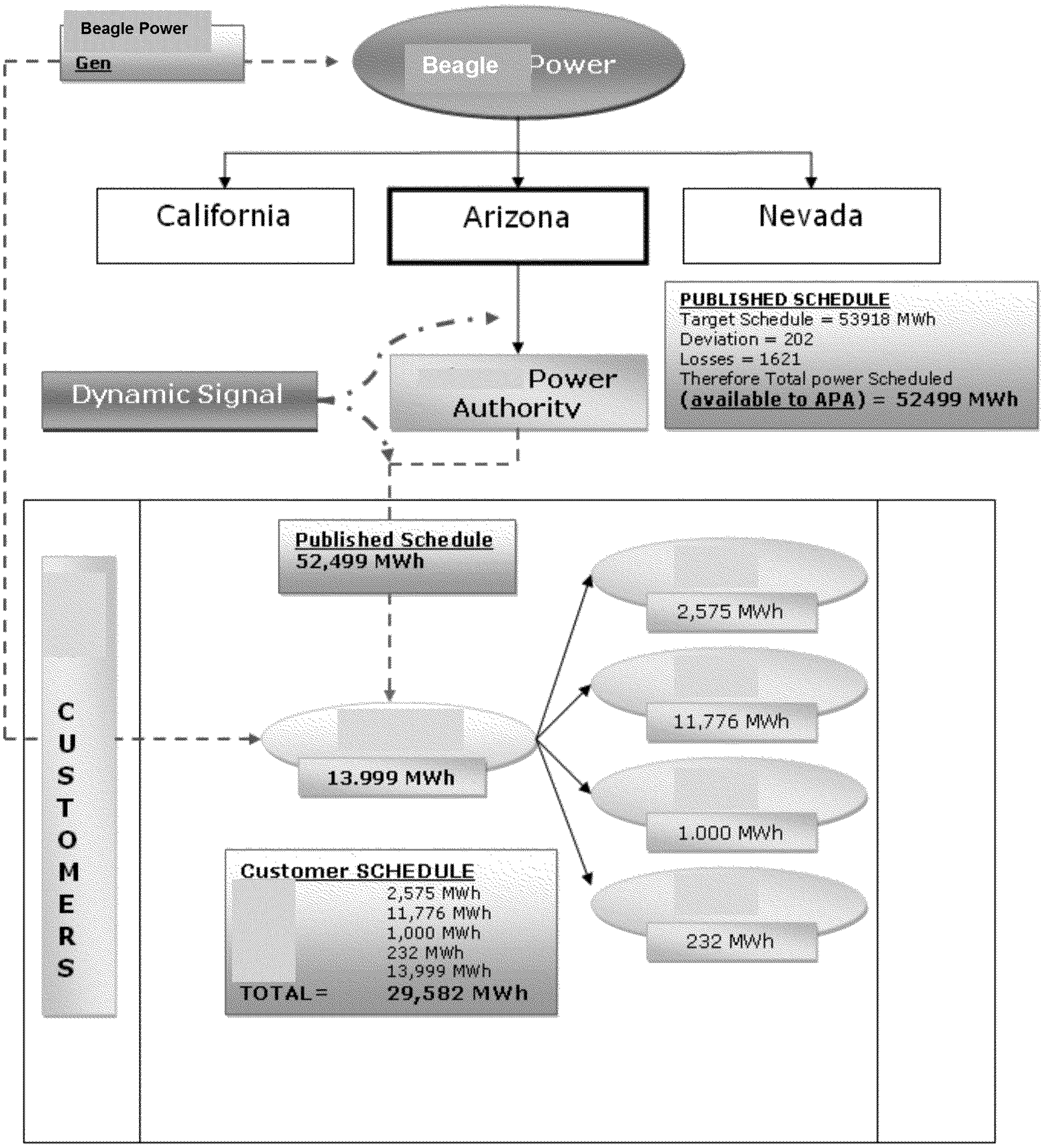


Figure 2-3 — Beagle Scheduling and Energy Bank Workflow (in January 2008).

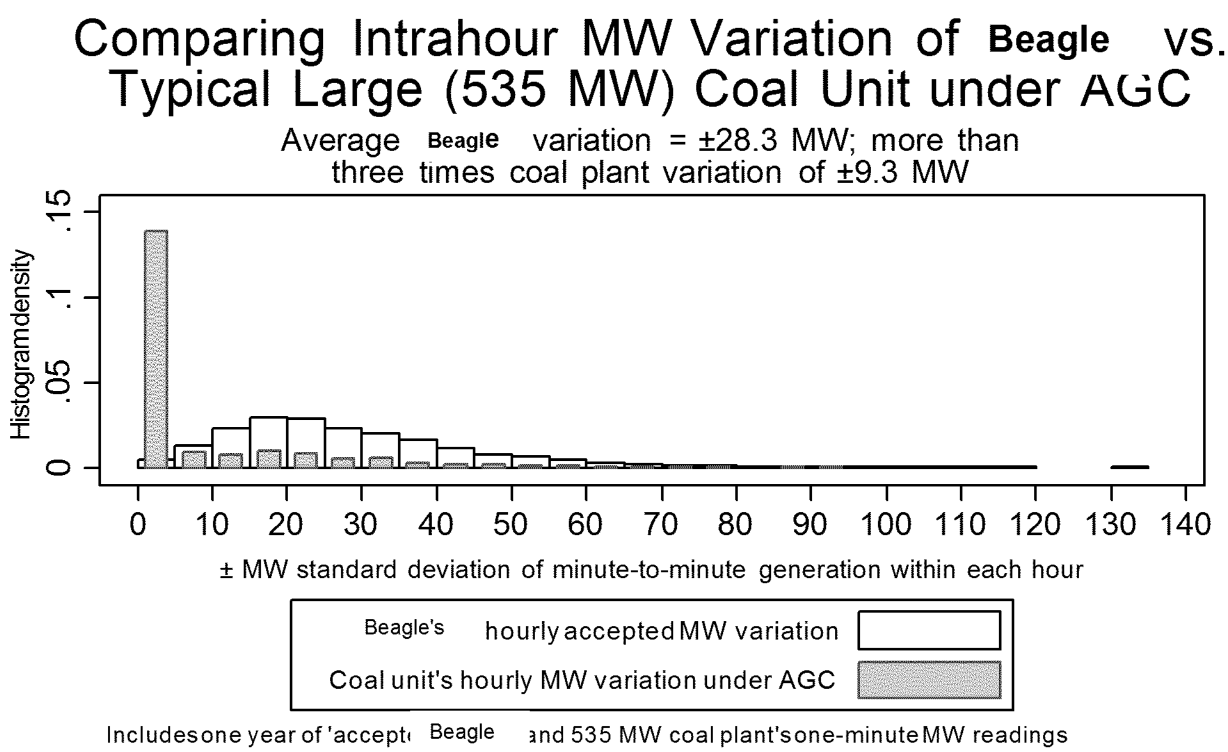


Figure 2-4 — Demonstrating Beagle's Ability to Avoid AGC at Three 535 MW Coal Units.

# Section 3

# BASE CASE ANALYSIS – VALUE OF BEAGLE ENERGY

Intertek APTECH estimated the economic benefits of Beagle power for GenCo X thermal portfolio for CY 2008 as the "base case". This section presents the modeling overview, summary results, and conclusions with respect to the energy benefits for the base case only (the sensitivity analysis is presented in Section 4). Note that the inputs, analysis, and results are presented in constant 2008 dollars.

The modeling approach for the base case is defined in the following sections:

- Base Case – Overview and Problem Formulation (Section 3.1)
- Results (Section 3.2)
- Conclusions (Section 3.3)

## 3.1 BASE CASE – OVERVIEW AND PROBLEM FORMULATION

GenCo X, as the current operator of the Beagle Dynamic Signal, schedules Beagle power on behalf of the Company's customers. As discussed in Section 2.2, GenCo X and the Company create an "energy bank" each month, with the caveat that the net energy bank for the year is zero. For CY 2008, the maximum energy "banked" by Company customers was in the month of May (approximately 183 gigawatt-hour (GWhr)). Intertek APTECH modeled these unique constraints in Cycling⬍Advisor and compared the "with" and "without" Beagle simulations for each of three base cases, accounting for varying levels of cycling cost inputs:

- A: Fuel Only, cycling costs[17] = 0

[17] Models were executed to account for various levels of cycling costs — 0%, 50%, and 100% — of what are thought to be GenCo X's actual cycling costs. Cycling⬍Advisor keeps track of (1) minimized conservative costs, which omit a specified percentage of the actual cycling costs; and, (2) actual costs, which include 100% of cycling costs. Indirect cycling costs are maintenance, capital, and forced outage costs due to wear and tear on equipment. Direct cycling costs are for startup fuel and auxiliary power.

- B: Assumed 50% of indirect cycling costs to dispatch
- C: Assumed 100% of indirect cycling costs to dispatch

Intertek APTECH chose these three cases to bound uncertainty in GenCo X's perception and accounting of indirect cycling costs in its dispatch decisions. All cases were modeled to determine the total production cost of GenCo X portfolio, which includes: baseload fuel use, direct startup costs, low-load fuel use, wear and tear effects, and purchase and sale transactions.

An important consideration for Intertek APTECH was to determine the value of Beagle to GenCo X at various levels of indirect cycling cost inputs. Since many utilities do not account for some or all of these indirect cycling costs in their economic dispatch analysis, it was important to ensure that the analysis covered the entire spectrum of cycling cost inputs. Moreover, every run also outputs the minimized input costs and "actual" costs. Cycling⬍Advisor minimizes the input cost and recognizes the possibility of GenCo X accounting for some percentage of the cycling costs, whereas the "actual cost" is the cost that Intertek APTECH believes should be close to the true cost of cycling. Each of the simulations produces cost outputs for both the input and the "actual" costs.

## 3.2 RESULTS

Figures 3-1, 3-2, and 3-3 show the net monthly benefit of Beagle power ("with" vs. "without" Beagle) and the net monthly generation in GWhr received from Beagle. Note that in the without-Beagle case, GenCo X does not have any obligation to the energy bank payback. This is why both Beagle GWhr and energy benefit value are significantly negative in late summer months. In August, and especially in September, GenCo X must pay back far more energy than it uses from Beagle, and when power prices are highest. In July, Beagle value is near zero, even though GenCo X pays back significantly more GWhr than it receives from Beagle. This is because, as emphasized throughout this report, the highly responsive 4-second Beagle signal produces benefits far beyond simple GWhr value, most notably the ability to avoid AGC in most GenCo X coal units.

Tables 3-1 through 3-6 break down six component costs by month for each model run, and are discussed in more detail below. The Beagle energy[18] value to GenCo X ranged from $XX.XX million to $XX.XX million; therefore, the amount of cycling accounted for in unit commitment decisions had less than a 10% impact on Beagle energy value.

It is clear that the baseload fuel cost dominates, along with the purchase and sale transactions. Still, the other costs play a significant role. Note that when wear and tear and low-load fuel cycling costs are not accounted for, the "actual" value of Beagle is higher than minimized output costs. Without Beagle, GenCo X incurs higher costs due to wear and tear and low-load fuel costs.

### 3.2.1 Base Case A

For the fuel-only case, the net Beagle benefit to GenCo X is $XX.X million for CY 2008. The "actual" net Beagle benefit to GenCo X is about $XX>X million. Tables 3-1 and 3-2 (results of the with- and without-Beagle runs, respectively, for Case A) show the monthly costs and purchase and sale transactions output from Cycling⬍Advisor. By definition, Case A does not account for indirect cycling costs within Cycling⬍Advisor. So, the wear and tear and the low-load fuel costs for each of the months in Tables 3-1 and 3-2 are zero, whether the Beagle signal is available or not.

Even though the total baseload fuel cost in the without-Beagle case is marginally lower than in the with-Beagle case (about $X million), the simulation from Cycling⬍Advisor suggests that net purchase and sales transactions are much higher without Beagle, primarily because of the reduced coal unit capacity due to their without-Beagle AGC obligations. To make up for this reduced capacity, the Case A simulation shows that GenCo X is more likely to purchase available power than to use its expensive gas units.

For comparison with Base Cases B and C, note that the actual cycling costs for low-load fuel and wear and tear in Tables 3-1 and 3-2 are $XX million and $XX million, respectively.

[18] See Section 5 of this report for an estimate of Beagle's capacity value.

### 3.2.2 Base Case B

Base Case B models the same portfolio and system topology as in the previous case, but accounts for what Intertek APTECH believes is half the value of "actual" indirect cycling costs. Hence, the input for the cycling-related costs is modified so that the indirect cost of cycling is half (50%) of the actual costs.

Beagle benefit to GenCo X is about $XX.X million (for CY 2008). The value increases slightly, to $XX.XX million, if the actual costs of cycling are accounted for. Tables 3-3 and 3-4 show the various monthly costs. The annual wear and tear costs and the low-load fuel costs are $X.XX million and $X.XX million, respectively, for the with-Beagle case. Without Beagle, both of these costs are higher, the former being $X.XX million and the latter about $X.X million. The actual costs are obviously twice the minimized output costs for both wear and tear and low-load fuel costs; namely, about $XX million or $XX million for either Case B simulation. Recall that actual indirect cycling costs were $XX million to $XX million for Case A. By accounting for half the cycling costs in load dispatch, over $XX million in actual cycling costs are prevented. Thus, accounting for as little as half the cycling costs is a profitable decision.

### 3.2.3 Base Case C

Base Case C accounts for 100% of cycling costs and, therefore, the minimized output and actual cycling-related costs are the same. Tables 3-5 and 3-6 provide details of the total production costs and cycling costs for the with- and without-Beagle cases. The Beagle energy benefit value in this case was estimated to be $XX.X million for CY 2008. The Beagle value to GenCo X does not vary much between Case C and Case B (where the model ignored half the cycling costs). The total costs in the with-Beagle case were estimated to be $XXX.XX million and in the without-Beagle case, $XXX.XX million. The difference largely can be attributed to the added purchases that the simulated GenCo X portfolio made when Beagle was unavailable to handle AGC and other fast cycling duties. Instead, these duties were transferred to GenCo X's coal units so that they had to run at reduced capacity to have the dynamic response capability and, thus, produce less low-cost energy.

Finally, note that total actual costs for Case C are nearly identical to those of Case B, with or without Beagle, so accounting for the "last half" of cycling costs has little impact.

## 3.3 CONCLUSIONS

The base case uses actual Beagle generation and GenCo X payback input for CY 2008. The fuel costs were the major costs incurred, and the change in value of Beagle energy from case to case remained in a small range. The key conclusions from this analysis are as follows:

- The energy benefit of Beagle from case to case was within a relatively small range of $XX.X million and $XX.X million.
- The actual energy benefit of Beagle from case to case, taking into account all direct and indirect costs, was within a relatively small range of $XX.X million and $XX.X million.
- If all indirect cycling costs were ignored, then the with- or without-Beagle analysis resulted in about a $XX million loss.
- Still, there is a relatively small penalty for ignoring half of the true indirect costs of cycling.

The net result of the three base cases is summarized in the table below. These results are based on the power being dispatched so as to minimize the input costs. For Base Case A, input cost includes no low-load fuel or wear and tear; for Case B it includes 50% of the low-load fuel and wear and tear costs; and, for Case C it includes 100% of the low-load fuel and wear and tear costs. However, it is important to note that the actual savings in the table below are based on 100% of low-load fuel and wear and tear costs for all three cases. This gives the reader a snapshot view of the small effect on total actual savings of including these additional expenses in the dispatching cost algorithm.

**Summary of Base Case Results with Net Energy Savings Based on Total Actual Costs Which Include Low Load Fuel and Wear and Tear**

| Case | Net "Actual" Energy Savings for [redacted] ($ Millions ) |
|---|---|
| Base Case A - Without Low-Load Fuel and Wear and Tear Costs Included in Dispatch | |
| Base Case B - With 50% of Low-Load Fuel and Wear and Tear Costs Included in Dispatch | |
| Base Case C - With 100% of Low-Load Fuel and Wear and Tear Costs Included in Dispatch | |

## Table 3-1

### BASE CASE A, WITH BEAGLE (CYCLING⬍ ADVISOR OUTPUT)

| Base Case A, With [redacted] | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Minimized (Optimal) Costs ($ M) | | | | | | | Total Actual Costs ($ M) | | | | | | |
| Month | Baseload Fuel | Low-Load Fuel | Wear & Tear | Startup Fuel & Aux. Power | Purchases | Sales | **Total** | Baseload Fuel | Low-Load Fuel | Wear & Tear | Startup Fuel & Aux. Power | Purchases | Sales | **Total** |
| Jan | | | | | | | | | | | | | | |
| Feb | | | | | | | | | | | | | | |
| Mar | | | | | | | | | | | | | | |
| Apr | | | | | | | | | | | | | | |
| May | | | | | | | | | | | | | | |
| Jun | | | | | | | | | | | | | | |
| Jul | | | | | | | | INTENTIONALLY DELETED | | | | | | |
| Aug | | | | | | | | | | | | | | |
| Sep | | | | | | | | | | | | | | |
| Oct | | | | | | | | | | | | | | |
| Nov | | | | | | | | | | | | | | |
| Dec | | | | | | | | | | | | | | |
| **Total** | | | | | | | | | | | | | | |

## Table 3-2

### BASE CASE A, WITHOUT BEAGLE (CYCLING⬍ ADVISOR OUTPUT)

| Base Case A, Without [redacted] | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Minimized (Optimal) Costs ($ M) | | | | | | | Total Actual Costs ($ M) | | | | | | |
| Month | Baseload Fuel | Low-Load Fuel | Wear & Tear | Startup Fuel & Aux. Power | Purchases | Sales | **Total** | Baseload Fuel | Low-Load Fuel | Wear & Tear | Startup Fuel & Aux. Power | Purchases | Sales | **Total** |
| Jan | | | | | | | | | | | | | | |
| Feb | | | | | | | | | | | | | | |
| Mar | | | | | | | | | | | | | | |
| Apr | | | | | | | | | | | | | | |
| May | | | | | | | | | | | | | | |
| Jun | | | | | | | | | | | | | | |
| Jul | | | | | | | | INTENTIONALLY DELETED | | | | | | |
| Aug | | | | | | | | | | | | | | |
| Sep | | | | | | | | | | | | | | |
| Oct | | | | | | | | | | | | | | |
| Nov | | | | | | | | | | | | | | |
| Dec | | | | | | | | | | | | | | |
| **Total** | | | | | | | | | | | | | | |

<u>Table 3-3</u>

**BASE CASE B, WITH BEAGLE (CYCLING◆ ADVISOR OUTPUT)**

| Base Case B, With [redacted] | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Minimized (Optimal) Costs ($ M) | | | | | | | Total Actual Costs ($ M) | | | | | | |
| Month | Baseload Fuel | Low-Load Fuel | Wear & Tear | Startup Fuel & Aux. Power | Purchases | Sales | **Total** | Baseload Fuel | Low-Load Fuel | Wear & Tear | Startup Fuel & Aux. Power | Purchases | Sales | **Total** |
| Jan | | | | | | | | | | | | | | |
| Feb | | | | | | | | | | | | | | |
| Mar | | | | | | | | | | | | | | |
| Apr | | | | | | | | | | | | | | |
| May | | | | | | | | | | | | | | |
| Jun | | | | | | | | | | | | | | |
| Jul | | | | | | | INTENTIONALLY DELETED | | | | | | | |
| Aug | | | | | | | | | | | | | | |
| Sep | | | | | | | | | | | | | | |
| Oct | | | | | | | | | | | | | | |
| Nov | | | | | | | | | | | | | | |
| Dec | | | | | | | | | | | | | | |
| **Total** | | | | | | | | | | | | | | |

<u>Table 3-4</u>

**BASE CASE B, WITHOUT HOOVER (CYCLING◆ ADVISOR OUTPUT)**

| Base Case B, Without [redacted] | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Minimized (Optimal) Costs ($ M) | | | | | | | Total Actual Costs ($ M) | | | | | | |
| Month | Baseload Fuel | Low-Load Fuel | Wear & Tear | Startup Fuel & Aux. Power | Purchases | Sales | **Total** | Baseload Fuel | Low-Load Fuel | Wear & Tear | Startup Fuel & Aux. Power | Purchases | Sales | **Total** |
| Jan | | | | | | | | | | | | | | |
| Feb | | | | | | | | | | | | | | |
| Mar | | | | | | | | | | | | | | |
| Apr | | | | | | | | | | | | | | |
| May | | | | | | | | | | | | | | |
| Jun | | | | | | | | | | | | | | |
| Jul | | | | | | | INTENTIONALLY DELETED | | | | | | | |
| Aug | | | | | | | | | | | | | | |
| Sep | | | | | | | | | | | | | | |
| Oct | | | | | | | | | | | | | | |
| Nov | | | | | | | | | | | | | | |
| Dec | | | | | | | | | | | | | | |
| **Total** | | | | | | | | | | | | | | |

## Table 3-5

### BASE CASE C, WITH BEAGLE (CYCLING♦ ADVISOR OUTPUT)

| Base Case C, With [redacted] | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Minimized (Optimal) Costs ($ M) | | | | | | | Total Actual Costs ($ M) | | | | | | |
| Month | Baseload Fuel | Low-Load Fuel | Wear & Tear | Startup Fuel & Aux. Power | Purchases | Sales | **Total** | Baseload Fuel | Low-Load Fuel | Wear & Tear | Startup Fuel & Aux. Power | Purchases | Sales | **Total** |
| Jan | | | | | | | | | | | | | | |
| Feb | | | | | | | | | | | | | | |
| Mar | | | | | | | | | | | | | | |
| Apr | | | | | | | | | | | | | | |
| May | | | | | | | | | | | | | | |
| Jun | | | | | | | | | | | | | | |
| Jul | | | | | | | INTENTIONALLY DELETED | | | | | | | |
| Aug | | | | | | | | | | | | | | |
| Sep | | | | | | | | | | | | | | |
| Oct | | | | | | | | | | | | | | |
| Nov | | | | | | | | | | | | | | |
| Dec | | | | | | | | | | | | | | |
| **Total** | | | | | | | | | | | | | | |

## Table 3-6

### BASE CASE C, WITHOUT BEAGLE (CYCLING♦ ADVISOR OUTPUT)

| Base Case C, Without [redacted] | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Minimized (Optimal) Costs ($ M) | | | | | | | Total Actual Costs ($ M) | | | | | | |
| Month | Baseload Fuel | Low-Load Fuel | Wear & Tear | Startup Fuel & Aux. Power | Purchases | Sales | **Total** | Baseload Fuel | Low-Load Fuel | Wear & Tear | Startup Fuel & Aux. Power | Purchases | Sales | **Total** |
| Jan | | | | | | | | | | | | | | |
| Feb | | | | | | | | | | | | | | |
| Mar | | | | | | | | | | | | | | |
| Apr | | | | | | | | | | | | | | |
| May | | | | | | | | | | | | | | |
| Jun | | | | | | | | | | | | | | |
| Jul | | | | | | | INTENTIONALLY DELETED | | | | | | | |
| Aug | | | | | | | | | | | | | | |
| Sep | | | | | | | | | | | | | | |
| Oct | | | | | | | | | | | | | | |
| Nov | | | | | | | | | | | | | | |
| Dec | | | | | | | | | | | | | | |
| **Total** | | | | | | | | | | | | | | |

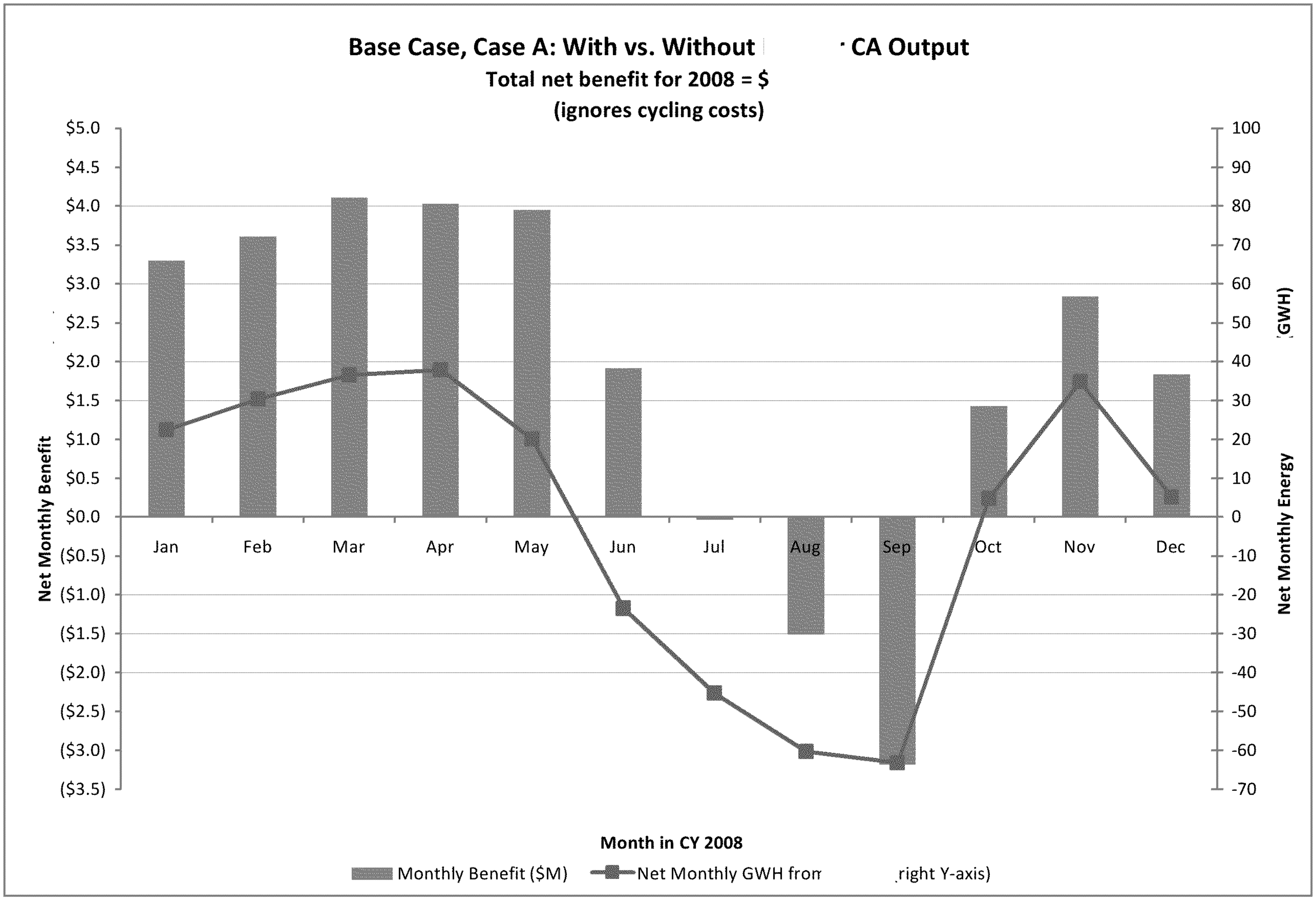


Figure 3-1 — GenCo X Beagle Benefit Under Base Case A (Cycling◆ Advisor Output).

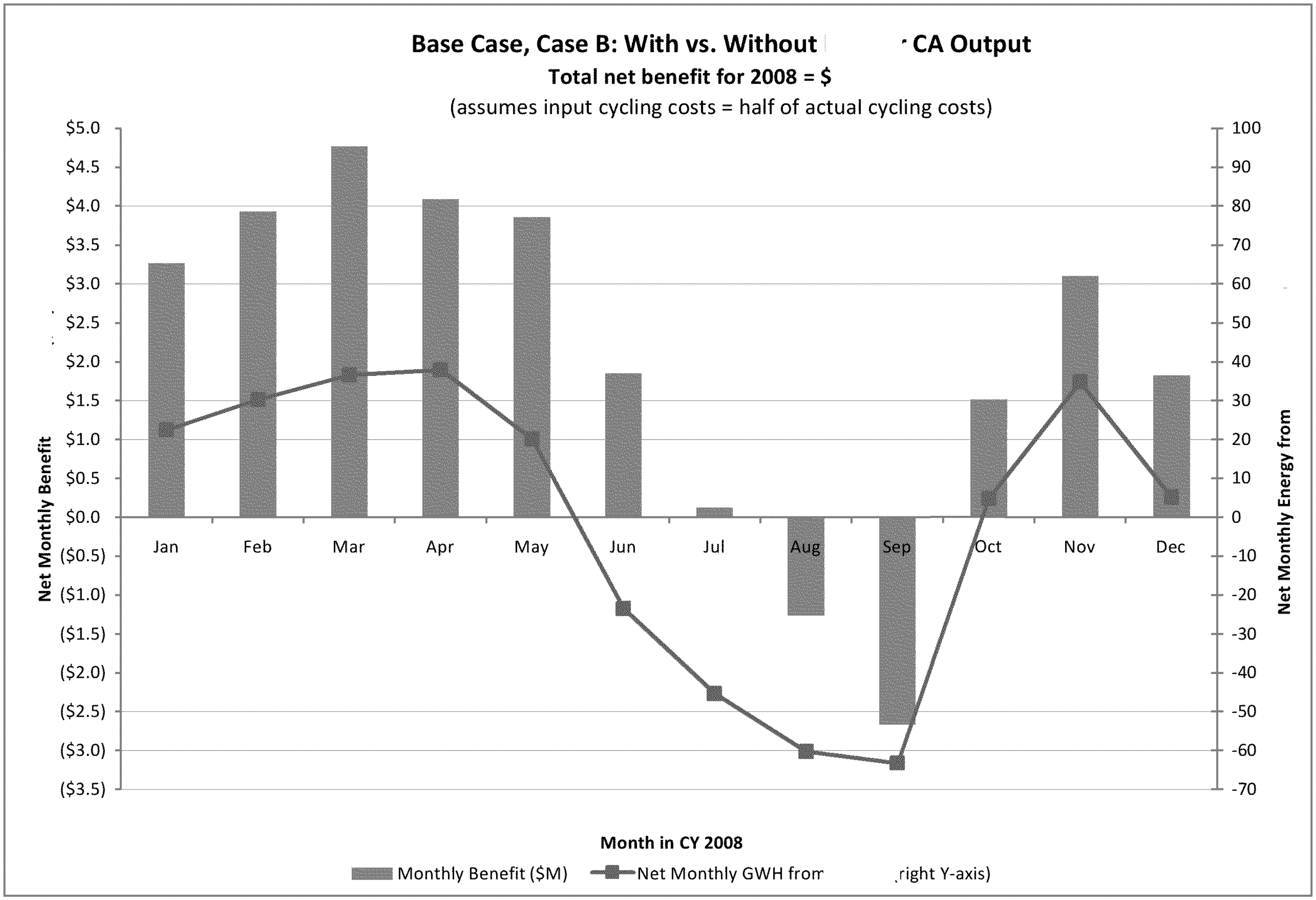


Figure 3-2 — GenCo X Beagle Benefit Under Base Case B (Cycling Advisor Output).

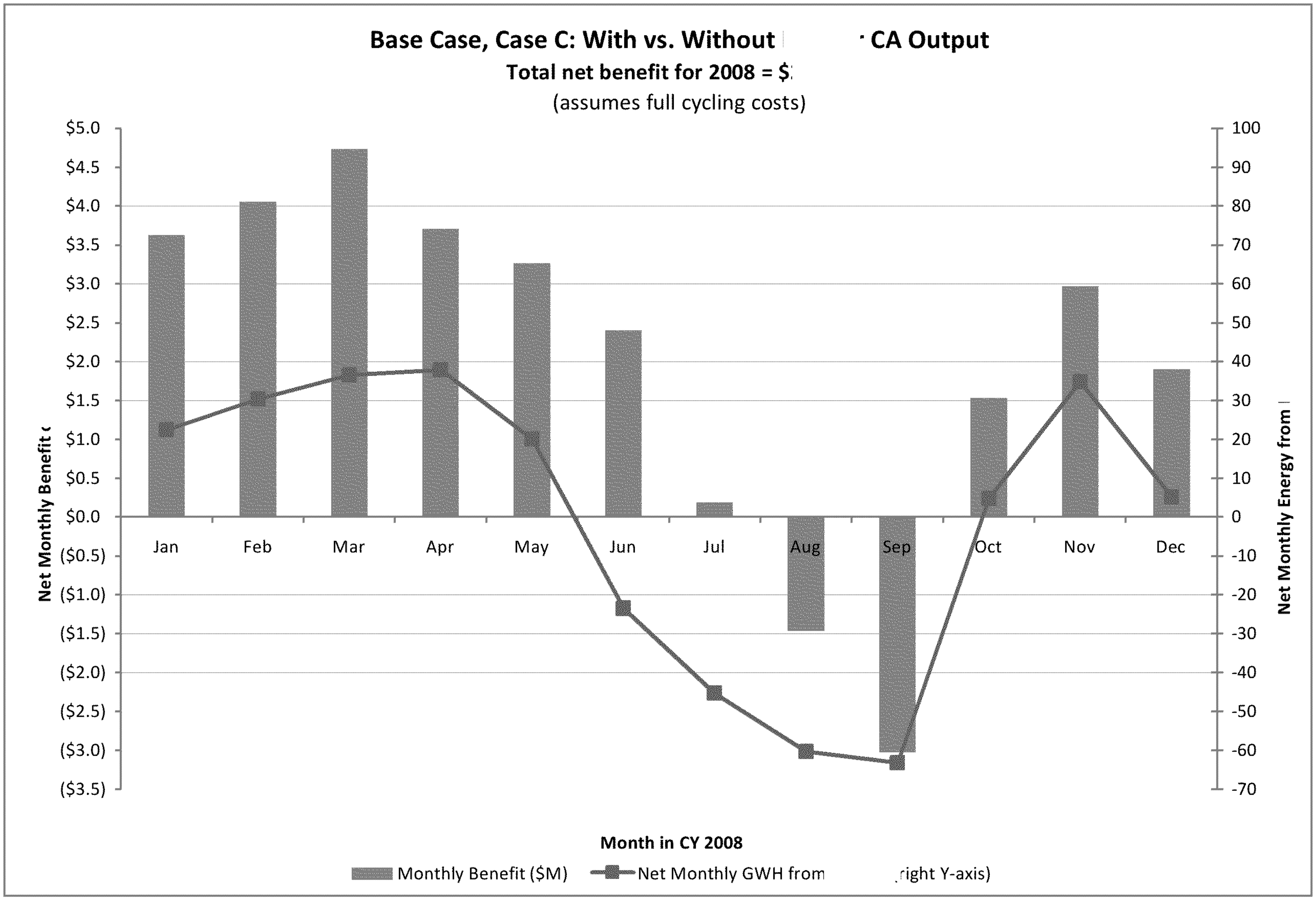


Figure 3-3 — GenCo X Beagle Benefit Under Base Case C (Cycling◆Advisor Output).

# Section 4
# SENSITIVITY ANALYSIS – VALUE OF HOOVER ENERGY

Analysis of the energy market clearly shows that GenCo X gas-fired generators are the marginal units. Given the volatility in natural gas prices and the overall economic conditions, Intertek APTECH designed scenarios for near-term gas prices and for possible future high fuel prices and emission costs to capture the range of possible impacts on the economic value of Beagle energy. A model was also developed to simulate a growth of 2.5% in annual demand to determine its effect on Beagle value to GenCo X.

The sensitivity analysis consists of alternate scenarios, as defined in the following subsections:

- Scenario 1 – Near-Term Gas Price (Section 4.1.1)
- Scenario 2 – Future High Fuel Price and Increased Emissions Cost (Section 4.1.2)
- Scenario 3 – Increased Load (Section 4.1.3)
- Scenario 4 – Beagle Dynamic Signal Split (Section 4.1.4)

Results for all of the scenarios are given in Section 4.2.

## 4.1 SCENARIOS – OVERVIEW AND PROBLEM FORMULATION

Each of the four scenarios listed above involved modifying certain inputs to the models. Figure 1-2 and Table 2-3, in earlier sections, provide a summary of these changes.

### 4.1.1 Scenario 1 – Near-Term Gas Price

GenCo X's wholesale market is largely driven by the price of natural gas. The model indicates that GenCo X's gas-fired generators were the marginal units for 2008. This scenario analysis was conducted to study the sensitivity of the Beagle value to GenCo X under varying natural gas prices. In its latest "Short-Term Energy and Summer Fuels Outlook", the US Energy



SB_GT&S_0466136

Information Administration (EIA) predicts that natural gas production will decline and prices will increase in 2011. However, the current economic conditions and high natural gas production have reduced the spot prices considerably (see the example in Table 4-1). EIA expects the Henry Hub spot price to average $X.XX/MMBtu in 2010 and $X.XX/MMBtu in 2011. The EIA also predicts, "With strong production and the absence of meaningful space-heating demand, lower-priced natural gas will once again compete with coal for a share of the baseload electricity supply — particularly in the spring and fall. Sustained low prices could reduce drilling activity over time".

To model the prevalent "low" natural gas prices would require extensive and out-of-scope modeling of the market conditions as well (market energy prices are largely driven by the natural gas prices). This would have been a considerable effort, especially assuming that the current low natural gas prices are a short-term scenario. Intertek APTECH therefore decided to look at a long-term natural gas price to evaluate Beagle value. A $X/MMBtu price for natural gas was assumed for Scenario 1.

### 4.1.2 Scenario 2 – High Fuel Price, Emissions, and Market Prices

There is high variability in EIA's forecast for natural gas prices, as can be seen in Figure 4-1. The historical prices have also been very volatile. So, Intertek APTECH decided that a scenario with higher prices should be studied to estimate the value of Beagle to GenCo X and the Company customers. Moreover, near-term carbon regulation appears to have become inevitable, as several states are developing regulations, so it seemed prudent to study the increased cost of emissions on GenCo X's coal plants. Assuming that the likely regulation for carbon will be the "cap and trade" policy, Intertek APTECH researched the expected costs associated with carbon emissions. Without a specific regulation, it was difficult to estimate any true costs, but a emissions-related charge of $0.XX/MMBtu on the coal plants was used to see its effect. Likewise, an increase in coal price, from $X.XX/MMBtu to $X.XX/MMBtu, was modeled to account for a "high" fuel-cost case. The natural gas price used was increased from $X.XX/MMBtu to $X.X/MMBtu. So, between price and emission cost, both coal and natural gas costs were increased by $X/MMBtu. Since these high prices will result in higher electricity market prices, the market prices were also inflated (about 10% higher than 2008) for Scenario 2.

### 4.1.3 Scenario 3 – High Demand

To account for an annual demand growth, Intertek APTECH increased the 2008 load by a conservative 2.5% to verify the sensitivity of Beagle value to the increase in demand. Again, the current lower demand prevalent in GenCo X's service area is assumed to be a short-term scenario, and it is assumed load requirements will eventually increase. This expected high-demand situation is represented in Scenario 3.

### 4.1.4 Scenario 4 – Beagle Dynamic Signal Split

The Company and Intertek APTECH collaborated on studying the effects of splitting the Beagle Dynamic Signal between two Scheduling Entities using the scenario described below. To effectively demonstrate the distribution of the Dynamic Signal to two different scheduling entities, the Company designated its largest customer — Central AnyState Water Conservation District (CAWCD) — as the other entity. Hence, CAWCD would employ its own Scheduling Entity to schedule its share of the Beagle capacity, while GenCo X continues to schedule the remaining Beagle power on behalf of the remaining Company customers. The Company asked Intertek APTECH to study the signal split by bounding the value of the remaining Beagle signal available to GenCo X.

According to the Company, if the Beagle Dynamic Signal were to be split, CAWCD would be entitled to a much higher fraction of MW peak capacity than of total MWhr energy generation. In other words, CAWCD would be entitled to a lower capacity factor than GenCo X and so, even though it would receive a large share of the Beagle capacity, the amount of energy available to it would be much lower. This would add new complexity to any single model of the remaining Beagle Signal to GenCo X system.

Hence, in discussion with the Company, Intertek APTECH ran two models that would provide bounds for the lost value of Beagle power to GenCo X. Specifically, for the upper bound of lost value, a reduction of the Beagle assets to GenCo X by 162/377 MW or 42.97% was modeled, applied as a proportional decrease of the total Beagle capacity available at any given time. For the lower bound of lost value, Intertek APTECH modeled a reduction of 151,000/710,929 MWhr or 21.24%, applied as a proportional decrease of the total Beagle energy available at any given time[19]. This approach provides the Company upper and lower bounds on the economic impact to GenCo X of losing the portion of the dynamic signal that is (in the model) attributable to CAWCD. Aside from providing the Company with its desired bounds, these analyses led to an understanding of any nonlinear impacts of a reduction of the Beagle power available to GenCo X.

## 4.2 RESULTS

The most important results of the scenario analysis are presented in the Executive Summary tables (Tables ES-1 through ES-5). These tables show that, for all base cases and for Scenarios 1 through 3 and their variations, both minimized (optimal) and actual energy values of Beagle power fall in a very narrow range:

- Conservative (minimized and optimal) energy values are between $XX.X million and $XX.X million.
- Actual energy values range between $XX.X million and $XX.X million.

The remainder of this section discusses the highlights of some intermediate results and component costs. For example, Figures 4-2 and 4-3 show a comparison of the monthly total minimized costs estimated by Cycling♦ Advisorfor the base case and the three scenarios for the with- and without- Beagle cases (50% cycling costs).

Scenario 1 results in the lowest total monthly costs due to the dominant lower fuel costs. In Scenario 2, the fuel costs were increased to the highest level (compared to all other cases) and, since the baseload fuel costs dominate the total production cost, it can be seen that the total monthly costs are the highest in this case. When the demand is increased, as in Scenario 3, naturally the total costs are higher than for the base case.

[19] The Company provided these capacity and generation reduction values. These capacity and generation reductions are rounded to 43% and 21%, respectively.

### 4.2.1 Scenario 1– Near-Term Gas Price

Figures 4-4, 4-5, and 4-6 show the net monthly benefit of Beagle power (with vs. without Beagle) and the net monthly Beagle power (i.e., scheduled Beagle minus energy bank payback) for Scenario 1. Clearly, the reduction in the total (fuel + emission) natural gas price, from $X.XX/MMBtu to $X.XX/MMBtu does not have an important impact on the Beagle value to GenCo X.

Intertek APTECH ran Scenario 1 with all three variations of cycling costs, similar to the analysis performed for the base case. Again, each case resulted in the conservative minimized costs and “actual” costs which revealed insignificant effects on Beagle energy benefit. With the $X/MMBtu natural gas price, the total production cost, including the damage cost, is lower than in the base case, due to the domination of fuel costs as a contribution to total costs.

#### 4.2.1.1 Near-Term Gas Price; Model Ignores Cycling Costs – Case A

No cycling costs are accounted for in this simulation. Figure 4-4 displays the net monthly benefit of Beagle power (with vs. without Beagle) for this case. The Beagle energy benefit to GenCo X without accounting for cycling costs is about $XX.X million. The total cost with Beagle is estimated as $XXX million, while operating without Beagle expectedly results in an increase and is estimated as $XXX million for the calendar year. The reduced costs with Beagle are largely attributed to the lower power purchase cost and higher power sales revenue. In the simulation, GenCo X generated more from its natural gas plants due to the artificially low prices.

#### 4.2.1.2 Near-Term Gas Price; Model Accounts for Half the Cycling Costs – Case B

This case was run to account for half the indirect costs of cycling. Figure 4-5 displays the monthly benefit of Beagle power. Benefit to GenCo X, accounting for half the indirect cycling costs was estimated to be $XX.X million. The total annual costs were estimated to be $XXX.X million for the with-Beagle and $XXX.X million for the without-Beagle simulations.

#### 4.2.1.3 Near-Term Gas Price; Model Accounts for All the Cycling Costs – Case C

These simulations accounted for 100% of the cycling-related costs. Figure 4-6 displays the monthly benefit of Beagle power. Benefit to GenCo X, accounting for all the indirect cycling costs, was estimated to be $XX.X million. The total annual costs were estimated to be $XXX.X million and $XXX.X million for the with- and without-Beagle simulations, respectively.

### 4.2.2 Scenario 2 – High Fuel Price, Emissions and Market Prices

For this scenario, fuel prices for both natural gas and coal were increased. The market prices to buy and sell energy were also inflated by 10% from 2008 levels to approximate a real market reaction. The simulations looked at Scenario 2, with and without Beagle power, for the 50% cycling cost case only.

With the high fuel and market prices, the annual total costs for the with- and without-Beagle case increased dramatically compared to the base case. The annual costs were $XXX.X million for the with-Beagle and $XXX.X million for the without-Beagle simulations, with half the cycling costs accounted for. However, the benefit to GenCo X was still in the $XX million per year range. In Scenario 2, GenCo X would incur high costs of running its plants due to the high fuel costs. Moreover, the cost to GenCo X to pay back Beagle power to Company customers also increases, rendering the value of the Beagle power similar to what it would be under the base case. GenCo X suffers from buying power from the market, and incurs huge costs in the months of August and September when it pays back the Beagle power to Company customers. Figure 4-7 shows the benefit of Beagle to GenCo X and Company customers.

If carbon regulation is passed, purchasing carbon credits will increase the cost of electricity from fossil plants. If the rate of emission of coal was 1 ton of $CO_2$ per MWhr, then a price of $XX/ton of $CO_2$ results in an increase of $XX/MWhr[20]. The cost of carbon emissions is likely going to be higher than $XX/ton and will result in a significant increase in the cost of energy. Hence, due to the high percentage of coal power plants in GenCo X's portfolio, this carbon-related cost could be significant. Availability of Beagle allows GenCo X to offset some of these costs.

### 4.2.3 Scenario 3 – High Demand

Scenario 3 simulates a growth in demand. The load was increased by 2.5% from the CY 2008 levels. Again, the model ran only the case with 50% cycling costs. These modifications resulted in increasing the annual total costs to $XXX.X million and $XXX.X million for the with- and without-Beagle simulations, respectively. As expected, the total annual fuel cost increases

[20] Source: O'Connell, R., Pletka, R., et al., 2007. *20 Percent Wind Energy Penetration in the United States: A Technical Analysis of the Energy Resource*. Overland Park, KS: Black & Veatch.

in this scenario with respect to the base case. For the with-Beagle simulation, this additional cost is about $XX million for the year. However, the additional cost is lower in the without-Beagle run, since the simulation allows GenCo X to minimize costs by sometimes purchasing power rather than generating it through its gas units. There is a minor increase in the cycling-related costs; however, this is attributed to the fact that GenCo X will have to generate more power due to the increased demand. The benefit to GenCo X from Beagle power is $XX.X million annually, which is only an increase of 1.5% from the base case scenario. Figure 4-8 shows the benefit of Beagle to GenCo X and Company customers.

#### 4.2.4 Scenario 4 – Beagle Dynamic Signal Split

Intertek APTECH ran two separate simulations to determine the value of Beagle to GenCo X when the available capacity of Beagle is reduced by 43% and 21%, respectively. The cases in Scenario 4 accounted for half the indirect cycling costs. The reduced Beagle capacity was modeled by adjusting the with-Beagle MW as described below (for more details, see Appendix A):

$$\begin{aligned} \text{MW (PF Reduced Beagle)} = &\ \text{MW (PF Beagle)} \\ &+ \text{MW ("reduced" accepted Beagle)} \\ &- \text{MW ("reduced" PF payback)} \end{aligned}$$

Here, “PF” represents the modeled GenCo X fossil units. The model also adjusted the effective MW capacity loss of GenCo X fossil units recognized as contributing toward AGC, given the reduced available Beagle capacity when the Beagle signal is split. Table 4-2 provides details of the capacity adjustment to GenCo X coal units. This adjustment ensures that the reduced capacity effects of units under AGC are accurately accounted for.

Moreover, extra fuel costs due to rapid AGC load variations are increased in the Scenario 4 analysis. Specifically, GenCo X will lose between 21% and 43% of the approximately $X million it saved due to avoiding AGC (see Appendix C).

Figure 4-9 shows the monthly cost comparison of the Scenario 4 cases (see also the load comparison in Figure 4-10). The total annual costs for GenCo X in CY 2008 are lowest with 100% Beagle availability ($XXX million), even with its full payback to Company customers.

These annual costs increase monotonically for the respective cases of 21%-reduced Beagle ($XXX million), 43%-reduced Beagle ($XXX million), and 0% Beagle ($XXX million) availability to GenCo X.

For the four respective cases, even the monthly costs increase monotonically for nine months out of the year. The exceptions are August and, especially, September, when banked energy payback obligations dominate, and July, when banked energy payback obligations balance Beagle's gross energy benefits almost perfectly.

Table 4-3 shows the percent reduction in Beagle value with respect to the base case Beagle value of $XX.X million. With a 43% reduction in Beagle available power and the corresponding reduction in the payback to Company customers, the Beagle value is $XX.XX million less than the $XX.X million base case value. This is a 42% reduction in Beagle value to GenCo X with respect to the base case. Moreover, with the 21% reduction in available Beagle power to GenCo X, the Beagle value is $XX.XX million. This corresponds to a 20% reduction in Beagle value to GenCo X compared to the base case. Thus, the results indicate that the value of Beagle power is related to its availability in a fairly linear manner.

Figures 4-11 and 4-12 plot the total monthly net benefit of Beagle power to GenCo X and the monthly Beagle availability for the 43%-reduced case and 21%-reduced case, respectively. The results shown in the figures are as expected; for example, when compared to the base case plot (see Figure 3-2 which uses the same y-axis scale), the net monthly benefits (nine months) and costs (August and September) of the Beagle signal to GenCo X are reduced in both cases. Also, the net Beagle benefits and costs for the 43%-reduced case are lower every month when compared to the 21%-reduced Beagle capacity case.

The table below is duplicated from page ii at the beginning of this report and summarizes the four scenarios included in the study. Base Case B was developed using 50% of the low-load fuel costs and wear and tear costs. The four scenarios were developed using this same dispatching cost criteria. However, the net savings are based on the total actual costs which include 100% of the low-load fuel costs and wear and tear costs in the total calculation. It is especially noteworthy that there is not a significant difference in the net Beagle savings under the first three scenarios which reflect potential economic factors affecting this analysis. It is also interesting that by decreasing the amount of Beagle available for dispatching and use in GenCo X area by 21% results in a 22% reduction in actual savings and by reducing the Beagle by 43% results in a 43% savings. This indicates that the net effect of Beagle on savings is proportional to the amount of Beagle available.

**SUMMARY OF SCENARIO RESULTS WITH NET ENERGY SAVINGS BASED ON ACTUAL COSTS WHICH INCLUDE 100% OF LOW-LOAD FUEL AND WEAR AND TEAR COSTS**

| Case (Dispatched Using 50% of Low Load Fuel and Wear and Tear Costs) | Net "Actual" Energy Savings for GenCo X ($ Millions) |
|---|---|
| Base Case B | Intentionally Deleted |
| Scenario 1 – Reduced Near-Term Gas Prices 26% | Intentionally Deleted |
| Scenario 2 – Raised Natural Gas Prices 11% | Intentionally Deleted |
| Scenario 3 – Increased GenCo X Demand 2.5% | Intentionally Deleted |
| Scenario 4-21 – Reduced Beagle 21% | Intentionally Deleted |
| Scenario 4-43 – Reduced Beagle 43% | Intentionally Deleted |

Table 4-1

**CITRUS PLANT – ANNUAL AVERAGE DAY AHEAD PEAK PRICES**

Federal Energy Regulatory Commission • Market Oversight @ FERC.gov

# Annual Average Bilateral Prices

**Annual Average Day Ahead On Peak Prices ($/MWh)**

| | 2005 | 2006 | 2007 | 2008 | 2009 | 5-Year Avg |
|---|---|---|---|---|---|---|
| F | | | | | | |

Source: Derived from *Platts* data.

Updated January 8, 2010

## Table 4-2

### SCENARIO 4, COAL UNIT – CAPACITY ADJUSTMENT FOR AGC

| Unit | With Beagle Capacity (MW) | No Beagle Capacity (MW) | Adjusted Capacity (43% Case) | Adjusted Capacity (21% Case) |
|---|---|---|---|---|
| Intentionally Deleted | 403 | 383 | 394 | 399 |
| | 403 | 383 | 394 | 399 |
| | 164 | 156 | 161 | 162 |
| | 165 | 157 | 162 | 163 |
| | 164 | 156 | 161 | 162 |
| | 122 | 116 | 119 | 121 |

Table 4-3

**SCENARIO 4, BEAGLE VALUE LOSS TO GenCo X**

| | | | | Perceived | Actual |
|---|---|---|---|---|---|
| Difference in | Value ($M) to | 43% Reduction In | Availability (& Payback) | $ | $ |
| % Difference in | Value to | 43% Reduction In | Availability (& Payback) | | |
| Difference in | Value ($M) to | 21% Reduction In | Availability (& Payback) | $ | $ |
| % Difference in | Value to | 21% Reduction In | Availability (& Payback) | | |

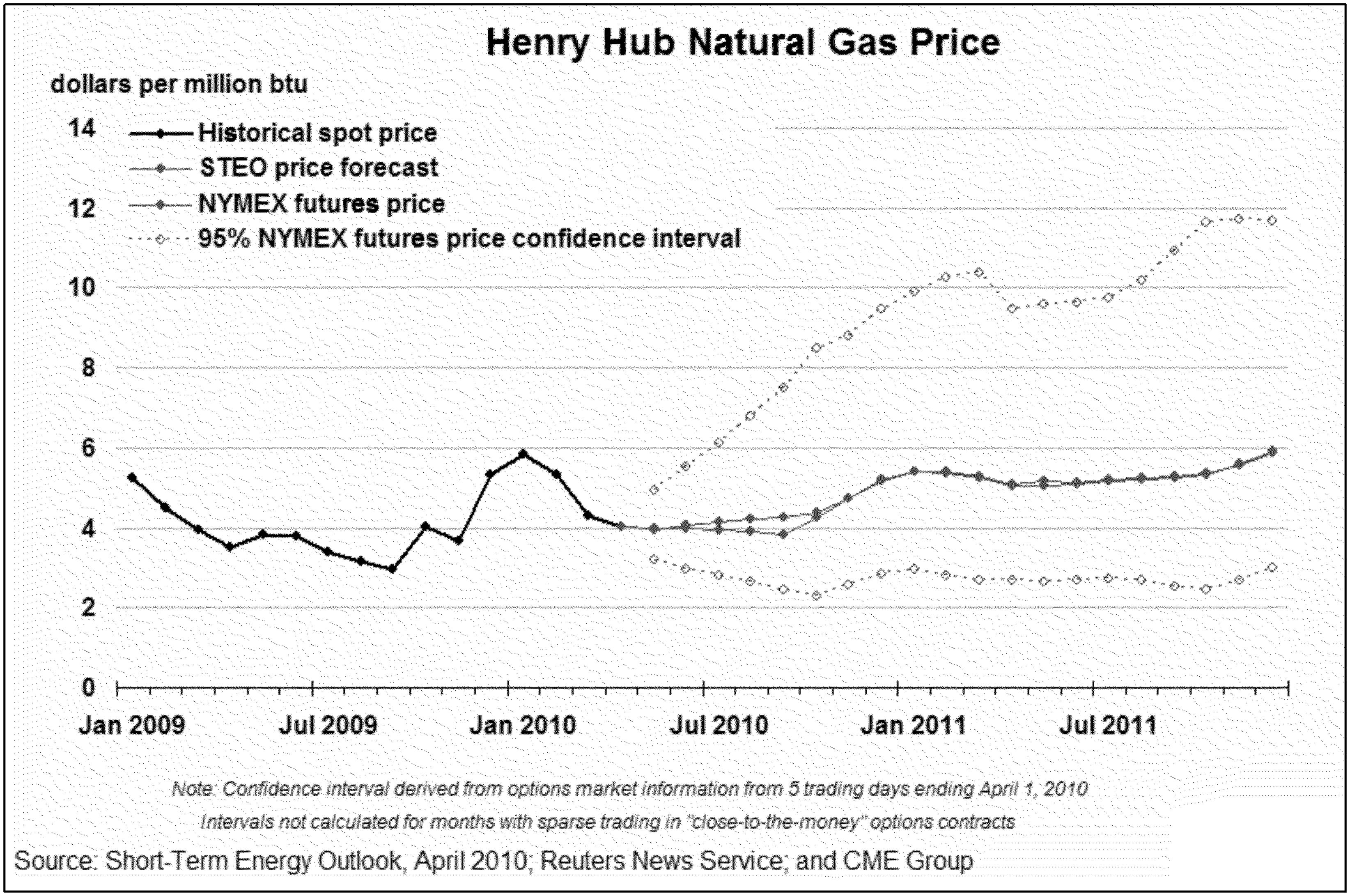


Figure 4-1 — Henry Hub Natural Gas Price, EIA Short-Term Outlook.

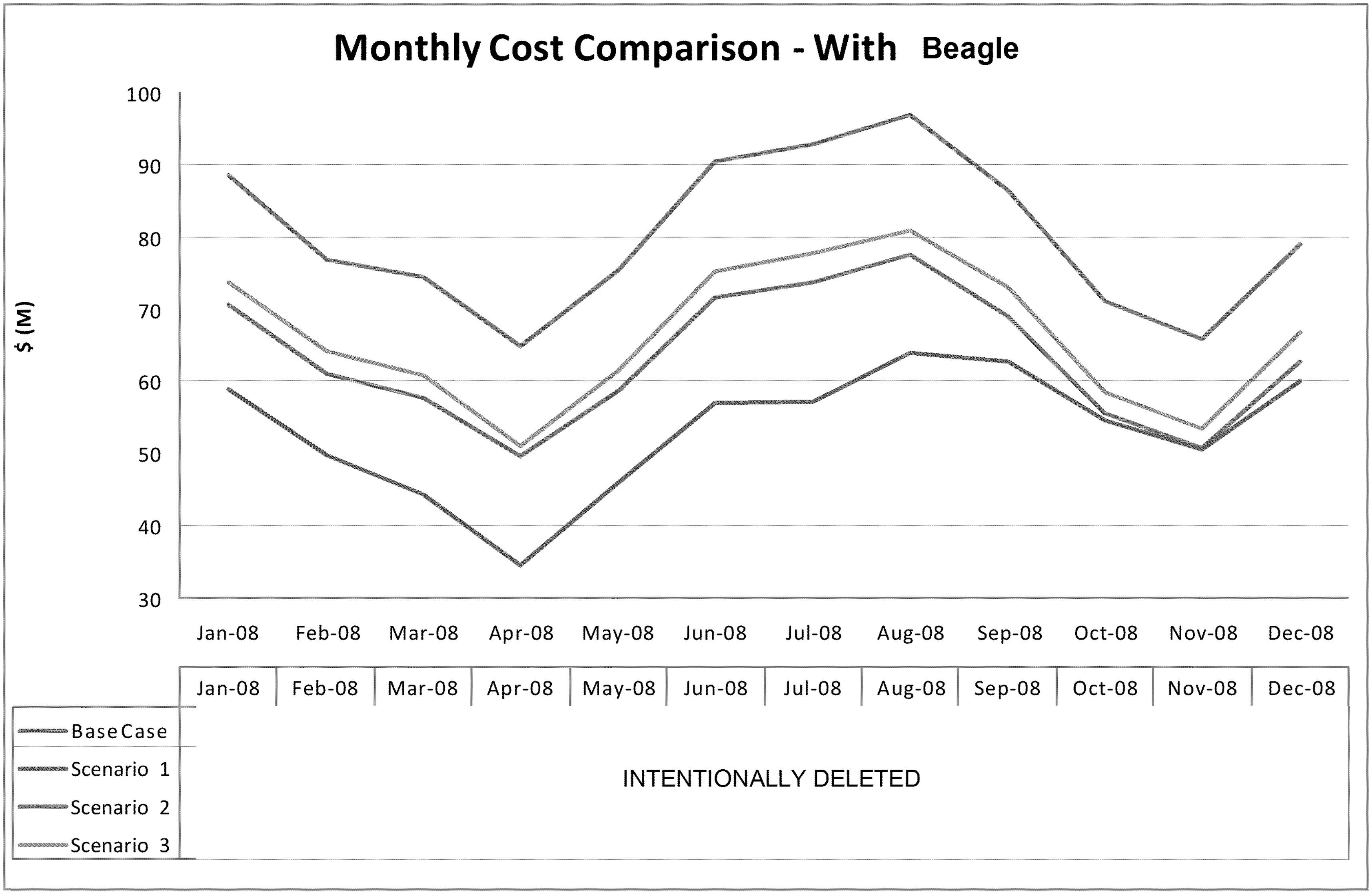


Figure 4-2 — Cost Comparison, Base Case and Scenarios – With Beagle.

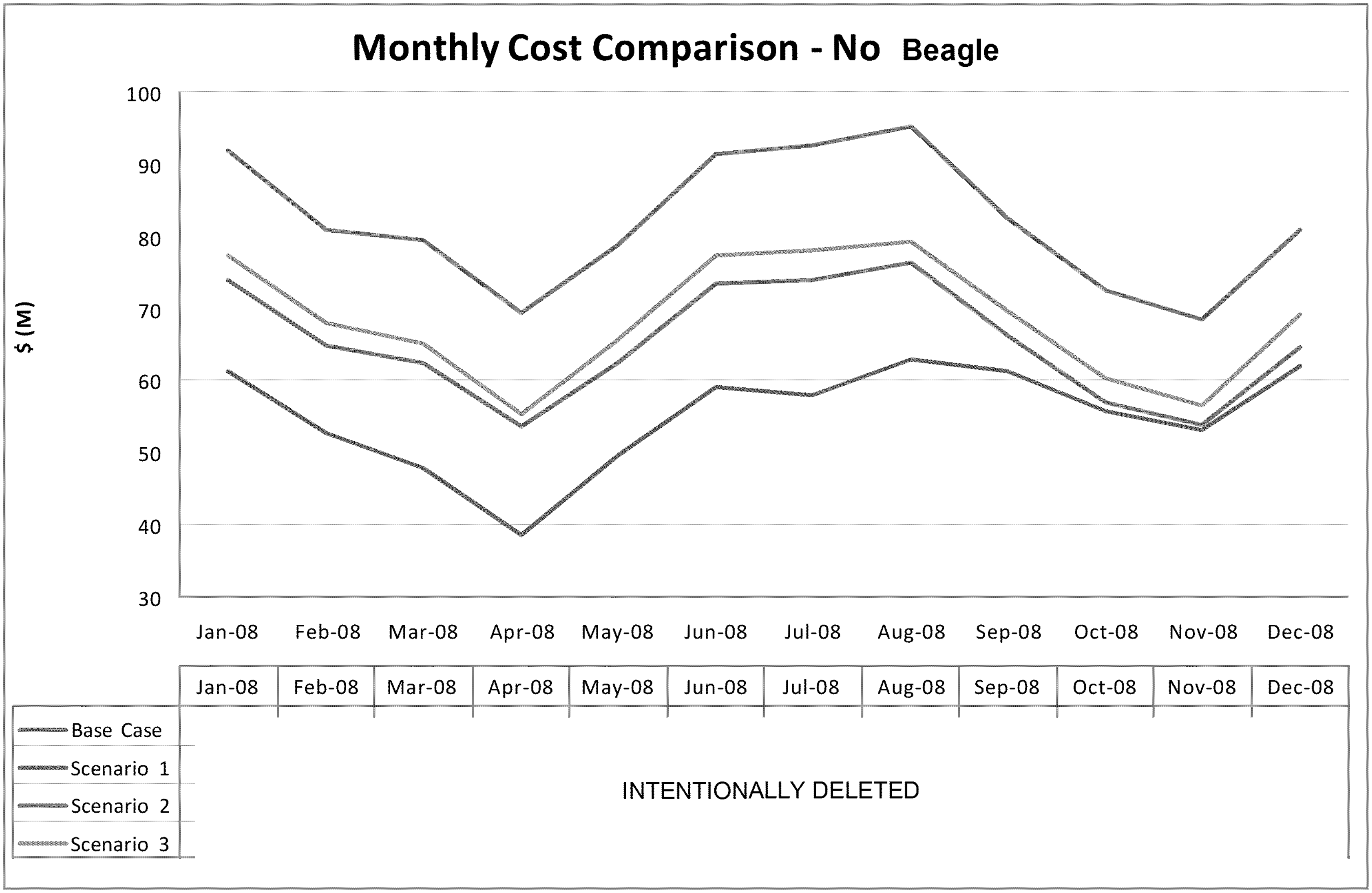


Figure 4-3 — Cost Comparison, Base Case and Scenarios – Without Beagle.

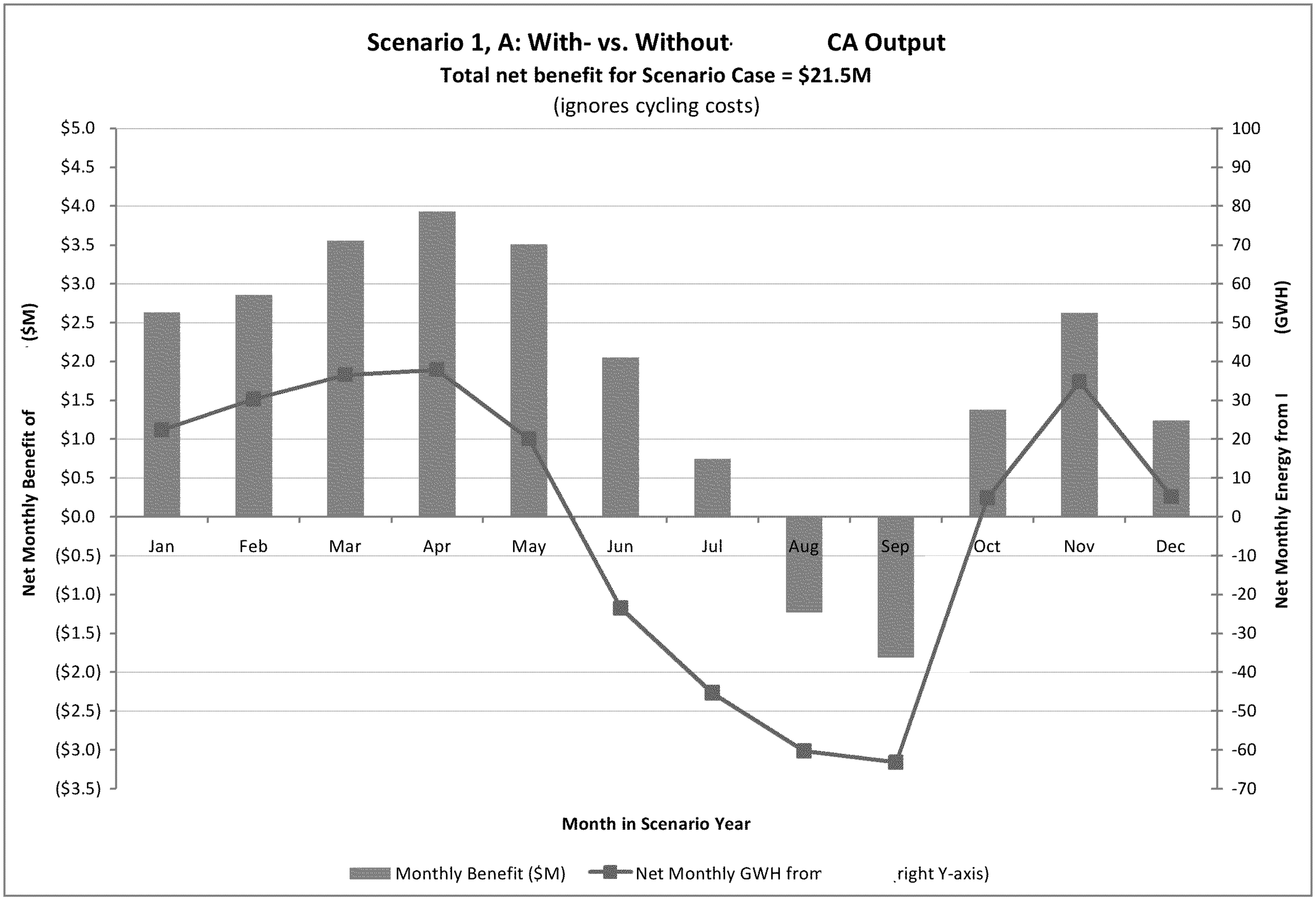


Figure 4-4 — GenCo X Beagle Benefit under Scenario 1, A (Cycling Advisor Output).

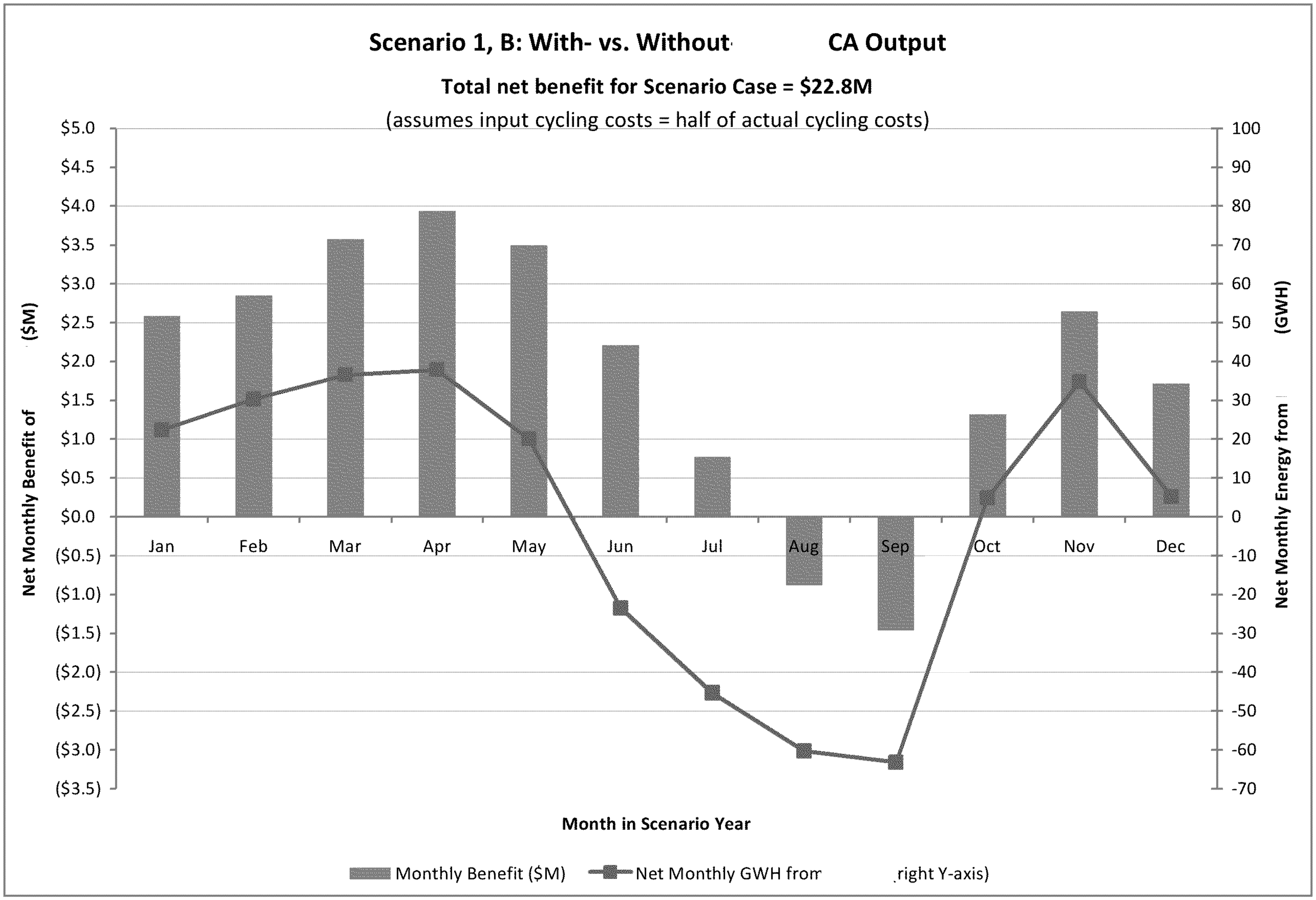


Figure 4-5 — GenCo X Beagle Benefit under Scenario 1, B (Cycling Advisor Output).

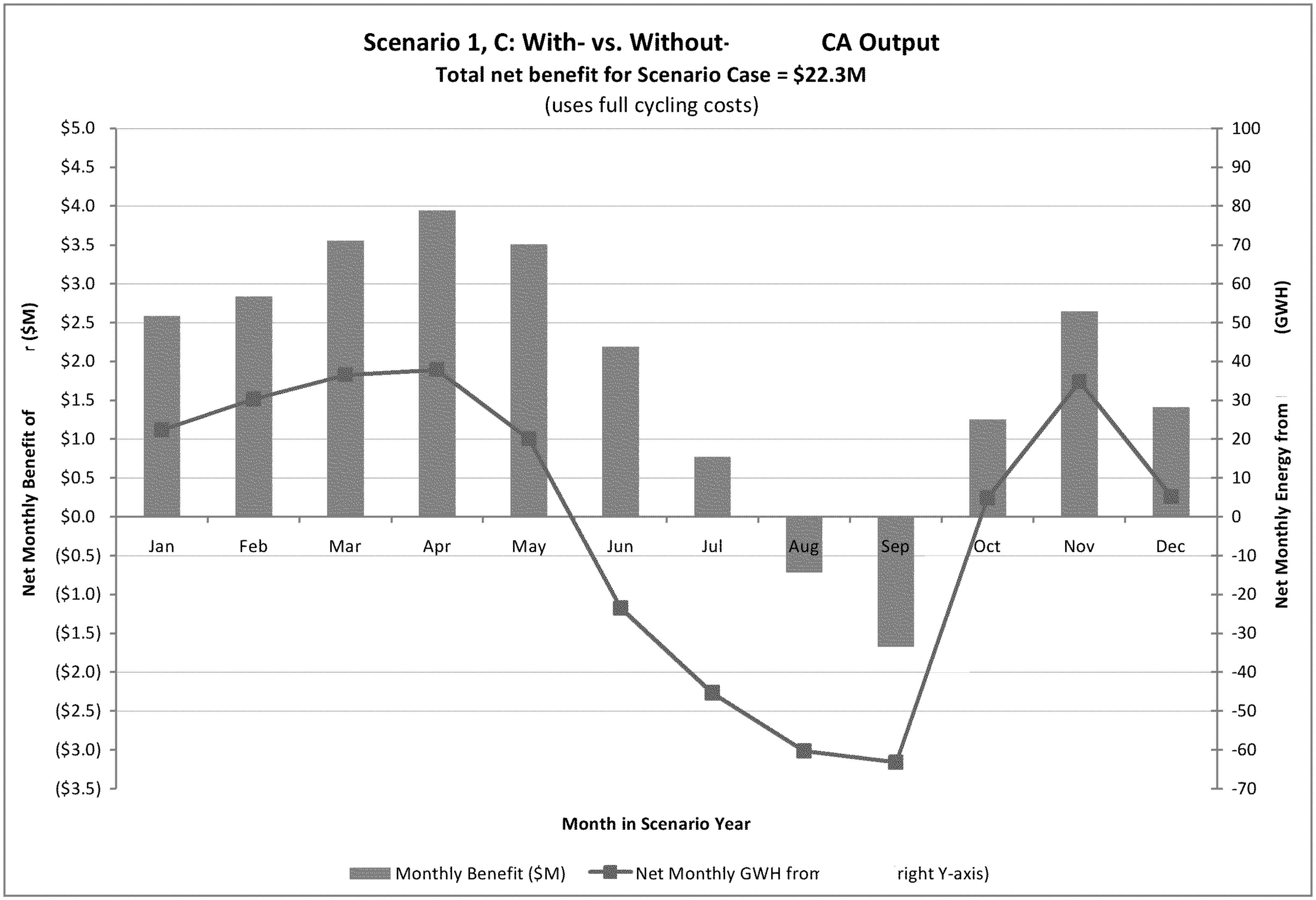


Figure 4-6 — GenCo X Beagle Benefit under Scenario 1, C (Cycling◆ Advisor Output).

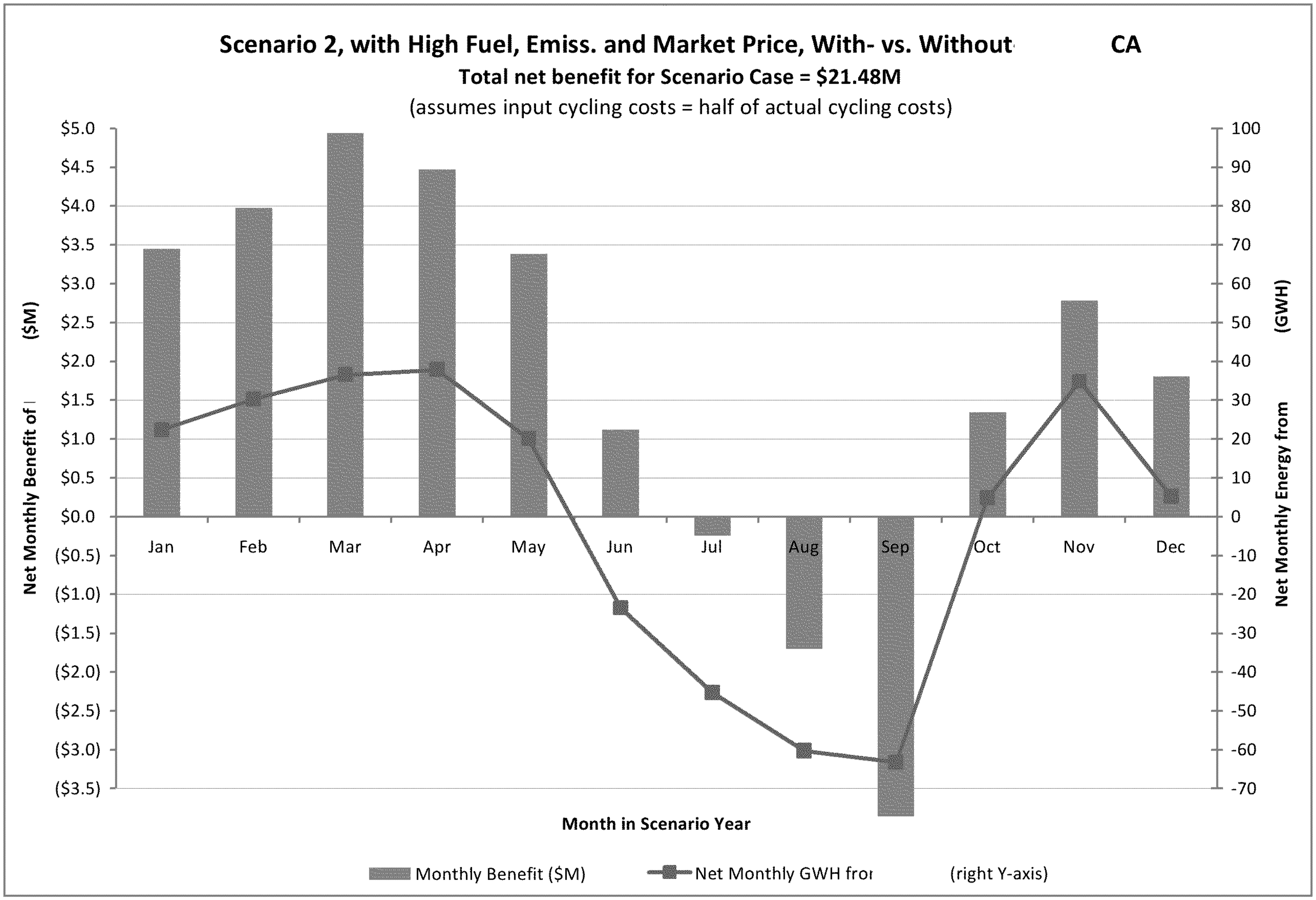


Figure 4-7 — GenCo X Beagle Benefit under Scenario 2 (Cycling Advisor Output). **Note:** The same scale is used here as in all net monthly benefit plots, obscuring the September value of Beagle power, which was minus $3.86 million.

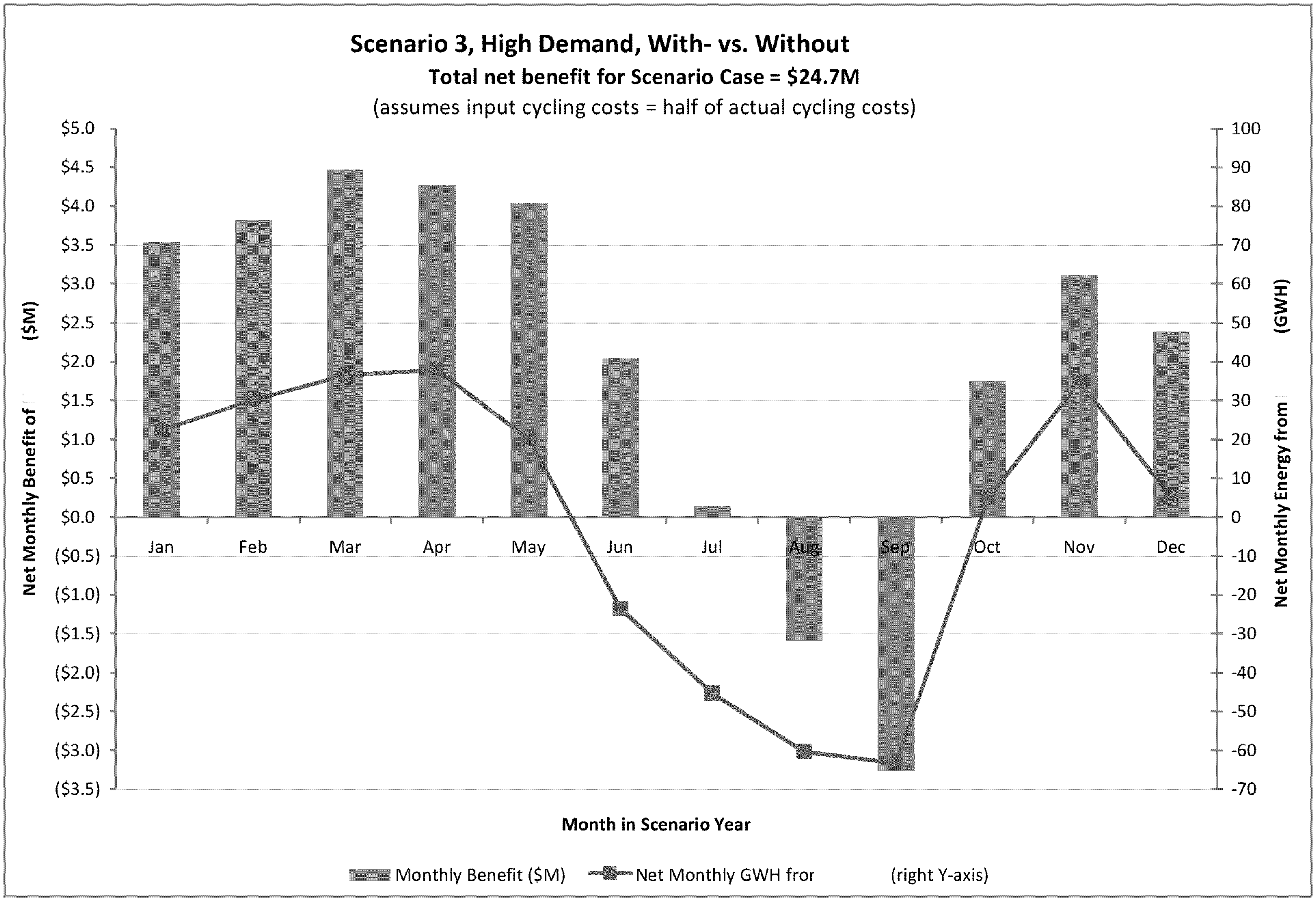


Figure 4-8 — GenCo X Beagle Benefit under Scenario 3 (Cycling Advisor Output).

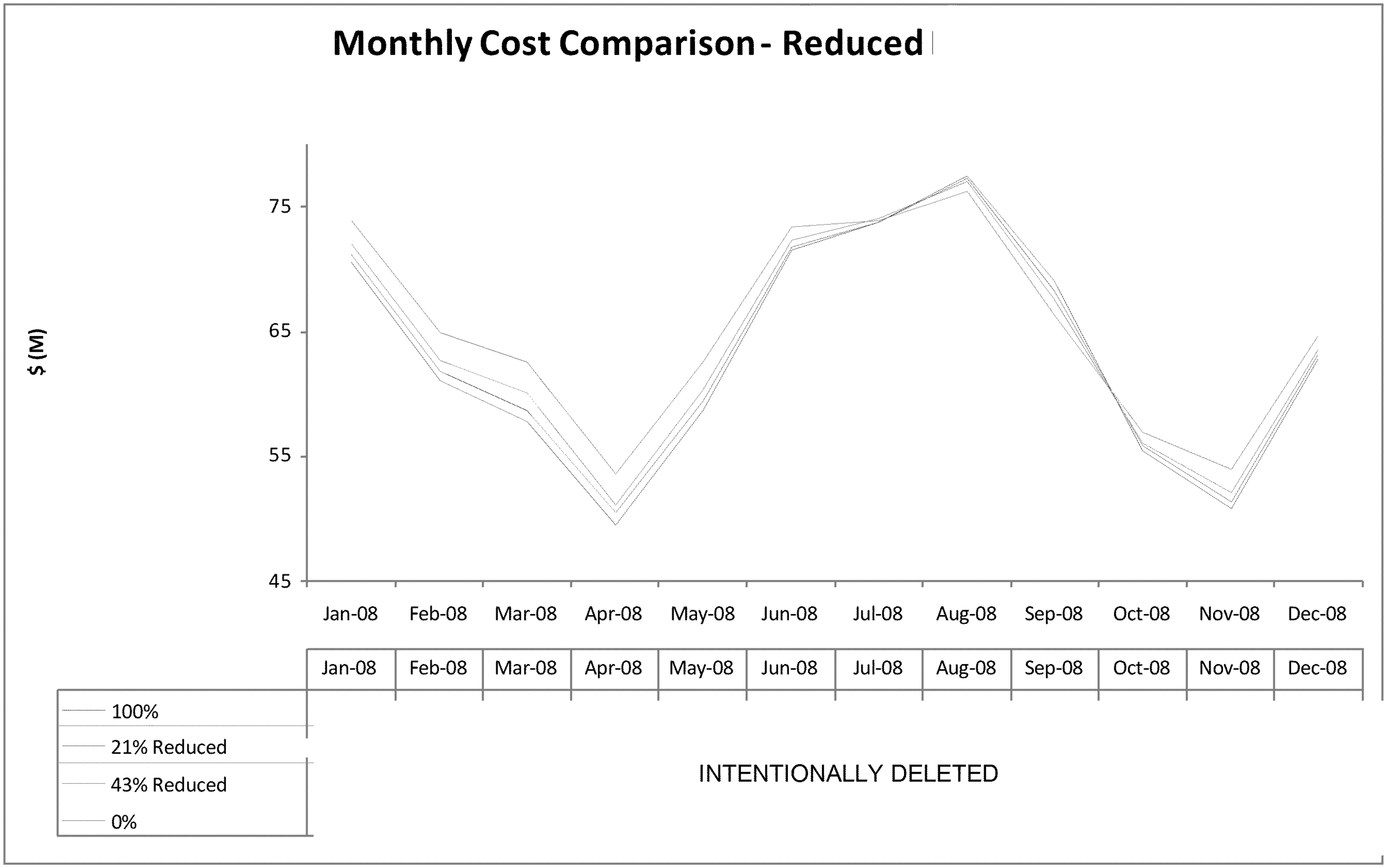


Figure 4-9 — Total Monthly Cost Comparison for Scenario 4 Cases (Cycling⬍ Advisor Output).

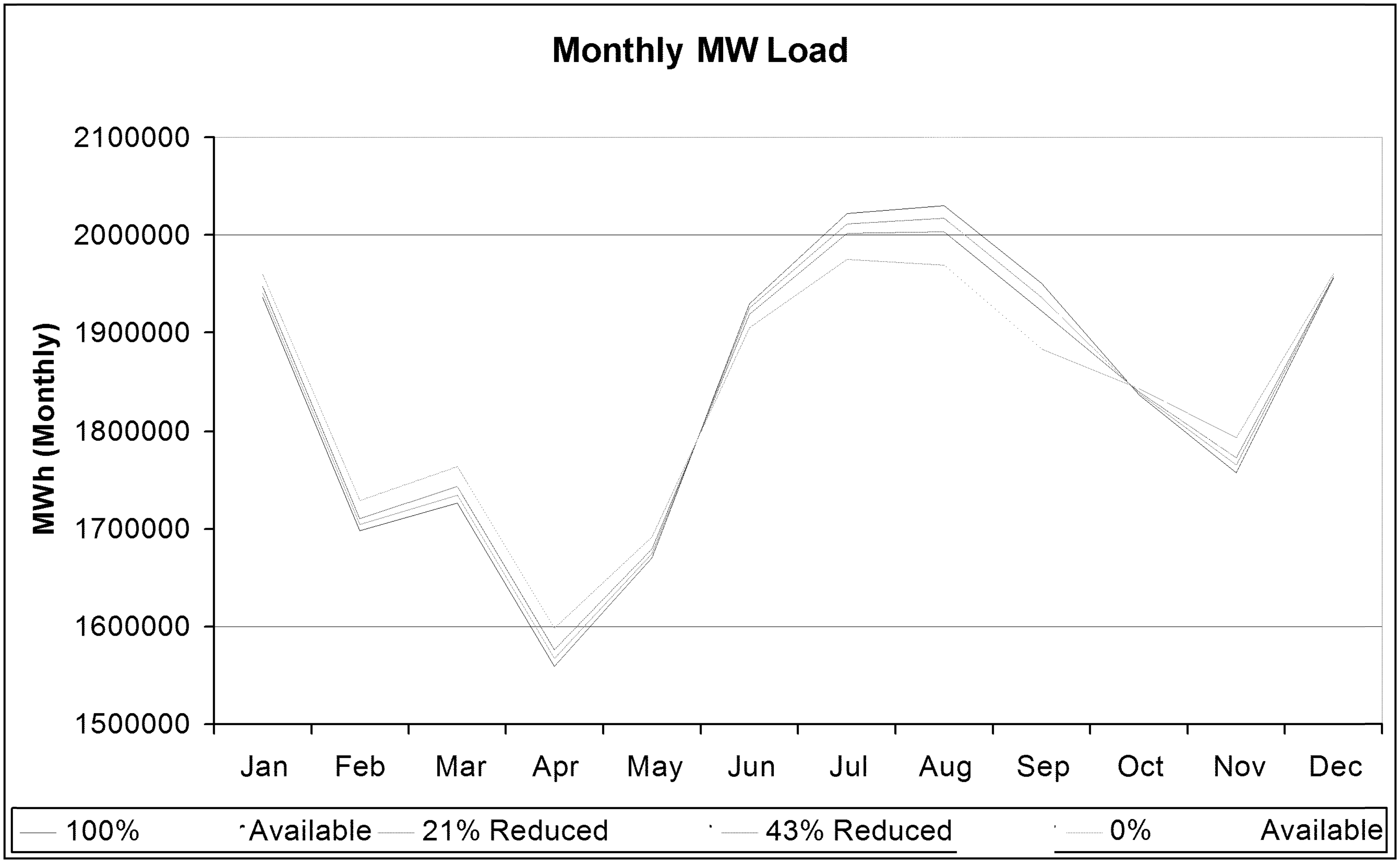


Figure 4-10 — Adjusted Monthly MW Load for Scenario 4 Cases.

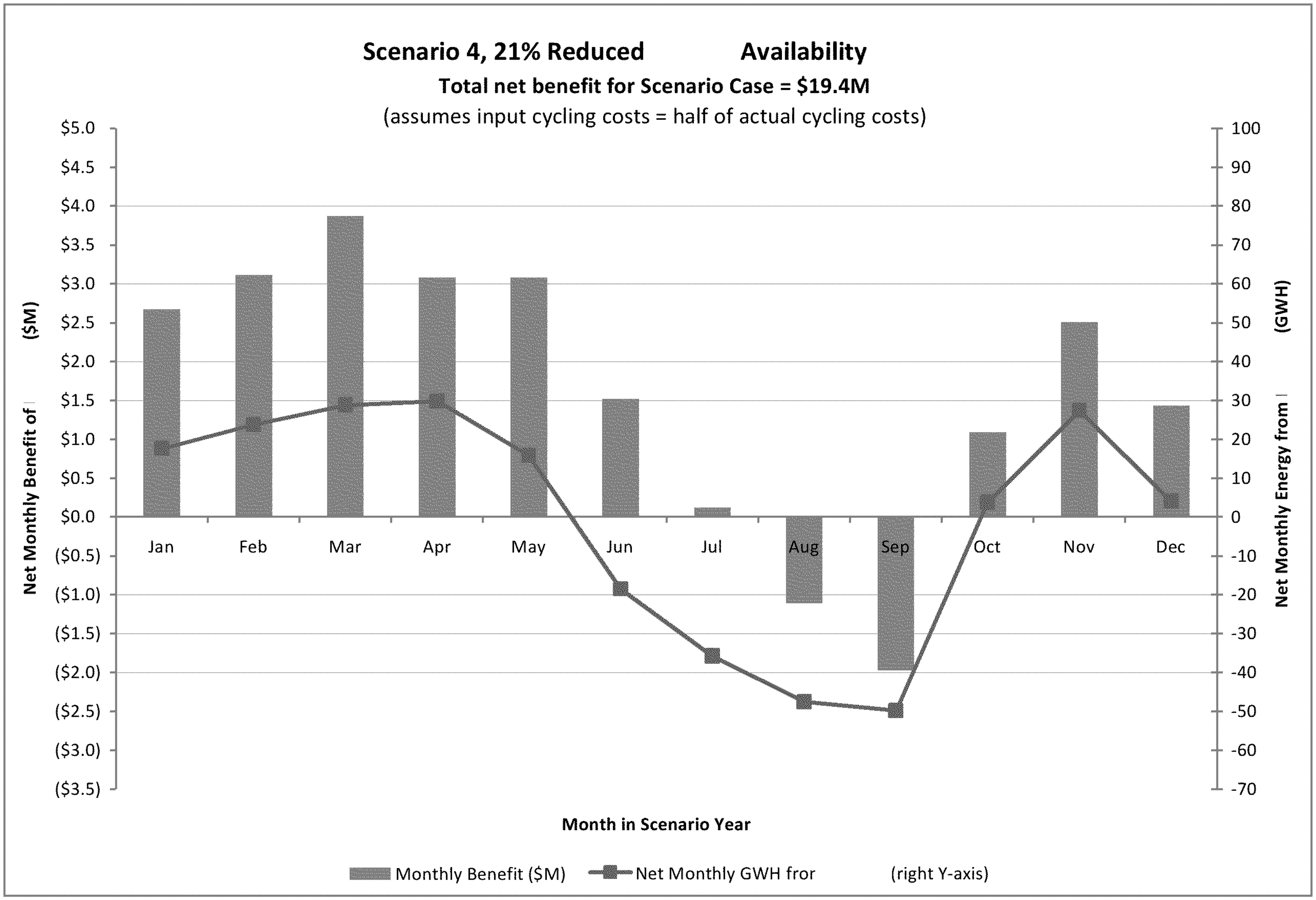


Figure 4-11 — GenCo X Beagle Benefit under Scenario 4, 21%-Reduced Beagle Availability (Cycling⬍ Advisor Output).

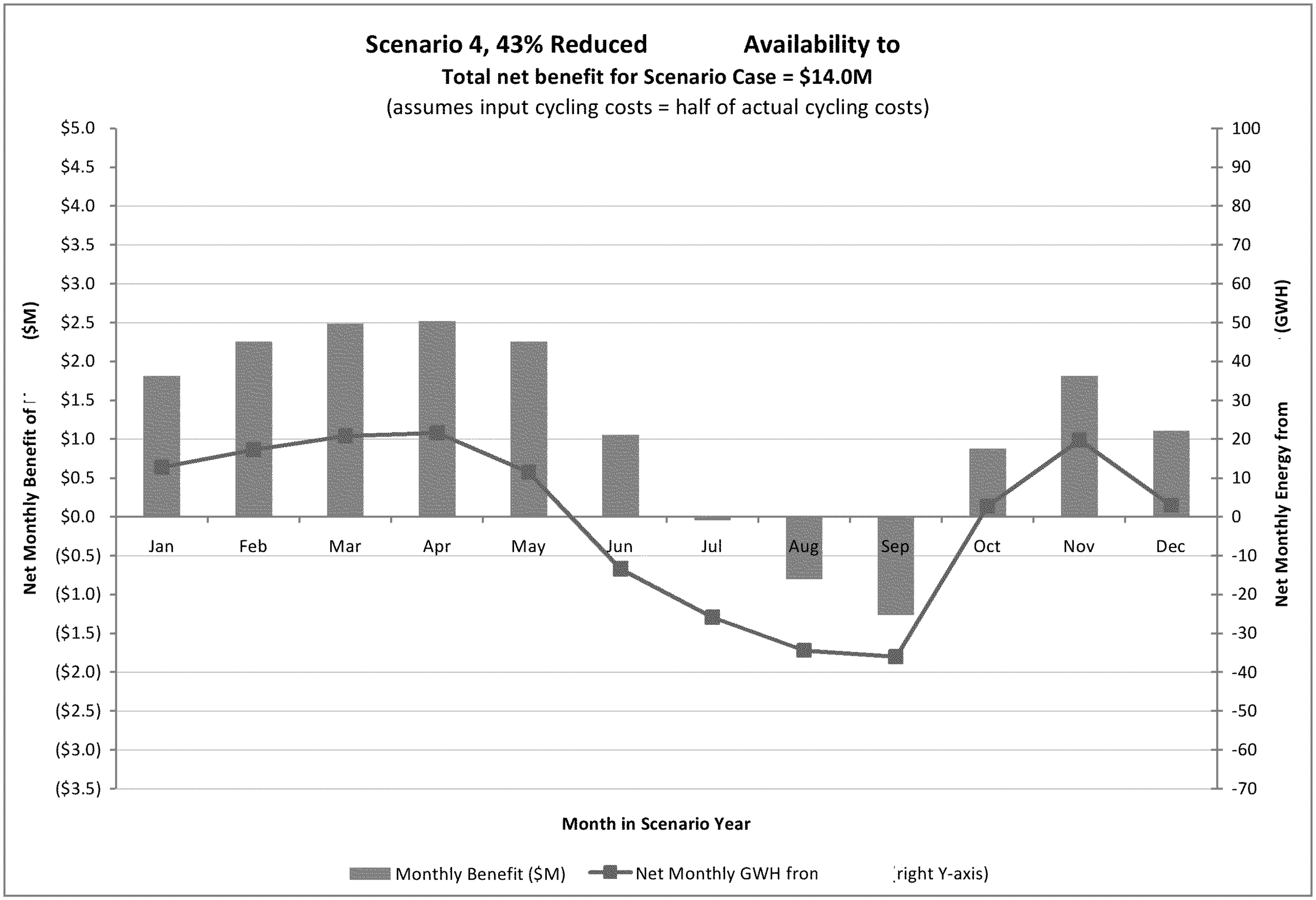


Figure 4-12 — GenCo X Beagle Benefit under Scenario 4, 43%-Reduced Beagle Availability (Cycling Advisor Output).

# Section 5
# HOOVER CAPACITY BENEFITS

The presence of firm capacity from Beagle allows GenCo X the benefits of deferring planning new reserve capacity for its system. This benefit is realized if the future contract between the Company and GenCo X is long-term, say more than 10 years. If GenCo X can count on 300 MW of firm capacity from the Company, then it will not need to add planning reserve capacity. Such capacity would typically mean either simple-cycle combustion turbines (CT) or a long-term contract with another entity that usually costs about the same as simple-cycle CT annual capacity costs.

GenCo X may argue that right now, due to the poor economy, it does not need new capacity reserves. Still, in its 2010 summer preparedness presentation to the AnyState Corporation Commission, GenCo X expects peak summer demand only slightly lower than last year. Systems loads will eventually go up again. Although GenCo X may argue that it is purchasing sizeable wind and solar capacity to cope with this eventuality, if these wind and solar purchases are not backed up by firm storage or thermal capacity, they cannot be counted as firm planning reserves. Similarly, demand side management and energy efficiency reductions are currently too small, and regulations require that these, too, be backed by firm capacity.

## 5.1 CAPACITY BENEFIT ANALYSIS

The "overnight cost" (OC), in economic terms, is the present value of the plant that would have to be paid as a lump sum up-front to pay completely for the construction of the plant. The EIA, in its "Assumptions to the Annual Energy Outlook 2010"[21], estimates the OC of a conventional CT to be approximately $XXX/kW (in 2009 $). Adjusting the cost for 2010 $, the OC is approximately $XXX/kW (annual inflation rate for 2009–2010 was about 2.72%).

[21] See http://www.eia.doe.gov/oiaf/aeo/assumption/electricity.html.

The OC captures the fixed capital cost of generation, to which we will add fixed annual operation and maintenance costs. In other words, the OC signifies the complete present value cost of the project. Therefore, in this case, the OC of a 300 MW simple cycle CT would be about $XXX.X million.

To analyze the capacity benefit of Beagle firm capacity to GenCo X, the following assumptions were made, and the annual levelized costs calculated, by evaluating the “fixed capital costs” and “fixed O&M costs,” as discussed below:

Assumptions:

| | | | |
|---|---|---|---|
| Interest rate on capital | = | 3.25% | (1) |
| Term of borrowing and resultant % added to interest to offset depreciation: | | | |
| For a new simple-cycle CT | = | 2.50% | (2) |
| Added percent for taxes and insurance | = | 1.50% | (3) |
| Fixed Charge Rate | = | 7.25% | (1) + (2) + (3) |
| Overnight Cost | = | $XXX/kW | (4) |
| Fixed O&M | = | $XX.00/kW | (5) |
| O&M and consumables cost escalation rate (%) | = | 3.00% | (6) |

This fixed charge rate includes annual interest, principal (20-year life), taxes (if any), and insurance. It was assumed, for consistency sake, that all major capital expenditures are funded through 100% borrowing at the current 3.25% interest rate.

The fixed O&M (5) is an approximate assumption of the cost as published by the EIA in its “Assumptions to the Annual Energy Outlook 2010”. Future fixed O&M costs can be adjusted using the O&M and consumables cost escalation rate.

## 5.2 CAPACITY BENEFIT RESULT

The capacity credit calculations are as follows:

Fixed Capital Cost = OC x FCR

| | | |
|---|---|---|
| | = | XXX x 7.25% |
| | = | $XX.XX/kW–yr |
| Fixed O&M | = | $XX/kW (adjusted with 3% cost escalation after current year) |
| Capacity of New Power Plant | = | 300 MW |
| The Capacity Credit in Current year $ | = | Total Fixed Costs x Capacity |
| | = | (Fixed Capital Cost + Fixed O&M Cost) x Capacity |
| | = | (XX.XX + XX) x 300 x 1000… in year 0 |
| | = | $XX.XX Million… in year 0 |

This capacity benefit increases each year, with the contribution of the increasing fixed O&M costs of the project, to about $XX.X million in Year 19.

It may be argued that, without the Beagle Dynamic Signal, GenCo X would not have an obligation to the Company customers and, hence, this capacity credit overestimates the cost of reserve capacity required by GenCo X. However, it should also be noted that GenCo X currently serves the Company customers, which demand steady uniform energy throughout the year. GenCo X, hence, receives significant value from utilizing the Beagle energy to manage its regulation, ramping, and spinning reserve requirements. Beagle allows GenCo X to ramp at 100 MW/min[22] to meet its system dispatch demands. A typical 7-FA CT can, at most, ramp at the rate of 30 MW/min and, hence, the loss of Beagle available capacity to GenCo X could significantly impact GenCo X's ability to manage its ramping needs. At times of rapid changes in system demands, GenCo X may require three 300 MW CTs to offset the benefit it receives from Beagle power.

Intertek APTECH came to the conclusion, after discussion with the Company, that the reserve capacity analysis of building a new simple-cycle gas turbine (GT) unit is valid. However, to keep the analysis conservative, it is possible to use a factor that adjusts for near-term overcapacity and capacity needs after a year or two. For example, the 2010 factor could be 5% of the current

[22] Source: U.S. Department of the Interior, Bureau of Reclamation: Beagle Load Following – Unit Controls Modernization Benefits Presentation.

capacity credit evaluated, but indicators are strong that it would go to 100% starting in about 2015. Figure 5-1 shows this adjusted capacity credit from 2010 through 2029. The blue line in the figure signifies the capacity credit for each year, while the red line is the adjusted capacity benefit that steadily rises from 2010 through 2015.

This adjustment factor could be modified for the purpose of negotiation to determine the capacity benefit of Beagle power to GenCo X. However, for the purpose of evaluating the capacity benefit of Beagle to GenCo X, it may be stated that: (1) the loss of Beagle capacity would likely significantly increase GenCo X's ramping requirements and (2) determining the reserve capacity benefit of Beagle to GenCo X using one 300 MW simple-cycle GT is both conservative and reasonable.

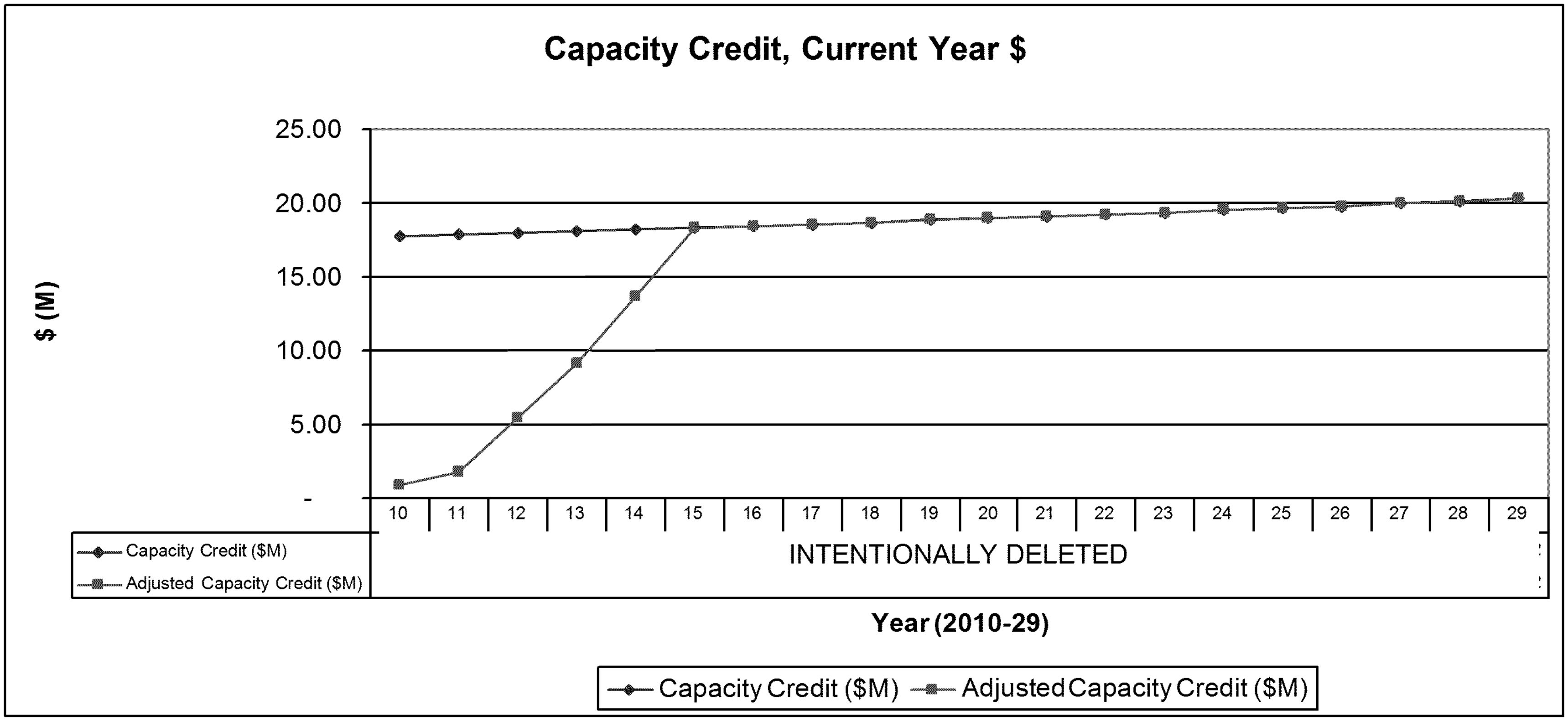


Figure 5-1 — Beagle Reserve Capacity Assessment.

# Section 6
# CONCLUDING REMARKS

Intertek APTECH conducted this study to determine the economic impacts of the availability of Beagle power to the state of AnyState. The primary focus was on the economic benefits to the Scheduling Entity that the Company has contracted to schedule power on behalf of all Company customers. Several models were developed to study the economic benefit of the availability of Beagle power to the Scheduling Entity, which at present is GenCo X. To ensure that the projections were realistic, the inputs were extensively researched and actual MW generation, market environments, and operating costs from CY 2008 were used for the models. Moreover, to offset the uncertainty of the lack of comprehensive market transaction data and GenCo X's future resources, care was taken to ensure that all inputs and results either were conservative or had their uncertainties included within the scenarios. Finally, the impact of volatility in market conditions and costs and the benefits that GenCo X or the Company customers receive from Beagle power under such conditions were also quantified in the various scenarios.

Based on the analysis conducted in this report, Intertek APTECH has reached the following conclusions:

- The total annual value of Beagle generation to GenCo X is approximately $XX million.
- In CY 2008, Beagle generation saved GenCo X $XX million to $XX million in fossil system production "energy" costs. These energy benefits were found to apply in current and future economies, as well.
- Beagle availability can also save GenCo X $18 million to $XX million in capacity costs.
- GenCo X has 15% targets for renewable integration (by 2025)[23]. This renewable portfolio will primarily consist of variable resources such as wind and solar, both of which add considerable costs on fossil plant cycling and other operations. The availability of

[23] Source: P Website: .

Beagle power helps GenCo X to mitigate these effects and keeps operational costs lower.

With expected increases in fuel prices, environmental regulations, increased renewable integration (and variability), and load growth, the economic benefits of Beagle power to the Company and its customers are of substantial value.

# Appendix A

## ESTIMATING HOURLY MW DEMAND ON PROJECT'S FOSSIL UNITS

# Appendix A

# ESTIMATING HOURLY MW DEMAND ON PROJECT'S FOSSIL UNITS

## INTRODUCTION

A key step in determining the production cost of GenCo X fossil system (PF) was to determine the with- and without-Beagle hourly MW demand during CY 2008.

Most of the hourly MW data needed to estimate PF demand were available[24], the notable exception being the hourly "payback" of GenCo X to return Beagle energy and meet its "banking" obligations. Intertek APTECH was provided the monthly payback generation data by the Company. However, a means for reasonably estimating the hourly payback generation was also needed to run the models, because in the without-Beagle model of GenCo X system, GenCo X obviously has no payback/banking obligations. Thus, to estimate GenCo X demand for without-Beagle models, it had to be possible to remove both the Beagle hourly generation asset and the approximate hourly GenCo X payback liability.

According to the Company, the lion's share of this payback generation is used for irrigating crops during the hot growth months of June through September. The Company provided monthly generation data for this payback, so the model uses accurate seasonal generation data.

## GENCO X FOSSIL UNIT DEMAND ESTIMATES

### "With Beagle"

The MW (PF Beagle) estimate is straightforward. After accounting for GenCo X's less than 100% ownership share of certain fossil units, it was merely necessary to add the hourly MW contributions of all PF units during CY 2008.

[24] Hourly MW data on the PF units are available on the Environmental Protection Agency's web site. Beagle hourly MW values accepted by PF are calculated from 4-second data provided by Power Company.

**"Without Beagle"**

Intertek APTECH estimated MW (PF No Beagle) by:

1. Starting with the above MW (PF Beagle)

2. Adding the hourly generation accepted from Beagle — MW (accepted Beagle) — that GenCo X would have to generate

3. First estimating, and then subtracting, the hourly MW (PF Payback) that PF units would no longer need to generate to fulfill its banking obligations

The equation representing the above three steps is simply:

MW (PF No Beagle) = MW (PF Beagle) + MW (accepted Beagle) – MW (PF Payback)

**COMPARING GENCO X FOSSIL SYSTEM DEMANDS WITH- AND WITHOUT-BEAGLE**

Figure A-1 plots the results of applying these equations for a single high-demand week at the end of August (CY 2008). The green trace is PF demand with actual 2008 Beagle and banking power and the other curve (blue dashes in Figure A-1) shows the estimated PF demand in the absence of both Beagle and banking power.

Figure A-1 assumes that the monthly energy paid back to Company's irrigation and other customers is spread uniformly over all hours for each month. Specifically, for each hour within August, MW (PF Payback) = 159, including the week shown in Figure A-1.

Despite y-axis scale issues due to the fact that the aggregate capacity of the PF units is more than ten times the available Beagle capacity, it is easy to see that the blue dash curve in Figure A-1 is both more demanding than the solid green one and contains significantly more cycling damage. Despite its higher cycling damage content, we believe that the blue dash curve in Figure A-1 is conservative; that is, it is favorable to GenCo X because it is less demanding and has less cycling damage than the true no-Beagle hourly loading situation. This is because GenCo X has some freedom to distribute the hourly payback load as it sees fit, and it stands to reason that they would choose a scenario more economical than the option represented by the simple uniform distribution, constant hourly MW in Figure A-1.

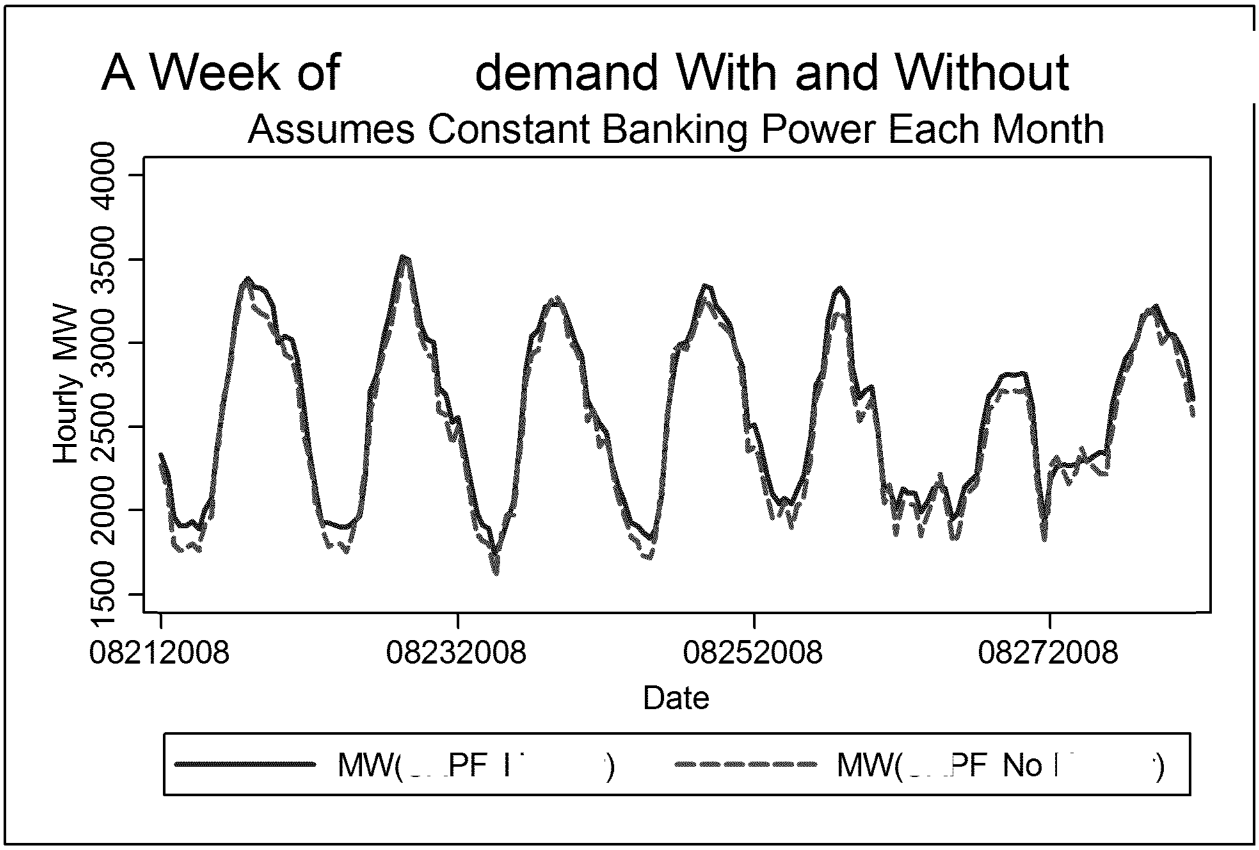


Figure A-1 — Comparing GenCo X Fossil System Demand, With- and Without-Beagle

# Appendix B
# HEAT RATE ANALYSIS

# Appendix B
# HEAT RATE ANALYSIS

## MAJOR FUEL USAGE AND COST RESULTS

The effects of cycling on heat rate and, ultimately, on fuel costs for all 20 modeled PF units were investigated using hourly coal burn data (obtained from an Environmental Protection Agency website[25]) covering the years 2006 through 2008. This was done to estimate actual in-service heat rate[26] effects, fuel usage, and ultimately fuel cost, for Cycling⬍ Advisor runs under both baseloading and cycling operation. Table B-1 summarizes the most important fuel usage results.

As seen, Table B-1 lists gross MW, heat rate, and fuel usage data in formats and units consistent with the EPA data source. It also lists total unit capacity, making no provision for the percentage ownership of GenCo X. So, the results of Table B-1 were adjusted to reflect net generation and percentage GenCo X ownership before being included in the Cycling⬍ Advisor fuel cost model.

For most analyses, to convert fuel usage to average CY 2008 fuel cost, a coal price of $2.07/MMBtu and a natural gas price of $8.12/MMBtu were assumed[27]. As covered in Section 4 of this report, several sensitivity runs were made to explore the effects of scenarios with fuel costs that differed significantly from these 2008 averages.

[25] The site link is ftp://ftp.epa.gov/dmdnload/emissions/hourly/monthly/
[26] As opposed to lower test heat rates under optimal idealized conditions.
[27] To model emission costs for 2008, the EPA base case of 2006 was used (http://www.epa.gov/airmarkets/progsregs/epa-ipm/docs/Section-5.pdf). The emissions costs of 26 cents/MMBtu for coal plants and 2 cents/MMBtu for the gas plants were calculated and adjusted for CY 2008. So, for most models, coal fuel plus emission cost was input as $2.33/MMBtu and gas as $8.14/MMBtu.

## GENERAL HEAT RATE RESULTS

### Daily Data

Figures B-1 through B-17 summarize the results of the daily fuel burn analysis for all the units listed in Table B-1, except for AF Units 1, 2, and 3[28]. In all 17 plots, the red points and curves cover days with starts and the green ones cover days with no starts. Plotted data points show average daily heat rates for all days, except those off-line, or with near zero MW, and a few outliers[29]. The jagged dashed curves are fits using an advanced nonlinear regression tool[30]. The reason the dashed heat rate vs. hourly MW curves are jagged is that they model much of the variability inherent in the data points, because they are fit to several other independent variables. These are:

1. All average online daily MW readings above the first percentile
2. Each month of the year (individually), to model seasonal effects
3. Calendar year (individually), to model any recent aging and other longer term changes
4. Number of starts (0, 1, or 2) each day

The MW variable is fit using nonlinear polynomials with two to four coefficients. The other variables are handled using linear terms. The average “fit errors” of these highly scattered hourly readings ranged from 2.5% to 6%; these are better-than-acceptable results for EPA data for gas and especially for coal units, especially given so few outliers removed. Also, the regression “explained” 60% to 95% of the large daily heat variations (green or red points) in Figures B-1 through B-17.

### Cycling Heat Rate Effects

As mentioned above, daily power plant starts were explicitly included in the nonlinear regression model of heat rate, again while properly accounting for all the other listed heat rate effects

[28] The three AF units were also subjected to a heat rate analysis, and estimated real rates under near-capacity load are given in Table B-1. However, almost all days that these three units were used involved starts. So, a “cycling heat rate analysis” comparing days with and without starts for Agua Fria could not be done. The lack of this analysis had negligible impact on this report because AF units are used very rarely both by PF and in the Cycling♦ Advisor simulation runs.

[29] Using Intertek APTECH’s proprietary screening algorithm, all units were lightly screened and had less than 0.5% of daily readings removed as outliers; this is an acceptably low percentage based on previous studies using EPA hourly or daily data for coal and gas units.

[30] The “multivariable fractional polynomial (mfp)” model was implemented using computer program Stata, which is a “statistical package designed for researchers of all disciplines.” See http://www.stata.com and http://www.stata.com/help.cgi?mfp.

including MW itself. These starts markedly increased daily heat rates and fuel burned for all units, and almost all of these increases were comfortably statistically significant. Also, many of the 17 plots clearly show the start-associated heat rate increases.

It is important to note that only days generating above the 1st percentile of on-line (i.e., positive) MW were included in this “cycling heat rate” part of the analysis, so these results should not include the majority of direct startup fuel costs, which are estimated elsewhere. However, in some cases, it was difficult to separate the startup fuel consumption from fuel burned slightly below or near the minimum load. So, to avoid double counting cycling-related fuel consumption, the startup fuel estimates above were subtracted from those gleaned from the EPA analysis in this section. Thus, it is Intertek APTECH’s opinion that the net cycling-related fuel consumption is understated in this report. It is also important to note that the extra start-associated fuel usages quoted in Table B-1 are in addition to the fuel cost inefficiencies caused by running well below capacity, as represented by the general shape of the heat rate curves in Figures B-1 through B-17.

There are not enough data to differentiate the immediate heat rate costs of hot, warm, and cold starts, so the Table B-1 fuel usage estimates above are applied to all shutdown-start cycles with only small experience-based[31] adjustments.

[31] Intertek APTECH recently completed a large study for European clients on many coal units similar to those of PF. These data were used in calculating these minor adjustments.

<u>Table B-1</u>

**KEY RESULTS OF CYCLING HEAT RATE ANALYSIS OF GenCo X FOSSIL UNITS**

| Unit | Average online MW (gross) | In-service baseload heat rate (BTU/KWh) | Extra MMBTU per start | MMBTU per start per avg. mw | Comment |
|---|---|---|---|---|---|
| INTENTIONALLY DELETED | 781 | 8,734 | 7,494 | 9.60 | |
| | 800 | 8,687 | 6,795 | 8.49 | |
| | 38 | 17,951 | 375 | 10.00 | Nearly all online days had starts |
| | 36 | 17,754 | 365 | 10.00 | Nearly all online days had starts |
| | 80 | 15,514 | 800 | 10.00 | Nearly all online days had starts |
| | 416 | 10,033 | 3,208 | 7.71 | |
| | 420 | 9,902 | 3,007 | 7.16 | |
| | 250 | 7,852 | 1,944 | 7.78 | |
| | 234 | 7,837 | 2,323 | 9.93 | |
| | 217 | 7,058 | 1,162 | 5.35 | |
| | 773 | 10,481 | 8,076 | 10.45 | |
| | 780 | 10,307 | 11,580 | 14.85 | |
| | 770 | 10,528 | 11,902 | 15.46 | |
| | 239 | 7,327 | 3,016 | 12.62 | |
| | 226 | 7,488 | 2,069 | 9.16 | |
| | 235 | 7,135 | 3,013 | 12.82 | |
| | 432 | 10,058 | 11,312 | 26.18 | |
| | 431 | 10,361 | 8,165 | 18.95 | |
| | 424 | 9,666 | 7,027 | 16.57 | |
| | 273 | 9,984 | 1,962 | 7.19 | |

**Notes:**
[1] Source is EPA hourly MW and fuel usage data, 2006-2008
[2] Cycling heat rate analysis compared days with and without starts and accounted for loading, seasonal, year-to-year and unit and plant effects on heat rate.

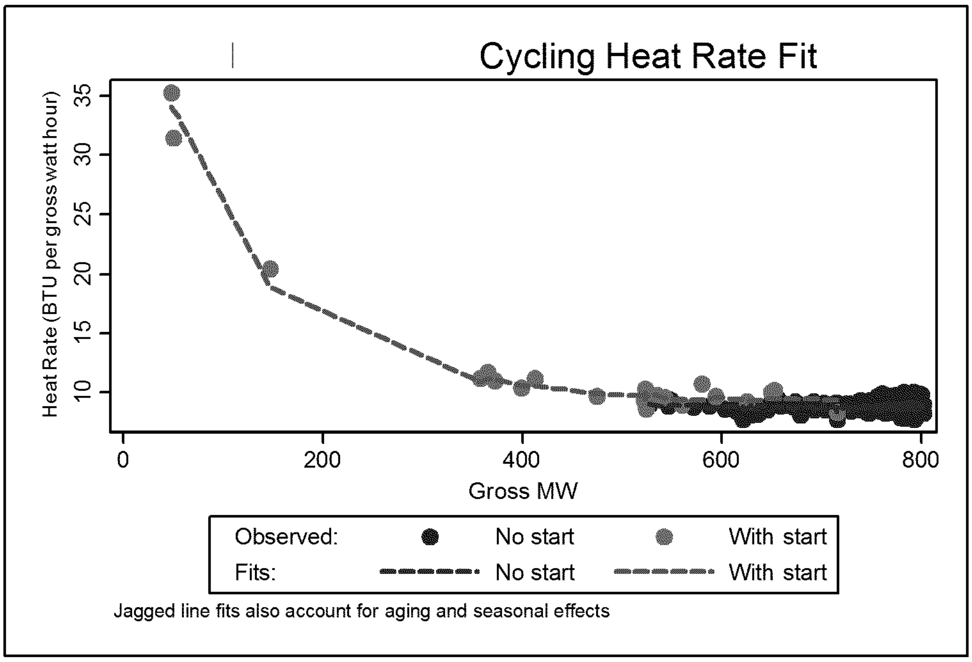


Figure B-1 — Heat Rate Analysis for FC Unit 4[32].

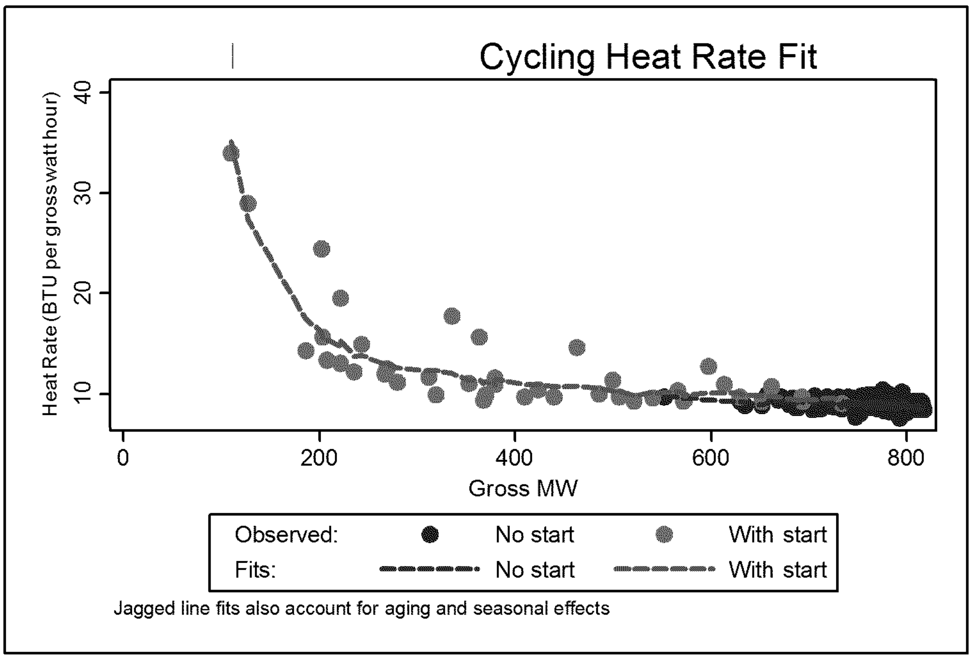


Figure B-2 — Heat Rate Analysis for FC, Unit 5.

[32] Figures B-1 to B-17 represent the heat rate analysis performed on the SRP units and used to estimate extra low- and variable-load fuel burned by the units. The plots exclude startup fuel.

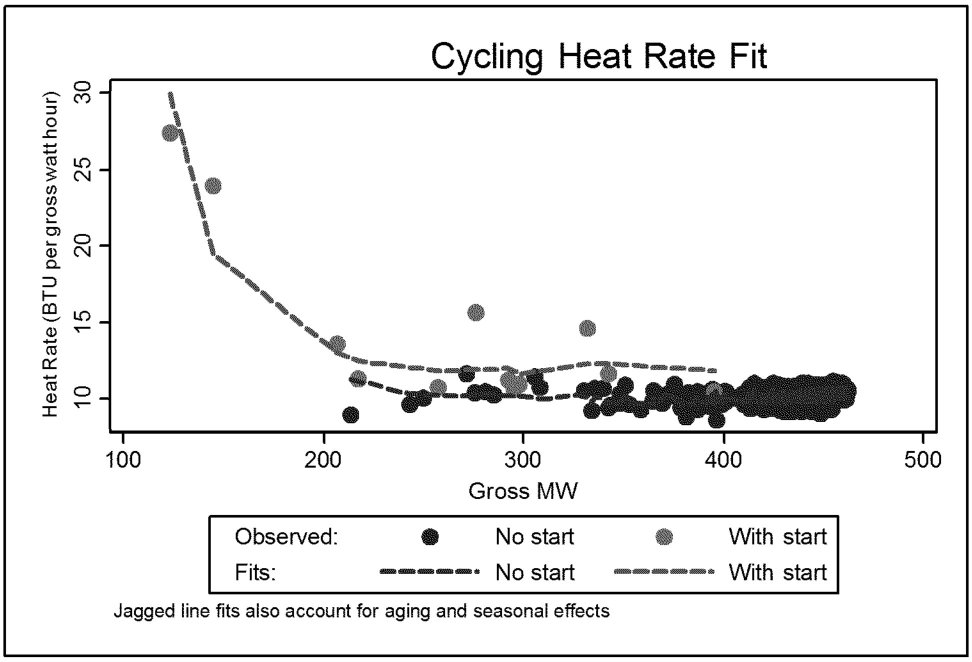


Figure B-3 — Heat Rate Analysis for CC1.

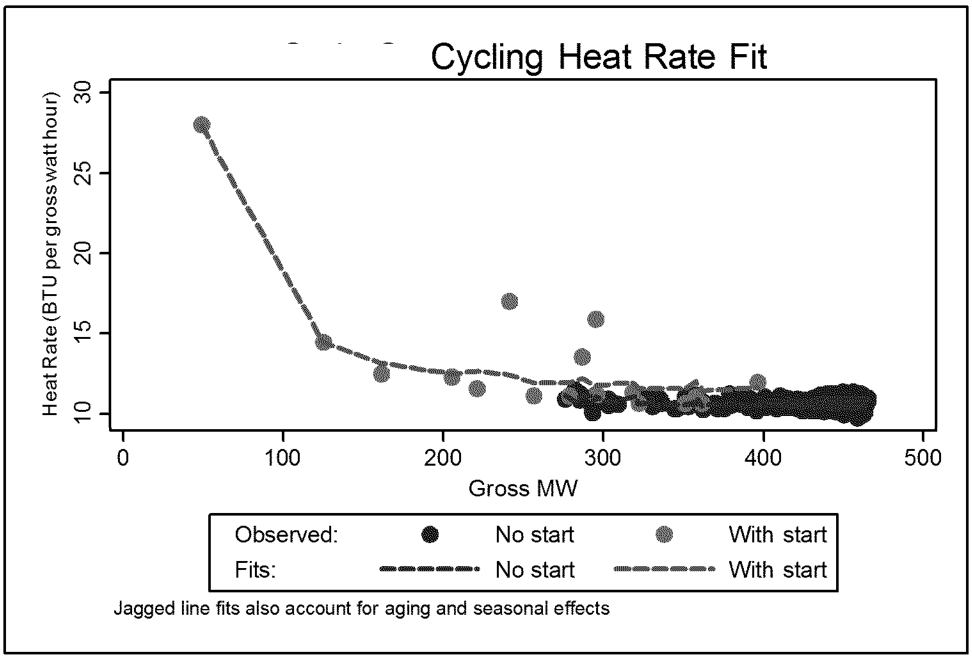


Figure B-4 — Heat Rate Analysis for CC2.

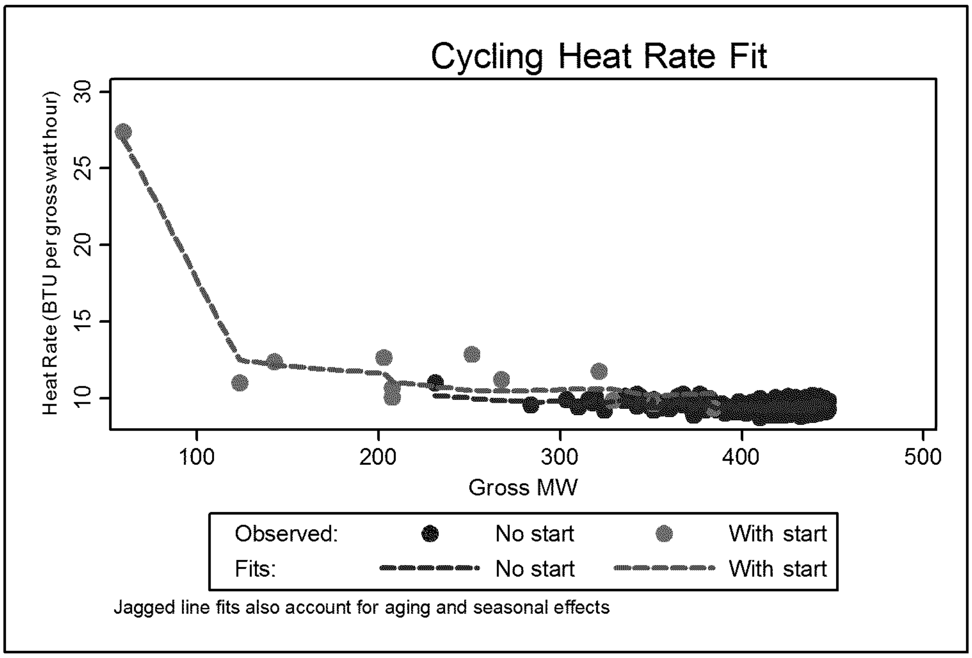


Figure B-5 — Heat Rate Analysis for CC3.

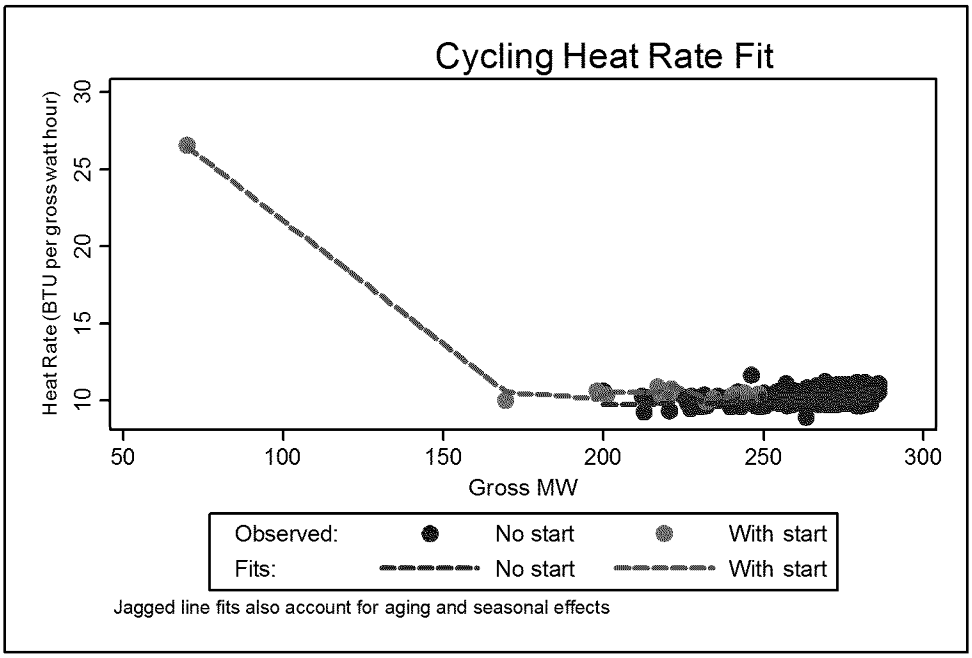


Figure B-6 — Heat Rate Analysis for H2.

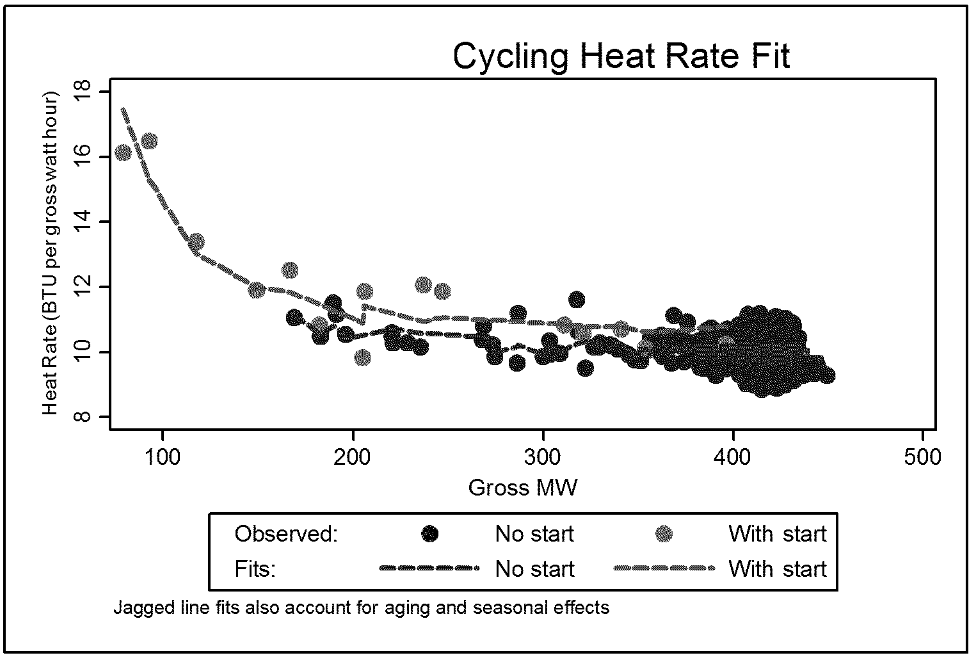


Figure B-7 — Heat Rate Analysis for Com Unit 1.

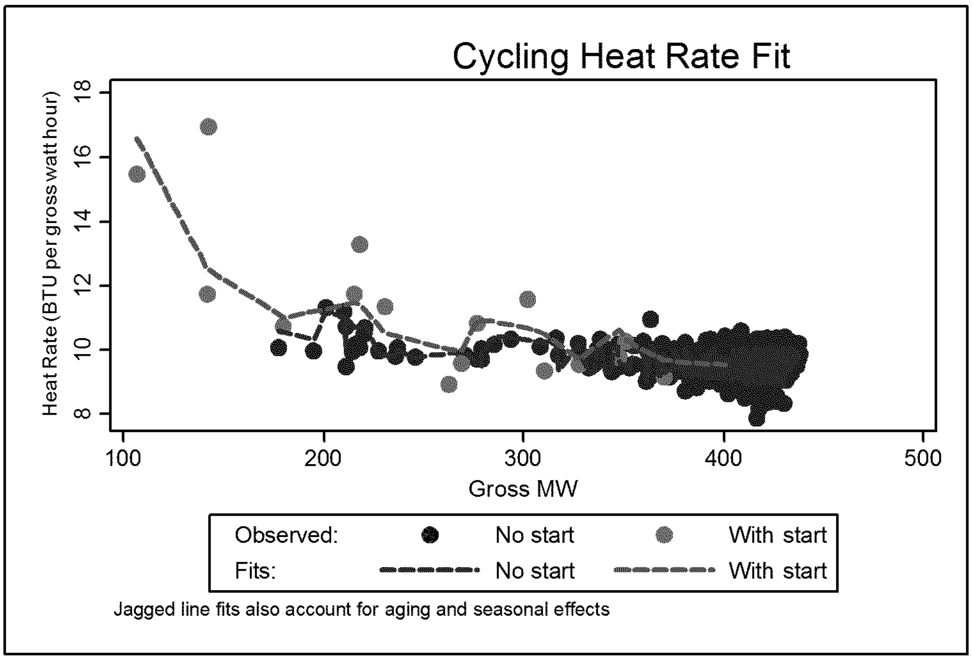


Figure B-8 — Heat Rate Analysis for Com Unit 2.

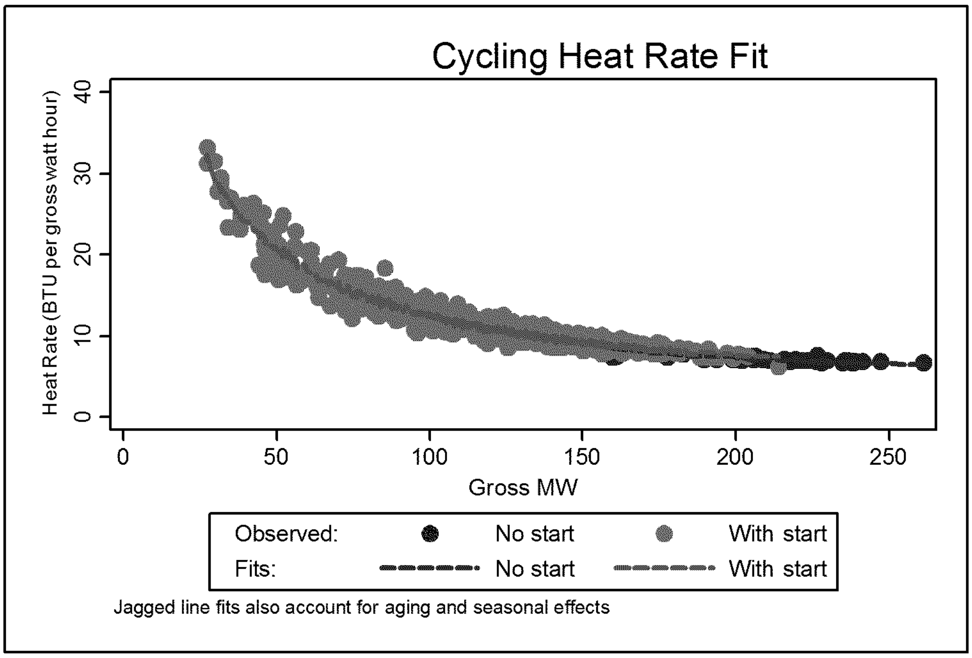


Figure B-9 — Heat Rate Analysis for Kite Unit 7.

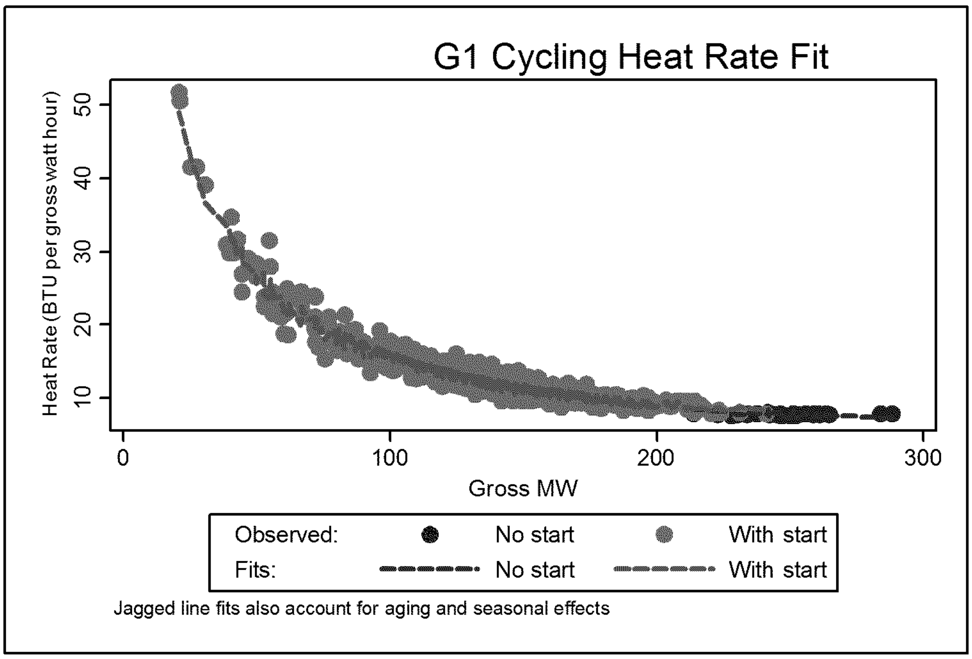


Figure B-10 — Heat Rate Analysis for DB Unit G1.

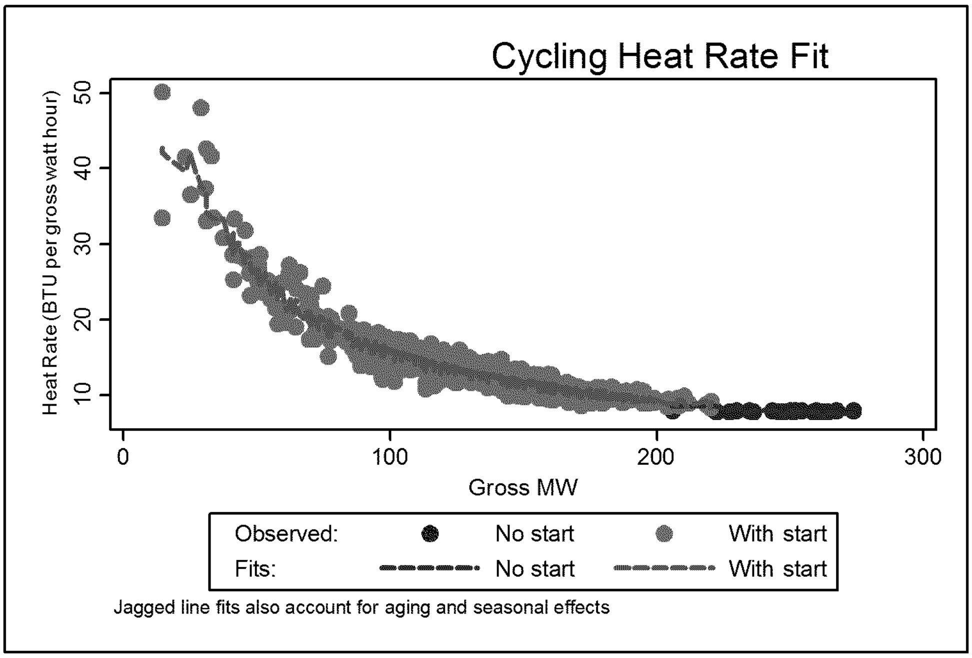


Figure B-11 — Heat Rate Analysis for DB Unit G2.

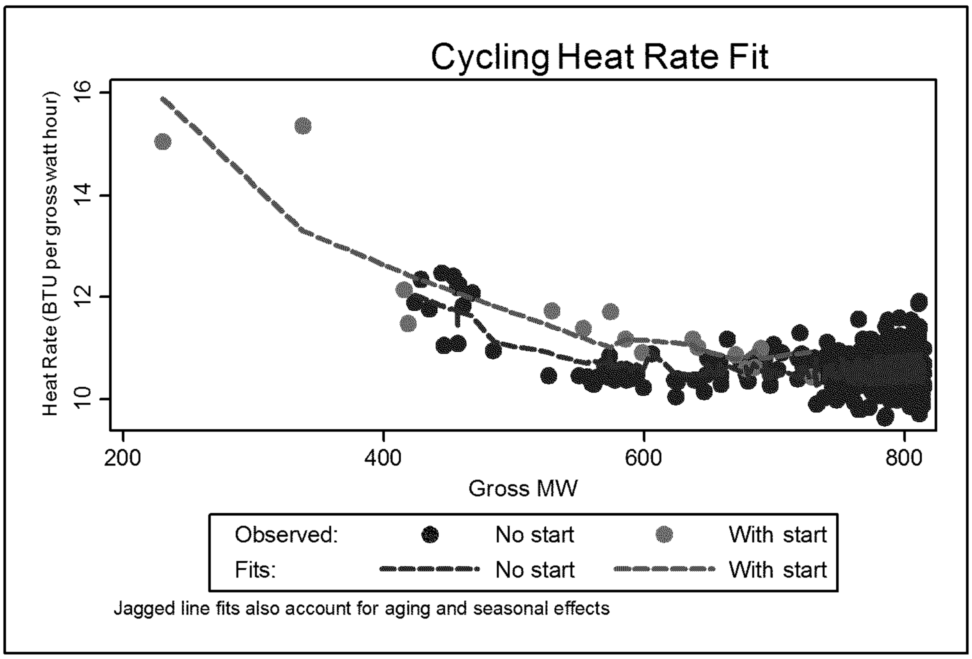


Figure B-12 — Heat Rate Analysis for Nordic Unit 1.

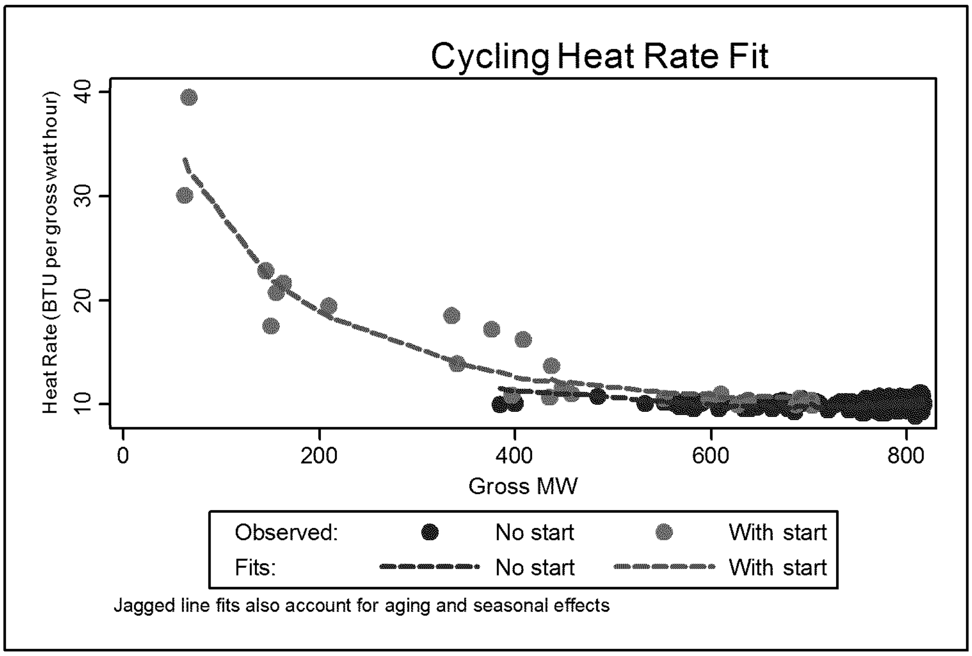


Figure B-13 — Heat Rate Analysis for Nordic Unit 2.

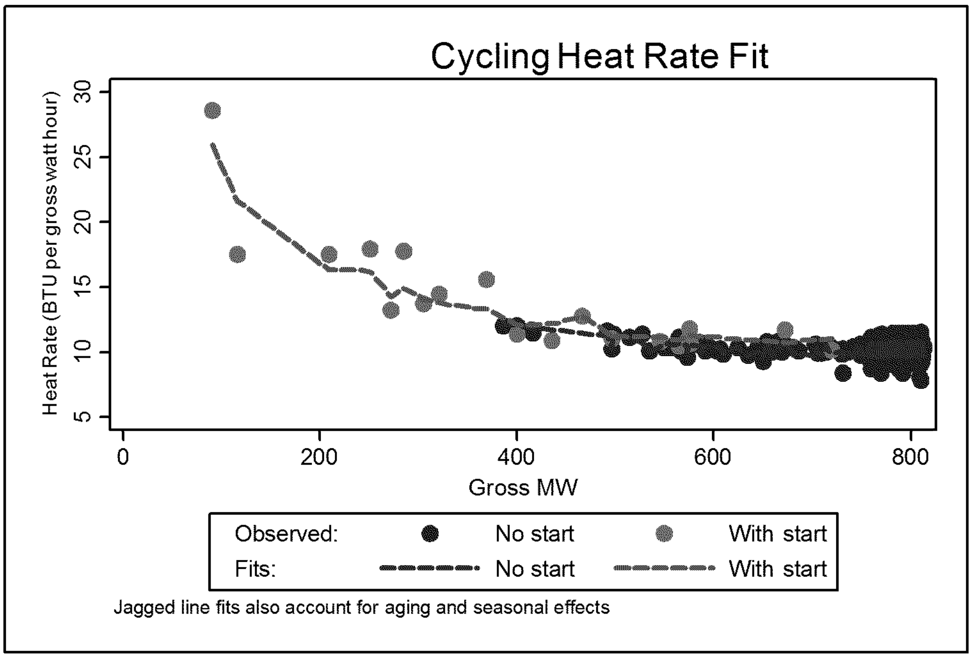


Figure B-14 — Heat Rate Analysis for Nordic Unit 3.

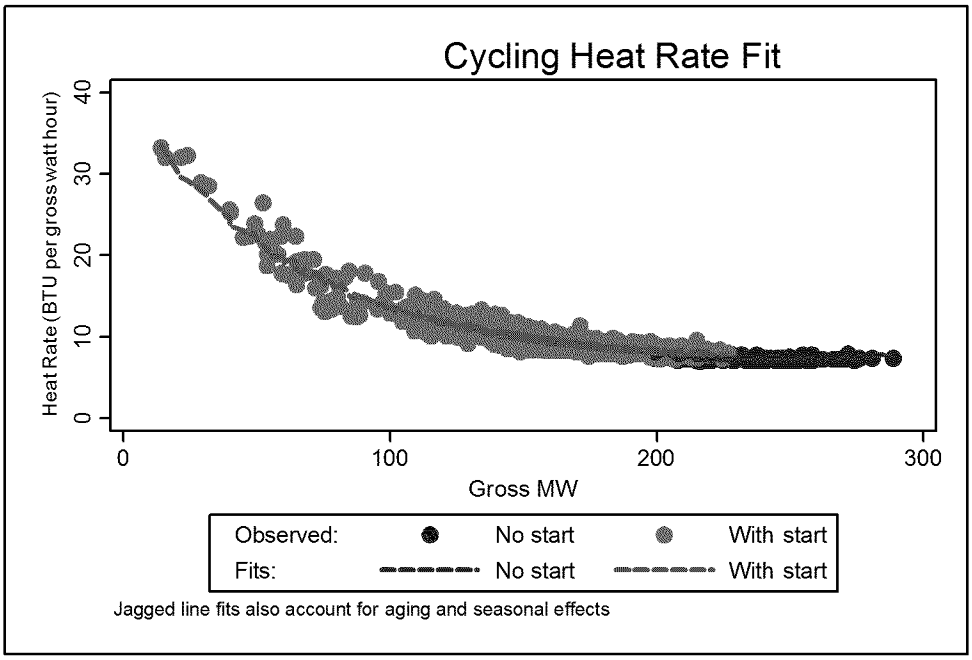


Figure B-15 — Heat Rate Analysis for Savage Unit 5A.

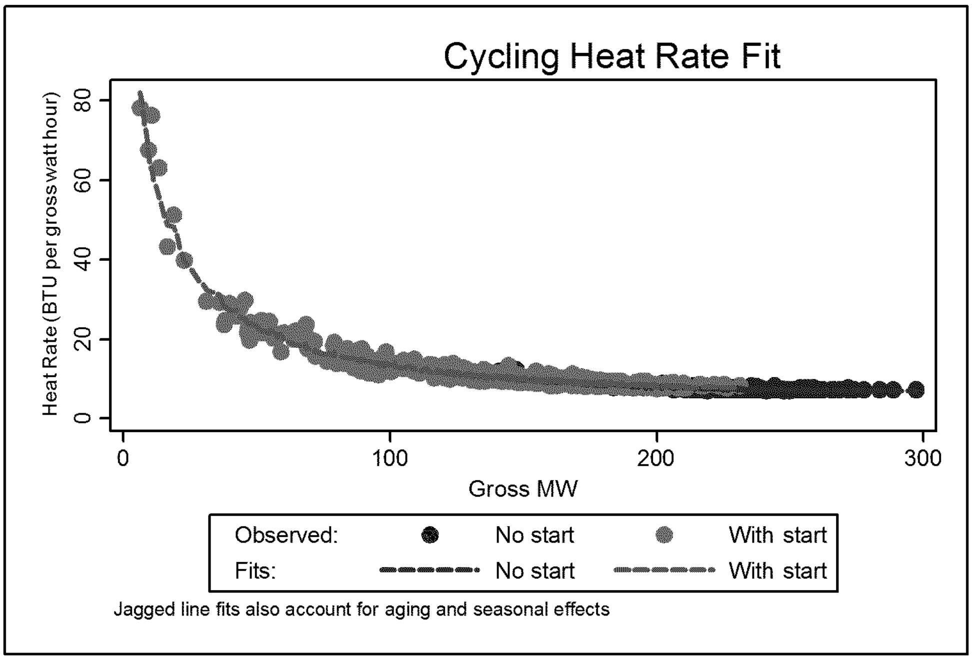


Figure B-16 — Heat Rate Analysis for Savage Unit 5B.

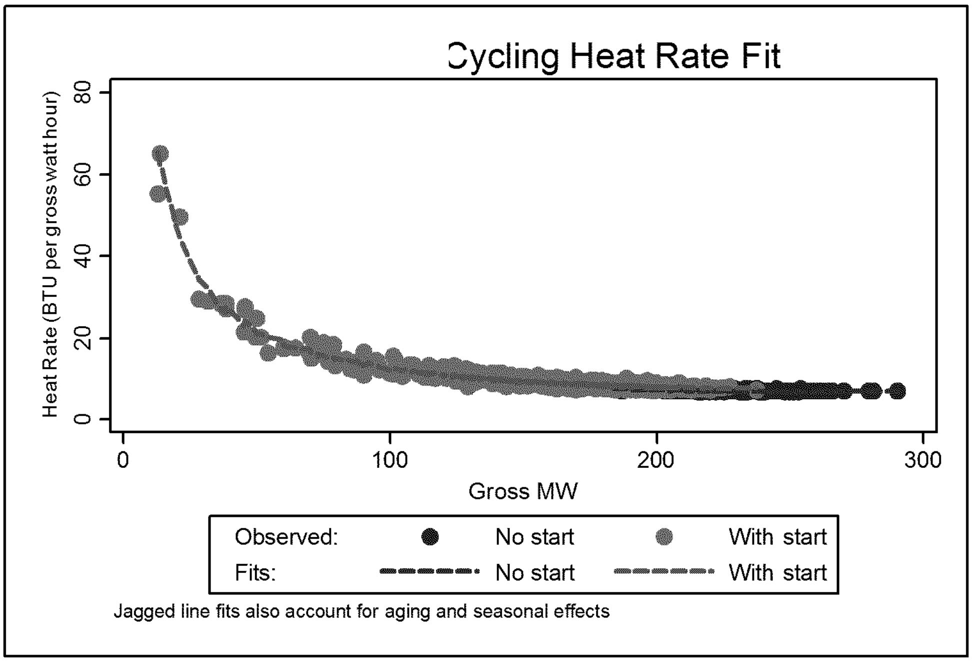


Figure B-17 — Heat Rate Analysis for Savage Unit 6A.

# Appendix C
# AGC FUEL COST EFFECTS

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## BEAGLE FUEL COST SAVINGS ASSOCIATED WITH AGC

Intertek APTECH estimated the fuel savings from avoiding, through use of Beagle generation, the heat rate increases due to automatic generation control (AGC) and concluded that Beagle saved GenCo X nearly $1 million in such fuel costs in 2008. Listed below are the unrounded calculations and assumptions leading to this $1 million estimate.

1. Without Beagle, the equivalent of at least three coal units with total capacity 3 x 535 = 1,605 MW would have to support AGC (see Figure 2-4 in Section 2). (If gas units had to join in this AGC support, the Beagle savings would exceed the estimate herein.)
2. From Prowse et al.[33], AGC increases heat rates of such coal units by approximately 0.35%.
3. The capacity factor of the coal unit studied in Figure 2-4 is 77% and its average baseload heat rate is 10.8 Btu per watt hour.
4. In 2008, three such coal units would burn coal heat input equivalent to 0.77 x 1,605 x 8,784 x 10.8 = 117,241,629 MMBtu.
5. With no AGC support, 0.35% of such heat input would be avoided, equivalent to 0.0035 x 117,241,629 = 410,346 MMBtu.
6. The savings associated with this avoidance, at the base case's $X.XX per MMBtu in coal price plus emission cost, equals X.XX x XXX,XXX = $XXX,XXX.

[33] Prowse, D. C. H., P. Koskela, T. A. Grove, and L. R. Larson, "Experience With Joint AGC Regulation", *IEEE Transactions on Power Systems*, Vol. 9, No. 4, November 1994, pp. 1974-1979.

## Appendix D

## CYCLING⬍ADVISOR CONVERGENCE

# Appendix D

## CYCLING⬍ADVISOR CONVERGENCE

Cycling⬍Advisor convergence[34] criteria to minimize PF system production costs for both the with- and without-Beagle models were standardized to be the same for all simulation runs in this report. The criteria were based on experience running the program and generally stopped the model run when the monthly production cost could not be improved (decreased) by more than 1%[35]. Since each model included 12 months with Beagle and 12 months without Beagle, the 24-month total took about 5.5 hours to complete for each model.

One additional run was made to verify the accuracy of the final convergence criterion used for all the reported Cycling⬍Advisor simulations. The full-cycling cost run for 2008 was re-executed using monthly optimizations lasting nearly an hour each (a factor of four longer than the standard runs used throughout the report) and totaling about 22 hours of run time to complete 12 months with Beagle and 12 months without.

Figure D-1 summarizes the results, which show the insensitivity of demanding further convergence beyond the standard convergence criteria described in the first paragraph above. Comparing the red and blue bars in this plot, the pattern of the monthly benefits is the same for the two convergence criteria. Specifically, the plot shows that all monthly differences in the Beagle benefit estimates were less than $0.5 million and there was no consistent pattern of which criterion produced greater monthly benefits. Most importantly, there was only about a 1.5% difference in the 2008 total Cycling⬍Advisor value-of-Beagle estimates using the two very different convergence criteria.

[34] Mathematical models (simulations) require several inputs to represent reality. These inputs result in a number of possible final results, which can be "converged" upon using a set of parameters (criteria). One of the criteria is run time of the simulation. In Cycling⬍Advisor, these convergence criteria result in an optimal hourly dispatch decision. In most models, after a point, increasing this run time criterion does not significantly reduce production costs.

[35] All quoted run times were based on a 3.5-year old Dell PC with an Intel Core 2 CPU 6600 processor @ 2.40 GHz. The FORTRAN program used a Lahey compiler that could not take advantage of the computer's dual core architecture.

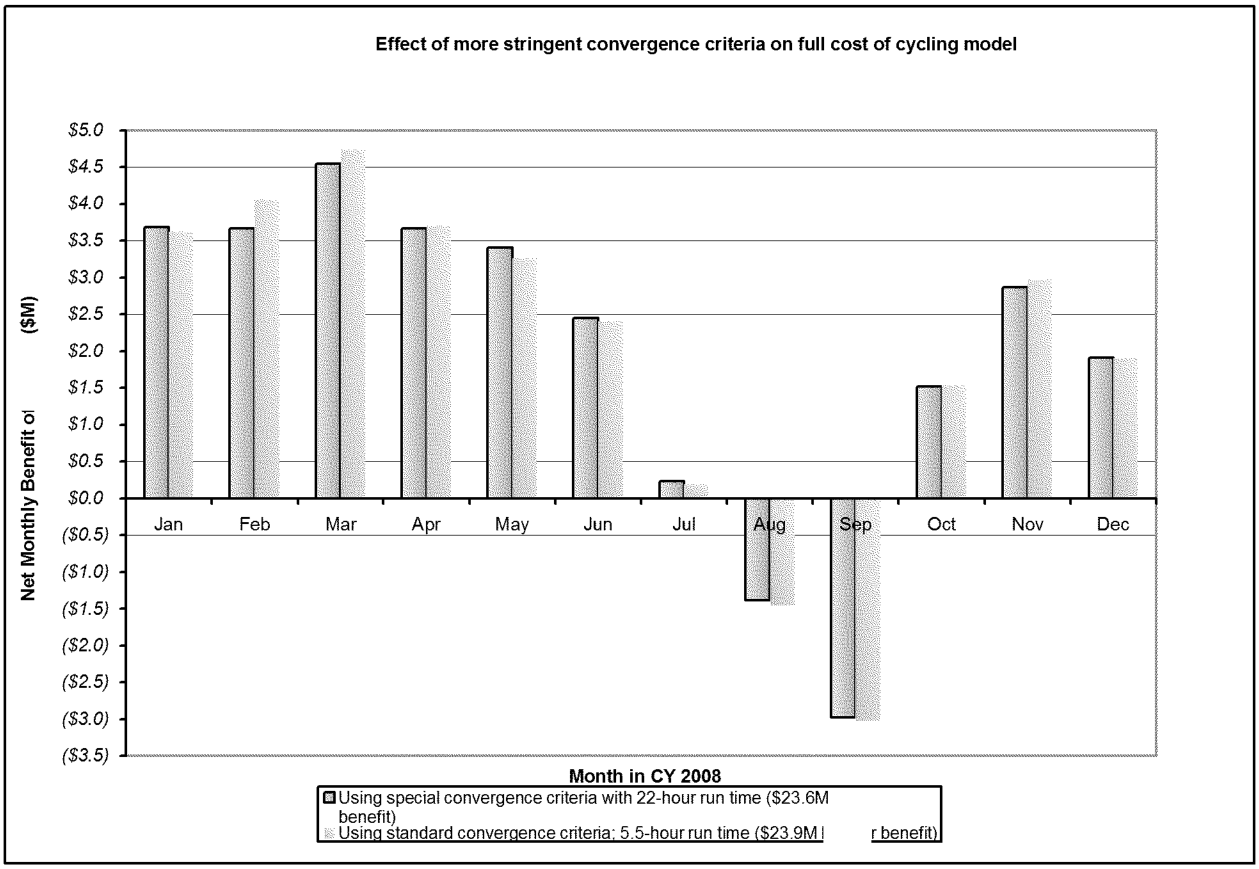


Figure D-1 — Cycling⬍ Advisor Convergence.

# Appendix E
# GLOSSARY

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## GLOSSARY

1. **AGC**: Automatic Generation Control. AGC is an instantaneous control system used to balance load and demand.

2. **Company**: Power Company (also abbreviated in tables and figures as APA).

3. **Cycling Cost**: Cycling costs are the maintenance related costs that are the result of a power plant providing dynamic load following and on/off service. Each time a conventional thermal power plant is cycled (load ramping or on/off service) – the feedwater heaters, pumps, boiler, steam lines, steam turbine, gas turbines, and auxiliary components go through unavoidably rapid large thermal and pressure stresses, which cause long-term, irreparable structural damage ultimately leading to fatigue damage and eventual component failure.

4. **Input Cycling Cost for Cycling⬍ Advisor**: Since there is uncertainty in how certain cycling costs are accounted for by utilities making unit commitment decisions, Intertek APTECH investigates the effects of a range of cycling costs — 0%, 50%, and 100% in this report. To keep our estimates conservative, we used a reduced cycling cost input to determine total maintenance and wear and tear costs. The Cycling⬍ Advisor program seeks to minimize total production costs using these input cycling costs, but also keeps track of the actual costs for comparison.

5. **Actual Cycling Cost**: Cycling⬍ Advisor uses the conservative input cycling-related costs, and outputs the optimized hourly dispatch of GenCo X portfolio. However, when we simulate the 0% and 50% cycling costs scenarios, the program hourly dispatch is in fact incurring higher "actual" costs of cycling. Note that, in the 100% case the output total production costs are the same.

6. **EFOR**: Equivalent forced outage rate. EFOR reflects the percent of time when due to unplanned events a power plant is completely out of service or when it remains in operation but is forced to reduce its power output during the time that it is required to generate power. More specifically, NERC (see below) defines:

$$EFOR = [(FOH + EFDH)/(FOH + SH + EFDHRS)] \times 100\ (\%)$$

Here FOH = forced outage hours, EFDH = equivalent forced derated hours, SH = service hours, and EFDHRS = equivalent forced derated hours during reserve shutdown.

7. **EHS**: Equivalent hot start. The damage accumulation rates computed by Intertek APTECH's loads model are related to the fatigue, creep, and fatigue-creep interaction damage emanating from an idealized gentle load transient known as an equivalent hot start (EHS). EHS provides a means for comparing the cycling damage and costs of different units under the same loading pattern. Of course, the actual hot start cycles at the units differ markedly from our reference EHS cycle. Accordingly, the EHS cycle is used only as a convenient reference for the damage calculations, and has no other significance.

8. **FERC**: Federal Energy Regulatory Commission

9. **Beagle Dynamic Signal**: The Dynamic Signal is an electronic signal sent every two seconds to the control center of AREA's Desert Southwest Office, located in Phoenix, AnyState, to control the power output of the synchronized generation scheduled by the Scheduling Entity on behalf of the Company at Beagle Dam.

10. **Indirect Cycling Costs**: Indirect cycling costs are maintenance, capital, and forced outage costs due to wear and tear on equipment. Direct cycling costs are cycling costs for startup fuel and auxiliary power.

11. **Marginal Cost**: Rate of change of cost with output at a given level of output ($MC = dVC/dQ$, VC = Variable Cost, Q = Quantity). Marginal cost is the change in cost of production due to one additional unit.

12. **NERC**: North American Electric Reliability Corporation

13. **Scheduling Entity**: The Scheduling Entity is a utility that has instantaneous generation scheduling responsibility for meeting load requirements and that enters into a

contract with the Company to dispatch the Beagle power available to the Company.

14. **GenCo X**: GenCo X. GenCo X is one of the largest government-owned utilities in the US. The GenCo X Agricultural Improvement and Power District, a political subdivision of the State of AnyState, provides electricity and distributes power to nearly a million customers.

15. **Synchronized Generation**: The total capacity available from the Beagle power plant generating units synchronized to the power system.

16. **Variable- and Low-Load Fuel Costs**: Fuel costs due to inefficiencies caused by running a power plant well below its capacity.

17. **AREA**: The AREA Power Administration (also abbreviated in tables and figures)