

CALIFORNIA  
ENERGY  
COMMISSION

# COMPARATIVE COST OF CALIFORNIA CENTRAL STATION ELECTRICITY GENERATION TECHNOLOGIES

Prepared in Support of the Electricity and  
Natural Gas Report under the Integrated  
Energy Policy Report Proceeding  
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# CALIFORNIA ENERGY COMMISSION

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## Introduction

This Energy Commission staff report presents the levelized cost estimates for several generic central-station electricity generation technologies. This is one of a number of reports that the Energy Commission staff is preparing, under the direction of the Ad Hoc Integrated Energy Policy Report Committee, to support the development of the *2003 Integrated Energy Policy Report*.

The Energy Commission staff would like to acknowledge the work of several consultants in putting together the information for this project. Dr. Richard McCann, along with Ron Ishii, Ed Miller, Peter Asmus, Larry Slomiski, John Kessler, and L. Knox provided the data the Energy Commission staff used in this report. In addition to providing data, Dr. McCann provided the financial models used in this analysis.

## Overview

California has traditionally adopted energy policies that balance the goals of supporting economic development, improving environmental quality and promoting resource diversity. In order to be effective, such policies must be based on comprehensive and timely information. With this goal in mind, the purpose of the report is to provide levelized cost estimates for a set of renewable (e.g., solar) and nonrenewable (e.g., natural gas-fired) central-station electricity generation resources, based on each technology's operation and capital cost. Decision-makers and others can use this information in assessing the generic costs to build a specific technology. This report also identifies the type of fuel used by each technology and a description of the manner in which the technology operates in the generation system.

This report is intended to provide a basic understanding of some of the fundamental attributes that are generally considered when evaluating the cost of building and operating different electricity generation technology resources. But these costs do not reflect the total costs to consumers of adding these technologies to a resource portfolio. The technology costs in this report are not site-specific. If a developer builds a specific power plant at a specific location, the cost of siting that plant at that specific location must be considered. Some projects may require radial transmission additions, fuel delivery, system upgrades or environmental mitigation expenses.

This levelized cost analysis does not capture all of the system, environmental or other relevant attributes that would typically be examined by a portfolio manager when conducting a comprehensive "comparative value analysis" of a variety of competing resource options. A portfolio analysis will vary depending on the particular criteria and measurement goals of each study. For example, some forms of firm capacity are typically needed in conjunction with wind generation to support system reliability requirements. Some projects may also require radial transmission additions, fuel delivery, system upgrades or environmental mitigation expenses.

Staff has made numerous changes to the preliminary draft report that was originally published on February 11, 2003. The Integrated Energy Policy Report Committee held a workshop on February 26, 2003 to take public comments on the matter. The original study focused on capital, rather than developmental costs. The report now includes development, land acquisition, and permitting costs for all technologies based on comments received at the workshop. Certain parties also expressed concern that staff had systematically understated several costs associated with gas-fired plants. In response to this latter set of comments, staff has:

- Changed the heat rate assumed for Combined Cycle units from 6,900 to 7,100 MMBtu/kWh,
- Included water cooling costs for gas-fired units,
- Added air-district-specific emissions costs that are shown in **Table 4**, and
- Made more precise estimates of costs associated with Significant Catalytic Reduction (SCR) operations, solid waste disposal, costs of overhauls, and capacity degradation rates.

## Purpose

As part of the Integrated Energy Policy Report proceeding, the California Energy Commission staff developed cost estimates for central-station electricity generation technologies. These estimates are intended to provide a general guideline on the expected costs of different technologies for policy makers and the public, and to assist resource planners in screening generation options.

## Technology Costs

**Table 1** shows the results of the cost analyses for various technologies. Expected levelized costs, constant annual payments made over the life of the plants, are shown to provide a common basis of measurement. By convention, *levelized costs are given in constant, or real, dollars* and use 2002 as the base year. To the extent possible, this evaluation relies on general economic and electricity system assumptions. Details about assumptions specific to each technology are included in the individual technology characterizations in the attached appendices. These costs are for generalized project descriptions and costs for actual projects will vary from those shown below, depending on a number of possible site-specific considerations. This information should be used only as general estimates of ownership costs for different technologies. They are not intended to be the sole criterion used in an investment decision, which necessarily involves an evaluation of many other factors.

Estimates of levelized costs are provided for power plants that use natural gas as an energy source and for plants that use renewable energy sources. The costs for these technologies are listed below in **Table 1**. Gas-fired plant costs are derived from Energy Commission staff analyses. The expected levelized cost for a generic new baseload combined cycle plant is

5.18 cents per kWh. However, this estimate increases to 5.34 cents per kWh for a unit located in the South Coast Air Quality Management District. When duct firing is added to the above-mentioned unit, this cost increases further to 5.37 cents per kWh.

Energy Commission staff estimates show that a combustion turbine, with an in-service year of 2004 and used for peaking service with a 10 percent capacity factor, can be expected to deliver this peak capacity and energy at a cost of 15.71 cents per kWh. Geothermal flash technology has the lowest levelized costs at 4.52 cents per kWh, with wind next at 4.93 cents per kWh. Hydropower is projected to provide load-following power at 6.04 cents per kWh. Geothermal binary plants have an expected cost of 7.37 cents per kWh. Solar thermal parabolic trough units have expected levelized costs ranging from 13.52 to 21.53 cents per kWh.

**Table 1  
Levelized Costs by Technology**

<b>Technology</b>	<b>Energy Source Fuel</b>	<b>Operating Mode</b>	<b>Economic Lifetime (years)</b>	<b>Gross Capacity (MW)</b>	<b>Direct Cost Levelized (cents/kWh)</b>
Combined Cycle	Natural Gas	Baseload	20	500	5.18
Simple Cycle	Natural Gas	Peaking	20	100	15.71
Wind	Wind; Resource Limited	Intermittent	30	100	4.93
Hydropower	Water; Resource Limited	Load-Following, Peaking	30	100	6.04
<b>Solar Thermal</b>					
Parabolic Trough	Sun; Resource Limited	Load-Following	30	110	21.53
Parabolic Trough-TES	Sun; Resource Limited	Load-Following	30	110	17.36
Parabolic Trough-Gas	Sun/Natural Gas; Partially resource limited	Load-Following; Peaking	30	110	13.52
<b>Geothermal</b>					
Flash	Water	Baseload	30	50	4.52
Binary	Water	Baseload	30	35	7.37

In considering these figures, it is important to note the relationship between the expected economic (or “book”) life of a project and levelized cost. In this report, the standard loan period is 12 years. For project finance, this means that the entire dollar outlay associated with completing the project (or the “instant cost”) is allocated during years one-through-twelve of the project. In contrast, levelized cost calculation spreads these costs across *all* years of a project’s operation. The levelized cost of a highly capital intensive project, such as

hydroelectric, will depend greatly on the project life assumed. If an economic lifetime is assumed to be 50 years, the levelized cost estimate for hydroelectric generation would fall precipitously. This greater economic lifetime would allow the relatively large capital cost to spread over a greater number of years, decreasing its contribution to the levelized cost calculation. The figures in **Table 1** would then overestimate the levelized cost of a hydroelectric project with an economic lifetime of more than 30 years.

Technological advancement plays an important role in determining the actual life of a project. For a mature technology, such as with hydroelectric facilities, generation efficiency has not significantly changed over time. As a result, a project built in 2003 may not be much more efficient than one built in 1983. The same cannot be said for an emerging technology, such as solar thermal generation. In this case, technology can change rapidly and at an unpredictable pace. State-of-the-art products may quickly become obsolete. In these cases, technological advances might induce developers to abandon the projects far short of the hypothesized 20- or 30-year economic lives. Of course, re-computing book lives over shorter time horizons will cause a project's instant costs to be allocated over a smaller number of years, increasing its levelized cost. Projects that exceed their expected economic lifetimes will reduce the levelized costs.

## **Applicability of Levelized Costs**

Different generation operational modes will range from baseload, to intermediate, to a peaking type of facility. A baseload facility generally delivers power at a constant rate whenever the plant is available. A facility may also be used to provide spinning reserve to deliver power during intermittent emergencies on extremely short notice. In between these modes of operation are intermediate/load-following facilities, where a plant follows the daily cycles in load. A peaking facility is called upon only during the highest daily loads during the seasonal peaks. Some facilities may provide ancillary services, where a plant provides system support, such as voltage regulation. An intermittent/variable facility may deliver power whenever the driving resource, such as wind, is available.

Comparing technologies on levelized cost alone is not appropriate, considering that different technologies provide different services. For example, wind is very competitive on the basis of cost per kWh, but it can only provide variable output. Other renewable resources, such as geothermal, have much more predictable output that may be more valuable, although improvements have been made in wind resource predictability as reflected in recent changes in ISO tariffs.

While particular generation technologies may have higher or lower costs than others, ratepayers may not see them unless the power purchase contracts specify that prices are based directly on costs. Power may be sold under a range of contractual and market transaction terms that may have no relationship to the actual cost of producing power from a specific plant. In fact, power contracts terms can be set entirely independently of the type of technology producing the power.

The combination of contract terms and technology type establishes the sharing of risks between ratepayers and generation investors. For a gas-fired plant, when fuel costs rise, it is likely that power market prices will also rise. Some contracts will pass these increases to ratepayers. In other contracts, gas-fired plants may be paid at fixed contract rates over a period of years. In these contracts, generators are exposed to fuel-cost risk, unless they also have signed a fixed-price contract for natural gas delivery. Generally, in exchange for fixed-price contracts, generators will charge a premium above the expected average market price for power to compensate for the shift in risk from ratepayers to generators.

For some renewables, the story is substantially different. If they hold a fixed price contract, ratepayers are not exposed to fuel price risk. If a renewable generator is paid based on the short-term market price, its revenues will vary with gas prices, even though its own costs remain relatively constant. In terms of a single project, ratepayers face virtually the same risk as they would with a gas-fired generator. However, ratepayers may face a smaller price risk when considering renewable projects as a whole. The more renewable projects that are present to improve fuel diversity, the less the price of electricity will likely move with changes in natural gas costs. Although renewable generator returns may fluctuate with the price of natural gas, a fixed-price contract tends to align the annual revenues with its minimal variation in costs, a more favorable outcome. In general, these types of contracts have similar terms to those signed with gas-fired generators. Considering that renewable technologies also provide other system and environmental benefits that are not generally reflected in market prices, public interest programs can improve the economic incentives for new development.

Risk-management strategies generally use some type of financial or contractual methods to reduce the variability of future costs. Without any risk management efforts, all parties are subjected to cost variations inherent in the marketplace. Risk management strategies used in energy markets include participating in forward markets, vertical and horizontal integration through market segments, long-term contracting, commodities hedging on the natural gas and electricity markets and, of course, diversification of fuel supplies, suppliers and technologies. In this sense, adoption of a renewable energy project may be viewed as part of a greater fuel diversification strategy, and the state may deem higher cost renewable projects to be an acceptable investment to pay for natural-gas price risk mitigation.

## **Methodology**

Costs associated with electric power facilities fall into three main categories. The first category is the initial investment costs necessary to plan, permit, construct, and start up a plant. These costs are typically financed through a combination of loans (“debt financing”) and investment ownership (“equity financing”). The costs are then repaid to lenders and investors over the life of the project.

Debt financing usually has fairly rigid conditions related to the term of the loan, the required periodic payments and the security of repayment, much like a home mortgage. Equity financing is usually repaid from the residual revenues remaining after paying all other costs

and, as a result, has a higher risk of not being fully repaid compared to debt financing. For purposes of cost comparisons, the assumption is made that these investments are recovered on a relatively constant annual basis without regard to the amount of generation output. This annual expenditure is then divided over the annual generation to derive the average cost per kWh for the investment or “capital” component.

For capital costs, common assumptions are used for debt financing such as interest rates, term and other requirements, and for expected investment return rates for equity financing. These assumptions are shown in **Table 2**. The debt interest rate assumptions are based on November, 2001 values when the market was stable. These assumptions cover three types of potential owners—merchant developers, investor-owned utilities, and municipal utilities and non-profit cooperatives. Capital costs specific to each technology are included in **Appendices C through S**.

**Table 2**  
**Assumptions for Equity Return and Debt Interest Rates**

Type of Owner	Return on Equity	Debt by Term (November, 2001) <sup>1</sup>					
		1	5	10	12	20	30
Merchant	16.0%	7.4%	7.4%	7.4%	7.4%	7.8%	8.0%
IOU	10.6%	6.3%	6.3%	6.3%	6.3%	7.1%	7.4%
Muni/Coop	NA	3.9%	3.9%	3.9%	3.9%	4.7%	4.8%

The second category is the annual operations and maintenance (O&M) costs that are relatively invariant with the amount of output, but would cease if plant operations ended. Operational costs include labor and management, insurance and other services, and certain types of consumables. Maintenance costs include scheduled overhauls and periodic upkeep. Unscheduled or “forced” outages that are a function of usage fall into the final category of costs described below. As with capital costs, these costs are summed and divided over the annual generation output to arrive at the average cost per kWh. However, unlike capital costs that are relatively insensitive to operational mode, the mode of operation can greatly affect these types of costs. For example, intervals between overhauls may be extended if a plant shifts from intermediate to peaking operations. Less labor may be required for a plant that operates only during the seasonal peak period rather than in baseload. In addition, these costs typically escalate over time, compared to capital costs which are considered constant and fixed once the initial investment is made. Nevertheless, once the mode of operation is determined, the annual O&M costs will vary little and are highly predictable over time.

The third category is the variable costs that are derived from fuel consumption, maintenance expenditures for forced outages, and other input costs driven directly by hourly plant operations. For a natural gas-fired plant, the largest component of these costs is the

<sup>1</sup> Staff finds that the market and debt interest rates during 2001 were stable compared to current conditions.

consumption of natural gas. Fuel costs can represent two-thirds or more of total average costs. Fuel usage, by technology, is shown in **Table 5** of **Appendices C** through **S**. Renewable resources typically have quite low variable costs because their fuel, other than biomass, have low or zero costs.

Variable input costs, particularly fuel costs, change over time. The fuel costs are often relatively unpredictable compared to other cost components. The staff's December 2002 projection of the price of natural gas for the years 2003-2013 is found in **Table 1, Appendix A**. After 2013, an average escalation factor of 5.60 percent is used to project natural gas price. This is the value of the predicted increase in fuel cost from 2012 to 2013. Variable costs also change directly with plant output and thus can vary substantially from year to year. However, they vary little, if at all, on an average cost basis. On the other hand, capital and O&M costs per kWh are inversely related to plant output—higher output means lower average costs for these components, and vice versa. Assumptions concerning annual plant operation are provided in **Table 6** of **Appendices C** through **S**.

Effects from federal and state tax policies are specified for each type of technology, as shown in **Table 3**. This table summarizes the various federal and state tax programs by technology and type of owner.

The federal corporate income tax rate is assumed to be 34 percent, and 8.84 percent is assumed for the California tax rate. The average property tax rate is 1.069 percent, and the average sales tax is 7.67 percent.<sup>2</sup> In addition, **Table 7** of **Appendices C** through **S** lists the renewable tax benefits applicable to each of the technologies.

To estimate operating and maintenance costs, common assumptions for salaries and associated benefits were developed for each specific technology. Staff used the 1996 United States Labor Department reported data for the different technologies as a conservative labor cost estimate in the analysis. The Labor Department information shows that labor costs were between \$20 – \$30 per hour, but more recent data shows that labor for some technologies is less than \$20.00 per hour.

Assumptions for each technology are shown in **Tables 8 and 9** of **Appendices C** through **S**. Based on the technological and financial data contained in this report, staff obtained cost summaries for each of the technologies studied. These summaries are provided in **Table 10** of **Appendices C** through **S**. Staff analyzed the impact of the emission mitigation and the cost of adding the duct firing to gas-fired facilities in different air quality management districts and summarized the results in **Table 4**. The emission cost used in the staff analysis was extracted from “Regional Cost Differences Siting New Power Generation in California Report” dated December, 2002. This report was prepared by the Aspen Environmental Group under a contract with the Energy Commission.

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<sup>2</sup> Elizabeth G. Hill, *California's Tax System: A Primer* (Sacramento, California: Legislative Analyst's Office, State of California, January 2001).

**Table 3  
Federal and State Tax Programs**

	<b>Merchant</b>	<b>IOU</b>	<b>Muni/Coop</b>
<b>Combustion Turbine</b>			
Federal Depreciation	MACRS <sup>3</sup> 20 years	MACRS 20 years	N/A
CA Depreciation	Plant Life	Plant Life	
Investment Tax Credit	No	No	No
Renewable Prod. Credit	No	No	No
<b>Wind</b>			
Federal Depreciation	MACRS 5 year	MACRS 5 year	N/A
CA Depreciation	Plant Life	Plant Life	N/A
Investment Tax Credit	No	No	N/A
Renewable Prod. Credit	Yes	No	Tier I
<b>Solar</b>			
Federal Depreciation	MACRS 5 year	MACRS 5 year	N/A
CA Depreciation	Plant Life	Plant Life	N/A
Investment Tax Credit	Yes	Yes	N/A
Renewable Prod. Credit	No	No	Tier I
<b>Geothermal</b>			
Federal Depreciation	MACRS 5 year	MACRS 5 year	N/A
CA Depreciation	Plant Life	Plant Life	N/A
Investment Tax Credit	Yes	Yes	N/A
Renewable Production Credit	No	No	Tier I

<sup>3</sup> Modified Accelerated Cost Recovery System.

**Table 4  
Gas-Fired Power Plants Cost Comparisons**

<b>Technology</b>	<b>Air District</b>	<b>Gas Utility</b>	<b>Fuel</b>	<b>Operative Mode</b>	<b>Direct Cost Levelized</b>
Combined Cycle	Bay Area	PG&E	Natural Gas	Baseload	\$0.0524
Combined Cycle	Sacramento	PG&E	Natural Gas	Baseload	\$0.0523
Combined Cycle	Kern County	SoCal	Natural Gas	Baseload	\$0.0518
Combined Cycle	Mojave Desert	SoCal	Natural Gas	Baseload	\$0.0519
Combined Cycle	South Coast	SoCal	Natural Gas	Baseload	\$0.0534
Combined Cycle	San Diego	SDG&E	Natural Gas	Baseload	\$0.0527
Combined Cycle w/Duct Firing	Bay Area	PG&E	Natural Gas	Baseload	\$0.0526
Combined Cycle w/Duct Firing	Sacramento	PG&E	Natural Gas	Baseload	\$0.0525
Combined Cycle w/Duct Firing	Kern County	SoCal	Natural Gas	Baseload	\$0.0520
Combined Cycle w/Duct Firing	Mojave Desert	SoCal	Natural Gas	Baseload	\$0.0522
Combined Cycle w/Duct Firing	South Coast	SoCal	Natural Gas	Baseload	\$0.0537
Combined Cycle w/Duct Firing	San Diego	SDG&E	Natural Gas	Baseload	\$0.0529
Simple Cycle CT	Bay Area	PG&E	Natural Gas	Peaking	\$0.1574
Simple Cycle CT	Sacramento	PG&E	Natural Gas	Peaking	\$0.1575
Simple Cycle CT	Kern County	SoCal	Natural Gas	Peaking	\$0.1571
Simple Cycle CT	Mojave Desert	SoCal	Natural Gas	Peaking	\$0.1571
Simple Cycle CT	South Coast	SoCal	Natural Gas	Peaking	\$0.1576
Simple Cycle CT	San Diego	SDG&E	Natural Gas	Peaking	\$0.1579

## **Caveats**

The analysis presents the costs in terms of levelized costs. Levelized costs can be interpreted as a constant level of revenue necessary each year to recover all expenses over the expected economic life of the project, assuming all costs are known. Levelized costs for any power

plant are a function of all the fixed and varying annual costs (e.g., financing, operations and maintenance, and fuel).

Capital costs for construction are a function of debt and equity financing terms. Debt financing is typically structured with a fixed term and interest rate, and periodic repayments. Equity financing is usually a residual return from revenues after all other costs, including debt repayment, have been covered. In this analysis, debt financing costs were based on the expected terms for a merchant-financed project with a 12-year loan and a BBB debt rating in November 2001. These terms may have changed significantly, and the industry certainly faces a much wider range of terms than it did at that time. Expected equity returns are typically between 12 and 16 percent. In this analysis, the equity target was set at twice the debt rate. In addition, other significant costs are incurred for arranging project financing. These costs range from 1.5 to 12 percent of total project investment, depending on the size of the project and the deemed creditworthiness of the project developer. This factor was set at zero percent for this analysis because no appropriate level could be chosen without project-specific details.

A second set of costs which vary by project are regional and site specific permitting and infrastructure costs. These cost differences have been documented in a report prepared by Aspen Environmental Group for the Commission in December 2002 “Regional Cost Differences Siting New Power Generation in California Report.” The cost of acquiring air quality permits and offsets, and water supply sources vary substantially depending on what region the plant is located. For example, emission offset costs for a 500 MW combined cycle plant can vary from less than \$5 million to over \$20 million. Water supply costs can vary from less than \$200 per acre-foot to over \$600. The costs for gas-fired power plants are presented for specific regions to reflect these differences. However, even these cost estimates may not accurately reflect the specific circumstances for any one project. Installation of pipelines, substations and transmission lines are a function of proximity to utility interconnections, and cannot be easily generalized. In addition, general permitting process costs vary substantially depending on project specifics and jurisdiction. For this reason, these costs are not included in this analysis.

The levelized costs shown in this report are for “greenfield” projects, so they do not include any demolition costs, nor do they reflect any benefits from previously existing infrastructure. The use of levelized costs over a 20 to 40 year time horizon largely mitigates the effects from any short-run price deviations. While prices may achieve short-run spikes for various reasons, including war or other tragedies, those prices may also plunge due to an over-supply. The forecast is intended to reflect an average of the expected range of conditions over time rather than to trace patterns.

On the other hand, projects may provide benefits to the generation portfolio by hedging risks associated with fuel-price or energy-availability volatility. Such benefits can be provided by projects that can deliver power at a consistent rate on demand from energy sources where costs are not correlated with fossil fuel prices. The magnitude of the benefits is a function of:

1. The volatility of natural gas prices and energy availability from intermittent renewables such as hydro and wind power, and
2. The consistency and control of the power output of the resource.

Some of these benefits can be gained through financial contracts that fix fuel prices, but “physical hedges” where the resource energy supply is separate from fossil fuel provide additional societal insurance. This cost model does not include the risk-hedging benefit because that analysis is complex and dependent on the system mix of resources and contracts for those resources.

Natural gas variability is an important factor that can affect the cost of the gas-fired technologies. Hedging natural gas prices and hedging cost could be an important element in determining the actual cost. However, in this analysis, staff did not consider the hedging impact.<sup>4</sup> One must also note that the intermittent nature of wind and run-of-river hydro projects decreases their value relative to dispatchable units.

The costs presented in this report taken alone are not sufficient to choose among technologies. The choice will depend on the resource system portfolio, and how the specific resource performs within that portfolio. Other factors such as reliability, operational flexibility, environmental considerations, and appropriate scale are important as well. Developing the appropriate resource portfolio involves balancing least cost and best fit objectives.

## Emerging Technologies

In addition to the technologies mentioned previously in this report, staff also obtained levelized cost estimates for emerging technologies. Such technologies require further breakthroughs in research and development before they will be considered commercially viable on a central-station scale. These technologies include various fuel cell units (costs given in **Appendices E – I**); Solar Photovoltaics, **Appendix M**; and Solar Thermal – Stirling Dish, **Appendix P**. Of these technologies, Solar PV has shown its usefulness as a distributed generation technology. However, the levelized cost, 42.72 cents per kWh for a 50 MW plant, makes it uncompetitive at a central-station scale.

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<sup>4</sup> For an estimate of the hedging cost associated with natural-gas-fired plants, see Bolinger, Wiser and Golove, *Quantifying the Value that Wind Power Provides as a Hedge Against Volatile Natural Gas Prices*, (Berkeley, Lawrence Berkeley National Laboratory, June 2002).

**Table 5**  
**Levelized Costs for Emerging Technologies**

<b>Technology</b>	<b>Energy Source Fuel</b>	<b>Operating Mode</b>	<b>Economic Lifetime (years)</b>	<b>Gross Capacity (MW)</b>	<b>Direct Cost Levelized (cents/kWh)</b>
Solar Thermal- Stirling Dish	Sun; Resource Limited	Load-Following	30	31.5	15.37
Photovoltaic	Sun; Resource Limited	Load-Following	30	50	42.72
Phosphoric Acid	Natural Gas	Baseload	20	25	21.27
Molten Carbonate	Natural Gas	Baseload	20	25	10.15
Solid Oxide	Natural Gas	Baseload	20	25	13.04
Hybrid	Natural Gas	Baseload	20	25	9.41

# ***Appendices A-Q***



# ***Appendix A***

## ***Natural Gas Price Forecast***

**Table A-1**  
**Energy Commission December 2002**  
**Natural Gas Price Forecast, 2003-2013**

<b>Year</b>	<b>Price</b>
2003	\$4.55
2004	\$4.10
2005	\$3.94
2006	\$4.11
2007	\$4.29
2008	\$4.50
2009	\$4.72
2010	\$4.97
2011	\$5.25
2012	\$5.54
2013	\$5.83

# ***Appendix B***

## ***Financial Information***

**Table B-1**  
**Financial Parameters**

<b>Category</b>	<b>Capital Structure</b>	<b>Capital Cost</b>
Equity	39.1%	16.0%
Preferred Equity	0.0%	0.0%
Debt	60.9%	7.4%
Discount Rate/Net Capital Cost	10.8%	
Debt Limit	100.0%	
Inflation Rate	2.0%	
Debt Coverage Ratio - Minimum	1.5	
Debt Coverage Ratio - Average	1.8	
Loan/Debt Term (years)	12.0	

# Appendix C

## Combine Cycle-Baseload (No Duct Firing)

**Table C-1  
Plant Information**

Technology Type	Natural Gas
Fuel	Natural Gas
<b>Owner/Investor</b>	Merchant
Base Year	2002
In-service Year	2004

**Table C-2  
Plant Size**

Gross Capacity (MW)	500.0
Parasitic Load (MW)	0.0
Net Capacity (MW)	500.0
Derate Factor (%)	100.0
Firm Capacity (MW)	500.0
Transmission Losses (%)	5.0
Required AS/reserves (%)	7.0
Average Hourly Output Rate (%)	100.0
Effective Load Carry Capacity (MW)	442.0
Annual capacity degradation rate (%)	0.0

**Table C-3  
Capital Costs**

Escalation in Capital Costs	0.0%
AFUDC Rate	10.3%
Cash Cost	100.0%

**Table C-4  
Construction Costs by Year  
Sum: 100%**

Years Out from On-Line Date	0	-1	-2	-3	-4
Cost %/Year	75%	20%	5%	0%	0%
Carry Over	\$550	\$137	\$27	\$0	\$0

**Table C-5  
Fuel Use**

Heat Rate (MMBtu/kWh)	7,100
Fuel Consumption (MMBtu/Hr)	3,550
Start up fuel use (MMBtu/start)	1,850
No. of annual starts	50
Annual Fuel Use (MMBtu)	28,577,700

**Table C-6  
Operational Information**

Availability/Year (%)	100.0
Availability/Year (Hours)	8,760
Equipment Life (Hours)	148,394
Equipment Life (Years)	18
Overhaul Interval (Hours)	14,839
Maintenance Outage (Days)	28
Maintenance Outage Rate (%)	3.8
Forced Outage (Hours/Year)	400
Forced Outage Rate (%)	4.6
Hours per Year Operation	8,024
Capacity Factor (%)	91.6
Annual Net Energy (GWh)	4,012

**Table C-7  
Renewable Tax Benefits**

Investment Tax Credit (%)	0
RETC Calculation (\$/kWh)	0
Production Incentive-Investor (¢/kWh)	0
Geothermal Depletion Allowance	0
RE Production Incentive Tier I	0
RE Production Incentive Tier II	0
REPI Tier II Proportion Paid (%)	10

**Table C-8  
Operation & Maintenance Costs**

<b>Employee Category</b>	<b>Full Time Employees</b>	<b>Hours/Year</b>	<b>Compensation per Employee</b>
Managers	4	1,800	\$77,031 per year
Plant Operators	12	2,200	\$17 per hour
Mechanics	2	2,300	\$18 per hour
Laborers	2	2,200	\$12 per hour
Support Staff	3	2,000	\$13 per hour

**Table C-9  
Operation & Maintenance Costs (Other)**

<b>Fixed O&amp;M (\$/kW-Yr)</b>	<b>3.33</b>
Fixed O&M/Instant Cost (%)	0.61
O&M Escalation (%)	0.5
Insurance (%)	1.5
Labor Escalation Cost (%)	0.5
Overhead Multiplier	1.6
<b>Other Operating Costs</b>	
Water Supply (\$/AF)	197.0
Consumption (AF/Yr)	2,600.0
<b>Plant Scheduling Costs</b>	
Transmission Service (\$/MW)	

**Table C-10  
Cost Summary**

Financing Costs (\$/kW-Yr)	75
Fixed Operational Costs (\$/kW-Yr)	15
Tax (w/Credits) (\$/kW-Yr)	1
<b>Fixed Costs</b>	<b>90</b>
Fuel Costs (\$/kW-Yr)	307
Variable O&M (\$/kW-Yr)	19.09
<b>Variable Costs</b>	<b>326</b>
<b>Total Levelized Costs (\$/kW-Yr)</b>	<b>416</b>
Capital (\$/MWH)	11.25
Variable (\$/MWH)	40.59
<b>Total Levelized Costs (\$/MWH)</b>	<b>51.84</b>
<b>Capital Costs</b>	
Instant Cost (\$/kW)	542
Installed Cost (\$/MWH)	592
<b>In-service Cost in 2004 (\$/KW)</b>	<b>616</b>

**Table C-11  
Capital Cost Detail**

<b>Total (\$)</b>	<b>270,896,567</b>
<b>Component Cost (\$)</b>	<b>239,289,126</b>
Turbine/Engine [Not itemized] (\$)	234,597,182
Generator/Gearhead (\$)	
Boiler/HRSG (\$)	
Fuel Pipeline/Tank (\$)	
Slab & Engine Mount (\$)	
Miscellaneous fitting & hoses (\$)	4,691,944
Office space (\$)	
Control Room(\$)	
<b>Financial Transaction Costs (%)</b>	<b>0</b>
<b>Land Costs (\$)</b>	<b>1,477,941</b>
Acreage/Plant	15
Cost per Acre (\$)	100,000
Acquisition Cost (\$)	1,470,588
Land Prep Costs (\$/Acre)	500
Total Land Prep Costs (\$)	7,353
<b>Permitting Costs (\$)</b>	<b>5,129,500</b>
Local building permits (\$)	
Environmental permits (\$)	
Air Emission Permits (\$)	5,129,500
<b>Interconnection Costs (\$)</b>	<b>0</b>
Transmission Lines (\$)	
Substation (\$)	
Induction Equipment (\$)	
<b>Environmental Controls (\$)</b>	<b>25,000,000</b>
Installation Costs (\$)	25,000,000
Replacement Costs (\$)	

**Table C-12  
Maintenance Cost Detail**

<b>Routine Maintenance Costs</b>		Annual Costs
Replacement Interval (Hours)	8,024	
Filter Price (\$)	400,000	400,000
Maintenance Interval (Hours)	8,024	
Price (\$)	400,000	400,000
Interval (Hours)	1,000	
Item Price (\$)	0	0
Labor Hours/Day	0	
Labor Price (\$/Hour)	28	0
<b>Annual Routine Maintenance</b>		<b>0</b>
<b>Major Overhauls</b>		
Hours to Major Overhaul:	20,000	
Major Overhaul Labor (Man-Hours)	23,000	
Labor Cost (\$/Hour)	56	
Major Overhaul Labor Cost (\$)	1,288,000	
Major Overhaul Replacement (\$)	3,712,000	<b>5,441,690</b>
NPV Cost (\$)		
<b>Minor Overhauls</b>		
Annual Cost Item 1 (\$)	1,200,000	
Hours to Item 1 Job	8,024	1
Annual Cost Item 2 (\$)	0	
Hours to Item 2 Job	0	
<b>Annualized Overhauls</b>		<b>0</b>
<b>Unscheduled Maintenance</b>		
Forced Outage Hours/Year	400	
Labor Rate (\$/Hour)	28	
Hours of Labor	400	
Parts Costs (\$)	374,400	
Total (\$)	385,600	
<b>Total Annual Maintenance</b>		<b>4,837,644</b>
<b>Maintenance (\$/kW-Yr)</b>	<b>9.68</b>	
<b>Maintenance (\$/MWh)</b>	<b>1.21</b>	

**Table C-13  
Environmental Control Costs**

<b>Total Annual Costs (\$)</b>	<b>\$2,721,205</b>
<b>Media &amp; Technology</b>	<b>Cost</b>
<b>Air Emissions</b>	
Control Technology (e.g. SCR) (\$)	\$15,000,000
Installation Cost (\$/kW)	\$30
Annual Labor (Hours/Year)	100
Loaded Labor Rate (\$/Hour)	\$28
Labor Cost (\$)	\$2,800
Annual Consumables-Catalyst (\$)	\$333,333
Replacement Cost (\$/kW)	\$20
Component Life (Hours)	141,760
Annualized Cost (\$)	\$1,028,436
<b>Water Cooling</b>	
Control Technology (e.g. wastewater) (\$)	\$10,000,000
Installation Cost (\$/kW)	\$20
Annual Labor (Hours/Year)	1000
Loaded Labor Rate (\$/Hour)	\$28
Labor Cost (\$)	\$28,000
Annual Consumables (\$)	\$300,000
Replacement Cost (\$/kW)	\$20
Component Life (Hours)	141,760
Annualized Cost (\$)	\$1,028,436
<b>Solid Waste Disposal</b>	
Non hazardous material	
Tons per Year	1
Collection and hauling (\$/Ton)	\$10
Landfill tipping fees (\$/Ton)	\$30
Total Costs (\$)	\$40
Hazardous materials	
Tons per Year	1
Collection and hauling (\$/Ton)	\$60
Landfill tipping fees (\$/Ton)	\$100
Total Disposal Costs (\$)	\$160

# APPENDIX D

## Combustion Turbine

**Table D-1  
Plant Information**

Technology Type	Natural Gas
Fuel	Natural Gas
<b>Owner/Investor</b>	Merchant
Base Year	2002
In-service Year	2004

**Table D-2  
Plant Size**

Gross Capacity (MW)	100.0
Parasitic Load (MW)	0.0
Net Capacity (MW)	100.0
Derate Factor (%)	100.0
Firm Capacity (MW)	100.0
Transmission Losses (%)	5.0
Required AS/reserves (%)	7.0
Average Hourly Output Rate (%)	100.0
Effective Load Carry Capacity (MW)	88.0
Annual capacity degradation rate (%)	0.15

**Table D-3  
Capital Costs**

Escalation in Capital Costs	0.0%
AFUDC Rate	10.3%
Cash Cost	100.0%

**Table D-4  
Construction Costs by Year  
Sum: 100%**

Years Out from On-Line Date	0	-1	-2	-3	-4
Cost %/Year	75%	20%	5%	0%	0%
Carry Over	\$424	\$105	\$21	\$0	\$0

**Table D-5  
Fuel Use**

Heat Rate (MMBtu/kWh)	9,300
Fuel Consumption (MMBtu/Hr)	930
Start up fuel use (MMBtu/start)	180
No. of annual starts	120
Annual Fuel Use (MMBtu)	785,682

**Table D-6  
Operational Information**

Availability/Year (%)	10
Availability/Year (Hours)	876
Equipment Life (Hours)	148,394
Equipment Life (Years)	30
Overhaul Interval (Hours)	876
Maintenance Outage (Days)	4
Maintenance Outage Rate (%)	1.2
Forced Outage (Hours/Year)	44
Forced Outage Rate (%)	0.5
Hours per Year Operation	822
Capacity Factor (%)	9.4
Annual Net Energy (GWh)	82

**Table D-7  
Renewable Tax Benefits**

Investment Tax Credit (%)	0
RETC Calculation (\$/kWh)	0
Production Incentive-Investor (¢/kWh)	0
Geothermal Depletion Allowance	0
RE Production Incentive Tier I	0
RE Production Incentive Tier II	0
REPI Tier II Proportion Paid (%)	10

**Table D-8  
Operations & Maintenance Costs (Employees)**

Employee Category	Full Time Employees	Hours/Year	Compensation per Employee
Managers	1	1,800	\$90,000 per year
Plant Operators	4	1,800	\$17 per hour
Mechanics	1	1,800	\$18 per hour
Laborers	1	1,800	\$12 per hour
Support Staff	1	1,800	\$13 per hour

**Table D-9  
Operations & Maintenance Costs (Other)**

<b>Fixed O&amp;M (\$/kW-Yr)</b>	<b>9.81</b>
Fixed O&M/Instant Cost (%)	2.35
O&M Escalation (%)	0.5
Insurance (%)	1.5
Labor Escalation Cost (%)	0.5
Overhead Multiplier	1.6
<b>Other Operating Costs</b>	
Water Supply (\$/AF)	197.0
Consumption (AF/Yr)	520.0
<b>Plant Scheduling Costs</b>	
Transmission Service (\$/MW)	

**Table D-10  
Cost Summary**

Financing Costs (\$/kW-Yr)	57
Fixed Operational Costs (\$/kW-Yr)	20
Tax (w/Credits) (\$/kW-Yr)	1
<b>Fixed Costs</b>	<b>78</b>
Fuel Costs (\$/kW-Yr)	42
Variable O&M (\$/kW-Yr)	9
<b>Variable Costs</b>	<b>51</b>
<b>Total Levelized Costs (\$/kW-Yr)</b>	<b>129</b>
Capital (\$/MWH)	94.99
Variable (\$/MWH)	62.11
<b>Total Levelized Costs (\$/MWH)</b>	<b>157.11</b>
<b>Capital Costs</b>	
Instant Cost (\$/kW)	417
Installed Cost (\$/MWH)	456
<b>In-service Cost in 2004 (\$/KW)</b>	<b>475</b>

**Table D-11  
Capital Cost Detail**

<b>Total (\$)</b>	<b>41,715,152</b>
<b>Component Cost (\$)</b>	<b>31,620,000</b>
Turbine/Engine [Not itemized] (\$)	31,000,000
Generator/Gearhead (\$)	
Boiler/HRSG (\$)	
Fuel Pipeline/Tank (\$)	
Slab & Engine Mount (\$)	
Miscellaneous fitting & hoses (\$)	620,000
Office space (\$)	
Control Room(\$)	
<b>Financial Transaction Costs (%)</b>	<b>0</b>
<b>Land Costs (\$)</b>	<b>5,007,353</b>
Acreage/Plant	50
Cost per Acre (\$)	100,000
Acquisition Cost (\$)	5,000,000
Land Prep Costs (\$/Acre)	500
Total Land Prep Costs (\$)	7,353
<b>Permitting Costs (\$)</b>	<b>87,799</b>
Local building permits (\$)	
Environmental permits (\$)	
Air Emission Permits (\$)	87,799
<b>Interconnection Costs (\$)</b>	<b>0</b>
Transmission Lines (\$)	
Substation (\$)	
Induction Equipment (\$)	
<b>Environmental Controls (\$)</b>	<b>5,000,000</b>
Installation Costs (\$)	5,000,000
Replacement Costs (\$)	

**Table D-12  
Maintenance Cost Detail**

<b>Routine Maintenance Costs</b>		Annual Costs
Replacement Interval (Hours)	822	
Filter Price (\$)	40,000	40,000
Maintenance Interval (Hours)	822	
Price (\$)	40,000	40,000
Interval (Hours)	1,000	
Item Price (\$)	0	0
Labor Hours/Day	0.00	
Labor Price (\$/Hour)	28	0
<b>Annual Routine Maintenance</b>		<b>80,000</b>
<b>Major Overhauls</b>		
Hours to Major Overhaul:	8,360	
Major Overhaul Labor (Man-Hours)	4,600	
Labor Cost (\$/Hour)	56	
Major Overhaul Labor Cost (\$)	257,600	
Major Overhaul Replacement (\$)	3,742,400	<b>193,253</b>
NPV Cost (\$)		
<b>Minor Overhauls</b>		
Annual Cost Item 1 (\$)	100,000	
Hours to Item 1 Job	822	
Annual Cost Item 2 (\$)	0	
Hours to Item 2 Job	0	
<b>Annualized Overhauls</b>		<b>102,212</b>
<b>Unscheduled Maintenance</b>		
Forced Outage Hours/Year	44	
Labor Rate (\$/Hour)	28	
Hours of Labor	44	
Parts Costs (\$)	374,400	
Total (\$)	375,626	
<b>Total Annual Maintenance</b>		<b>751,091</b>
<b>Maintenance (\$/kW-Yr)</b>	<b>7.51</b>	
<b>Maintenance (\$/MWh)</b>	<b>9.14</b>	

**Table D-13  
Environmental Control Costs**

<b>Total Annual Costs (\$)</b>	<b>440,506</b>
<b>Media &amp; Technology</b>	<b>Cost</b>
<b>Air Emissions</b>	
Control Technology (e.g. SCR) (\$)	
Installation Cost (\$/kW)	30
Annual Labor (Hours/Year)	100
Loaded Labor Rate (\$/Hour)	28
Labor Cost (\$)	2,800
Annual Consumables-Catalyst (\$)	33,333
Replacement Cost (\$/kW)	20
Component Life (Hours)	141,760
Annualized Cost (\$)	169,286
<b>Water Cooling</b>	
Control Technology (e.g. wastewater) (\$)	200,000
Installation Cost (\$/kW)	20
Annual Labor (Hours/Year)	200
Loaded Labor Rate (\$/Hour)	28
Labor Cost (\$)	5,600
Annual Consumables (\$)	60,000
Replacement Cost (\$/kW)	20
Component Life (Hours)	141,760
Annualized Cost (\$)	
<b>Solid Waste Disposal</b>	
Non hazardous material	
Tons per Year	1
Collection and hauling (\$/Ton)	10
Landfill tipping fees (\$/Ton)	30
Total Costs (\$)	40
Hazardous materials	
Tons per Year	1
Collection and hauling (\$/Ton)	60
Landfill tipping fees (\$/Ton)	100
Total Disposal Costs (\$)	160

# Appendix E

## Fuel Cell - CT Hybrid

**Table E-1  
Plant Information**

Technology Type	Natural Gas
Fuel	Natural Gas
<b>Owner/Investor</b>	Merchant
Base Year	2002
In-service Year	2004

**Table E-2  
Plant Size**

Gross Capacity (MW)	25.0
Parasitic Load (MW)	0.0
Net Capacity (MW)	25.0
Derate Factor (%)	100.0
Firm Capacity (MW)	25.0
Transmission Losses (%)	0.0
Required AS/reserves (%)	0.0
Average Hourly Output Rate (%)	100.0
Effective Load Carry Capacity (MW)	25.0
Annual capacity degradation rate (%)	0.0

**Table E-3  
Capital Costs**

Escalation in Capital Costs	0.0%
AFUDC Rate	10.3%
Cash Cost	100.0%

**Table E-4  
Construction Costs by Year  
Sum: 100%**

Years Out from On-Line Date	0	-1	-2	-3	-4
Cost %/Year	100%	0%	0%	0%	0%
Carry Over	\$1,164	\$0	\$0	\$0	\$0

**Table E-5  
Fuel Use**

Heat Rate (MMBtu/kWh)	5,700.0
Fuel Consumption (MMBtu/Hr)	142.5
Start up fuel use (MMBtu/start)	0.0
No. of annual starts	0.0
Annual Fuel Use (MMBtu)	1,123,470.0

**Table E-6  
Operational Information**

Availability/Year (%)	100
Availability/Year (Hours)	8,760
Equipment Life (Hours)	222,592
Equipment Life (Years)	28
Overhaul Interval (Hours)	7,884
Maintenance Outage (Days)	18
Maintenance Outage Rate (%)	5
Forced Outage (Hours/Year)	438
Forced Outage Rate (%)	5
Hours per Year Operation	7,884
Capacity Factor (%)	90
Annual Net Energy (GWh)	197

**Table E-7  
Renewable Tax Benefits**

Investment Tax Credit (%)	0
RETC Calculation (\$/kWh)	0
Production Incentive-Investor (¢/kWh)	0
Geothermal Depletion Allowance	0
RE Production Incentive Tier I	0
RE Production Incentive Tier II	0
REPI Tier II Proportion Paid (%)	10

**Table E-8  
Maintenance & Operations Costs (Employees)**

Employee Category	Full Time Employees	Hours/Year	Compensation per Employee
Managers	1	1,800	\$120,000 per year
Plant Operators	4	1,800	\$30 per hour
Mechanics	0	1,800	\$30 per hour
Laborers	2.5	1,800	\$20 per hour
Support Staff	0	1,800	\$20 per hour

**Table E-9  
Maintenance & Operations Costs (Other)**

<b>Fixed O&amp;M (\$/kW-Yr)</b>	<b>191.0</b>
Fixed O&M/Instant Cost (%)	16.40
O&M Escalation (%)	0.5
Insurance (%)	1.5
Labor Escalation Cost (%)	0.5
Overhead Multiplier	1.6
<b>Other Operating Costs</b>	
Water Supply (\$/AF)	
Consumption (AF/Yr)	
<b>Plant Scheduling Costs</b>	
Transmission Service (\$/MW)	

**Table E-10  
Cost Summary**

Financing Costs (\$/kW-Yr)	150
Fixed Operational Costs (\$/kW-Yr)	260
Tax (w/Credits) (\$/kW-Yr)	7
<b>Fixed Costs</b>	<b>417</b>
Fuel Costs (\$/kW-Yr)	275
Variable O&M (\$/kW-Yr)	50
<b>Variable Costs</b>	<b>325</b>
<b>Total Levelized Costs (\$/kW-Yr)</b>	<b>742</b>
Capital (\$/MWH)	52.93
Variable (\$/MWH)	41.16
<b>Total Levelized Costs (\$/MWH)</b>	<b>94.10</b>
<b>Capital Costs</b>	
Instant Cost (\$/kW)	1,164
Installed Cost (\$/MWH)	1,253
<b>In-service Cost in 2004 (\$/KW)</b>	<b>1,304</b>

**Table E-11  
Capital Cost Detail**

<b>Total (\$)</b>	<b>29,096,786</b>
<b>Component Cost (\$)</b>	<b>28,850,000</b>
SOFC Generator Equipment (\$)	8,350,000
SOFC Power Conditioning Equipment (\$)	3,675,000
Gas Turbine Generator Equipment (\$)	5,000,000
Balance of Plant Equipment (\$)	4,450,000
Site Preparation (\$)	425,000
Project Management and Engineering (\$)	925,000
Overhead and Profit Allowance (\$)	6,025,000
<b>Financial Transaction Costs (%)</b>	<b>0</b>
<b>Land Costs (\$)</b>	<b>246,786</b>
Sq Ft/MW	4,300
Acreage/Plant	2.47
Cost per Acre (\$)	100,000
Acquisition Cost (\$)	246,786
Land Prep Costs (\$/Acre)	0
Total Land Prep Costs (\$)	0
<b>Permitting Costs [not separate] (\$)</b>	<b>0</b>
Local building permits (\$)	
Environmental permits (\$)	
<b>Interconnection Costs (\$)</b>	<b>0</b>
Transmission Lines (\$)	
Substation (\$)	
Induction Equipment (\$)	

**Minutes**  
**Table E-12**  
**Maintenance Cost Detail**

<b>Routine Maintenance Costs</b>		<b>Annual Costs</b>
Replacement Interval (Hours)	1	
Filter Price (\$)	0	0
Maintenance Interval (Hours)	1	
Price (\$)	0	0
Oil Price (\$/Gallon)	3.40	
Oil Capacity	0	0
Oil Added per Day	0	0
Interval (Hours)	1,000	
Item Price (\$)	0	0
Labor Hours/Day	0	
Labor Price (\$/Hour)	48	0
<b>Annual Routine Maintenance</b>		<b>0</b>
<b>Major Overhauls</b>		
Hours to Major Overhaul:	0	
Major Overhaul Labor (Man-Hours)	0	
Labor Cost (\$/Hour)	48	
Major Overhaul Labor Cost (\$)	0	
Major Overhaul Replacement (\$)	0	
NPV Cost (\$)		
<b>Minor Overhauls</b>		
Annual Cost Item 1 (\$)	22,925,101	
Hours to Item 1 Job	40,000	5
Annual Cost Item 2 (\$)	4,585,020	
Hours to Item 2 Job	55,188	7
<b>Annualized Overhauls</b>		<b>4,069,350</b>
<b>Unscheduled Maintenance</b>		
Forced Outage Hours/Year	438	
Labor Rate (\$/Hour)	48	
Hours of Labor	438	
Parts Costs (\$)	0	
Total (\$)	21,024	
<b>Total Annual Maintenance</b>		<b>4,090,374</b>
<b>Maintenance (\$/kW-Yr)</b>	<b>163.61</b>	
Maintenance (\$/MWh)	20.75	

**Table E-13  
Environmental Control Costs**

<b>Total Annual Costs (\$)</b>	<b>0</b>
<b>Media &amp; Technology</b>	<b>Cost</b>
<b>Air Emissions</b>	
Control Technology (e.g. SCR) (\$)	
Installation Cost (\$/kW)	0
Annual Labor (Hours/Year)	0
Loaded Labor Rate (\$/Hour)	48
Labor Cost (\$)	0
Annual Consumables-Catalyst (\$)	0
Replacement Cost (\$/kW)	0
Component Life (Hours)	141,760
Annualized Cost (\$)	
<b>Water Cooling</b>	
Control Technology (e.g. wastewater) (\$)	
Installation Cost (\$/kW)	0
Annual Labor (Hours/Year)	0
Loaded Labor Rate (\$/Hour)	48
Labor Cost (\$)	0
Annual Consumables (\$)	0
Replacement Cost (\$/kW)	0
Component Life (Hours)	141,760
Annualized Cost (\$)	
<b>Solid Waste Disposal</b>	
Non hazardous material	
Tons per Year	0
Collection and hauling (\$/Ton)	10
Landfill tipping fees (\$/Ton)	30
Total Costs (\$)	0
Hazardous materials	
Tons per Year	0
Collection and hauling (\$/Ton)	10
Landfill tipping fees (\$/Ton)	30
Total Disposal Costs (\$)	0

# Appendix F

## Fuel Cell - Molten Carbonate

**Table F-1  
Plant Information**

Technology Type	Natural Gas
Fuel	Natural Gas
<b>Owner/Investor</b>	Merchant
Base Year	2001
In-service Year	2004

**Table F-2  
Plant Size**

Gross Capacity (MW)	25.0
Parasitic Load (MW)	0.0
Net Capacity (MW)	25.0
Derate Factor (%)	100.0
Firm Capacity (MW)	25.0
Transmission Losses (%)	0.0
Required AS/reserves (%)	0.0
Average Hourly Output Rate (%)	100.0
Effective Load Carry Capacity (MW)	25.0
Annual capacity degradation rate (%)	0.0

**Table F-3  
Capital Costs**

Escalation in Capital Costs	0.0%
AFUDC Rate	10.3%
Cash Cost	100.0%

**Table F-4  
Construction Costs by Year  
Sum: 100%**

Years Out from On-Line Date	0	-1	-2	-3	-4
Cost %/Year	100%	0%	0%	0%	0%
Carry Over	\$1,509	\$0	\$0	\$0	\$0

**Table F-5  
Fuel Use**

Heat Rate (MMBtu/kWh)	7,511.0
Fuel Consumption (MMBtu/Hr)	187.8
Start up fuel use (MMBtu/start)	0.0
No. of annual starts	0.0
Annual Fuel Use (MMBtu)	1,480,418.0

**Table F-6  
Operational Information**

Availability/Year (%)	100
Availability/Year (Hours)	8,760
Equipment Life (Hours)	222,592
Equipment Life (Years)	28
Overhaul Interval (Hours)	7,884
Maintenance Outage (Days)	18
Maintenance Outage Rate (%)	5
Forced Outage (Hours/Year)	438
Forced Outage Rate (%)	5
Hours per Year Operation	7,884
Capacity Factor (%)	90
Annual Net Energy (GWh)	197

**Table F-7  
Renewable Tax Benefits**

Investment Tax Credit (%)	0
RETC Calculation (\$/kWh)	0
Production Incentive-Investor (¢/kWh)	0
Geothermal Depletion Allowance	0
RE Production Incentive Tier I	0
RE Production Incentive Tier II	0
REPI Tier II Proportion Paid (%)	10

**Table F-8  
Operation & Maintenance Costs**

<b>Employee Category</b>	<b>Full Time Employees</b>	<b>Hours/Year</b>	<b>Compensation per Employee</b>
Managers	0	1,800	\$80,000 per year
Plant Operators	0	1,800	\$30 per hour
Mechanics	0	1,800	\$30 per hour
Laborers	0	1,800	\$20 per hour
Support Staff	0	1,800	\$20 per hour

**Table F-9  
Operation & Maintenance Costs (Other)**

<b>Fixed O&amp;M (\$/kW-Yr)</b>	<b>120.0</b>
Fixed O&M/Instant Cost (%)	7.99
O&M Escalation (%)	0.5
Insurance (%)	1.5
Labor Escalation Cost (%)	0.5
Overhead Multiplier	1.6
<b>Other Operating Costs</b>	
Water Supply (\$/AF)	
Consumption (AF/Yr)	
<b>Plant Scheduling Costs</b>	
Transmission Service (\$/MW)	

**Table F-10  
Cost Summary**

Financing Costs (\$/kW-Yr)	198
Fixed Operational Costs (\$/kW-Yr)	180
Tax (w/Credits) (\$/kW-Yr)	10
<b>Fixed Costs</b>	<b>388</b>
Fuel Costs (\$/kW-Yr)	362
Variable O&M (\$/kW-Yr)	50
<b>Variable Costs</b>	<b>412</b>
<b>Total Levelized Costs (\$/kW-Yr)</b>	<b>800</b>
Capital (\$/MWH)	49.23
Variable (\$/MWH)	52.24
<b>Total Levelized Costs (\$/MWH)</b>	<b>101.47</b>
<b>Capital Costs</b>	
Instant Cost (\$/kW)	1,509
Installed Cost (\$/MWH)	1,624
<b>In-service Cost in 2004 (\$/KW)</b>	<b>1,724</b>

**Table F-11  
Capital Cost Detail**

<b>Total (\$)</b>	<b>37,718,090</b>
<b>Component Cost (\$)</b>	<b>37,500,000</b>
[Not itemized-"All In" cost] (\$)	37,500,000
Office space	
Control Room	
Other infrastructure	
<b>Financial Transaction Costs (%)</b>	<b>0</b>
<b>Land Costs (\$)</b>	<b>218,090</b>
Sq Ft/MW	3,800
Acreage/Plant	2.18
Cost per Acre (\$)	100,000
Acquisition Cost (\$)	218,090
Land Prep Costs (\$/Acre)	0
Total Land Prep Costs (\$)	0
<b>Permitting Costs [not separate] (\$)</b>	<b>0</b>
Local building permits	
Environmental permits	
<b>Interconnection Costs (\$)</b>	<b>0</b>
Transmission Lines	
Substation	
Induction Equipment	

**Table F-12  
Maintenance Cost Detail**

<b>Routine Maintenance Costs</b>		Annual Costs
Replacement Interval (Hours)	1	
Filter Price (\$)	0	0
Maintenance Interval (Hours)	1	
Price (\$)	0	0
Oil Price (\$/Gallon)	3.40	
Oil Capacity	0	0
Oil Added per Day	0	0
Interval (Hours)	1,000	
Item Price (\$)	0	0
Labor Hours/Day	0	
Labor Price (\$/Hour)	48	0
<b>Annual Routine Maintenance</b>		<b>0</b>
<b>Major Overhauls</b>		
Hours to Major Overhaul:	0	
Major Overhaul Labor (Man-Hours)	0	
Labor Cost (\$/Hour)	48	
Major Overhaul Labor Cost (\$)	0	
Major Overhaul Replacement (\$)	0	
NPV Cost (\$)		
<b>Minor Overhauls</b>		
Annual Cost Item 1 (\$)	10,000,000	
Hours to Item 1 Job	23,652	3
Annual Cost Item 2 (\$)	0	
Hours to Item 2 Job	55,188	7
<b>Annualized Overhauls</b>		<b>2,991,198</b>
<b>Unscheduled Maintenance</b>		
Forced Outage Hours/Year	438	
Labor Rate (\$/Hour)	48	
Hours of Labor	438	
Parts Costs (\$)	0	
Total (\$)	21,024	
<b>Total Annual Maintenance</b>		<b>3,012,222</b>
<b>Maintenance (\$/kW-Yr)</b>	<b>120.49</b>	
Maintenance (\$/MWh)	15.28	

**Table F-13  
Environmental Control Costs**

<b>Total Annual Costs (\$)</b>	<b>0</b>
<b>Media &amp; Technology</b>	<b>Cost</b>
<b>Air Emissions</b>	
Control Technology (e.g. SCR) (\$)	
Installation Cost (\$/kW)	0
Annual Labor (Hours/Year)	0
Loaded Labor Rate (\$/Hour)	48
Labor Cost (\$)	0
Annual Consumables-Catalyst (\$)	0
Replacement Cost (\$/kW)	0
Component Life (Hours)	141,760
Annualized Cost (\$)	
<b>Water Cooling</b>	
Control Technology (e.g. wastewater) (\$)	
Installation Cost (\$/kW)	0
Annual Labor (Hours/Year)	0
Loaded Labor Rate (\$/Hour)	48
Labor Cost (\$)	0
Annual Consumables (\$)	0
Replacement Cost (\$/kW)	0
Component Life (Hours)	141,760
Annualized Cost (\$)	
<b>Solid Waste Disposal</b>	
Non hazardous material	
Tons per Year	0
Collection and hauling (\$/Ton)	10
Landfill tipping fees (\$/Ton)	30
Total Costs (\$)	0
Hazardous materials	
Tons per Year	0
Collection and hauling (\$/Ton)	10
Landfill tipping fees (\$/Ton)	30
Total Disposal Costs (\$)	0

# APPENDIX G

## Fuel Cell - Phosphoric Acid

**Table G-1  
Plant Information**

Technology Type	Natural Gas
Fuel	Natural Gas
Owner/Investor	Merchant
Base Year	2002
In-service Year	2003

**Table G-2  
Plant Size**

Gross Capacity (MW)	25.0
Parasitic Load (MW)	0.0
Net Capacity (MW)	25.0
Derate Factor (%)	100.0
Firm Capacity (MW)	25.0
Transmission Losses (%)	0.0
Required AS/reserves (%)	0.0
Average Hourly Output Rate (%)	100.0
Effective Load Carry Capacity (MW)	25.0
Annual capacity degradation rate (%)	0.0

**Table G-3  
Capital Costs**

Escalation in Capital Costs	0.0%
AFUDC Rate	10.3%
Cash Cost	100.0%

**Table G-4  
Construction Costs by Year  
Sum: 100%**

Years Out from On-Line Date	0	-1	-2	-3	-4
Cost %/Year	100%	0%	0%	0%	0%
Carry Over	\$4,520	\$0	\$0	\$0	\$0

**Table G-5  
Fuel Use**

Heat Rate (MMBtu/kWh)	9,389.0
Fuel Consumption (MMBtu/Hr)	234.7
Start up fuel use (MMBtu/start)	0.0
No. of annual starts	0.0
Annual Fuel Use (MMBtu)	1,850,572.0

**Table G-6  
Operational Information**

Availability/Year (%)	100
Availability/Year (Hours)	8,760
Equipment Life (Hours)	222,592
Equipment Life (Years)	28
Overhaul Interval (Hours)	7,884
Maintenance Outage (Days)	18
Maintenance Outage Rate (%)	5
Forced Outage (Hours/Year)	438
Forced Outage Rate (%)	5
Hours per Year Operation	7,884
Capacity Factor (%)	90
Annual Net Energy (GWh)	197

**Table G-7  
Renewable Tax Benefits**

Investment Tax Credit (%)	0
RETC Calculation (\$/kWh)	0
Production Incentive-Investor (¢/kWh)	0
Geothermal Depletion Allowance	0
RE Production Incentive Tier I	0
RE Production Incentive Tier II	0
REPI Tier II Proportion Paid (%)	10

**Table G-8  
Operations & Maintenance Costs (Employee)**

<b>Employees</b>	<b>Full Time Employees</b>	<b>Hours/Year</b>	<b>Compensation per Employee</b>
Managers	0	1,800	\$80,000 per year
Plant Operators	0	1,800	\$30 per hour
Mechanics	0	1,800	\$30 per hour
Laborers	0	1,800	\$20 per hour
Support Staff	0	1,800	\$20 per hour

**Table G-9  
Operation & Maintenance Costs (Other)**

<b>Fixed O&amp;M (\$/kW-Yr)</b>	<b>271.0</b>
Fixed O&M/Instant Cost (%)	5.99
O&M Escalation (%)	0.5
Insurance (%)	1.5
Labor Escalation Cost (%)	0.5
Overhead Multiplier	1.6
<b>Other Operating Costs</b>	
Water Supply (\$/AF)	
Consumption (AF/Yr)	
<b>Plant Scheduling Costs</b>	
Transmission Service (\$/MW)	

**Table G-10  
Cost Summary**

Financing Costs (\$/kW-Yr)	571
Fixed Operational Costs (\$/kW-Yr)	424
Tax (w/Credits) (\$/kW-Yr)	28
<b>Fixed Costs</b>	<b>1,023</b>
Fuel Costs (\$/kW-Yr)	437
Variable O&M (\$/kW-Yr)	217
<b>Variable Costs</b>	<b>654</b>
<b>Total Levelized Costs (\$/kW-Yr)</b>	<b>1,677</b>
Capital (\$/MWH)	129.76
Variable (\$/MWH)	82.96
<b>Total Levelized Costs (\$/MWH)</b>	<b>212.72</b>
<b>Capital Costs</b>	
Instant Cost (\$/kW)	4,520
Installed Cost (\$/MWH)	4,867
<b>In-service Cost in 2004 (\$/KW)</b>	<b>4,964</b>

**Table G-11  
Capital Cost Detail**

<b>Total (\$)</b>	<b>113,005,051</b>
<b>Component Cost (\$)</b>	<b>112,500,000</b>
[Not itemized="All In" cost] (\$)	112,500,000
Office space	
Control Room	
Other infrastructure	
<b>Financial Transaction Costs (%)</b>	<b>0</b>
<b>Land Costs (\$)</b>	<b>505,051</b>
Sq Ft/MW	8,800
Acreage/Plant	5.05
Cost per Acre (\$)	100,000
Acquisition Cost (\$)	505,051
Land Prep Costs (\$/Acre)	0
Total Land Prep Costs (\$)	0
<b>Permitting Costs [not separate] (\$)</b>	<b>0</b>
Local building permits	
Environmental permits	
<b>Interconnection Costs (\$)</b>	<b>0</b>
Transmission Lines	
Substation	
Induction Equipment	

**Table G-12  
Maintenance Cost Detail**

<b>Routine Maintenance Costs</b>		Annual Costs
Replacement Interval (Hours)	1	
Filter Price (\$)	0	0
Maintenance Interval (Hours)	1	
Price (\$)	0	0
Oil Price (\$/Gallon)	3.40	
Oil Capacity	0	0
Oil Added per Day	0	0
Interval (Hours)	1,000	
Item Price (\$)	0	0
Labor Hours/Day	0.00	
Labor Price (\$/Hour)	48	0
<b>Annual Routine Maintenance</b>		<b>0</b>
<b>Major Overhauls</b>		
Hours to Major Overhaul:	0	
Major Overhaul Labor (Man-Hours)	0	
Labor Cost (\$/Hour)	48	
Major Overhaul Labor Cost (\$)	0	
Major Overhaul Replacement (\$)	0	
NPV Cost (\$)		
<b>Minor Overhauls</b>		
Annual Cost Item 1 (\$)	37,500,000	
Hours to Item 1 Job	39,420	5
Annual Cost Item 2 (\$)	7,500,000	
Hours to Item 2 Job	55,188	7
<b>Annualized Overhauls</b>		<b>6,746,247</b>
<b>Unscheduled Maintenance</b>		
Forced Outage Hours/Year	438	
Labor Rate (\$/Hour)	48	
Hours of Labor	438	
Parts Costs (\$)	0	
Total (\$)	21,024	
<b>Total Annual Maintenance</b>		<b>6,767,271</b>
Maintenance (\$/kW-Yr)	270.69	
Maintenance (\$/MWh)	\$34.33	

**Table G-13  
Environmental Control Costs**

<b>Total Annual Costs (\$)</b>	<b>0</b>
<b>Media &amp; Technology</b>	<b>Cost</b>
<b>Air Emissions</b>	
Control Technology (e.g. SCR) (\$)	
Installation Cost (\$/kW)	0
Annual Labor (Hours/Year)	0
Loaded Labor Rate (\$/Hour)	48
Labor Cost (\$)	0
Annual Consumables-Catalyst (\$)	0
Replacement Cost (\$/kW)	0
Component Life (Hours)	141,760
Annualized Cost (\$)	
<b>Water Cooling</b>	
Control Technology (e.g. wastewater) (\$)	
Installation Cost (\$/kW)	0
Annual Labor (Hours/Year)	0
Loaded Labor Rate (\$/Hour)	48
Labor Cost (\$)	0
Annual Consumables (\$)	0
Replacement Cost (\$/kW)	0
Component Life (Hours)	141,760
Annualized Cost (\$)	
<b>Solid Waste Disposal</b>	
Non hazardous material	
Tons per Year	0
Collection and hauling (\$/Ton)	10
Landfill tipping fees (\$/Ton)	30
Total Costs (\$)	0
Hazardous materials	
Tons per Year	0
Collection and hauling (\$/Ton)	10
Landfill tipping fees (\$/Ton)	30
Total Disposal Costs (\$)	0

# **APPENDIX H**

## **Fuel Cell - Proton Exchange Membrane**

**Table H-1  
Plant Information**

Technology Type	Natural Gas
Fuel	Natural Gas
<b>Owner/Investor</b>	Merchant
Base Year	2002
In-service Year	2005

**Table H-2  
Plant Size**

Gross Capacity (MW)	25.0
Parasitic Load (MW)	0.0
Net Capacity (MW)	25.0
Derate Factor (%)	100.0
Firm Capacity (MW)	25.0
Transmission Losses (%)	0.0
Required AS/reserves (%)	0.0
Average Hourly Output Rate (%)	100.0
Effective Load Carry Capacity (MW)	25.0
Annual capacity degradation rate (%)	0.0

**Table H-3  
Capital Costs**

Escalation in Capital Costs	0.0%
AFUDC Rate	10.3%
Cash Cost	100.0%

**Table H-4  
Construction Costs by Year  
Sum: 100%**

Years Out from On-Line Date	0	-1	-2	-3	-4
Cost %/Year	100%	0%	0%	0%	0%
Carry Over	\$1,511	\$0	\$0	\$0	\$0

**Table H-5  
Fuel Use**

Heat Rate (MMBtu/kWh)	9,389.0
Fuel Consumption (MMBtu/Hr)	234.7
Start up fuel use (MMBtu/start)	0.0
No. of annual starts	0.0
Annual Fuel Use (MMBtu)	1,850,572.0

**Table H-6  
Operational Information**

Availability/Year (%)	100
Availability/Year (Hours)	8,760
Equipment Life (Hours)	222,592
Equipment Life (Years)	28
Overhaul Interval (Hours)	7,884
Maintenance Outage (Days)	18
Maintenance Outage Rate (%)	5
Forced Outage (Hours/Year)	438
Forced Outage Rate (%)	5
Hours per Year Operation	7,884
Capacity Factor (%)	90
Annual Net Energy (GWh)	197

**Table H-7  
Renewable Tax Benefits**

Investment Tax Credit (%)	0
RETC Calculation (\$/kWh)	0
Production Incentive-Investor (¢/kWh)	0
Geothermal Depletion Allowance	0
RE Production Incentive Tier I	0
RE Production Incentive Tier II	0
REPI Tier II Proportion Paid (%)	10

**Table H-8  
Operation & Maintenance Costs (Employee)**

<b>Employees</b>	<b>Full Time Employees</b>	<b>Hours/Year</b>	<b>Compensation per Employee</b>
Managers	0	1,800	\$80,000 per year
Plant Operators	0	1,800	\$30 per hour
Mechanics	0	1,800	\$30 per hour
Laborers	0	1,800	\$20 per hour
Support Staff	0	1,800	\$20 per hour

**Table H-9  
Operation & Maintenance Costs (Other)**

<b>Fixed O&amp;M (\$/kW-Yr)</b>	<b>271.0</b>
Fixed O&M/Instant Cost (%)	17.91
O&M Escalation (%)	0.5
Insurance (%)	1.5
Labor Escalation Cost (%)	0.5
Overhead Multiplier	1.6
<b>Other Operating Costs</b>	
Water Supply (\$/AF)	
Consumption (AF/Yr)	
<b>Plant Scheduling Costs</b>	
Transmission Service (\$/MW)	

**Table H-10  
Cost Summary**

Financing Costs (\$/kW-Yr)	199
Fixed Operational Costs (\$/kW-Yr)	367
Tax (w/Credits) (\$/kW-Yr)	10
<b>Fixed Costs</b>	<b>575</b>
Fuel Costs (\$/kW-Yr)	474
Variable O&M (\$/kW-Yr)	217
<b>Variable Costs</b>	<b>691</b>
<b>Total Levelized Costs (\$/kW-Yr)</b>	<b>1,266</b>
Capital (\$/MWH)	72.92
Variable (\$/MWH)	87.68
<b>Total Levelized Costs (\$/MWH)</b>	<b>160.60</b>
<b>Capital Costs</b>	
Instant Cost (\$/kW)	1,511
Installed Cost (\$/MWH)	1,627
<b>In-service Cost in 2004 (\$/KW)</b>	<b>1,727</b>

**Table H-11  
Capital Cost Detail**

<b>Total (\$)</b>	<b>37,781,221</b>
<b>Component Cost (\$)</b>	<b>37,500,000</b>
[Not Itemized – “All In” cost]	37,500,000
Office space	
Control Room	
Other Infrastructure	
<b>Financial Transaction Costs (%)</b>	<b>0</b>
<b>Land Costs (\$)</b>	<b>281,221</b>
Sq Ft/MW	4,900
Acreage/Plant	2.81
Cost per Acre (\$)	100,000
Acquisition Cost (\$)	281,221
Land Prep Costs (\$/Acre)	0
Total Land Prep Costs (\$)	0
<b>Permitting Costs [not separate (\$)]</b>	<b>0</b>
Local building permits (\$)	
Environmental permits (\$)	
<b>Interconnection Costs (\$)</b>	<b>0</b>
Transmission Lines (\$)	
Substation (\$)	
Induction Equipment (\$)	

**Table H-12  
Maintenance Cost Detail**

<b>Routine Maintenance Costs</b>		Annual Costs
Replacement Interval (Hours)	1	
Filter Price (\$)	0	0
Maintenance Interval (Hours)	1	
Price (\$)	0	0
Oil Price (\$/Gallon)	3.40	
Oil Capacity	0	0
Oil Added per Day	0	0
Interval (Hours)	1,000	
Item Price (\$)	0	0
Labor Hours/Day	0.00	
Labor Price (\$/Hour)	48	0
<b>Annual Routine Maintenance</b>		<b>0</b>
<b>Major Overhauls</b>		
Hours to Major Overhaul	0	
Major Overhaul Labor (Man-Hours)	0	
Labor Cost (\$/Hour)	48	
Major Overhaul Labor Cost (\$)	0	
Major Overhaul Replacement (\$)	0	
NPV Cost (\$)		
<b>Minor Overhauls</b>		
Annual Cost Item 1 (\$)	37,500,000	
Hours to Item 1 Job	39,420	5
Annual Cost Item 2 (\$)	7,500,000	
Hours to Item 2 Job	55,188	7
<b>Annualized Overhauls</b>		<b>6,746,247</b>
<b>Unscheduled Maintenance</b>		
Forced Outage Hours/Year	438	
Labor Rate (\$/Hour)	48	
Hours of Labor	438	
Parts Costs (\$)	0	
Total (\$)	21,024	
<b>Total Annual Maintenance</b>		<b>6,767,271</b>
Maintenance (\$/kW-Yr)	270.69	
Maintenance (\$/MWh)	34.33	

**Table H-13  
Environmental Control Costs**

<b>Total Annual Costs (\$)</b>	<b>0</b>
<b>Media &amp; Technology</b>	<b>Cost</b>
<b>Air Emissions</b>	
Control Technology (e.g. SCR) (\$)	
Installation Cost (\$/kW)	0
Annual Labor (Hours/Year)	0
Loaded Labor Rate (\$/Hour)	48
Labor Cost (\$)	0
Annual Consumables-Catalyst (\$)	0
Replacement Cost (\$/kW)	0
Component Life (Hours)	141,760
Annualized Cost (\$)	
<b>Water Cooling</b>	
Control Technology (e.g. wastewater) (\$)	
Installation Cost (\$/kW)	0
Annual Labor (Hours/Year)	0
Loaded Labor Rate (\$/Hour)	48
Labor Cost (\$)	0
Annual Consumables (\$)	0
Replacement Cost (\$/kW)	0
Component Life (Hours)	141,760
Annualized Cost (\$)	
<b>Solid Waste Disposal</b>	
Non hazardous material	
Tons per Year	0
Collection and hauling (\$/Ton)	10
Landfill tipping fees (\$/Ton)	30
Total Costs (\$)	0
Hazardous materials	
Tons per Year	0
Collection and hauling (\$/Ton)	10
Landfill tipping fees (\$/Ton)	30
Total Disposal Costs (\$)	0

# APPENDIX I

## Fuel Cell - Solid Oxide

**Table I-1  
Plant Information**

Technology Type	Natural Gas
Fuel	Natural Gas
<b>Owner/Investor</b>	Merchant
Base Year	2002
In-service Year	2004

**Table I-2  
Plant Size**

Gross Capacity (MW)	25.0
Parasitic Load (MW)	0.0
Net Capacity (MW)	25.0
Derate Factor (%)	100.0
Firm Capacity (MW)	25.0
Transmission Losses (%)	0.0
Required AS/reserves (%)	0.0
Average Hourly Output Rate (%)	100.0
Effective Load Carry Capacity (MW)	25.0
Annual capacity degradation rate (%)	0.0

**Table I-3  
Capital Costs**

Escalation in Capital Costs	0.0%
AFUDC Rate	10.3%
Cash Cost	100.0%

**Table I-4  
Construction Costs by Year  
Sum: 100%**

Years Out from On-Line Date	0	-1	-2	-3	-4
Cost %/Year	100%	0%	0%	0%	0%
Carry Over	\$1,577	\$0	\$0	\$0	\$0

**Table I-5  
Fuel Use**

Heat Rate (MMBtu/kWh)	8,345.0
Fuel Consumption (MMBtu/Hr)	208.6
Start up fuel use (MMBtu/start)	0.0
No. of annual starts	0.0
Annual Fuel Use (MMBtu)	1,644,800.0

**Table I-6  
Operational Information**

Availability/Year (%)	100
Availability/Year (Hours)	8,760
Equipment Life (Hours)	222,592
Equipment Life (Years)	28
Overhaul Interval (Hours)	7,884
Maintenance Outage (Days)	18
Maintenance Outage Rate (%)	5
Forced Outage (Hours/Year)	438
Forced Outage Rate (%)	5
Hours per Year Operation	7,884
Capacity Factor (%)	90
Annual Net Energy (GWh)	197

**Table I-7  
Renewable Tax Benefits**

Investment Tax Credit (%)	0
RETC Calculation (\$/kWh)	0
Production Incentive-Investor (¢/kWh)	0
Geothermal Depletion Allowance	0
RE Production Incentive Tier I	0
RE Production Incentive Tier II	0
REPI Tier II Proportion Paid (%)	10

**Table I-8  
Operation & Maintenance Costs**

<b>Employees</b>	<b>Full Time Employees</b>	<b>Hours/Year</b>	<b>Compensation per Employee</b>
Managers	1	1,800	\$120,000 per year
Plant Operators	4	1,800	\$30 per hour
Mechanics	0	1,800	\$30 per hour
Laborers	2.5	1,800	\$20 per hour
Support Staff	0	1,800	\$20 per hour

**Table I-9  
Operation & Maintenance Costs (Other)**

<b>Fixed O&amp;M (\$/kW-Yr)</b>	<b>294.0</b>
Fixed O&M/Instant Cost (%)	18.67
O&M Escalation (%)	0.5
Insurance (%)	1.5
Labor Escalation Cost (%)	0.5
Overhead Multiplier	1.6
<b>Other Operating Costs</b>	
Water Supply (\$/AF)	
Consumption (AF/Yr)	
<b>Plant Scheduling Costs</b>	
Transmission Service (\$/MW)	

**Table I-10  
Cost Summary**

Financing Costs (\$/kW-Yr)	203
Fixed Operational Costs (\$/kW-Yr)	397
Tax (w/Credits) (\$/kW-Yr)	10
<b>Fixed Costs</b>	<b>610</b>
Fuel Costs (\$/kW-Yr)	403
Variable O&M (\$/kW-Yr)	16
<b>Variable Costs</b>	<b>418</b>
<b>Total Levelized Costs (\$/kW-Yr)</b>	<b>1,028</b>
Capital (\$/MWH)	77.34
Variable (\$/MWH)	53.04
<b>Total Levelized Costs (\$/MWH)</b>	<b>130.38</b>
<b>Capital Costs</b>	
Instant Cost (\$/kW)	1,577
Installed Cost (\$/MWH)	1,698
<b>In-service Cost in 2004 (\$/KW)</b>	<b>1,766</b>

**Table I-11  
Capital Cost Detail**

Total (\$)	<b>39,423,440</b>
<b>Component Cost (\$)</b>	
Turbine/Engine [Not itemized] (\$)	<b>39,142,219</b>
Generator/Gearhead (\$)	
Boiler/HRSG (\$)	13,658,609
Fuel Pipeline/Tank (\$)	13,658,609
Slab & Engine Mount (\$)	
Miscellaneous fitting & hoses (\$)	4,450,000
Office space (\$)	425,000
Control Room(\$)	925,000
Duct Burners (\$)	6,025,000
<b>Financial Transaction Costs (%)</b>	
<b>Land Costs (\$)</b>	0
Acreage/Plant	<b>281,221</b>
Cost per Acre (\$)	4,900
Acquisition Cost (\$)	2.81
Land Prep Costs (\$/Acre)	100,000
Total Land Prep Costs (\$)	281,221
<b>Permitting Costs (\$)</b>	0
Local building permits (\$)	0
Environmental permits (\$)	0
Air Emission Permits (\$)	<b>0</b>
<b>Interconnection Costs (\$)</b>	0
Transmission Lines (\$)	0
Substation (\$)	
Induction Equipment (\$)	
<b>Environmental Controls (\$)</b>	0
Installation Costs (\$)	0
Replacement Costs (\$)	0

**Table I-12  
Maintenance Cost Detail**

<b>Routine Maintenance Costs</b>		Annual Costs
Replacement Interval (Hours)	1	
Filter Price (\$)	0	0
Maintenance Interval (Hours)	1	
Price (\$)	0	0
Oil Price (\$/Gallon)	3.40	
Oil Capacity	0	0
Oil Added per Day	0	0
Interval (Hours)	1,000	
Item Price (\$)	0	0
Labor Hours/Day	0	
Labor Price (\$/Hour)	48	0
<b>Annual Routine Maintenance</b>		<b>0</b>
<b>Major Overhauls</b>		
Hours to Major Overhaul	0	
Major Overhaul Labor (Man-Hours)	0	
Labor Cost (\$/Hour)	48	
Major Overhaul Labor Cost (\$)	0	
Major Overhaul Replacement (\$)	0	
NPV Cost (\$)		
<b>Minor Overhauls</b>		
Annual Cost Item 1 (\$)	37,500,000	
Hours to Item 1 Job	40,000	5
Annual Cost Item 2 (\$)	7,500,000	
Hours to Item 2 Job	55,188	7
<b>Annualized Overhauls</b>		<b>6,656,486</b>
<b>Unscheduled Maintenance</b>		
Forced Outage Hours/Year	438	
Labor Rate (\$/Hour)	48	
Hours of Labor	438	
Parts Costs (\$)	0	
Total (\$)	21,024	
<b>Total Annual Maintenance</b>		<b>6,677,510</b>
Maintenance (\$/kW-Yr)	267.10	
Maintenance (\$/MWh)	33.88	

**Table I-13  
Environmental Control Costs**

<b>Total Annual Costs (\$)</b>	<b>0</b>
<b>Media &amp; Technology</b>	<b>Cost</b>
<b>Air Emissions</b>	
Control Technology (e.g. SCR) (\$)	
Installation Cost (\$/kW)	0
Annual Labor (Hours/Year)	0
Loaded Labor Rate (\$/Hour)	48
Labor Cost (\$)	0
Annual Consumables-Catalyst (\$)	0
Replacement Cost (\$/kW)	0
Component Life (Hours)	141,760
Annualized Cost (\$)	
<b>Water Cooling</b>	
Control Technology (e.g. wastewater) (\$)	
Installation Cost (\$/kW)	0
Annual Labor (Hours/Year)	0
Loaded Labor Rate (\$/Hour)	48
Labor Cost (\$)	0
Annual Consumables (\$)	0
Replacement Cost (\$/kW)	0
Component Life (Hours)	141,760
Annualized Cost (\$)	
<b>Solid Waste Disposal</b>	
Non hazardous material	
Tons per Year	0
Collection and hauling (\$/Ton)	10
Landfill tipping fees (\$/Ton)	30
Total Costs (\$)	0
Hazardous materials	
Tons per Year	0
Collection and hauling (\$/Ton)	10
Landfill tipping fees (\$/Ton)	30
Total Disposal Costs (\$)	0

# APPENDIX J

## Geothermal Binary 35 MW

**Table J-1  
Plant Information**

Technology Type	Geothermal
Fuel	Geothermal
<b>Owner/Investor</b>	Merchant
Base Year	2002
In-service Year	2005

**Table J-2  
Plant Size**

Gross Capacity (MW)	35.0
Parasitic Load (MW)	10.0
Net Capacity (MW)	25.0
Derate Factor (%)	100.0
Firm Capacity (MW)	25.0
Transmission Losses (%)	2.0
Required AS/reserves (%)	0.0
Average Hourly Output Rate (%)	100.0
Effective Load Carry Capacity (MW)	25.0
Annual capacity degradation rate (%)	0.0

**Table J-3  
Capital Costs**

Escalation in Capital Costs	0.0%
AFUDC Rate	10.3%
Cash Cost	100.0%

**Table J-4  
Construction Costs by Year  
Sum: 100%**

Years Out from On-Line Date	0	-1	-2	-3	-4
Cost %/Year	20%	70%	10%	0%	0%
Carry Over	\$3,360	\$2,585	\$321	\$0	\$0

**Table J-5  
Fuel Use**

Heat Rate (MMBtu/kWh)	N/A
Fuel Consumption (MMBtu/hour)	0.0
Start up fuel use (MMBtu/start)	0.0
Make-up water (Gallons)	250,000.0

**Table J-6  
Operational Information**

Availability/Year (%)	99
Availability/Year (Hours)	8,672
Equipment Life (Hours)	260,000
Equipment Life (Years)	30
Overhaul Interval (Hours)	45,000
Maintenance Outage (Days)	5
Maintenance Outage Rate (%)	0.3
Forced Outage (Hours/Year)	24
Forced Outage Rate (%)	0.3
Hours per Year Operation	8,624
Capacity Factor (%)	98.5
Annual Net Energy (GWh)	216

**Table J-7  
Renewable Tax Benefits**

Investment Tax Credit (%)	10
RETC Calculation (\$/kWh)	384
Production Incentive-Investor (¢/kWh)	0
Geothermal Depletion Allowance	Yes
RE Production Incentive Tier I	0
RE Production Incentive Tier II	0
REPI Tier II Proportion Paid (%)	10

**Table J-8  
Operation & Maintenance Costs (Employees)**

Employee Category	Full Time Employees	Hours/Year	Compensation per Employee
Managers	1	1,800	\$80,000 per year
Plant Operators	8	1,800	\$30 per hour
Mechanics	1	1,800	\$30 per hour
Laborers	2	1,800	\$20 per hour
Support Staff	0	1,800	\$20 per hour

**Table J-9  
Operation & Maintenance Costs (Other)**

<b>Fixed O&amp;M (\$/kW-Yr)</b>	<b>158.0</b>
Fixed O&M/Instant Cost (%)	4.93
O&M Escalation (%)	0.5
Insurance (%)	1.5
Labor Escalation Cost (%)	0.5
Overhead Multiplier	2.0
<b>Other Operating Costs</b>	
Water Supply (\$/AF)	250,000.0
Consumption (AF/Yr)	25,000.0
<b>Plant Scheduling Costs</b>	
Transmission Service (\$/MW)	156,000.0

**Table J-10  
Cost Summary**

Financing Costs (\$/kW-Yr)	442
Fixed Operational Costs (\$/kW-Yr)	265
Tax (w/Credits) (\$/kW-Yr)	(78)
<b>Fixed Costs</b>	<b>628</b>
Fuel Costs (\$/kW-Yr)	7
Variable O&M (\$/kW-Yr)	0
<b>Variable Costs</b>	<b>7</b>
<b>Total Levelized Costs (\$/kW-Yr)</b>	<b>635</b>
Capital (\$/MWH)	72.83
Variable (\$/MWH)	0.82
<b>Total Levelized Costs (\$/MWH)</b>	<b>73.65</b>
<b>Capital Costs</b>	
Instant Cost (\$/kW)	3,210
Installed Cost (\$/MWH)	3,618
<b>In-service Cost in 2004 (\$/KW)</b>	<b>3,839</b>

**Table J-11  
Capital Cost Detail**

Total (\$)	<b>80,255,463</b>
<b>Component Cost (\$)</b>	<b>79,700,000</b>
Exploration Costs (\$)	3,000,000
Wellfield Development (\$)	34,700,000
Plant Equipment (\$)	42,000,000
<b>Financial Transaction Costs (%)</b>	0
<b>Land Costs (\$)</b>	<b>555,463</b>
Occupied Acreage	40
Total Project Area (Acres)	12000
BLM Pre-Development Lease Fee	44
Total Land "Cost Burden"	531,463
Land Prep Costs (\$/Acre)	600
Total Land Prep Costs (\$)	24,000
<b>Permitting Costs (\$)</b>	<b>0</b>
Local building permits (\$)	
Environmental permits (\$)	
<b>Interconnection Costs (\$)</b>	<b>300,000</b>
Transmission Lines (\$)	
Substation (\$)	
<b>Environmental Controls (\$)</b>	<b>0</b>
Installation Costs (\$)	0
Replacement Costs (\$)	

**Table J-12  
Maintenance Cost Detail**

<b>Routine Maintenance Costs</b>	<b>Annual Costs</b>
<b>Plant costs</b>	
OECs	250,000
Elec. & Control System	50,000
Cooling systems	76,000
Auxiliary Systems	26,000
Cooling water Chemicals	212,000
Isopentane system	75,000
Miscellaneous Consumables	50,000
<b>Wellfield Costs</b>	
Wellfield Costs	
Well clean out	185,000
Well pumps maintenance	50,000
Brine chemicals	100,000
Miscellaneous	35,000
<b>Annual Routine Maintenance</b>	<b>1,109,000</b>
<b>Major Overhauls</b>	
Hours to Major Overhaul:	45,000
Major Overhaul Labor (Man-hours)	200
Labor Cost (\$/Hour)	60
Major Overhaul Labor Cost (\$)	12,000
Major Overhaul Replacement (\$)	1,000,000
NPV Cost (\$)	
<b>Minor Overhauls</b>	
Well Work Over (\$)	50,000
Hours to Item 1 Job	6,000
Well Replacement (\$)	2,300,000
Hours to Item 2 Job	42,500
Pump Replacement (\$)	350,000
Hours to Item 3Job	3,500
<b>Annualized Overhauls (\$)</b>	<b>1,062,686</b>
<b>Unscheduled Maintenance</b>	
Forced Outage (Hours/Year)	24
Labor Rate (\$/Hour)	60
Hours of Labor	12
Parts Costs (\$)	25,000
Total (\$)	25,720
<b>Total Annual Maintenance (\$)</b>	<b>2,197,406</b>
Maintenance (\$/kW-Yr)	87.90
Maintenance (\$/MWh)	10.19

**Table J-13  
Environmental Control Costs**

<b>Total Annual Costs (\$)</b>	<b>50,000</b>
<b>Media &amp; Technology</b>	<b>Cost</b>
<b>Air Emissions</b>	
Control Technology (e.g. SCR) (\$)	
Installation Cost (\$/kW)	0
Annual Labor (Hours/Year)	0
Loaded Labor Rate (\$/Hour)	60
Labor Cost (\$)	0
Annual Consumables-Catalyst (\$)	0
Replacement Cost (\$/kW)	0
Component Life (Hours)	0
Annualized Cost (\$)	
<b>Water Cooling</b>	
Control Technology (e.g. wastewater) (\$)	
Installation Cost (\$/kW)	0
Annual Labor (Hours/Year)	0
Loaded Labor Rate (\$/Hour)	60
Labor Cost (\$)	0
Annual Consumables (\$)	0
Replacement Cost (\$/kW)	0
Component Life (Hours)	0
Annualized Cost (\$)	
<b>Solid Waste Disposal</b>	
Non hazardous material	
Tons per Year	0
Collection and hauling (\$/Ton)	30
Landfill tipping fees (\$/Ton)	0
Total Costs (\$)	0
Hazardous materials	
Tons per Year	10000
Collection and hauling (\$/Ton)	0
Landfill tipping fees (\$/Ton)	5
Total Disposal Costs (\$)	50,000

# APPENDIX K

## Geothermal Flash 50 MW

**Table K-1  
Plant Information**

Technology Type	Geothermal
Fuel	Geothermal
<b>Owner/Investor</b>	Merchant
Base Year	2002
In-service Year	2005

**Table K-2  
Plant Size**

Gross Capacity (MW)	49.9
Parasitic Load (MW)	5.0
Net Capacity (MW)	45.0
Derate Factor (%)	100.0
Firm Capacity (MW)	45.0
Transmission Losses (%)	2.0
Required AS/reserves (%)	0.0
Average Hourly Output Rate (%)	100.0
Effective Load Carry Capacity (MW)	44.0
Annual capacity degradation rate (%)	0.0

**Table K-3  
Capital Costs**

Escalation in Capital Costs	0.0%
AFUDC Rate	10.3%
Cash Cost	100.0%

**Table K-4  
Construction Costs by Year  
Sum: 100%**

Years Out from On-Line Date	0	-1	-2	-3	-4
Cost %/Year	20%	60%	20%	0%	0%
Carry Over	\$2,239	\$1,724	\$426	\$0	\$0

**Table K-5  
Fuel Use**

Heat Rate	N/A
Fuel Consumption (MMBtu/Hr)	0.0
Start up fuel use (MMBtu/Start)	0.0
Make-up water (Gallons)	12,000.0

**Table K-6  
Operational Information**

Availability/Year (%)	97.2
Availability/Year (Hours)	8,515
Equipment Life (Hours)	260,000
Equipment Life (Years)	30
Overhaul Interval (Hours)	25,000
Maintenance Outage (Days)	7
Maintenance Outage Rate (%)	0.6
Forced Outage (Hours/Year)	50
Forced Outage Rate (%)	0.6
Hours per Year Operation	8,409
Capacity Factor (%)	96.0
Annual Net Energy (GWh)	378

**Table K-7  
Renewable Tax Benefits**

Investment Tax Credit (%)	10
RETC Calculation (\$/kWh)	256
Production Incentive-Investor (¢/kWh)	0
Geothermal Depletion Allowance	Yes
RE Production Incentive Tier I	0
RE Production Incentive Tier II	0
REPI Tier II Proportion Paid (%)	10

**Table K-8  
Operation & Maintenance Costs (Employees)**

Employees	Full Time Employees	Hours/Year	Compensation per Employee
Managers	1	1,800	\$80,000 per year
Plant Operators	8	1,800	\$30 per hour
Mechanics	1	1,800	\$30 per hour
Laborers	2	1,800	\$20 per hour
Support Staff	0	1,800	\$20 per hour

**Table K-9  
Operation & Maintenance Costs (Other)**

<b>Fixed O&amp;M (\$/kW-Yr)</b>	<b>60.0</b>
Fixed O&M/Instant Cost (%)	2.81
O&M Escalation (%)	0.5
Insurance (%)	1.5
Labor Escalation Cost (%)	0.5
Overhead Multiplier	1.6
<b>Other Operating Costs</b>	
Water Supply (\$/AF)	12,000.0
Consumption (AF/Yr)	25,000.0
<b>Plant Scheduling Costs</b>	
Transmission Service (\$/MW)	156,000.0

**Table K-10  
Cost Summary**

Financing Costs (\$/kW-Yr)	294
Fixed Operational Costs (\$/kW-Yr)	120
Tax (w/Credits) (\$/kW-Yr)	(45)
<b>Fixed Costs</b>	<b>369</b>
Fuel Costs (\$/kW-Yr)	10
Variable O&M (\$/kW-Yr)	1
<b>Variable Costs</b>	<b>11</b>
<b>Total Levelized Costs (\$/kW-Yr)</b>	<b>380</b>
Capital (\$/MWH)	43.91
Variable (\$/MWH)	1.30
<b>Total Levelized Costs (\$/MWH)</b>	<b>45.21</b>
<b>Capital Costs</b>	
Instant Cost (\$/kW)	2,128
Installed Cost (\$/MWH)	2,410
<b>In-service Cost in 2004 (\$/KW)</b>	<b>2,558</b>

**Table K-11  
Capital Cost Detail**

Total (\$)	<b>95,539,694</b>
<b>Component Cost (\$)</b>	<b>95,200,000</b>
Exploration Costs (\$)	3,000,000
Wellfield Development (\$)	32,200,000
Plant Equipment (\$)	60,000,000
<b>Financial Transaction Costs (%)</b>	<b>0</b>
<b>Land Costs (\$)</b>	<b>339,694</b>
Occupied Acreage	40
Total Project Area (Acres)	6000
Lease Fee (\$/Acre)	53
Total Land "Cost Burden"	315,694
Land Prep Costs (\$/Acre)	600
Total Land Prep Costs (\$)	24,000
<b>Permitting Costs (\$)</b>	<b>0</b>
Local building permits (\$)	
Environmental permits (\$)	
<b>Interconnection Costs (\$)</b>	<b>300,000</b>
Transmission Lines (\$)	
Substation (\$)	
<b>Environmental Controls (\$)</b>	<b>0</b>
Installation Costs (\$)	0
Replacement Costs (\$)	

**Table K-12  
Maintenance Cost Detail**

<b>Routine Maintenance Costs</b>	<b>Annual Costs</b>
<b>Plant costs</b>	
Turbine/Generator (\$)	55,000
Electrical & Control System (\$)	86,000
Cooling systems (\$)	12,000
Auxiliary Systems (\$)	26,000
Cooling water Chemicals (\$)	93,000
Miscellaneous Consumables (\$)	50,000
<b>Wellfield Costs</b>	
Well clean out (\$)	185,000
Brine chemicals (\$)	100,000
Miscellaneous (\$)	35,000
<b>Annual Routine Maintenance (\$)</b>	<b>642,000</b>
<b>Major Overhauls</b>	
Hours to Major Overhaul	25,000
Major Overhaul Labor (Man-Hours)	400
Labor Cost (\$/Hour)	48
Major Overhaul Labor Cost (\$)	19,200
Major Overhaul Replacement (\$)	1,300,000
NPV Cost (\$)	
<b>Minor Overhauls</b>	
Well Work Over (\$)	50,000
Hours to Item 1 Job	6,000
Well Replacement (\$)	2,300,000
Hours to Item 2 Job	25,000
<b>Annualized Overhauls (\$)</b>	<b>762,755</b>
<b>Unscheduled Maintenance</b>	
Forced Outage (Hours/Year)	50
Labor Rate (\$/Hour)	48
Hours of Labor	25
Parts Costs (\$)	50,000
	51,200
<b>Total Annual Maintenance (\$)</b>	<b>1,455,955</b>
Maintenance/kW-yr	32.43
Maintenance/MWh	3.86

**Table K-13  
Environmental Control Costs**

<b>Total Annual Costs (\$)</b>	<b>174,000</b>
<b>Media &amp; Technology</b>	<b>Cost</b>
<b>Air Emissions</b>	
Control Technology (e.g. SCR) (\$)	
Installation Cost (\$/kW)	0
Annual Labor (Hours/Year)	0
Loaded Labor Rate (\$/Hour)	48
Labor Cost (\$)	0
Annual Consumables-Catalyst (\$)	0
Replacement Cost (\$/kW)	0
Component Life (Hours)	0
Annualized Cost (\$)	
<b>Water Cooling</b>	
Control Technology (e.g. wastewater) (\$)	
Installation Cost (\$/kW)	0
Annual Labor (Hours/Year)	0
Loaded Labor Rate (\$/Hour)	48
Labor Cost (\$)	0
Annual Consumables (\$)	0
Replacement Cost (\$/kW)	0
Component Life (Hours)	0
Annualized Cost (\$)	
<b>Solid Waste Disposal</b>	
Non hazardous material	
Tons per Year	5800
Collection and hauling (\$/Ton)	30
Landfill tipping fees (\$/Ton)	0
Total Costs (\$)	174,000
Hazardous materials	
Tons per Year	0
Collection and hauling (\$/Ton)	0
Landfill tipping fees (\$/Ton)	30
Total Disposal Costs (\$)	0

# APPENDIX L

## HYDROPOWER

**Table L-1  
Plant Information**

Technology Type	Hydro
Fuel	None
<b>Owner/Investor</b>	Merchant
Base Year	2002
In-service Year	2007

**Table L-2  
Plant Size**

Gross Capacity (MW)	100.0
Parasitic Load (MW)	0.1
Net Capacity (MW)	100.0
Derate Factor (%)	100.0
Firm Capacity (MW)	100.0
Transmission Losses (%)	2.5
Required AS/reserves (%)	0.0
Average Hourly Output Rate (%)	100.0
Effective Load Carry Capacity (MW)	97.0
Annual capacity degradation rate (%)	0.0

**Table L-3  
Capital Costs**

Escalation in Capital Costs	0.0%
AFUDC Rate	10.3%
Cash Cost	100.0%

**Table L-4  
Construction Costs by Year  
Sum: 100%**

Years Out from On-Line Date	0	-1	-2	-3	-4
Cost %/Year	45%	45%	4%	3%	3%
Carry Over	\$1,198	\$646	\$121	\$71	\$35

**Table L-5  
Fuel Use**

Heat Rate (MMBtu/kWh)	N/A
Fuel Consumption (MMBtu/Hr)	0.0
Start up fuel use (MMBtu/start)	0.0
No. of annual starts	0.0
Annual Fuel Use (MMBtu)	0.0

**Table L-6  
Operational Information**

Availability/Year (%)	42.5
Availability/Year (Hours)	3,723
Equipment Life (Hours)	262,800
Equipment Life (Years)	30
Overhaul Interval (Hours)	8,400
Maintenance Outage (Days)	10
Maintenance Outage Rate (%)	1.4
Forced Outage (Hours/Year)	120
Forced Outage Rate (%)	1.4
Hours per Year Operation	3,483
Capacity Factor (%)	39.8
Annual Net Energy (GWh)	348

**Table L-7  
Renewable Tax Benefits**

Investment Tax Credit (%)	0
RETC Calculation (\$/kWh)	0
Production Incentive-Investor (¢/kWh)	0
Geothermal Depletion Allowance	
RE Production Incentive Tier I	0
RE Production Incentive Tier II	0
REPI Tier II Proportion Paid (%)	10

**Table L-8  
Operation & Maintenance Costs (Employees)**

Employees	Full Time Employees	Hours/Year	Compensation per Employee
Managers	3	1,800	\$80,000 per year
Plant Operators	3	1,800	\$30 per hour
Mechanics	2	1,800	\$30 per hour
Laborers	1	1,800	\$20 per hour
Support Staff	1	1,800	\$20 per hour

**Table L-9  
Operation & Maintenance Costs (Other)**

<b>Fixed O&amp;M (\$/kW-Yr)</b>	<b>10.0</b>
Fixed O&M/Instant Cost (%)	0.90
O&M Escalation (%)	0.5
Insurance (%)	1.5
Labor Escalation Cost (%)	0.5
Overhead Multiplier	1.6
<b>Other Operating Costs</b>	
Water Supply (\$/AF)	
Consumption (AF/Yr)	
<b>Plant Scheduling Costs</b>	
Transmission Service (\$/MW)	

**Table L-10  
Cost Summary**

Financing Costs (\$/kW-Yr)	161
Fixed Operational Costs (\$/kW-Yr)	39
Tax (w/Credits) (\$/kW-Yr)	10
<b>Fixed Costs</b>	<b>210</b>
Fuel Costs (\$/kW-Yr)	0
Variable O&M (\$/kW-Yr)	0
<b>Variable Costs</b>	<b>0</b>
<b>Total Levelized Costs (\$/kW-Yr)</b>	<b>210</b>
Capital (\$/MWH)	60.37
Variable (\$/MWH)	0.00
<b>Total Levelized Costs (\$/MWH)</b>	<b>60.37</b>
<b>Capital Costs</b>	
Instant Cost (\$/kW)	1,153
Installed Cost (\$/MWH)	1,290
<b>In-service Cost in 2004 (\$/KW)</b>	<b>1,424</b>

**Table L-11  
Capital Cost Detail**

Total (\$)	<b>115,188,000</b>
<b>Component Cost (\$)</b>	<b>109,000,000</b>
Turbine/Engine (\$)	5,000,000
Generator/Gearhead (\$)	6,000,000
Penstock & Surge Tank (\$)	30,000,000
Building & Foundation (\$)	3,000,000
Miscellaneous fitting & hoses (\$)	3,500,000
Office space (\$)	
Control Room(\$)	1,500,000
Dam & Reservoir (\$)	60,000,000
<b>Financial Transaction Costs (%)</b>	<b>0</b>
<b>Land Costs (\$)</b>	<b>6,188,000</b>
Acreage/Plant	1,400
Cost per Acre (\$)	1,420
Acquisition Cost (\$)	1,988,000
Land Prep Costs (\$/Acre)	3,000
Total Land Prep Costs (\$)	4,200,000
<b>Permitting Costs (\$)</b>	<b>0</b>
Local building permits (\$)	
Environmental permits (\$)	
<b>Interconnection Costs (\$)</b>	<b>0</b>
Transmission Lines (\$)	0
Substation (\$)	0
Induction Equipment (\$)	
<b>Environmental Controls (\$)</b>	<b>0</b>
Installation Costs (\$)	0
Replacement Costs (\$)	

**Table L-12  
Maintenance Detail**

<b>Routine Maintenance Costs</b>		<b>Annual Costs</b>
Replacement Interval (Hours)	1	
Filter Price (\$)	0	0
Maintenance Interval (Hours)	1	
Price (\$)	0	0
Oil Price (\$/Gallon)	3.40	
Oil Capacity	0	0
Oil Added per Day	0	0
Interval (Hours)	1,000	
Item Price (\$)	0	0
Labor Hours/Day	0	
Labor Price (\$/Hour)	48	0
<b>Annual Routine Maintenance</b>		<b>0</b>
<b>Major Overhauls</b>		
Hours to Major Overhaul:	43,800	
Major Overhaul Labor (Man-Hours)	600	
Labor Cost (\$/Hour)	48	
Major Overhaul Labor Cost (\$)	28,800	
Major Overhaul Replacement (\$)	2,300,000	101,626.13
NPV Cost (\$)		
<b>Minor Overhauls</b>		
Annual Cost Item 1 (\$)	0	
Hours to Item 1 Job	8,760	3
Annual Cost Item 2 (\$)	0	
Hours to Item 2 Job	0	7
<b>Annualized Overhauls</b>		<b>0</b>
<b>Unscheduled Maintenance</b>		
Forced Outage Hours/Year	120	
Labor Rate (\$/Hour)	48	
Hours of Labor	120	
Parts Costs (\$)	0	
Total (\$)	5,760	
<b>Total Annual Maintenance</b>		<b>107,386</b>
Maintenance (\$/kW-Yr)	1.07	
Maintenance (\$/MWh)	0.31	

**Table L-13  
Environmental Control Costs**

<b>Total Annual Costs (\$)</b>	<b>0</b>
<b>Media &amp; Technology</b>	<b>Cost</b>
<b>Air Emissions</b>	
Control Technology (e.g. SCR) (\$)	
Installation Cost (\$/kW)	0
Annual Labor (Hours/Year)	0
Loaded Labor Rate (\$/Hour)	48
Labor Cost (\$)	0
Annual Consumables-Catalyst (\$)	0
Replacement Cost (\$/kW)	0
Component Life (Hours)	141,760
Annualized Cost (\$)	
<b>Water Cooling</b>	
Control Technology (e.g. wastewater) (\$)	
Installation Cost (\$/kW)	0
Annual Labor (Hours/Year)	0
Loaded Labor Rate (\$/Hour)	48
Labor Cost (\$)	0
Annual Consumables (\$)	0
Replacement Cost (\$/kW)	0
Component Life (Hours)	141,760
Annualized Cost (\$)	
<b>Solid Waste Disposal</b>	
Non hazardous material	
Tons per Year	0
Collection and hauling (\$/Ton)	10
Landfill tipping fees (\$/Ton)	30
Total Costs (\$)	0
Hazardous materials	
Tons per Year	0
Collection and hauling (\$/Ton)	10
Landfill tipping fees (\$/Ton)	30
Total Disposal Costs (\$)	0

# APPENDIX M

## SOLAR PHOTOVOLTAICS

**Table M-1  
Plant Information**

Technology Type	Solar
Fuel	None
<b>Owner/Investor</b>	Merchant
Base Year	2002
In-service Year	2003

**Table M-2  
Plant Size**

Gross Capacity (MW)	50.0
Parasitic Load (MW)	0.0
Net Capacity (MW)	50.0
Derate Factor (%)	100.0
Firm Capacity (MW)	50.0
Transmission Losses (%)	5.0
Required AS/reserves (%)	0.0
Average Hourly Output Rate (%)	100.0
Effective Load Carry Capacity (MW)	48.0
Annual capacity degradation rate (%)	1.0

**Table M-3  
Capital Costs**

Escalation in Capital Costs	0.0%
AFUDC Rate	10.3%
Cash Cost	100.0%

**Table M-4  
Construction Costs by Year  
Sum: 100%**

Years Out from On-Line Date	0	-1	-2	-3	-4
Cost %/Year	100%	0%	0%	0%	0%
Carry Over	\$6,653	\$0	\$0	\$0	\$0

**Table M-5  
Fuel Use**

Heat Rate (MMBtu/kWh)	N/A
Fuel Consumption (MMBtu/Hr)	0.0
Start up fuel use (MMBtu/start)	0.0
No. of annual starts	0.0
Annual Fuel Use (MMBtu)	0.0

**Table M-6  
Operational Information**

Availability/Year (%)	25
Availability/Year (Hours)	2,190
Equipment Life (Hours)	62,580
Equipment Life (Years)	30
Overhaul Interval (Hours)	2,190
Maintenance Outage (Days)	4
Maintenance Outage Rate (%)	1.1
Forced Outage (Hours/Year)	8
Forced Outage Rate (%)	0.1
Hours per Year Operation	2,086
Capacity Factor (%)	23.8
Annual Net Energy (GWh)	104

**Table M-7  
Renewable Tax Benefits**

Investment Tax Credit (%)	10
RETC Calculation (\$/kWh)	731
Production Incentive-Investor (¢/kWh)	0
Geothermal Depletion Allowance	
RE Production Incentive Tier I	0
RE Production Incentive Tier II	0
REPI Tier II Proportion Paid (%)	10

**Table M-8  
Operation & Maintenance Costs (Employees)**

<b>Employees</b>	<b>Full Time Employees</b>	<b>Hours/Year</b>	<b>Compensation per Employee</b>
Managers	1	1,800	\$80,000 per year
Plant Operators	1	1,800	\$30 per hour
Mechanics	2	1,800	\$30 per hour
Laborers	2	1,800	\$20 per hour
Support Staff	0	1,800	\$20 per hour

**Table M-9  
Operation & Maintenance Costs (Other)**

<b>Fixed O&amp;M (\$/kW-Yr)</b>	<b>10.0</b>
Fixed O&M/Instant Cost (%)	0.15
O&M Escalation (%)	0.5
Insurance (%)	1.5
Labor Escalation Cost (%)	0.5
Overhead Multiplier	1.6
<b>Other Operating Costs</b>	
Water Supply (\$/AF)	
Consumption (AF/Yr)	
<b>Plant Scheduling Costs</b>	
Transmission Service (\$/MW)	

**Table M-10  
Cost Summary**

Financing Costs (\$/kW-Yr)	841
Fixed Operational Costs (\$/kW-Yr)	142
Tax (w/Credits) (\$/kW-Yr)	(92)
<b>Fixed Costs</b>	<b>891</b>
Fuel Costs (\$/kW-Yr)	0
Variable O&M (\$/kW-Yr)	0
<b>Variable Costs</b>	<b>0</b>
<b>Total Levelized Costs (\$/kW-Yr)</b>	<b>891</b>
Capital (\$/MWH)	427.16
Variable (\$/MWH)	0.00
<b>Total Levelized Costs (\$/MWH)</b>	<b>427.16</b>
<b>Capital Costs</b>	
Instant Cost (\$/kW)	6,653
Installed Cost (\$/MWH)	7,163
<b>In-service Cost in 2004 (\$/KW)</b>	<b>7,306</b>

**Table M-11  
Capital Cost Detail**

Total (\$)	<b>332,630,100</b>
<b>Component Cost (\$)</b>	<b>330,000,000</b>
PV Modules (\$)	225,000,000
Structures (\$)	25,000,000
Inverter (\$)	25,000,000
Installation (\$)	37,500,000
Engr, Const, Proj Management (\$)	17,500,000
<b>Financial Transaction Costs (%)</b>	<b>0</b>
<b>Land Costs (\$)</b>	<b>2,630,100</b>
Acreage/Plant	250
Cost per Acre (\$)	3,100
Acquisition Cost (\$)	775,000
Land Prep Costs (\$/Acre)	7,420
Total Land Prep Costs (\$)	1,855,100
<b>Permitting Costs (\$)</b>	<b>0</b>
Local building permits (\$)	
Environmental permits (\$)	
<b>Interconnection Costs (\$)</b>	<b>0</b>
Transmission Lines (\$)	
Substation (\$)	
Induction Equipment (\$)	
<b>Environmental Controls (\$)</b>	<b>0</b>
Installation Costs (\$)	0
Replacement Costs (\$)	

**Table M-12  
Maintenance Cost Detail**

<b>Routine Maintenance Costs</b>		Annual Costs
Replacement Interval (Hours)	1	
Filter Price (\$)	0	0
Maintenance Interval (Hours)	1	
Price (\$)	0	0
Oil Price (\$/Gallon)	3.40	
Oil Capacity	0	0
Oil Added per Day	0	0
Interval (Hours)	1,000	
Item Price (\$)	0	0
Labor Hours/Day	0	
Labor Price (\$/Hour)	48	0
<b>Annual Routine Maintenance</b>		<b>0</b>
<b>Major Overhauls</b>		
Hours to Major Overhaul	31,290	
Major Overhaul Labor (Man-Hours)	1,250	
Labor Cost (\$/Hour)	48	
Major Overhaul Labor Cost (\$)	60,000	
Major Overhaul Replacement (\$)	0	1,499.73
NPV Cost (\$)		
Annual Cost Item 1 (\$)	0	
Hours to Item 1 Job	2,086	1
Annual Cost Item 2 (\$)	0	
Hours to Item 2 Job	0	7
<b>Annualized Overhauls</b>		<b>0</b>
<b>Unscheduled Maintenance</b>		
Forced Outage Hours/Year	8	
Labor Rate (\$/Hour)	48	
Hours of Labor	8	
Parts Costs (\$)	1,000	
Total (\$)	1,384	
<b>Total Annual Maintenance</b>		<b>2,884</b>
Maintenance (\$/kW-Yr)	0.06	
Maintenance (\$/MWh)	0.03	

**Table M-13  
Environmental Control Costs**

<b>Total Annual Costs (\$)</b>	<b>0</b>
<b>Media &amp; Technology</b>	<b>Cost</b>
<b>Air Emissions</b>	
Control Technology (e.g. SCR) (\$)	
Installation Cost (\$/kW)	0
Annual Labor (Hours/Year)	0
Loaded Labor Rate (\$/Hour)	48
Labor Cost (\$)	0
Annual Consumables-Catalyst (\$)	0
Replacement Cost (\$/kW)	0
Component Life (Hours)	141,760
Annualized Cost (\$)	
<b>Water Cooling</b>	
Control Technology (e.g. wastewater) (\$)	
Installation Cost (\$/kW)	0
Annual Labor (Hours/Year)	0
Loaded Labor Rate (\$/Hour)	48
Labor Cost (\$)	0
Annual Consumables (\$)	0
Replacement Cost (\$/kW)	0
Component Life (Hours)	141,760
Annualized Cost (\$)	
<b>Solid Waste Disposal</b>	
Non hazardous material	
Tons per Year	0
Collection and hauling (\$/Ton)	10
Landfill tipping fees (\$/Ton)	30
Total Costs (\$)	0
Hazardous materials	
Tons per Year	0
Collection and hauling (\$/Ton)	10
Landfill tipping fees (\$/Ton)	30
Total Disposal Costs (\$)	0

# **APPENDIX N**

## **Solar Parabolic w/o Thermally-Enhanced Storage or Gas**

**Table N-1  
Plant Information**

Technology Type	Solar
Fuel	None
<b>Owner/Investor</b>	Merchant
Base Year	2002
In-service Year	2003

**Table N-2  
Plant Size**

Gross Capacity (MW)	110.0
Parasitic Load (MW)	10.0
Net Capacity (MW)	100.0
Derate Factor (%)	100.0
Firm Capacity (MW)	100.0
Transmission Losses (%)	1.5
Required AS/reserves (%)	0.0
Average Hourly Output Rate (%)	60.0
Effective Load Carry Capacity (MW)	59.0
Annual capacity degradation rate (%)	0.0

**Table N-3  
Capital Costs**

Escalation in Capital Costs	0.0%
AFUDC Rate	10.3%
Cash Cost	100.0%

**Table N-4  
Construction Costs by Year  
Sum: 100%**

Years Out from On-Line Date	0	-1	-2	-3	-4
Cost %/Year	100%	0%	0%	0%	0%
Carry Over	\$2,600	\$0	\$0	\$0	\$0

**Table N-5  
Fuel Use**

Heat Rate (MMBtu/kWh)	N/A
Fuel Consumption (MMBtu/Hr)	0.0
Start up fuel use (MMBtu/start)	0.0
No. of annual starts	346.0
Annual Fuel Use (MMBtu)	0.0

**Table N-6  
Operational Information**

Availability/Year (%)	41.7
Availability/Year (Hours)	3,650
Equipment Life (Hours)	70,000
Equipment Life (Years)	22
Overhaul Interval (Hours)	3,210
Maintenance Outage (Days)	10
Maintenance Outage Rate (%)	2.7
Forced Outage (Hours/Year)	200
Forced Outage Rate (%)	2.3
Hours per Year Operation	3,210
Capacity Factor (%)	22.0
Annual Net Energy (GWh)	193

**Table N-7  
Renewable Tax Benefits**

Investment Tax Credit (%)	10
RETC Calculation (\$/kWh)	286
Production Incentive-Investor (¢/kWh)	0
Geothermal Depletion Allowance	
RE Production Incentive Tier I	0
RE Production Incentive Tier II	0
REPI Tier II Proportion Paid (%)	10

**Table N-8  
Operation & Maintenance Costs (Employees)**

<b>Employees</b>	<b>Full Time Employees</b>	<b>Hours/Year</b>	<b>Compensation per Employee</b>
Managers	1	1,800	\$80,000 per year
Plant Operators	10	1,800	\$30 per hour
Mechanics	6	1,800	\$30 per hour
Laborers	3	1,800	\$20 per hour
Support Staff	1	1,800	\$20 per hour

**Table N-9  
Operation & Maintenance Costs (Other)**

<b>Fixed O&amp;M (\$/kW-Yr)</b>	<b>26.0</b>
Fixed O&M/Instant Cost (%)	1.01
O&M Escalation (%)	0.5
Insurance (%)	1.5
Labor Escalation Cost (%)	0.5
Overhead Multiplier	1.6
<b>Other Operating Costs</b>	
Water Supply (\$/AF)	
Consumption (AF/Yr)	
<b>Plant Scheduling Costs</b>	
Transmission Service (\$/MW)	

**Table N-10  
Cost Summary**

Financing Costs (\$/kW-Yr)	345
Fixed Operational Costs (\$/kW-Yr)	80
Tax (w/Credits) (\$/kW-Yr)	(50)
<b>Fixed Costs</b>	<b>375</b>
Fuel Costs (\$/kW-Yr)	0
Variable O&M (\$/kW-Yr)	40
<b>Variable Costs</b>	<b>40</b>
<b>Total Levelized Costs (\$/kW-Yr)</b>	<b>415</b>
Capital (\$/MWH)	194.73
Variable (\$/MWH)	20.58
<b>Total Levelized Costs (\$/MWH)</b>	<b>215.31</b>
<b>Capital Costs</b>	
Instant Cost (\$/kW)	2,600
Installed Cost (\$/MWH)	2,799
<b>In-service Cost in 2004 (\$/KW)</b>	<b>2,855</b>

**Table N-11  
Capital Cost Detail**

Total (\$)	<b>259,998,383</b>
<b>Component Cost (\$)</b>	<b>254,212,164</b>
Structure & Improvements (\$)	2,720,813
Collector System (\$)	147,795,374
Thermal Storage System	0
Steam Gen or HX System (\$)	10,764,670
Aux Heater/Boiler (\$)	0
EPGS (\$)	47,651,991
Master Control System (\$)	0
Balance of Plant (\$)	27,706,701
Engr, Const, Proj Management (\$)	17,572,616
<b>Financial Transaction Costs (%)</b>	<b>0</b>
<b>Land Costs (\$)</b>	<b>5,786,219</b>
Acreage/MW	5
Acreage/Plant	550
Cost per Acre (\$)	3,100
Acquisition Cost (\$)	1,705,000
Land Prep Costs (\$/Acre)	7,420
Total Land Prep Costs (\$)	4,081,219
<b>Permitting Costs (\$)</b>	<b>0</b>
Local building permits (\$)	
Environmental permits (\$)	
<b>Interconnection Costs (\$)</b>	<b>0</b>
Transmission Lines (\$)	0
Substation (\$)	0
Induction Equipment (\$)	
<b>Environmental Controls (\$)</b>	<b>0</b>
Installation Costs (\$)	0
Replacement Costs (\$)	

**Table N-12  
Maintenance Cost Detail**

<b>Routine Maintenance Costs</b>		Annual Costs
Replacement Interval (Hours)	1	
Filter Price (\$)	0	0
Maintenance Interval (Hours)	1	
Price (\$)	0	0
Oil Price (\$/Gallon)	3.40	
Oil Capacity	0	0
Oil Added per Day	0	0
Interval (Hours)	1,000	
Item Price (\$)	0	0
Labor Hours/Day	0.00	
Labor Price (\$/Hour)	48	0
<b>Annual Routine Maintenance</b>		<b>0</b>
<b>Major Overhauls</b>		
Hours to Major Overhaul:	35,000	
Major Overhaul Labor (Man-Hours)	125	
Labor Cost (\$/Hour)	48	
Major Overhaul Labor Cost (\$)	6,000	
Major Overhaul Replacement (\$)	0	240.00
NPV Cost (\$)		
<b>Minor Overhauls</b>		
Annual Cost Item 1 (\$)	925,019	
Hours to Item 1 Job	3,210	1
Annual Cost Item 2 (\$)	0	
Hours to Item 2 Job	0	7
<b>Annualized Overhauls</b>		<b>883,617</b>
<b>Unscheduled Maintenance</b>		
Forced Outage Hours/Year	200	
Labor Rate (\$/Hour)	48	
Hours of Labor	200	
Parts Costs (\$)	0	
Total (\$)	9,600	
<b>Total Annual Maintenance</b>		<b>893,457</b>
Maintenance (\$/kW-Yr)	8.93	
Maintenance (\$/MWh)	4.64	

**Table N-13  
Environmental Control Costs**

<b>Total Annual Costs (\$)</b>	<b>0</b>
<b>Media &amp; Technology</b>	<b>Cost</b>
<b>Air Emissions</b>	
Control Technology (e.g. SCR) (\$)	
Installation Cost (\$/kW)	0
Annual Labor (Hours/Year)	0
Loaded Labor Rate (\$/Hour)	48
Labor Cost (\$)	0
Annual Consumables-Catalyst (\$)	0
Replacement Cost (\$/kW)	0
Component Life (Hours)	141,760
Annualized Cost (\$)	
<b>Water Cooling</b>	
Control Technology (e.g. wastewater) (\$)	
Installation Cost (\$/kW)	0
Annual Labor (Hours/Year)	0
Loaded Labor Rate (\$/Hour)	48
Labor Cost (\$)	0
Annual Consumables (\$)	0
Replacement Cost (\$/kW)	0
Component Life (Hours)	141,760
Annualized Cost (\$)	
<b>Solid Waste Disposal</b>	
Non hazardous material	
Tons per Year	0
Collection and hauling (\$/Ton)	10
Landfill tipping fees (\$/Ton)	30
Total Costs (\$)	0
Hazardous materials	
Tons per Year	0
Collection and hauling (\$/Ton)	10
Landfill tipping fees (\$/Ton)	30
Total Disposal Costs (\$)	0

# APPENDIX O

## Solar Parabolic with Gas Only

**Table O-1  
Plant Information**

Technology Type	Solar
Fuel	Natural Gas
Owner/Investor	Merchant
Base Year	2002
In-service Year	2003

**Table O-2  
Plant Size**

Gross Capacity (MW)	110.0
Parasitic Load (MW)	10.0
Net Capacity (MW)	100.0
Derate Factor (%)	100.0
Firm Capacity (MW)	100.0
Transmission Losses (%)	1.5
Required AS/reserves (%)	0.0
Average Hourly Output Rate (%)	60.0
Effective Load Carry Capacity (MW)	59.0
Annual capacity degradation rate (%)	0.0

**Table O-3  
Capital Costs**

Escalation in Capital Costs	0.0%
AFUDC Rate	10.3%
Cash Cost	100.0%

**Table O-4  
Construction Costs by Year  
Sum: 100%**

Years Out from On-Line Date	0	-1	-2	-3	-4
Cost %/Year	100%	0%	0%	0%	0%
Carry Over	\$2,841	\$0	\$0	\$0	\$0

**Table O-5  
Fuel Use**

Heat Rate (MMBtu/kWh)	2,480
Fuel Consumption (MMBtu/Hr)	248
Start up fuel use (MMBtu/start)	0
No. of annual starts	346
Annual Fuel Use (MMBtu)	1,520,240

**Table O-6  
Operational Information**

Availability/Year (%)	75.0
Availability/Year (Hours)	6,570
Equipment Life (Hours)	70,000
Equipment Life (Years)	11
Overhaul Interval (Hours)	6,130
Maintenance Outage (Days)	10
Maintenance Outage Rate (%)	2.7
Forced Outage (Hours/Year)	200
Forced Outage Rate (%)	2.3
Hours per Year Operation	6,130
Capacity Factor (%)	42.0
Annual Net Energy (GWh)	368

**Table O-7  
Renewable Tax Benefits**

Investment Tax Credit (%)	10
RETC Calculation (\$/kWh)	312
Production Incentive-Investor (¢/kWh)	0
Geothermal Depletion Allowance	
RE Production Incentive Tier I	0
RE Production Incentive Tier II	0
REPI Tier II Proportion Paid (%)	10

**Table O-8  
Operation & Maintenance Costs (Employees)**

<b>Employees</b>	<b>Full Time Employees</b>	<b>Hours/Year</b>	<b>Compensation per Employee</b>
Managers	1	1,800	\$80,000 per year
Plant Operators	10	1,800	\$30 per hour
Mechanics	6	1,800	\$30 per hour
Laborers	3	1,800	\$20 per hour
Support Staff	1	1,800	\$20 per hour

**Table O-9  
Operation & Maintenance Costs (Other)**

<b>Fixed O&amp;M (\$/kW-Yr)</b>	<b>40.0</b>
Fixed O&M/Instant Cost (%)	1.42
O&M Escalation (%)	0.5
Insurance (%)	1.5
Labor Escalation Cost (%)	0.5
Overhead Multiplier	1.6
<b>Other Operating Costs</b>	
Water Supply (\$/AF)	462.0
Consumption (AF/Yr)	200.0
<b>Plant Scheduling Costs</b>	
Transmission Service (\$/MW)	

**Table O-10  
Cost Summary**

Financing Costs (\$/kW-Yr)	377
Fixed Operational Costs (\$/kW-Yr)	101
Tax (w/Credits) (\$/kW-Yr)	(55)
<b>Fixed Costs</b>	<b>423</b>
Fuel Costs (\$/kW-Yr)	48
Variable O&M (\$/kW-Yr)	26
<b>Variable Costs</b>	<b>74</b>
<b>Total Levelized Costs (\$/kW-Yr)</b>	<b>497</b>
Capital (\$/MWH)	115.14
Variable (\$/MWH)	20.08
<b>Total Levelized Costs (\$/MWH)</b>	<b>135.21</b>
<b>Capital Costs</b>	
Instant Cost (\$/kW)	2,841
Installed Cost (\$/MWH)	3,059
<b>In-service Cost in 2004 (\$/KW)</b>	<b>3,120</b>

**Table O-11  
Capital Cost Detail**

Total (\$)	<b>284,065,853</b>
<b>Component Cost (\$)</b>	<b>276,835,787</b>
Structure & Improvements (\$)	2,720,813
Collector System (\$)	147,795,374
Thermal Storage System	0
Steam Gen or HX System (\$)	11,251,870
Aux Heater/Boiler (\$)	20,597,257
EPGS (\$)	47,651,991
Master Control System (\$)	0
Balance of Plant (\$)	27,706,701
Engr, Const, Proj Management (\$)	19,111,781
<b>Financial Transaction Costs (%)</b>	<b>0</b>
<b>Land Costs (\$)</b>	<b>5,786,219</b>
Acreage/MW	5
Acreage/Plant	550
Cost per Acre (\$)	3,100
Acquisition Cost (\$)	1,705,000
Land Prep Costs (\$/Acre)	7,420
Total Land Prep Costs (\$)	4,081,219
<b>Permitting Costs (\$)</b>	<b>343,847</b>
Local building permits (\$)	0
Environmental permits (\$)	343,847
<b>Interconnection Costs (\$)</b>	<b>0</b>
Transmission Lines (\$)	0
Substation (\$)	0
Induction Equipment (\$)	0
<b>Environmental Controls (\$)</b>	<b>1,100,000</b>
Installation Costs (\$)	1,100,000
Replacement Costs (\$)	0

**Table O-12  
Maintenance Cost Detail**

<b>Routine Maintenance Costs</b>		<b>Annual Costs</b>
Replacement Interval (Hours)	1	
Filter Price (\$)	0	0
Maintenance Interval (Hours)	1	
Price (\$)	0	0
Oil Price (\$/Gallon)	3.40	
Oil Capacity	0	0
Oil Added per Day	0	0
Interval (Hours)	1,000	
Item Price (\$)	0	0
Labor Hours/Day	0	
Labor Price (\$/Hour)	48	0
<b>Annual Routine Maintenance</b>		<b>0</b>
<b>Major Overhauls</b>		
Hours to Major Overhaul:	35,000	
Major Overhaul Labor (Man-Hours)	125	
Labor Cost (\$/Hour)	48	
Major Overhaul Labor Cost (\$)	6,000	
Major Overhaul Replacement (\$)	0	1,015.72
NPV Cost (\$)		
<b>Minor Overhauls</b>		
Annual Cost Item 1 (\$)	925,019	
Hours to Item 1 Job	6,130	1
Annual Cost Item 2 (\$)	0	
Hours to Item 2 Job	0	7
<b>Annualized Overhauls</b>		<b>1,184,298</b>
<b>Unscheduled Maintenance</b>		
Forced Outage Hours/Year	200	
Labor Rate (\$/Hour)	48	
Hours of Labor	200	
Parts Costs (\$)	0	
Total (\$)	9,600	
<b>Total Annual Maintenance</b>		<b>1,194,913</b>
Maintenance (\$/kW-Yr)	11.95	
Maintenance (\$/MWh)	3.25	

**Table O-13  
Environmental Control Costs**

<b>Total Annual Costs (\$)</b>	<b>1,100,000</b>
<b>Media &amp; Technology</b>	<b>Cost</b>
<b>Air Emissions</b>	
Control Technology (e.g. SCR) (\$)	1,100,000
Installation Cost (\$/kW)	10
Annual Labor (Hours/Year)	0
Loaded Labor Rate (\$/Hour)	48
Labor Cost (\$)	0
Annual Consumables-Catalyst (\$)	0
Replacement Cost (\$/kW)	0
Component Life (Hours)	141,760
Annualized Cost (\$)	
<b>Water Cooling</b>	
Control Technology (e.g. wastewater) (\$)	
Installation Cost (\$/kW)	0
Annual Labor (Hours/Year)	0
Loaded Labor Rate (\$/Hour)	48
Labor Cost (\$)	0
Annual Consumables (\$)	0
Replacement Cost (\$/kW)	0
Component Life (Hours)	141,760
Annualized Cost (\$)	
<b>Solid Waste Disposal</b>	
Non hazardous material	
Tons per Year	0
Collection and hauling (\$/Ton)	10
Landfill tipping fees (\$/Ton)	30
Total Costs (\$)	0
Hazardous materials	
Tons per Year	0
Collection and hauling (\$/Ton)	10
Landfill tipping fees (\$/Ton)	30
Total Disposal Costs (\$)	0

# APPENDIX P

## Solar Thermal-Stirling Dish

**Table P-1  
Plant Information**

Technology Type	Solar
Fuel	None
<b>Owner/Investor</b>	Merchant
Base Year	2002
In-service Year	2003

**Table P-2  
Plant Size**

Gross Capacity (MW)	31.5
Parasitic Load (MW)	1.5
Net Capacity (MW)	30.0
Derate Factor (%)	100.0
Firm Capacity (MW)	30.0
Transmission Losses (%)	1.5
Required AS/reserves (%)	0.0
Average Hourly Output Rate (%)	100.0
Effective Load Carry Capacity (MW)	30.0
Annual capacity degradation rate (%)	0.0

**Table P-3  
Capital Costs**

Escalation in Capital Costs	0.0%
AFUDC Rate	10.3%
Cash Cost	100.0%

**Table P-4  
Construction Costs by Year  
Sum: 100%**

Years Out from On-Line Date	0	-1	-2	-3	-4
Cost %/Year	100%	0%	0%	0%	0%
Carry Over	\$3,270	\$0	\$0	\$0	\$0

**Table P-5  
Fuel Use**

Heat Rate (MMBtu/kWh)	N/A
Fuel Consumption (MMBtu/Hr)	0
Start up fuel use (MMBtu/start)	0
No. of annual starts	0
Annual Fuel Use (MMBtu)	0

**Table P-6  
Operational Information**

Availability/Year (%)	40.0
Availability/Year (Hours)	3,504
Equipment Life (Hours)	10,000
Equipment Life (Years)	3
Overhaul Interval (Hours)	3,000
Maintenance Outage (Days)	5
Maintenance Outage Rate (%)	1.4
Forced Outage (Hours/Year)	200
Forced Outage Rate (%)	2.3
Hours per Year Operation	3,184
Capacity Factor (%)	36.3
Annual Net Energy (GWh)	96

**Table P-7  
Renewable Tax Benefits**

Investment Tax Credit (%)	10
RETC Calculation (\$/kWh)	359
Production Incentive-Investor (¢/kWh)	0
Geothermal Depletion Allowance	
RE Production Incentive Tier I	0
RE Production Incentive Tier II	0
REPI Tier II Proportion Paid (%)	10

**Table P-8  
Operation & Maintenance Costs (Employees)**

<b>Employees</b>	<b>Full Time Employees</b>	<b>Hours/Year</b>	<b>Compensation per Employee</b>
Managers	1	1,800	\$80,000 per year
Plant Operators	4	1,800	\$30 per hour
Mechanics	3	1,800	\$30 per hour
Laborers	3	1,800	\$20 per hour
Support Staff	1	1,800	\$20 per hour

**Table P-9  
Operation & Maintenance Costs (Other)**

<b>Fixed O&amp;M (\$/kW-Yr)</b>	<b>48.0</b>
Fixed O&M/Instant Cost (%)	1.48
O&M Escalation (%)	0.5
Insurance (%)	1.5
Labor Escalation Cost (%)	0.5
Overhead Multiplier	1.6
<b>Other Operating Costs</b>	
Water Supply (\$/AF)	
Consumption (AF/Yr)	
<b>Plant Scheduling Costs</b>	
Transmission Service (\$/MW)	

**Table P-10  
Cost Summary**

Financing Costs (\$/kW-Yr)	434
Fixed Operational Costs (\$/kW-Yr)	119
Tax (w/Credits) (\$/kW-Yr)	(64)
<b>Fixed Costs</b>	<b>489</b>
Fuel Costs (\$/kW-Yr)	0
Variable O&M (\$/kW-Yr)	0
<b>Variable Costs</b>	<b>0</b>
<b>Total Levelized Costs (\$/kW-Yr)</b>	<b>489</b>
Capital (\$/MWH)	153.67
Variable (\$/MWH)	0.00
<b>Total Levelized Costs (\$/MWH)</b>	<b>153.67</b>
<b>Capital Costs</b>	
Instant Cost (\$/kW)	3,270
Installed Cost (\$/MWH)	3,520
<b>In-service Cost in 2004 (\$/KW)</b>	<b>3,591</b>

**Table P-11  
Capital Cost Detail**

Total (\$)	<b>98,090,550</b>
<b>Component Cost (\$)</b>	<b>92,607,300</b>
Concentrator (\$)	51,615,000
Receiver (\$)	2,664,000
Engine (\$)	8,658,000
Generator (\$)	1,498,500
Cooling System (\$)	1,332,000
Electrical (\$)	1,165,500
Balance of Plant (\$)	9,990,000
General Plant Facilities (\$)	4,995,000
Engineering & Startup (\$)	10,689,300
<b>Financial Transaction Costs (%)</b>	<b>0</b>
<b>Land Costs (\$)</b>	<b>5,483,250</b>
Acres/MW	5
Acreage/Plant	157.5
Cost per Acre (\$)	3,100
Acquisition Cost (\$)	488,250
Land Prep Costs (\$/Acre)	31,714
Total Land Prep Costs (\$)	4,995,000
<b>Permitting Costs (\$)</b>	<b>0</b>
Local building permits (\$)	
Environmental permits (\$)	
<b>Interconnection Costs (\$)</b>	<b>0</b>
Transmission Lines (\$)	0
Substation (\$)	0
Induction Equipment (\$)	
<b>Environmental Controls (\$)</b>	<b>0</b>
Installation Costs (\$)	0
Replacement Costs (\$)	

**Table P-12  
Maintenance Cost Detail**

<b>Routine Maintenance Costs</b>		<b>Annual Costs</b>
Replacement Interval (Hours)	1	
Filter Price (\$)	0	0
Maintenance Interval (Hours)	1	
Price (\$)	0	0
Oil Price (\$/Gallon)	3.40	
Oil Capacity	0	0
Oil Added per Day	0	0
Interval (Hours)	1,000	
Item Price (\$)	0	0
Labor Hours/Day	0	
Labor Price (\$/Hour)	48	0
<b>Annual Routine Maintenance</b>		<b>0</b>
<b>Major Overhauls</b>		
Hours to Major Overhaul:	3,000	
Major Overhaul Labor (Man-Hours)	36	
Labor Cost (\$/Hour)	48	
Major Overhaul Labor Cost (\$)	1,728	
Major Overhaul Replacement (\$)	0	5,573
NPV Cost (\$)		
<b>Minor Overhauls</b>		
Annual Cost Item 1 (\$)	484,000	
Hours to Item 1 Job	3,184	1
Annual Cost Item 2 (\$)	0	
Hours to Item 2 Job	0	7
<b>Annualized Overhauls</b>		<b>475,829</b>
<b>Unscheduled Maintenance</b>		
Forced Outage Hours/Year	200	
Labor Rate (\$/Hour)	48	
Hours of Labor	200	
Parts Costs (\$)	0	
Total (\$)	9,600	
<b>Total Annual Maintenance</b>		<b>491,002</b>
Maintenance (\$/kW-Yr)	16.37	
Maintenance (\$/MWh)	5.14	

**Table P-13  
Environmental Control Costs**

<b>Total Annual Costs (\$)</b>	<b>0</b>
<b>Media &amp; Technology</b>	<b>Cost</b>
<b>Air Emissions</b>	
Control Technology (e.g. SCR) (\$)	
Installation Cost (\$/kW)	0
Annual Labor (Hours/Year)	0
Loaded Labor Rate (\$/Hour)	48
Labor Cost (\$)	0
Annual Consumables-Catalyst (\$)	0
Replacement Cost (\$/kW)	0
Component Life (Hours)	141,760
Annualized Cost (\$)	
<b>Water Cooling</b>	
Control Technology (e.g. wastewater) (\$)	
Installation Cost (\$/kW)	0
Annual Labor (Hours/Year)	0
Loaded Labor Rate (\$/Hour)	48
Labor Cost (\$)	0
Annual Consumables (\$)	0
Replacement Cost (\$/kW)	0
Component Life (Hours)	141,760
Annualized Cost (\$)	
<b>Solid Waste Disposal</b>	
Non hazardous material	
Tons per Year	0
Collection and hauling (\$/Ton)	10
Landfill tipping fees (\$/Ton)	30
Total Costs (\$)	0
Hazardous materials	
Tons per Year	0
Collection and hauling (\$/Ton)	10
Landfill tipping fees (\$/Ton)	30
Total Disposal Costs (\$)	0

# APPENDIX Q

## Solar Parabolic w/ Thermally-Enhanced Storage Only

**Table Q-1  
Plant Information**

Technology Type	Solar
Fuel	None
<b>Owner/Investor</b>	Merchant
Base Year	2002
In-service Year	2003

**Table Q-2  
Plant Size**

Gross Capacity (MW)	110.0
Parasitic Load (MW)	10.0
Net Capacity (MW)	100.0
Derate Factor (%)	100.0
Firm Capacity (MW)	100.0
Transmission Losses (%)	1.5
Required AS/reserves (%)	0.0
Average Hourly Output Rate (%)	60.0
Effective Load Carry Capacity (MW)	59.0
Annual capacity degradation rate (%)	0.0

**Table Q-3  
Capital Costs**

Escalation in Capital Costs	0.0%
AFUDC Rate	10.3%
Cash Cost	100.0%

**Table Q-4  
Construction Costs by Year  
Sum: 100%**

Years Out from On-Line Date	0	-1	-2	-3	-4
Cost %/Year	100%	0%	0%	0%	0%
Carry Over	\$3,993	\$0	\$0	\$0	\$0

**Table Q-5  
Fuel Use**

Heat Rate (MMBtu/kWh)	N/A
Fuel Consumption (MMBtu/Hr)	0
Start up fuel use (MMBtu/start)	0
No. of annual starts	346
Annual Fuel Use (MMBtu)	0

**Table Q-6  
Operational Information**

Availability/Year (%)	75.0
Availability/Year (Hours)	6,570
Equipment Life (Hours)	70,000
Equipment Life (Years)	11
Overhaul Interval (Hours)	6,130
Maintenance Outage (Days)	10
Maintenance Outage Rate (%)	2.7
Forced Outage (Hours/Year)	200
Forced Outage Rate (%)	2.3
Hours per Year Operation	6,130
Capacity Factor (%)	42.0
Annual Net Energy (GWh)	368

**Table Q-7  
Renewable Tax Benefits**

Investment Tax Credit (%)	10
RETC Calculation (\$/kWh)	438
Production Incentive-Investor (¢/kWh)	0
Geothermal Depletion Allowance	
RE Production Incentive Tier I	0
RE Production Incentive Tier II	0
REPI Tier II Proportion Paid (%)	10

**Table Q-8  
Operation & Maintenance Costs (Employees)**

<b>Employees</b>	<b>Full Time Employees</b>	<b>Hours/Year</b>	<b>Compensation per Employee</b>
Managers	1	1,800	\$80,000 per year
Plant Operators	10	1,800	\$30 per hour
Mechanics	6	1,800	\$30 per hour
Laborers	3	1,800	\$20 per hour
Support Staff	1	1,800	\$20 per hour

**Table Q-9  
Operation & Maintenance Costs (Other)**

<b>Fixed O&amp;M (\$/kW-Yr)</b>	<b>29.0</b>
Fixed O&M/Instant Cost (%)	0.74
O&M Escalation (%)	0.5
Insurance (%)	1.5
Labor Escalation Cost (%)	0.5
Overhead Multiplier	1.6
<b>Other Operating Costs</b>	
Water Supply (\$/AF)	
Consumption (AF/Yr)	
<b>Plant Scheduling Costs</b>	
Transmission Service (\$/MW)	

**Table Q-10  
Cost Summary**

Financing Costs (\$/kW-Yr)	530
Fixed Operational Costs (\$/kW-Yr)	110
Tax (w/Credits) (\$/kW-Yr)	(77)
<b>Fixed Costs</b>	<b>563</b>
Fuel Costs (\$/kW-Yr)	0
Variable O&M (\$/kW-Yr)	76
<b>Variable Costs</b>	<b>76</b>
<b>Total Levelized Costs (\$/kW-Yr)</b>	<b>639</b>
Capital (\$/MWH)	153.05
Variable (\$/MWH)	20.58
<b>Total Levelized Costs (\$/MWH)</b>	<b>173.64</b>
<b>Capital Costs</b>	
Instant Cost (\$/kW)	3,993
Installed Cost (\$/MWH)	4,299
<b>In-service Cost in 2004 (\$/KW)</b>	<b>4,385</b>

**Table Q-11  
Capital Cost Detail**

Total (\$)	<b>399,264,733</b>
<b>Component Cost (\$)</b>	<b>391,702,016</b>
Structure & Improvements (\$)	3,450,478
Collector System (\$)	207,425,745
Thermal Storage System	66,593,338
Steam Gen or HX System (\$)	11,872,762
Aux Heater/Boiler (\$)	0
EPGS (\$)	47,651,991
Master Control System (\$)	0
Balance of Plant (\$)	27,706,701
Engr, Const, Proj Management (\$)	27,001,001
<b>Financial Transaction Costs (%)</b>	<b>0</b>
<b>Land Cost (\$)</b>	<b>7,562,716</b>
Acreage/MW	7
Acreage/Plant	770
Cost per Acre (\$)	3,100
Acquisition Cost (\$)	2,387,000
Land Prep Costs (\$/Acre)	6,722
Total Land Prep Costs (\$)	5,175,716
<b>Permitting Costs (\$)</b>	<b>0</b>
Local building permits (\$)	
Environmental permits (\$)	
<b>Interconnection Costs (\$)</b>	<b>0</b>
Transmission Lines (\$)	0
Substation (\$)	0
Induction Equipment (\$)	
<b>Environmental Controls (\$)</b>	<b>0</b>
Installation Costs (\$)	0
Replacement Costs (\$)	

**Table Q-12  
Maintenance Cost Detail**

<b>Routine Maintenance Costs</b>		Annual Costs
Replacement Interval (Hours)	1	
Filter Price (\$)	0	0
Maintenance Interval (Hours)	1	
Price (\$)	0	0
Oil Price (\$/Gallon)	3.40	
Oil Capacity	0	0
Oil Added per Day	0	0
Interval (Hours)	1,000	
Item Price (\$)	0	0
Labor Hours/Day	0	
Labor Price (\$/Hour)	48	0
<b>Annual Routine Maintenance</b>		<b>0</b>
<b>Major Overhauls</b>		
Hours to Major Overhaul:	35,000	
Major Overhaul Labor (Man-Hours)	125	
Labor Cost (\$/Hour)	48	
Major Overhaul Labor Cost (\$)	6,000	
Major Overhaul Replacement (\$)	0	1,015.72
NPV Cost (\$)		
<b>Minor Overhauls</b>		
Annual Cost Item 1 (\$)	925,019	
Hours to Item 1 Job	6,130	1
Annual Cost Item 2 (\$)	0	
Hours to Item 2 Job	0	7
<b>Annualized Overhauls</b>		<b>1,184,298</b>
<b>Unscheduled Maintenance</b>		
Forced Outage Hours/Year	200	
Labor Rate (\$/Hour)	48	
Hours of Labor	200	
Parts Costs (\$)	0	
Total (\$)	9,600	
<b>Total Annual Maintenance</b>		<b>1,194,913</b>
Maintenance (\$/kW-Yr)	11.95	
Maintenance (\$/MWh)	3.25	

**Table Q-13  
Environmental Control Costs**

<b>Total Annual Costs (\$)</b>	<b>0</b>
<b>Media &amp; Technology</b>	<b>Cost</b>
<b>Air Emissions</b>	
Control Technology (e.g. SCR) (\$)	
Installation Cost (\$/kW)	0
Annual Labor (Hours/Year)	0
Loaded Labor Rate (\$/Hour)	48
Labor Cost (\$)	0
Annual Consumables-Catalyst (\$)	0
Replacement Cost (\$/kW)	0
Component Life (Hours)	141,760
Annualized Cost (\$)	
<b>Water Cooling</b>	
Control Technology (e.g. wastewater) (\$)	
Installation Cost (\$/kW)	0
Annual Labor (Hours/Year)	0
Loaded Labor Rate (\$/Hour)	48
Labor Cost (\$)	0
Annual Consumables (\$)	0
Replacement Cost (\$/kW)	0
Component Life (Hours)	141,760
Annualized Cost (\$)	
<b>Solid Waste Disposal</b>	
Non hazardous material	
Tons per Year	0
Collection and hauling (\$/Ton)	10
Landfill tipping fees (\$/Ton)	30
Total Costs (\$)	0
Hazardous materials	
Tons per Year	0
Collection and hauling (\$/Ton)	10
Landfill tipping fees (\$/Ton)	30
Total Disposal Costs (\$)	0

# APPENDIX R

## Wind Farm

**Table R-1  
Plant Information**

Technology Type	Wind
Fuel	None
<b>Owner/Investor</b>	Merchant
Base Year	2001
In-service Year	2004

**Table R-2  
Plant Size**

Gross Capacity (MW)	100.0
Parasitic Load (MW)	0.1
Net Capacity (MW)	100.0
Derate Factor (%)	40.0
Firm Capacity (MW)	40.0
Transmission Losses (%)	5.0
Required AS/reserves (%)	7.0
Average Hourly Output Rate (%)	66.0
Effective Load Carry Capacity (MW)	58.0
Annual capacity degradation rate (%)	0.1

**Table R-3  
Capital Costs**

Escalation in Capital Costs	0.0%
AFUDC Rate	10.3%
Cash Cost	100.0%

**Table R-4  
Construction Costs by Year  
Sum: 100%**

Years Out from On-Line Date	0	-1	-2	-3	-4
Cost %/Year	100%	0%	0%	0%	0%
Carry Over	\$887	\$0	\$0	\$0	\$0

**Table R-5  
Fuel Use**

Heat Rate (MMBtu/kWh)	N/A
Fuel Consumption (MMBtu/Hr)	0
Start up fuel use (MMBtu/start)	0
No. of annual starts	0
Annual Fuel Use (MMBtu)	0

**Table R-6  
Operational Information**

Availability/Year (%)	70.0
Availability/Year (Hours)	6,132
Equipment Life (Hours)	66,700
Equipment Life (Years)	13
Overhaul Interval (Hours)	40,000
Maintenance Outage (Days)	28
Maintenance Outage Rate (%)	1.1
Forced Outage (Hours/Year)	700
Forced Outage Rate (%)	8.0
Hours per Year Operation	5,336
Capacity Factor (%)	40.2
Annual Net Energy (GWh)	352

**Table R-7  
Renewable Tax Benefits**

Investment Tax Credit (%)	0
RETC Calculation (\$/kWh)	0
Production Incentive-Investor (¢/kWh)	1.695
Geothermal Depletion Allowance	
RE Production Incentive Tier I	0
RE Production Incentive Tier II	0
REPI Tier II Proportion Paid (%)	10

**Table R-8  
Operation & Maintenance Costs (Employees)**

Employees	Full Time Employees	Hours/Year	Compensation per Employee
Managers	2	1,800	\$80,000 per year
Plant Operators	2	1,800	\$30 per hour
Mechanics	6	1,800	\$30 per hour
Laborers	4	1,800	\$20 per hour
Support Staff	2	1,800	\$20 per hour

**Table R-9  
Operation & Maintenance Costs (Other)**

<b>Fixed O&amp;M (\$/kW-Yr)</b>	<b>39.0</b>
Fixed O&M/Instant Cost (%)	4.35
O&M Escalation (%)	0.5
Insurance (%)	1.5
Labor Escalation Cost (%)	0.5
Overhead Multiplier	1.6
<b>Other Operating Costs</b>	
Water Supply (\$/AF)	
Consumption (AF/Yr)	
<b>Plant Scheduling Costs</b>	
Transmission Service (\$/MW)	

**Table R-10  
Cost Summary**

Financing Costs (\$/kW-Yr)	123
Fixed Operational Costs (\$/kW-Yr)	63
Tax (w/Credits) (\$/kW-Yr)	(12)
<b>Fixed Costs</b>	<b>174</b>
Fuel Costs (\$/kW-Yr)	0
Variable O&M (\$/kW-Yr)	0
<b>Variable Costs</b>	<b>0</b>
<b>Total Levelized Costs (\$/kW-Yr)</b>	<b>174</b>
Capital (\$/MWH)	49.33
Variable (\$/MWH)	0.00
<b>Total Levelized Costs (\$/MWH)</b>	<b>49.33</b>
<b>Capital Costs</b>	
Instant Cost (\$/kW)	887
Installed Cost (\$/MWH)	955
<b>In-service Cost in 2004 (\$/KW)</b>	<b>1,014</b>

**Table R-11  
Capital Cost Detail**

Total (\$)	<b>399,264,733</b>
<b>Component Cost (\$)</b>	<b>391,702,016</b>
Structures & Improvements (\$)	3,450,478
Collector System (\$)	207,425,745
Thermal Storage System (\$)	66,593,338
Steam Gen or HX System (\$)	11,872,762
Auxiliary Heater/Boiler (\$)	0
EPGS (\$)	47,651,991
Master Control System (\$)	0
Balance of Plant (\$)	27,706,701
Engineering, Construction, Project Management	27,001,001
<b>Financial Transaction Costs (%)</b>	<b>0</b>
<b>Land Costs (\$)</b>	<b>7,562,716</b>
Acreage/MW	7
Acreage/Plant	770
Cost per Acre (\$)	3,100
Acquisition Cost (\$)	2,387,000
Land Prep Costs (\$/Acre)	6,722
<b>Permitting Costs (\$)</b>	<b>5,175,716</b>
Local building permits (\$)	<b>0</b>
Environmental permits (\$)	
Air Emission Permits (\$)	
<b>Interconnection Costs (\$)</b>	<b>0</b>
Transmission Lines (\$)	0
Substation (\$)	0
Induction Equipment (\$)	
<b>Environmental Controls (\$)</b>	<b>0</b>
Installation Costs (\$)	0
Replacement Costs (\$)	

**Table R-12  
Maintenance Cost Detail**

<b>Routine Maintenance Costs</b>		<b>Annual Costs</b>
Replacement Interval (Hours)	1	
Filter Price (\$)	0	0
Maintenance Interval (Hours)	1	
Price (\$)	0	0
Oil Price (\$/Gallon)	3.40	
Oil Capacity	0	0
Oil Added per Day	0	0
Interval (Hours)	1,000	
Item Price (\$)	0	0
Labor Hours/Day	0	
Labor Price (\$/Hour)	48	0
<b>Annual Routine Maintenance</b>		<b>0</b>
<b>Major Overhauls</b>		
Hours to Major Overhaul:	35,000	
Major Overhaul Labor (Man-Hours)	125	
Labor Cost (\$/Hour)	48	
Major Overhaul Labor Cost (\$)	6,000	
Major Overhaul Replacement (\$)	0	1,015.72
NPV Cost (\$)		
<b>Minor Overhauls</b>		
Annual Cost Item 1 (\$)	925,019	
Hours to Item 1 Job	6,130	1
Annual Cost Item 2 (\$)	0	
Hours to Item 2 Job	0	7
<b>Annualized Overhauls</b>		<b>1,184,298</b>
<b>Unscheduled Maintenance</b>		
Forced Outage Hours/Year	200	
Labor Rate (\$/Hour)	48	
Hours of Labor	200	
Parts Costs (\$)	0	
Total (\$)	9,600	
<b>Total Annual Maintenance</b>		<b>1,194,913</b>
Maintenance (\$/kW-Yr)	11.95	
Maintenance (\$/MWh)	3.25	

**Table R-13  
Environmental Control Costs**

<b>Total Annual Costs (\$)</b>	<b>0</b>
<b>Media &amp; Technology</b>	<b>Cost</b>
<b>Air Emissions</b>	
Control Technology (e.g. SCR) (\$)	
Installation Cost (\$/kW)	0
Annual Labor (Hours/Year)	0
Loaded Labor Rate (\$/Hour)	48
Labor Cost (\$)	0
Annual Consumables-Catalyst (\$)	0
Replacement Cost (\$/kW)	0
Component Life (Hours)	141,760
Annualized Cost (\$)	
<b>Water Cooling</b>	
Control Technology (e.g. wastewater) (\$)	
Installation Cost (\$/kW)	0
Annual Labor (Hours/Year)	0
Loaded Labor Rate (\$/Hour)	48
Labor Cost (\$)	0
Annual Consumables (\$)	0
Replacement Cost (\$/kW)	0
Component Life (Hours)	141,760
Annualized Cost (\$)	
<b>Solid Waste Disposal</b>	
Non hazardous material	
Tons per Year	0
Collection and hauling (\$/Ton)	10
Landfill tipping fees (\$/Ton)	30
Total Costs (\$)	0
Hazardous materials	
Tons per Year	0
Collection and hauling (\$/Ton)	10
Landfill tipping fees (\$/Ton)	30
Total Disposal Costs (\$)	0

# Appendix S

## Combine Cycle-Baseload (With Duct Firing)

**Table S-1  
Plant Information**

Technology Type	Natural Gas
Fuel	Natural Gas
<b>Owner/Investor</b>	Merchant
Base Year	2002
In-service Year	2004

**Table S-2  
Plant Size**

Gross Capacity (MW)	100.0
Parasitic Load (MW)	0.0
Net Capacity (MW)	100.0
Derate Factor (%)	100.0
Firm Capacity (MW)	520.0
Transmission Losses (%)	5.0
Required AS/reserves (%)	7.0
Average Hourly Output Rate (%)	100.0
Effective Load Carry Capacity (MW)	88.0
Annual capacity degradation rate (%)	0.0

**Table S-3  
Capital Costs**

Escalation in Capital Costs	0.0%
AFUDC Rate	10.3%
Cash Cost	100.0%

**Table S-4  
Construction Costs by Year  
Sum: 100%**

Years Out from On-Line Date	0	-1	-2	-3	-4
Cost %/Year	75%	20%	5%	0%	0%
Carry Over	\$424	\$105	\$21	\$0	\$0

**Table S-5  
Fuel Use**

Base Heat Rate (MMBtu/kWh)	9,300
Fuel Consumption (MMBtu/Hr)	930
Start up fuel use (MMBtu/Start)	180
No. of annual starts	120

**Table S-6  
Operational Information**

Availability/Year (%)	10.0
Availability/Year (Hours)	876
Equipment Life (Hours)	148,394
Equipment Life (Years)	30
Overhaul Interval (Hours)	876
Maintenance Outage (Days)	4
Maintenance Outage Rate (%)	1.2
Forced Outage (Hours/Year)	44
Forced Outage Rate (%)	0.5
Hours per Year Operation	822
Capacity Factor (%)	9.4
Annual Net Energy (GWh)	82

**Table S-7  
Renewable Tax Benefits**

Investment Tax Credit (%)	0
RETC Calculation (\$/kWh)	0
Production Incentive-Investor (¢/kWh)	0
Geothermal Depletion Allowance	
RE Production Incentive Tier I	0
RE Production Incentive Tier II	0
REPI Tier II Proportion Paid (%)	10

**Table S-8  
Operation & Maintenance Costs**

<b>Employee Category</b>	<b>Full Time Employees</b>	<b>Hours/Year</b>	<b>Compensation per Employee</b>
Managers	1	1,800	\$77,031 per year
Plant Operators	12	2,200	\$17 per hour
Mechanics	4	2,300	\$18 per hour
Laborers	2	2,200	\$12 per hour
Support Staff	3	2,000	\$13 per hour

**Table S-9  
Operation & Maintenance Costs (Other)**

<b>Fixed O&amp;M (\$/kW-Yr)</b>	<b>3.20</b>
Fixed O&M/Instant Cost (%)	0.60
O&M Escalation (%)	0.5
Insurance (%)	1.5
Labor Escalation Cost (%)	0.5
Overhead Multiplier	1.6
<b>Other Operating Costs</b>	
Water Supply (\$/AF)	197.0
Consumption (AF/Yr)	2,704.0
<b>Plant Scheduling Costs</b>	
Transmission Service (\$/MW)	

**Table S-10  
Cost Summary**

Financing Costs (\$/kW-Yr)	73
Fixed Operational Costs (\$/kW-Yr)	14
Tax (w/Credits) (\$/kW-Yr)	1
<b>Fixed Costs</b>	<b>88</b>
Fuel Costs (\$/kW-Yr)	295
Variable O&M (\$/kW-Yr)	18.59
<b>Variable Costs</b>	<b>314</b>
<b>Total Levelized Costs (\$/kW-Yr)</b>	<b>402</b>
Capital (\$/MWH)	11.42
Variable (\$/MWH)	40.62
<b>Total Levelized Costs (\$/MWH)</b>	<b>52.04</b>
<b>Capital Costs</b>	
Instant Cost (\$/kW)	531
Installed Cost (\$/MWH)	580
<b>In-service Cost in 2004 (\$/KW)</b>	<b>604</b>

**Table S-11  
Capital Cost Detail**

Total (\$)	<b>275896567</b>
<b>Component Cost (\$)</b>	<b>243,289,126</b>
Turbine/Engine [Not itemized] (\$)	234,597,182
Generator/Gearhead (\$)	
Boiler/HRSG (\$)	
Fuel Pipeline/Tank (\$)	
Slab & Engine Mount (\$)	
Miscellaneous fitting & hoses (\$)	4,691,944
Office space (\$)	
Control Room(\$)	
Duct Burners (\$)	4,000,000
<b>Financial Transaction Costs (%)</b>	<b>0</b>
<b>Land Costs (\$)</b>	<b>1,477,941</b>
Acreage/Plant	15
Cost per Acre (\$)	100,000
Acquisition Cost (\$)	1,470,588
Land Prep Costs (\$/Acre)	500
Total Land Prep Costs (\$)	7,353
<b>Permitting Costs (\$)</b>	<b>5,129,500</b>
Local building permits (\$)	
Environmental permits (\$)	
Air Emission Permits (\$)	5,129,500
<b>Interconnection Costs (\$)</b>	<b>0</b>
Transmission Lines (\$)	
Substation (\$)	
Induction Equipment (\$)	
<b>Environmental Controls (\$)</b>	<b>26,000,000</b>
Installation Costs (\$)	26,000,000
Replacement Costs (\$)	

**Table S-12  
Maintenance Cost Detail**

<b>Routine Maintenance Costs</b>		<b>Annual Costs</b>
Replacement Interval (Hours)	1	
Filter Price (\$)	0	0
Maintenance Interval (Hours)	1	
Price (\$)	0	0
Oil Price (\$/Gallon)	3.40	
Oil Capacity	0	0
Oil Added per Day	0	0
Interval (Hours)	1,000	
Item Price (\$)	0	0
Labor Hours/Day	0	
Labor Price (\$/Hour)	48	0
<b>Annual Routine Maintenance</b>		<b>0</b>
<b>Major Overhauls</b>		
Hours to Major Overhaul:	14,839	
Major Overhaul Labor (Man-Hours)	50,000	
Labor Cost (\$/Hour)	48	
Major Overhaul Labor Cost (\$)	2,400,000	
Major Overhaul Replacement (\$)	8,000,000	<b>5,441,690</b>
NPV Cost (\$)		
<b>Minor Overhauls</b>		
Annual Cost Item 1 (\$)	0	
Hours to Item 1 Job	7,420	1
Annual Cost Item 2 (\$)	0	
Hours to Item 2 Job	0	
<b>Annualized Overhauls</b>		<b>0</b>
<b>Unscheduled Maintenance</b>		
Forced Outage Hours/Year	400	
Labor Rate (\$/Hour)	48	
Hours of Labor	400	
Parts Costs (\$)	374,400	
Total (\$)	393,600	
<b>Total Annual Maintenance</b>		<b>5,835,290</b>
Maintenance (\$/kW-Yr)	11.22	
Maintenance (\$/MWh)	1.45	

**Table S-13  
Environmental Control Costs**

<b>Total Annual Costs (\$)</b>	<b>1,019,680</b>
<b>Media &amp; Technology</b>	<b>Cost</b>
<b>Air Emissions</b>	
Control Technology (e.g. SCR) (\$)	15,600,000
Installation Cost (\$/kW)	30
Annual Labor (Hours/Year)	100
Loaded Labor Rate (\$/Hour)	48
Labor Cost (\$)	4,800
Annual Consumables-Catalyst (\$)	1,000,000
Replacement Cost (\$/kW)	20
Component Life (Hours)	141,760
Annualized Cost (\$)	8,548,981
<b>Water Cooling</b>	
Control Technology (e.g. wastewater) (\$)	
Installation Cost (\$/kW)	20
Annual Labor (Hours/Year)	100
Loaded Labor Rate (\$/Hour)	48
Labor Cost (\$)	4,800
Annual Consumables (\$)	10,000
Replacement Cost (\$/kW)	20
Component Life (Hours)	141,760
Annualized Cost (\$)	
<b>Solid Waste Disposal</b>	
Non hazardous material	
Tons per Year	1
Collection and hauling (\$/Ton)	10
Landfill tipping fees (\$/Ton)	30
Total Costs (\$)	40
Hazardous materials	
Tons per Year	1
Collection and hauling (\$/Ton)	10
Landfill tipping fees (\$/Ton)	30
Total Disposal Costs (\$)	40