

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  
Docket 02-IEP-01

STAFF DRAFT REPORT

February 11, 2003  
100-03-001SD



Gray Davis, Governor

# CALIFORNIA ENERGY COMMISSION

Magdy Badr  
Richard Benjamin  
*Principal Authors*

Al Alvarado  
*Electricity &  
Natural Gas Report  
Project Manager*

David Ashuckian  
*Manager*  
Electricity Analysis Office

Terry O'Brien  
*Deputy Director*  
Systems Assessment  
and Facilities Siting Division

Bob Therkelsen  
*Executive Director*

## Introduction

This Energy Commission staff draft report presents preliminary levelized cost estimates for several generic central-station electricity generation technologies. This is the first of a number of draft reports that the Energy Commission staff are 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 Ad Hoc Integrated Energy Policy Report Committee will conduct a workshop on February 25-26, 2003, to receive public comments on this and several other staff draft reports. The public comments will be instrumental towards improving the Commission staff analysis for evaluating California's energy reliability concerns.

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 gathering of information. With this goal in mind, the purpose of the report is to provide comparative 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 to compare the generic costs to build a specific technology. These costs 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. The Energy Commission staff 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.

The target audiences of this report are both policy-makers and anyone wishing to understand some of the fundamental attributes that are generally considered when evaluating the cost of building and operating different electricity generation technology resources. These costs do not reflect the total costs to consumers of adding these technologies to a resource portfolio. These technology characterizations do not capture all of the system, environmental or other relevant attributes that would typically be needed by a portfolio manager to conduct a comprehensive "comparative value analysis." A portfolio analysis will vary depending on the particular criteria and measurement goals of each study. For example, some form of firm capacity are typically needed with wind generation to support system reliability

requirements. Some projects may also require radial transmission additions, fuel delivery, system upgrades or environmental mitigation expenses.

## Comparative Technology Costs

**Table 1** shows the results of the comparative cost analysis for the various technologies. Expected levelized costs, constant annual payments made over the life of the plants, are shown to provide a common basis of measurement. 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. These estimates should be used only for general comparison purposes among technologies. They are not intended to be the sole criterion used in investment decisions.

**Table 1**  
**Comparative Technology Costs**

Technology	Fuel	Operative Mode	Economic Lifetime (years)	Gross Capacity (MW)	Direct Cost Levelized (cents/kWh)
Combined Cycle	Natural Gas	Baseload	20	500	4.58
Simple Cycle	Natural Gas	Peaking	20	100	14.06
Wind	None	Variable	30	100	5.44
Hydropower	Water	Load-Following	30	100	7.20
<b>Solar Thermal</b>					
Parabolic Trough	None	Load-Following	30	110	22.79
Parabolic Trough- TES	None	Load-Following	30	110	18.27
Parabolic Trough-Gas	Natural Gas	Load-Following	30	110	14.99
Stirling Dish	None	Load-Following	30	31.5	16.74
<b>Fuel Cells</b>					
PEM	Natural Gas	Baseload	20	25	15.42
Phosphoric Acid	Natural Gas	Baseload	20	25	20.89
Molten Carbonate	Natural Gas	Baseload	20	25	9.65
Solid Oxide	Natural Gas	Baseload	20	25	11.12
Hybrid	Natural Gas	Baseload	20	25	9.10
<b>Geothermal</b>					
Flash	Water	Baseload	30	50	4.71
Binary	Water	Baseload	30	35	7.64

The costs for representative natural gas-fired combined cycle and simple cycle combustion turbines are shown to provide a baseline for comparing costs across different categories of resources. The gas-fired plant costs are derived from Energy Commission staff analyses. The expected levelized cost for a new baseload combined cycle plant is 4.58 cents per kWh. Energy Commission staff estimates show that a combustion turbine, with an in-service year of 2003 and used for peaking service with a 10 percent capacity factor, can be expected to deliver power at a cost of 14.06 cents per kWh.

The costs for various renewable technologies are also listed above in **Table 1**. Geothermal flash technology is the least expensive at 4.71 cents per kWh, with wind next at 5.44 cents per kWh. Both supply baseload power, but capacity support will be needed to firm up wind generation. Hydropower is projected to provide load-following power at 7.20 cents per kWh. Geothermal binary plants have an expected cost of 7.64 cents per kWh. Central Station fuel cell costs are expected to range from 9.10 to 20.89 cents per kWh. Solar thermal technology costs range from 14.99 to 22.79 cents per kWh.

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 initial project cost is allocated during years one through twelve of the project, with the only capital cost after that point being the return to equity. Therefore, (discounted) annual costs for years thirteen and beyond will be much smaller than the previous years. In the case of a highly capital intensive project, such as hydro, this greatly reduces the required return on the project for these years. The longer the project lasts, the more “low cost” years there are relative to the first twelve “high cost” years, which lowers the levelized cost of the project. Thus, while the levelized cost for hydro looks quite high, if the project produces electricity for more than thirty years, its levelized cost will be quite lower. Conversely, while the levelized cost for wind looks low, if the project does not produce power for the 30-year assumed economic life, the levelized cost would be much higher.

A technological advancement also plays an important role in determining the actual life of project. For a mature technology, such as hydroelectric generation, 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 fuel cells. 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 increase the ratio of high-cost to low-cost years, increasing levelized costs. Conversely, mature technologies such as gas-fired generation and hydroelectric projects tend to have longer lives.

## Applicability

In considering a technology's qualities, the analyst must recognize the operational mode in which it functions. Different generation operational modes will range from a baseload, an intermediate or 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 demand. 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 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 and fuel cells 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 those actual costs 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 costs to produce that power from a specific plant. In fact, power contracts terms can be set entirely independent of the type of technology producing the power.

The combination of the contract terms and the technology type establishes the sharing of risks between ratepayers and generation investors. For a gas-fired plant, when fuel costs rise, it is likely power market prices will also rise. These increases in fuel prices may possibly be passed through directly to ratepayers. On the other hand, if a gas-fired plant is paid at a fixed contract rate over a period of years, the generator is exposed to the fuel-cost risk, unless that generator also has signed a fixed-price contract for natural gas delivery. Generally, in exchange for this fixed-price contract, generators will charge a premium above the expected average cost for power in the short-term market for that power to compensate for the shift in risk from ratepayers to generators.

For some renewables, the story is substantially different. If the 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 generators 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 Q**.

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

Type of Owner	Return on Equity	Debt by Term (Nov, 2001)					
		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 with inflation, 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 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 Q**. Renewable resources typically have quite low variable costs because fuel or other energy sources have low or no costs.

Variable input costs, particularly fuel costs, change over time. They are often relatively unpredictable compared to other cost components. The Energy Commission’s December 2002 projection of the price of natural gas for the years 2003-2013 is given in **Table 1, Appendix A**. After 2013, an average escalation factor of 5.60 percent is used. 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 do not vary 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 given in **Table 6 of Appendices C through Q**.

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.

**Table 3  
Federal and State Tax Programs by Technology and Owner**

	Merchant	IOU	Muni/Coop
<b>Combustion Turbine</b>			
Federal Depreciation	MACRS 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 Prod. Credit	No	No	Tier I

The federal corporate income tax rate is assumed to be 34 percent, and 8.84 percent for the California tax rate. The average property tax rate is 1.069 percent, and the average sales tax is 7.67 percent.<sup>1</sup> In addition, **Table 7 of Appendices C through Q** lists the renewable tax benefits applicable to each of the technologies.

For operating and maintenance costs, common assumptions for salaries and associated benefits were developed, but most other costs are technology specific. Assumptions for each technology are shown in **Tables 8 and 9 of Appendices C through Q**. Based on the technological and financial data contained in this report, staff obtained cost summaries for each of the technologies studied. These summaries are given in **Table 10 of Appendices C through Q**.

---

<sup>1</sup> Elizabeth G. Hill, *California's Tax System: A Primer* (Sacramento, California: Legislative Analyst's Office, State of California, January 2001).

## ***Appendices A-Q***

# Table of Contents

	<b>Page</b>
Appendix A Natural Gas Price Forecast.....	A-1
Appendix B Financial Information.....	B-1
Appendix C Combined Cycle-Baseload.....	C-1
Appendix D Combustion Turbine.....	D-1
Appendix E Fuel Cell - CT Hybrid.....	E-1
Appendix F Fuel Cell - Molten Carbonate.....	F-1
Appendix G Fuel Cell - Phosphoric Acid.....	G-1
Appendix H Fuel Cell - Proton Exchange Membrane.....	H-1
Appendix I Fuel Cell - Solid Oxide.....	I-1
Appendix J Geothermal Binary 35 MW.....	J-1
Appendix K Geothermal Flash 50 MW.....	K-1
Appendix L Hydropower.....	L-1
Appendix M Solar Parabolic w/o Thermally-Enhanced Storage or Gas.....	M-1
Appendix N Solar Parabolic with Gas Only.....	N-1
Appendix O Solar Thermal-Stirling Dish.....	O-1
Appendix P Solar Parabolic w/ Thermally-Enhanced Storage Only.....	P-1
Appendix Q Wind Farm.....	Q-1

# ***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

## Combined Cycle-Baseload

**Table C-1  
Plant Information**

Technology Type	Natural Gas
Fuel	Natural Gas
Owner/Investor	Merchant
Base Year	2002
In-service Year	2004
Utility Service Area	PG&E
Air Quality Management District	Bay Area

**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	10.8%
Cash Cost	100.0%

**Table C-4  
Construction Costs by Year**

	Years Out from On-Line Date				
	0	-1	-2	-3	-4
Cost (%/Year)	75%	15%	10%	0%	0%
Carry Over	\$530	\$133	\$52	\$0	\$0

**Table C-5  
Fuel Use**

Heat Rate (MMBtu/kWh)	6,800
Fuel Consumption/Hour (MMBtu/Hr)	3,400
Start-up Fuel Use (MMBtu/Start)	10,000
No. of Annual Starts	0
Annual Fuel Use (Mmbtu)	27,281,600

**Table C-6  
Operational Information**

Availability/Year (%)	100
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**

Invest Tax Credit (%)	0
RETC Calculation (\$/kWh)	0
Production Incentive-Investor (¢/kWh)	0
REPI Tier II Proportion Paid (%)	10

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

Employee Category	Full Time Employees	Hours/Year	Compensation per Employee
Managers	1	1,800	\$80,000 per year
Plant Operators	12	1,800	\$30 per hour
Mechanics	2	1,800	\$30 per hour
Laborers	2	1,800	\$20 per hour
Support Staff	3	1,800	\$20 per hour

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

Fixed O&M (\$/kW-Yr)	17.0
Fixed O&M/Instant Cost (%)	3.21
O&M Escalation (%)	0.5
Insurance (%)	1.5
Labor Escalation Cost (%)	0.5
Overhead Multiplier	1.6
Other Operating Costs	
Make-up Water (\$)	
Reservoir management (\$)	
Plant Scheduling Costs	
Transmission Service (\$)	

**Table C-10  
Cost Summary**

Financing Costs (\$/kW-yr)	75
Fixed Operational Costs (\$/kW-yr)	30
Tax (w/Credits) (\$/kW-yr)	2
<b>Fixed Costs (\$/kW-yr)</b>	<b>107</b>
Fuel Costs (\$/kW-yr)	261
Variable O&M (\$/kW-yr)	0
<b>Variable Costs (\$/kW-yr)</b>	<b>261</b>
<b>Total Levelized Costs (\$/kW-yr)</b>	<b>368</b>
Capital (\$/MWh)	13.33
Variable (\$/MWh)	32.51
<b>Total Levelized Costs (\$/MWh)</b>	<b>45.84</b>
<b>Capital Costs</b>	
Instant Cost (\$/Kw)	520
Installed Cost (\$/kW)	71
<b>In-service Cost in 2004 (\$/kW)</b>	<b>594</b>

**Table C-11  
Capital Cost Detail**

<b>Total Capital Cost (\$)</b>	<b>260,192,770</b>
<b>Component Cost (\$)</b>	<b>234,597,182</b>
Turbine/Engine (\$)	234,597,182
Generator/Gearhead (\$)	
Boiler/HRSG (\$)	
Fuel Pipeline/Tank (\$)	
Slab & Engine Mount (\$)	
Miscellaneous Fitting & Hoses (\$)	
Office Space (\$/sq. ft.)	
Control Room (\$)	
Other Infrastructure (\$)	
<b>Land Costs (\$)</b>	<b>595,588</b>
Acreage/Plant (acres)	15
Cost (\$/acre)	40,000
Acquisition Cost (\$)	588,235
Land Preparation Costs( \$/acre)	500
Total Land Preparation Costs (\$)	7,353
<b>Permitting Costs (\$)</b>	<b>0</b>
Local building Permits (\$)	
Environmental Permits (\$)	
Air Emission Permits (\$)	0
<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>Cost Category</b>	<b>Parameter</b>	<b>Annual Cost (\$)</b>
<b>Routine Maintenance Costs</b>		
Filter Replacement Interval (hours)	1	
Filter Price (\$/unit)	0.00	0.00
Oil Change Interval (hours)	1	
Oil Filter Price (\$/unit)	0.00	0.00
Oil Price (\$/ gallon)	3.40	
Oil Capacity (gallons)	0	0.00
Oil Added (gallons/day)	0.00	0.00
Fuel Filter Interval (hours)	1,000	
Fuel Filter Price (\$/unit)	0.00	0.00
Labor (hours/day)	0.00	
Labor price (\$/hour)	48.00	0.00
<b>Total Annual Routine Maintenance</b>		<b>0</b>
<b>Major Overhauls</b>		
Time to Major Overhaul (hours)	14,839	
Major Overhaul Labor (man-hours)	1,250	
Labor Cost (\$/hour)	48.00	
Major Overhaul Labor Cost (\$)	60,000	
Major Overhaul Parts Cost (\$)	12,000,000	<b>6,295,368</b>
NPV Cost (\$)		
<b>Minor Overhauls</b>		
Annual Cost Item 1 (\$)	0	
Time to Item 1 Job (hours)	7,420	
Annual Cost Item 2 (\$)	0	
Time 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	
Labor Time per event (hours)	400	
Parts Costs (\$)	374,400	
	393,600	
<b>Total Annual Maintenance</b>		<b>6,688,968</b>
Maintenance (\$/KW-yr)	13.38	
Maintenance (\$/MWh)	1.67	

**Table C-13  
Environmental Control Costs**

<b>Total Annual Costs (\$)</b>	<b>29,680</b>
<b>Air Emissions</b>	
Control Technology (e.g., SCR)	
Installation Cost (\$/KW)	30
Annual Labor (hours/year)	100
Loaded Labor Rate (\$/hour)	48
Labor Cost (\$/year)	4,800
Annual Consumables (\$)	10,000
Replacement Cost (\$/kW)	20
Component Life (hours)	141,760
Annualized Cost (\$)	
<b>Water Discharge</b>	
Control Technology (e.g., wastewater)	
Installation Cost (\$kW)	20
Annual Labor (hours/year)	100
Loaded Labor Rate (\$)	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>	
<b>Non-hazardous Material</b>	
Tons per Year	1
Collection and Hauling (\$/ton)	10
Landfill Tipping Fees (\$/ton)	30
Total Costs (\$)	40
<b>Hazardous Materials</b>	
Tons per Year	1
Collection and Hauling (\$/ton)	10
Landfill Tipping Fees (\$/ton)	30
Total Disposal Costs (\$)	40

# Appendix D

## Combustion Turbine

**Table D-1  
Plant Information**

Technology Type	Natural Gas
Fuel	Natural Gas
Owner/Investor	Merchant
Base Year	2002
In-service Year	2004
Utility Service Area	PG&E
Air Quality Management District	Bay Area

**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 (%)	0.0

**Table D-3  
Capital Costs**

Escalation in Capital Costs	0.0%
AFUDC Rate	10.8%
Cash Cost	100.0%

**Table D-4  
Construction Costs by Year**

	Years Out from On-Line Date				
	0	-1	-2	-3	-4
Cost (% Year)	75%	15%	10%	0%	0%
Carry Over	\$367	\$92	\$36	\$0	\$0

**Table D-5  
Fuel Use**

Heat Rate (MM Btu/kWh)	9,300.0
Fuel Consumption/Hour (MMBtu/Hr)	930.0
Start up fuel use (MMBtu/Start)	10,000.0
No. of annual starts	0.0
Annual Fuel Use (MMBtu)	737,184.0

**Table D-6  
Operational Information**

Availability/Year (%)	10
Availability/Year (Hours)	876
Equipment Life (Hours):	148,394
Equipment Life (Years):	30
Overhaul Interval (Hours)	14,839
Maintenance Outage (Days)	28
Maintenance Outage Rate (%)	0.5
Forced Outage (Hours/Year)	44
Forced Outage Rate (%)	0.5
Hours per Year Operation (Hours)	793
Capacity Factor (%)	9
Annual Net Energy (GWh)	79

**Table D-7  
Renewable Tax Benefits**

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

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

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

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

Fixed O&M (\$/kW-Yr)	13.0
Fixed O&M/Instant Cost (%)	3.69
O&M Escalation (%)	0.5
Insurance (%)	1.5
Labor Escalation Cost (%)	0.5
Overhead Multiplier	1.6
Other Operating Costs	
Make-up Water (\$)	
Reservoir management (\$)	
Plant Scheduling Costs	
Transmission Service (\$)	

**Table D-10  
Cost Summary**

Financing Costs (\$/kW-yr)	52
Fixed Operational Costs (\$/kW-yr)	23
Tax (w/Credits) (\$/kW-yr)	1
<b>Fixed Costs (\$/kW-yr)</b>	<b>76</b>
Fuel Costs (\$/kW-yr)	35
Variable O&M (\$/kW-yr)	0
<b>Variable Costs (\$/kW-yr)</b>	<b>35</b>
<b>Total Levelized Costs (\$/kW-yr)</b>	<b>111</b>
Capital (\$/MWh)	96.10
Variable (\$/MWh)	44.47
<b>Total Levelized Costs (\$/MWh)</b>	<b>140.56</b>
Capital Costs (\$/kW)	
Instant Cost (\$/kW)	361
Installed Cost (\$/kW)	396
<b>In-service Cost in 2004 (\$/kW)</b>	<b>412</b>

**Table D-11  
Capital Cost Detail**

<b>Total Capital Cost (\$)</b>	<b>36,057,353</b>
<b>Component Cost (\$)</b>	<b>31,000,000</b>
Turbine/Engine (\$)	31,000,000
Generator/Gearhead (\$)	
Boiler/HRSG (\$)	
Fuel Pipeline/Tank (\$)	
Slab & Engine Mount (\$)	
Miscellaneous Fitting & Hoses (\$)	
Office Space (\$/sq. ft.)	
Control Room (\$)	
Other Infrastructure (\$)	
<b>Land Costs (\$)</b>	<b>57,353</b>
Acreage/Plant (acres)	50
Cost (\$/acre)	1,000
Acquisition Cost (\$)	50,000
Land Prep Costs( \$/acre)	500
Total Land Prep Costs (\$)	7,353
<b>Permitting Costs (\$)</b>	<b>0</b>
Local building Permits (\$)	
Environmental Permits (\$)	
Air Emission Permits (\$)	0
<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>Cost Category</b>	<b>Parameter</b>	<b>Annual cost (\$)</b>
<b>Routine Maintenance Costs</b>		
Filter Replacement Interval (hours)	1	
Filter Price (\$/unit)	0.00	0.00
Oil Change Interval (hours)	1	
Oil Filter Price (\$/unit)	0.00	0.00
Oil Price (\$/ gallon)	3.40	
Oil Capacity (gallons)	0	0.00
Oil Added (gallons/day)	0.00	0.00
Fuel Filter Interval (hours)	1,000	
Fuel Filter Price (\$/unit)	0.00	0.00
Labor (hours/day)	0.00	
Labor price (\$/hour)	48.00	0.00
<b>Total Annual Routine Maintenance</b>		<b>0</b>
<b>Major Overhauls</b>		
Time to Major Overhaul (hours)	14,839	
Major Overhaul Labor (man-hours)	1,250	
Labor Cost (\$/hour)	48.00	
Major Overhaul Labor Cost (\$)	60,000	
Major Overhaul Parts Cost (\$)	10,333,333	<b>173,059</b>
NPV Cost (\$)		
<b>Minor Overhauls</b>		
Annual Cost Item 1 (\$)	0	
Time to Item 1 Job (hours)	7,134	
Annual Cost Item 2 (\$)	0	
Time to Item 2 Job	0	
<b>Annualized Overhauls</b>		<b>0</b>
<b>Unscheduled Maintenance</b>		
Forced Outage (hours/year)	44	
Labor Rate (\$/hour)	48	
Labor Time per Event (hours)	88	
Parts Costs (\$)	450,000	
Total Cost	454,205	
<b>Total Annual Maintenance</b>		<b>627,264</b>
Maintenance (\$/KW-yr)	6.27	
Maintenance (\$/MWh)	7.91	

**Table D-13  
Environmental Control Costs**

<b>Total Annual Costs (\$)</b>	<b>29,680</b>
<b>Air Emissions</b>	
Control Technology (e.g., SCR)	
Installation Cost (\$/kW)	30
Annual Labor (hours/year)	100
Loaded Labor Rate (\$/hour)	48
Labor Cost (\$/year)	4,800
Annual Consumables (\$)	10,000
Replacement Cost (\$/kW)	20
Component Life (hours)	141,760
Annualized Cost (\$)	
<b>Water Discharge</b>	
Control Technology (e.g., wastewater)	
Installation Cost (\$/kW)	20
Annual Labor (hours/year)	100
Loaded Labor Rate (\$)	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
<b>Hazardous Materials</b>	
Tons per Year	1
Collection and Hauling (\$/ton)	10
Landfill Tipping Fees (\$/ton)	30
Total Disposal Costs (\$)	40

# Appendix E

## Fuel Cell - CT Hybrid

**Table E-1  
Plant Information**

Technology Type	Natural Gas
Fuel	Natural Gas
Owner/Investor	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	10.8%
Cash Cost	100.0%

**Table E-4  
Construction Costs by Year**

	Years Out from On-Line Date				
	0	-1	-2	-3	-4
Cost (%/Year)	100%	0%	0%	0%	0%
Carry Over	\$1,510	\$0	\$0	\$0	\$0

**Table E-5  
Fuel Use**

Heat Rate (MMBtu/kWh)	6,475
Fuel Consumption (MMBtu/Hour)	161.9
Start up fuel use (MMBtu/Start)	0
No. of annual starts	0
Annual Fuel Use (Mmbtu)	1,276,223

**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**

Invest Tax Credit (%)	0
RETC Calculation (\$/kWh)	0
Production Incentive-Investor (¢/kWh)	0
REPI Tier II Proportion Paid (%)	10

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

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

Fixed O&M (\$/kW-yr)	120.0
Fixed O&M/Instant Cost (%)	7.95
O&M Escalation (%)	0.5
Insurance (%)	1.5
Labor Escalation Cost (%)	0.5
Overhead Multiplier	1.6
Other Operating Costs	
Make-up Water (\$)	
Reservoir management (\$)	
Plant Scheduling Costs	
Transmission Service (\$)	

**Table E-10  
Cost Summary**

Financing Costs (\$/kW-yr)	204.00
Fixed Operational Costs (\$/kW-yr)	178.00
Tax (w/Credits) (\$/kW-yr)	12.00
<b>Fixed Costs (\$/kW-yr)</b>	<b>394.00</b>
Fuel Costs (\$/kW-yr)	274.00
Variable O&M (\$/kW-yr)	49.00
<b>Variable Costs (\$/kW-yr)</b>	<b>323.00</b>
<b>Total Levelized Costs (\$/kW-yr)</b>	<b>717.00</b>
Capital (\$/MWh)	49.98
Variable (\$/MWh)	41.00
<b>Total Levelized Costs (\$/MWh)</b>	<b>90.98</b>
<b>Capital Costs</b>	
Instant Cost (\$/kW)	1,510.00
Installed Cost (\$/kW)	1,626.00
<b>In-service Cost in 2004 (\$/kW)</b>	<b>1,691.00</b>

**Table E-11  
Capital Cost Detail**

<b>Total Capital Cost (\$)</b>	<b>37,746,786</b>
<b>Component Cost (\$)</b>	<b>37,500,000</b>
Turbine/Engine (\$)	<b>37,500,000</b>
Generator/Gearhead (\$)	
Boiler/HRSG (\$)	
Fuel Pipeline/Tank (\$)	
Slab & Engine Mount (\$)	
Miscellaneous Fitting & Hoses (\$)	
Office Space (\$/sq. ft.)	
Control Room (\$)	
Other Infrastructure (\$)	
<b>Land Costs (\$)</b>	<b>246,786</b>
Acreage/Plant	2
Cost (\$/acre)	100,000
Acquisition Cost (\$)	246,786
Land Preparation Costs (\$/acre)	0
Total Land Preparation Costs (\$)	0
<b>Permitting Costs (\$)</b>	<b>0</b>
Local Building Permits (\$)	
Environmental Permits (\$)	
Air Emission Permits (\$)	0
<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 E-12  
Maintenance Cost Detail**

<b>Cost Category</b>	<b>Parameter</b>	<b>Annual cost (\$/year)</b>
<b>Routine Maintenance Costs</b>		
Filter Replacement Interval (hours)	1	
Filter Price (\$/unit)	0.00	0.00
Oil Change Interval (hours)	1	
Oil Filter Price (\$/unit)	0.00	0.00
Oil Price (\$/ gallon)	3.40	
Oil Capacity (gallons)	0	0.00
Oil Added (gallons/day)	0.00	0.00
Fuel Filter Interval (hours)	1,000	
Fuel Filter Price (\$/unit)	0.00	0.00
Labor (hours/day)	0.00	
Labor Price (\$/hour)	48.00	0.00
<b>Total Annual Routine Maintenance</b>		<b>0</b>
<b>Major Overhauls</b>		
Time to Major Overhaul (hours)	0	
Major Overhaul Labor (man-hours)	0	
Labor Cost (\$/hour)	48.00	
Major Overhaul Labor Cost (\$)	0	
Major Overhaul Parts Cost (\$)	0	
NPV Cost (\$)		
<b>Minor Overhauls</b>		
Annual Cost Item 1 (\$)	10,000,000	
Time to Item 1 Job (hours)	23,652	
Annual Cost Item 2 (\$)	0	
Time to Item 2 Job	55,188	
<b>Annualized Overhauls</b>		<b>2,979,344</b>
<b>Unscheduled Maintenance</b>		
Forced Outage (hours/year)	438	
Labor Rate (\$/hour)	48	
Labor Time per event (hours)	438	
Parts Costs (\$)	0	
Total Cost	21,024	
<b>Total Annual Maintenance</b>		<b>3,000,368</b>
Maintenance (\$/kW-yr)	120.01	
Maintenance (\$/MWh)	15.22	

**Table E-13  
Environmental Control Costs**

<b>Total Annual Costs (\$)</b>	<b>0</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 (\$/Year)	0
Annual Consumables (\$)	0
Replacement Cost (\$/kW)	0
Component Life (hours)	141,760
Annualized Cost (\$)	
<b>Water Discharge</b>	
Control Technology (e.g., wastewater)	
Installation Cost (\$/kW)	0
Annual Labor (hours/year)	0
Loaded Labor Rate (\$)	48
Labor Cost (\$)	0
Annual Consumables (\$)	0
Replacement Cost (\$/kW)	0
Component Life (hours)	141,760
Annualized Cost (\$)	
<b>Solid Waste Disposal</b>	
<b>Non-hazardous Material</b>	
Tons per Year	0
Collection and Hauling (\$/ton)	10
Landfill Tipping Fees (\$/ton)	30
Total Costs (\$)	0
<b>Hazardous Materials</b>	
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
Owner/Investor	Merchant
Base Year	2002
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	10.8%
Cash Cost	100.0%

**Table F-4  
Construction Costs by Year**

	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 (Btu/kWh)	7,511
Fuel Consumption/Hour (MMBtu/Hr)	187.8
Start up fuel use (MMBtu/Start)	0
No. of annual starts	0
Annual Fuel Use (MMBtu)	1,480,418

**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 (Hours):	7,884
Capacity Factor (%)	90
Annual Net Energy (GWh)	197

**Table F-7  
Renewable Tax Benefits**

Invest Tax Credit (%)	0
RETC Calculation (\$/kWh)	0
Production Incentive-Investor (¢/kWh)	0
REPI Tier II Proportion Paid (%)	10

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

Employee Category	Full Time Employees	Hours/Year	Compensation per Employee
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  
Operations & Maintenance Costs (Other)**

Fixed O&M (\$/kWh-yr)	120.0
O&M Escalation (%)	0.5
Insurance (%)	1.5
Labor Escalation Cost (%)	0.5
Overhead Multiplier	1.6
Other Operating Costs	
Make-up Water (\$)	
Reservoir management (\$)	
Plant Scheduling Costs	
Transmission Service (\$)	

**Table F-10  
Cost Summary**

Financing Costs (\$/kW-yr)	204
Fixed Operational Costs (\$/kW-yr)	178
Tax (w/Credits) (\$/kW-yr)	12
<b>Fixed Costs (\$/kW-yr)</b>	<b>394</b>
Fuel Costs (\$/kW-yr)	318
Variable O&M (\$/kW-yr)	49
<b>Variable Costs (\$/kW-yr)</b>	<b>367</b>
<b>Total Levelized Costs (\$/kW-yr)</b>	<b>761</b>
Capital (\$/MWh)	49.96
Variable (\$/MWh)	46.56
<b>Total Levelized Costs (\$/MWh)</b>	<b>96.51</b>
<b>Capital Costs</b>	
Instant Cost (\$/kW)	1,509
Installed Cost(\$/kW)	1,624
<b>In-service Cost in 2004 (\$/kW)</b>	<b>1,690</b>

**Table F-11  
Capital Cost Detail**

<b>Total Capital Cost (\$)</b>	<b>37,718,090</b>
<b>Component Cost (\$)</b>	<b>37,500,000</b>
Turbine/Engine (\$)	37,500,000
Generator/Gearhead (\$)	
Boiler/HRSG (\$)	
Fuel Pipeline/Tank (\$)	
Slab & Engine Mount (\$)	
Miscellaneous Fitting & Hoses (\$)	
Office Space (\$/sq. ft.)	
Control Room (\$)	
Other Infrastructure (\$)	
<b>Land Costs (\$)</b>	<b>218,090</b>
Acreage/Plant	2
Cost (\$/acre)	100,000
Acquisition Cost (\$)	218,090
Land Preparation Costs( \$/acre)	0
Total Land Preparation Costs (\$)	0
<b>Permitting Costs (\$)</b>	<b>0</b>
Local Building Permits (\$)	
Environmental Permits (\$)	
Air Emission Permits (\$)	0
<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 F-12  
Maintenance Cost Detail**

<b>Cost Category</b>	<b>Parameter</b>	<b>Annual cost (\$/year)</b>
<b>Routine Maintenance Costs</b>		
Filter Replacement Interval (hours)	1	
Filter Price (\$/unit)	0.00	0.00
Oil Change Interval (hours)	1	
Oil Filter Price (\$/unit)	0.00	0.00
Oil Price (\$/gallon)	3.40	
Oil Capacity (gallons)	0	0.00
Oil Added (gallons/day)	0.00	0.00
Fuel Filter Interval (hours)	1,000	
Fuel Filter Price (\$/unit)	0.00	0.00
Labor (hours/day)	0.00	
Labor price (\$/hour)	48.00	0.00
<b>Total Annual Routine Maintenance</b>		<b>0</b>
<b>Major Overhauls</b>		
Time to Major Overhaul (hours)	0	
Major Overhaul Labor (man-hours)	0	
Labor Cost (\$/hour)	48.00	
Major Overhaul Labor Cost (\$)	0	
Major Overhaul Parts Cost (\$)	0	
NPV Cost (\$)		
<b>Minor Overhauls</b>		
Annual Cost Item 1 (\$)	10,000,000	
Time to Item 1 Job (hours)	23,652	
Annual Cost Item 2 (\$)	0	
Time to Item 2 Job	55,188	
<b>Annualized Overhauls</b>		<b>2,979,344</b>
<b>Unscheduled Maintenance</b>		
Forced Outage (hours/year)	438	
Labor Rate (\$/hour)	48	
Labor Time per event (hours)	438	
Parts Costs (\$)	\$0	
Total Cost	21,024	
<b>Total Annual Maintenance</b>		<b>3,000,368</b>
Maintenance (\$/KW-yr)	120.01	
Maintenance (\$/MWh)	15.22	

**Table F-13  
Environmental Control Costs**

<b>Total Annual Costs (\$)</b>	<b>29,680</b>
<b>Air Emissions</b>	
Control Technology (e.g., SCR)	
Installation Cost (\$/kW)	30
Annual Labor (hours/year)	100
Loaded Labor Rate (\$/hour)	48
Labor Cost (\$/Year)	4,800
Annual Consumables (\$)	10,000
Replacement Cost (\$/kW)	20
Component Life (hours)	141,760
Annualized Cost (\$)	
<b>Water Discharge</b>	
Control Technology (e.g., wastewater)	
Installation Cost (\$/kW)	20
Annual Labor (hours/year)	100
Loaded Labor Rate (\$)	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

# 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	10.8%
Cash Cost	100.0%

**Table G-4  
Construction Costs by Year**

	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 (Btu/kWh)	9,389
Fuel Consumption/Hour (MMBtu/Hr)	234.7
Start up fuel use (MMBtu/Start)	0
No. of annual starts	0
Annual Fuel Use (MMBtu)	1,850,572

**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 (Hours)	7,884
Capacity Factor (%)	90
Annual Net Energy (GWh)	197

**Table G-7  
Renewable Tax Benefits**

Invest Tax Credit (%)	0
RETC Calculation (\$/kWh)	0
Production Incentive-Investor (¢/kWh)	0
REPI Tier II Proportion Paid (%)	10

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

Employees	Full Time Employees	Hours/Year	Compensation per Employee
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  
Operations & Maintenance Costs (Other)**

Fixed O&M (\$/kWh-yr)	268.0
O&M Escalation (%)	0.5
Insurance (%)	1.5
Labor Escalation Cost (%)	0.5
Overhead Multiplier	1.6
Other Operating Costs	
Make-up Water (\$)	
Reservoir management (\$)	
Plant Scheduling Costs	
Transmission Service	

**Table G-10  
Cost Summary**

Financing Costs(\$/kW-yr)	599
Fixed Operational Costs (\$/kW-yr)	419
Tax (w/Credits) (\$/kW-yr)	35
<b>Fixed Costs (\$/kW-yr)</b>	<b>1,053</b>
Fuel Costs (\$/kW-yr)	378
Variable O&M (\$/kW-yr)	216
<b>Variable Costs (\$/kW-yr)</b>	<b>594</b>
<b>Total Levelized Costs (\$/kW-yr)</b>	<b>1,647</b>
Capital (\$/MMh)	133.59
Variable(\$/MMh)	75.30
<b>Total Levelized Costs (\$/MMh)</b>	<b>208.88</b>
Capital Costs	
Instant Cost (\$/kW)	4,520
Installed Cost(\$kW)	4,867
<b>In-service Cost in 2003 (\$/kW)</b>	<b>4,964</b>

**Table G-11  
Capital Cost Detail**

<b>Total Capital Cost (\$)</b>	<b>113,005,051</b>
<b>Component Cost (\$)</b>	<b>112,500,000</b>
Turbine/Engine (\$)	112,500,000
Generator/Gearhead (\$)	
Boiler/HRSG (\$)	
Fuel Pipeline/Tank (\$)	
Slab & Engine Mount (\$)	
Miscellaneous Fitting & Hoses (\$)	
Office Space (\$/sq. ft.)	
Control Room (\$)	
Other Infrastructure (\$)	
<b>Land Costs (\$)</b>	<b>505,051</b>
Acreage/Plant	5
Cost (\$/acre)	100,000
Acquisition Cost (\$)	505,051
Land Preparation Costs (\$/acre)	0
Total Land Preparation Costs (\$)	0
<b>Permitting Costs (\$)</b>	<b>0</b>
Local Building Permits (\$)	
Environmental Permits (\$)	
Air Emission 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 G-12  
Maintenance Cost Detail**

<b>Cost Category</b>	<b>Parameter</b>	<b>Cost (\$/year)</b>
<b>Routine Maintenance Costs</b>		
Filter Replacement Interval (hours)	1	
Filter Price (\$/unit)	0.00	0.00
Oil Change Interval (hours)	1	
Oil Filter Price (\$/unit)	0.00	0.00
Oil Price (\$/gallon)	3.40	
Oil Capacity (gallons)	0	0.00
Oil Added (gallons/day)	0.00	0.00
Fuel Filter Interval (hours)	1,000	
Fuel Filter Price (\$/unit)	0.00	0.00
Labor (hours/day)	0.00	
Labor price (\$/hour)	48.00	0.00
<b>Total Annual Routine Maintenance</b>		<b>0</b>
<b>Major Overhauls</b>		
Time to Major Overhaul (hours)	0	
Major Overhaul Labor (man-hours)	0	
Labor Cost (\$/hour)	48.00	
Major Overhaul Labor Cost (\$)	0	
Major Overhaul Parts Cost (\$)	0	
NPV Cost (\$)		
<b>Minor Overhauls</b>		
Annual Cost Item 1 (\$)	37,500,000	
Time to Item 1 Job (hours)	39,420	
Annual Cost Item 2 (\$)	7,500,000	
Time to Item 2 Job (hours)	55,188	
<b>Annualized Overhauls</b>		<b>6,690,159</b>
<b>Unscheduled Maintenance</b>		
Forced Outage (hours/year)	438	
Labor Rate (\$/hour)	48	
Labor Time per event (hours)	438	
Parts Costs (\$)	0	
Total Cost	21,024	
<b>Total Annual Maintenance</b>		<b>6,711,183</b>
Maintenance (\$/kW-yr)	268.45	
Maintenance (\$/MWh)	34.05	

**Table G-13  
Environmental Control Costs**

<b>Total Annual Costs (\$)</b>	<b>0</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 (\$/year)	0
Annual Consumables (\$)	0
Replacement Cost (\$/kW)	0
Component Life (hours)	141,760
Annualized Cost (\$)	
<b>Water Discharge</b>	
Control Technology (e.g., wastewater)	
Installation Cost (\$/kW)	0
Annual Labor (hours/year)	0
Loaded Labor Rate (\$)	48
Labor Cost (\$)	0
Annual Consumables (\$)	0
Replacement Cost (\$/kW)	0
Component Life (hours)	141,760
Annualized Cost (\$)	
<b>Solid Waste Disposal</b>	
<b>Non-hazardous Material</b>	
Tons per Year	0
Collection and Hauling (\$/ton)	10
Landfill Tipping Fees (\$/ton)	30
Total Costs (\$)	0
<b>Hazardous Materials</b>	
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
Owner/Investor	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	10.8%
Cash Cost	100.0%

**Table H-4  
Construction Costs by Year**

	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 (Btu/kWh)	9,389
Fuel Consumption/Hour (MMBtu/Hr)	234.7
Start up fuel use (MMBtu/Start)	0
No. of annual starts	0
Annual Fuel Use (MMBtu)	1,850,572

**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 (Hours)	7,884
Capacity Factor (%)	90
Annual Net Energy (GWh)	197

**Table H-7  
Renewable Tax Benefits**

Invest Tax Credit (%)	0
RETC Calculation (kWh)	0
Production Incentive-Investor (¢/kWh)	0
REPI Tier II Proportion Paid (%)	10

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

Employees	Full Time Employees	Hours/Year	Compensation per Employee
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  
Operations & Maintenance Costs (Other)**

Fixed O&M (\$/kWh-yr)	268.0
O&M Escalation (%)	0.5
Insurance (%)	1.5
Labor Escalation Cost (%)	0.5
Overhead Multiplier	1.6
Other Operating Costs	
Make-up Water (\$)	
Reservoir management (\$)	
Plant Scheduling Costs	
Transmission Service	

**Table H-10  
Cost Summary**

Financing Costs (\$/kW-yr)	208
Fixed Operational Costs (\$/kW-yr)	362
Tax (w/Credits) (\$/kW-yr)	12
<b>Fixed Costs (\$/kW-yr)</b>	<b>582</b>
Fuel Costs (\$/kW-yr)	418
Variable O&M (\$/kW-yr)	216
<b>Variable Costs (\$/kW-yr)</b>	<b>634</b>
<b>Total Levelized Costs (\$/kW-yr)</b>	<b>1,216</b>
Capital (\$MW/h)	73.86
Variable(\$MW/h)	80.36
<b>Total Levelized Costs (\$MW/h)</b>	<b>154.22</b>
<b>Capital Costs</b>	
Instant Cost (\$/kW)	1,511
Installed Cost (\$/kW)	1,627
<b>In-service Cost in 2005 (\$/kW)</b>	<b>1,727</b>

**Table H-11  
Capital Cost Detail**

<b>Total Capital Cost (\$)</b>	<b>37,781,221</b>
<b>Component Cost (\$)</b>	<b>37,500,000</b>
Turbine/Engine (\$)	37,500,000
Generator/Gearhead (\$)	
Boiler/HRSG (\$)	
Fuel Pipeline/Tank (\$)	
Slab & Engine Mount (\$)	
Miscellaneous Fitting & Hoses (\$)	
Office Space (\$/sq. ft.)	
Control Room (\$)	
Other Infrastructure (\$)	
<b>Land Costs (\$)</b>	<b>281,221</b>
Acreage/Plant	3
Cost (\$/acre)	100,000
Acquisition Cost (\$)	281,221
Land Preparation Costs ( \$/Acre)	0
Total Land Preparation Costs (\$)	0
<b>Permitting Costs (\$)</b>	<b>0</b>
Local Building Permits (\$)	
Environmental Permits (\$)	
Air Emission 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 H-12  
Maintenance Cost Detail**

<b>Cost Category</b>	<b>Parameter</b>	<b>Cost (\$/year)</b>
<b>Routine Maintenance Costs</b>		
Filter Replacement Interval (hours)	1	
Filter Price (\$/unit)	0.00	0.00
Oil Change Interval (hours)	1	
Oil Filter Price (\$/unit)	0.00	0.00
Oil Price (\$/gallon)	3.40	
Oil Capacity (gallons)	0	0.00
Oil Added (gallons/day)	0.00	0.00
Fuel Filter Interval (hours)	1,000	
Fuel Filter Price (\$/unit)	0.00	0.00
Labor (hours/day)	0.00	
Labor price (\$/hour)	48.00	0.00
<b>Total Annual Routine Maintenance</b>		<b>0</b>
<b>Major Overhauls</b>		
Time to Major Overhaul (hours)	0	
Major Overhaul Labor (man-hours)	0	
Labor Cost (\$/hour)	48.00	
Major Overhaul Labor Cost (\$)	0	
Major Overhaul Parts Cost (\$)	0	
NPV Cost (\$)		
<b>Minor Overhauls</b>		
Annual Cost Item 1 (\$)	37,500,000	
Time to Item 1 Job (hours)	39,420	
Annual Cost Item 2 (\$)	7,500,000	
Time to Item 2 Job	55,188	
<b>Annualized Overhauls</b>		<b>6,690,159</b>
<b>Unscheduled Maintenance</b>		
Forced Outage (hours/year)	438	
Labor Rate (\$/hour)	48	
Labor Time per event (hours)	438	
Parts Costs (\$)	0	
Total Cost	21,024	
<b>Total Annual Maintenance</b>		<b>6,711,183</b>
Maintenance (\$/kW-yr)	268.45	
Maintenance (\$/MWh)	34.05	

**Table H-13  
Environmental Control Costs**

<b>Total Annual Costs (\$)</b>	<b>0</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 (\$/year)	0
Annual Consumables (\$)	0
Replacement Cost (\$/kW)	0
Component Life (hours)	141,760
Annualized Cost (\$)	
<b>Water Discharge</b>	
Control Technology (e.g., wastewater)	
Installation Cost (\$/kW)	0
Annual Labor (hours/year)	0
Loaded Labor Rate (\$)	48
Labor Cost (\$)	0
Annual Consumables (\$)	0
Replacement Cost (\$/kW)	0
Component Life (hours)	141,760
Annualized Cost (\$)	
<b>Solid Waste Disposal</b>	
<b>Non-hazardous Material</b>	
Tons per Year	0
Collection and Hauling (\$/ton)	10
Landfill Tipping Fees (\$/ton)	30
Total Costs (\$)	0
<b>Hazardous Materials</b>	
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
Owner/Investor	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	10.8%
Cash Cost	100.0%

**Table I-4  
Construction Costs by Year**

	Years Out from On-Line Date				
	0	-1	-2	-3	-4
Cost (%/Year)	100	0	0	0	0
Carry Over	\$2,000	\$0	\$0	\$0	\$0

**Table I-5  
Fuel Use**

Heat Rate (Btu/kWh)	8,345
Fuel Consumption /Hour (MMBtu/Hr)	208.6
Start up fuel use (MMBtu/Start)	0
No. of annual starts	0
Annual Fuel Use (MMBtu)	1,644,800

**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 (Hours)	7,884
Capacity Factor (%)	90
Annual Net Energy (GWh)	197

**Table I-7  
Renewable Tax Benefits**

Invest Tax Credit (%)	0
RETC Calculation (\$/kWh)	0
Production Incentive-Investor (¢/kWh)	0
REPI Tier II Proportion Paid (%)	10

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

Fixed O&M (\$/kWh-yr)	120.0
O&M Escalation (%)	0.5
Insurance (%)	1.5
Labor Escalation Cost (%)	0.5
Overhead Multiplier	1.6
Other Operating Costs	
Make-up Water (\$)	
Reservoir management (\$)	
Plant Scheduling Costs	
Transmission Service (\$)	

**Table I-10  
Cost Summary**

Financing Costs (\$/kW -yr)	270
Fixed Operational Costs (\$/kW -yr)	188
Tax (w/Credits) (\$/kW -yr)	16
<b>Fixed Costs (\$/kW -yr)</b>	<b>474</b>
Fuel Costs (\$/kW -yr)	353
Variable O&M (\$/kW -yr)	49
<b>Variable Costs (\$/kW -yr)</b>	<b>402</b>
<b>Total Levelized Costs (\$/kW -yr)</b>	<b>876</b>
Capital (\$/MWh)	60.12
Variable (\$/MWh)	51.03
<b>Total Levelized Costs (\$/MWh)</b>	<b>111.15</b>
<b>Capital Costs</b>	
Instant Cost (\$/kW)	2,000
Installed Cost (\$/kW)	2,154
<b>In-service Cost in 2004 (\$/kW)</b>	<b>2,241</b>

**Table I-11  
Capital Cost Detail**

<b>Total Capital Cost (\$)</b>	<b>50,007,400</b>
<b>Component Cost (\$)</b>	<b>50,000,000</b>
Turbine/Engine (\$)	50,000,000
Generator/Gearhead (\$)	
Boiler/HRSG (\$)	
Fuel Pipeline/Tank (\$)	
Slab & Engine Mount (\$)	
Miscellaneous Fitting & Hoses (\$)	
Office Space (\$/sq. ft.)	
Control Room (\$)	
Other Infrastructure (\$)	
<b>Land Costs (\$)</b>	
Acreage/Plant	4
Cost (\$/acre)	3
Acquisition Cost (\$)	424,702
Land Preparation Costs (\$/acre)	1,194,351
Total Land Preparation Costs (\$)	0
<b>Permitting Costs (\$)</b>	0
Local Building Permits (\$)	0
Environmental Permits (\$)	
Air Emission Permits (\$)	
<b>Interconnection Costs (\$)</b>	0
Transmission Lines (\$)	
Substation (\$)	
Induction Equipment (\$)	
<b>Environmental Controls (\$)</b>	
Installation Costs (\$)	0
Replacement Costs (\$)	

**Table I-12  
Maintenance Cost Detail**

<b>Cost Category</b>	<b>Parameter</b>	<b>Cost (\$/year)</b>
<b>Routine Maintenance Costs</b>		
Filter Replacement Interval (hours)	1	
Filter Price (\$/unit)	0.00	0.00
Oil Change Interval (hours)	1	
Oil Filter Price (\$/unit)	0.00	0.00
Oil Price (\$/gallon)	3.40	
Oil Capacity (gallons)	0	0.00
Oil Added (gallons/day)	0.00	0.00
Fuel Filter Interval (hours)	1,000	
Fuel Filter Price (\$/unit)	0.00	0.00
Labor (hours/day)	0.00	
Labor price (\$/hour)	48.00	0.00
<b>Total Annual Routine Maintenance</b>		<b>0</b>
<b>Major Overhauls</b>		
Time to Major Overhaul (hours)	0	
Major Overhaul Labor (man-hours)	0	
Labor Cost (\$/hour)	48.00	
Major Overhaul Labor Cost (\$)	0	
Major Overhaul Parts Cost (\$)	0	
NPV Cost (\$)		
<b>Minor Overhauls</b>		
Annual Cost Item 1 (\$)	10,000,000	
Time to Item 1 Job (hours)	23,652	
Annual Cost Item 2 (\$)	0	
Time to Item 2 Job	55,188	
<b>Annualized Overhauls</b>		<b>2,979,344</b>
<b>Unscheduled Maintenance</b>		
Forced Outage (hours/year)	438	
Labor Rate (\$/hour)	48	
Labor Time per event (hours)	438	
Parts Costs (\$)	0	
Total Cost	21,024	
<b>Total Annual Maintenance</b>		<b>3,000,368</b>
Maintenance (\$/kW-yr)	120.01	
Maintenance (\$/MWh)	15.22	

**Table I-13  
Environmental Control Costs**

<b>Total Annual Costs (\$)</b>	<b>0</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 (\$/year)	0
Annual Consumables (\$)	0
Replacement Cost (\$/kW)	0
Component Life (hours)	141,760
Annualized Cost (\$)	
<b>Water Discharge</b>	
Control Technology (e.g., wastewater)	
Installation Cost (\$/kW)	0
Annual Labor (hours/year)	0
Loaded Labor Rate (\$)	48
Labor Cost (\$)	0
Annual Consumables (\$)	0
Replacement Cost (\$/kW)	0
Component Life (hours)	141,760
Annualized Cost (\$)	
<b>Solid Waste Disposal</b>	
<b>Non-hazardous Material</b>	
Tons per Year	0
Collection and Hauling (\$/ton)	10
Landfill Tipping Fees (\$/ton)	30
Total Costs (\$)	0
<b>Hazardous Materials</b>	
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
Owner/Investor	Merchant
Base Year	2002
In-service Year	2005

**Table J-2  
Plant Size**

Gross Capacity (MW)	35
Parasitic Load (MW)	10
Net Capacity (MW)	25
Derate Factor (%)	100
Firm Capacity (MW)	25
Transmission Losses (%)	2
Required AS/reserves (%)	0
Average Hourly Output Rate (%)	100
Effective Load Carry Capacity (MW)	25
Annual capacity degradation rate (%)	0

**Table J-3  
Capital Costs**

Escalation in Capital Costs	0.0%
AFUDC Rate	10.8%
Cash Cost	100.0%

**Table J-4  
Construction Costs by Year**

	Years Out from On-Line Date				
	0	-1	-2	-3	-4
Cost (%/Year)	20%	70%	10%	0%	0%
Carry Over	\$3,379	\$2,595	\$322	\$0	\$0

**Table J-5  
Fuel Use**

Heat Rate (MMBtu/kWh)	N/A
Fuel Consumption (MMBtu/Hour)	0.1
Start up fuel use (MMBtu/Start)	0
No. of annual starts	0
Annual Fuel Use (MMbtu)	533

**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 (Hours)	8,624
Capacity Factor (%)	98.5
Annual Net Energy (GWh)	216

**Table J-7  
Renewable Tax Benefits**

Invest Tax Credit (%)	10
RETC Calculation (\$/kWh)	386
Production Incentive-Investor (¢/kWh)	0
REPI Tier II Proportion Paid (%)	10

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

<b>Employee Category</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	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  
Operations & Maintenance Costs (Other)**

Fixed O&M (\$/kW-yr)	159.0
Fixed O&M/Instant Cost (%)	4.92
O&M Escalation (%)	0.5
Insurance (%)	1.5
Labor Escalation Cost (%)	0.5
Overhead Multiplier	2.0
Other Operating Costs	
Make-up water (\$)	250,000
Reservoir management (\$)	25,000
Plant Scheduling Costs	
Transmission Service (\$)	156,000

**Table J-10  
Cost Summary**

Financing Costs (\$/kW-yr)	466
Fixed Operational Costs (\$/kW-yr)	264
Tax (w/Credits) (\$/kW-yr)	(78)
<b>Fixed Costs (\$/kW-yr)</b>	<b>652</b>
Fuel Costs (\$/kW-yr)	7
Variable O&M (\$/kW-yr)	0
<b>Variable Costs (\$/kW-yr)</b>	<b>7</b>
<b>Total Levelized Costs (\$/kW-yr)</b>	<b>659</b>
Capital (\$/MWh)	75.59
Variable (\$/MWh)	0.79
<b>Total Levelized Costs (\$/MWh)</b>	<b>76.38</b>
<b>Capital Costs</b>	
Instant Cost (\$/kW)	3,222
Installed Cost (\$kW)	3,638
<b>In-service Cost in 2005 (\$/kW)</b>	<b>3,861</b>

**Table J-11  
Capital Cost Detail**

<b>Total Capital Cost (\$)</b>	<b>80,555,463</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>Land Costs (\$)</b>	<b>555,463</b>
Occupied Acreage	40
Total Project Area (acres)	1,200
BLM Pre-dav Lease Fee (\$)	44
Total Land "Cost Burden" (\$)	531,463
Land Preparation Costs (\$/Acre)	600
Total Land Preparation Costs (\$)	24,000
<b>Permitting Costs (\$)</b>	<b>300,000</b>
Environmental Permits (\$)	300,000
<b>Interconnection Costs (\$)</b>	<b>250,000</b>
Transmission Lines (\$)	250,000
Substation (\$)	
Induction Equipment (\$)	
<b>Environmental Controls (\$)</b>	<b>0</b>
Installation Costs (\$)	0
Replacement Costs (\$)	

**Table J-12  
Maintenance Cost Detail**

<b>Cost Category</b>	<b>Cost (\$/year, unless stated otherwise)</b>
<b>Routine Maintenance Costs</b>	
<b>Plant costs</b>	
OECs	250,000
Electric & Control Systems	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>	
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>	
Time to Major Overhaul (hours)	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
Time to Item 1 Job (hours)	6,000
Well Replacement	2,300,000
Time to Item 2 Job (hours)	42,500
Pump Replacement	350,000
Time to Item 3 Job (hours)	3,500
<b>Annualized Overhauls</b>	<b>1,071,033</b>
<b>Unscheduled Maintenance</b>	
Forced Outage Hours/Year	24
Labor Rate	60
Hrs of Labor	12
Parts Costs	25,000
Total Cost	25,720
<b>Total Annual Maintenance</b>	<b>2,205,753</b>
Maintenance (\$/kW-yr)	88.23
Maintenance (\$/MWh)	10.23

**Table J-13  
Environmental Control Costs**

<b>Total Annual Costs (\$)</b>	<b>50,000</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 (\$/year)	0
Annual Consumables (\$)	0
Replacement Cost (\$/kW)	0
Component Life (hours)	0
Annualized Cost (\$)	
<b>Water Discharge</b>	
Control Technology (e.g., wastewater)	
Installation Cost (\$/kW)	0
Annual Labor (hours/year)	0
Loaded Labor Rate (\$)	60
Labor Cost (\$)	0
Annual Consumables (\$)	0
Replacement Cost (\$/kW)	0
Component Life (hours)	0
Annualized Cost (\$)	
<b>Solid Waste Disposal</b>	
<b>Non-hazardous Material</b>	
Tons per Year	0
Collection and Hauling (\$/ton)	30
Landfill Tipping Fees (\$/ton)	0
Total Costs (\$)	0
<b>Hazardous Materials</b>	
Tons per Year	10,000
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
Owner/Investor	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 (%)	4990.0

**Table K-3  
Capital Costs**

Escalation in Capital Costs	0.0%
AFUDC Rate	10.8%
Cash Cost	100.0%

**Table K-4  
Construction Costs by Year**

	Years Out from On-Line Date				
	0	-1	-2	-3	-4
Cost (%/Year)	20	60	20	0	0
Carry Over	\$2,251	\$1,731	\$427	\$0	\$0

**Table K-5  
Fuel Use**

Heat Rate (MMBtu/kWh)	0
Fuel Consumption (MMBtu/Hour)	0
Start up fuel use (MMBtu/Start)	0
No. of annual starts	0
Annual Fuel Use (MMbtu)	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 (Hours)	8,409
Capacity Factor(%)	96
Annual Net Energy (GWh)	378

**Table K-7  
Renewable Tax Benefits**

Invest Tax Credit (%)	10
RETC Calculation (\$/kWh)	257
Production Incentive-Investor (¢/kWh)	0
REPI Tier II Proportion Paid (%)	10

**Table K-8  
Operations & 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	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  
Operations & Maintenance Costs (Other)**

Fixed O&M (\$/kW-yr)	60.0
O&M Escalation (%)	0.5
Insurance (%)	1.5
Labor Escalation Cost (%)	0.5
Overhead Multiplier	1.6
Other Operating Costs	
Make-up water (\$)	12,000
Reservoir management (\$)	25,000
Plant Scheduling Costs	
Transmission Service (\$)	156,000

**Table K-10  
Cost Summary**

Financing Costs (\$/kW-yr)	310
Fixed Operational Costs (\$/kW-yr)	119
Tax (w/Credits) (\$/kW-yr)	(44)
<b>Fixed Costs (\$/kW-yr)</b>	<b>385</b>
Fuel Costs (\$/kW-yr)	10
Variable O&M (\$/kW-yr)	1
<b>Variable Costs (\$/kW-yr)</b>	<b>11</b>
<b>Total Levelized Costs (\$/kW-yr)</b>	<b>396</b>
Capital (\$/MWh)	45.83
Variable (\$/MWh)	1.26
<b>Total Levelized Costs (\$/MWh)</b>	<b>47.09</b>
<b>Capital Costs</b>	
Instant Cost (\$/kW)	2,135
Installed Cost (\$/kW)	2,423
<b>In-service Cost in 2005 (\$/kW)</b>	<b>2,572</b>

**Table K-11  
Capital Cost Detail**

<b>Total Capital Cost (\$)</b>	<b>95,839,694</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>Land Costs (\$)</b>	<b>339,694</b>
Occupied Acreage	40
Total Project Area (acres)	1,200
Lease fee (\$/acre)	44
Total Land "Cost Burden" (\$)	315,694
Land Preparation Costs (\$/acre)	600
Total Land Preparation Costs (\$)	24,000
<b>Permitting Costs (\$)</b>	<b>300,000</b>
Environmental Permits (\$)	300,000
<b>Interconnection Costs (\$)</b>	<b>250,000</b>
Transmission Lines (\$)	250,000
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>Cost (\$/year, unless stated otherwise)</b>
<b>Plant costs</b>	
Turbine/Generator (\$)	55,000
Electronic & Control systems (\$)	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>	
Time to Major Overhaul (hours)	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
Time to Item 1 Job (hours)	6,000
Well Replacement (\$)	2,300,000
Time to Item 2 Job (hours)	25,000
<b>Annualized Overhauls (\$)</b>	<b>760,233</b>
<b>Unscheduled Maintenance</b>	
Forced Outage Hours/Year	50
Labor Rate (\$/hour)	48
Labor time (hours)	25
Parts Costs (\$)	50,000
Total Cost	51,200
<b>Total Annual Maintenance (\$)</b>	<b>1,453,433</b>
Maintenance/kW-yr	32
Maintenance/MWh	4

**Table K-13  
Environmental Control Costs**

<b>Total Annual Costs (\$)</b>	<b>174,000</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 (\$/year)	0
Annual Consumables (\$)	0
Replacement Cost (\$/kW)	0
Component Life (hours)	0
Annualized Cost (\$)	
<b>Water Discharge</b>	
Control Technology (e.g., wastewater)	
Installation Cost (\$/kW)	0
Annual Labor (hours/year)	0
Loaded Labor Rate (\$)	48
Labor Cost (\$)	0
Annual Consumables (\$)	0
Replacement Cost (\$/kW)	0
Component Life (hours)	0
Annualized Cost (\$)	
<b>Solid Waste Disposal</b>	
<b>Non-hazardous Material</b>	
Tons per Year	5,800
Collection and Hauling (\$/ton)	30
Landfill Tipping Fees (\$/ton)	0
Total Costs (\$)	174,000
<b>Hazardous Materials</b>	
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
Owner/Investor	Merchant
Base Year	2002
Inservice 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	10.8%
Cash Cost	100.0%

**Table L-4  
Construction Costs by Year**

	Years Out from On-Line Date				
	0	-1	-2	-3	-4
Cost (%/Year)	45%	45%	4%	3%	3%
Carry Over	\$1,377	\$742	\$139	\$82	\$40

**Table L-5  
Fuel Use**

Heat Rate (MMBtu/kWh)	0
Fuel Consumption (MMBtu/Hour)	0
Start up fuel use (MMBtu/Start)	0
No. of annual starts	0
Annual Fuel Use (MMbtu)	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 (Hours)	3,483
Capacity Factor(%)	39.8
Annual Net Energy (GWh)	348

**Table L-7  
Renewable Tax Benefits**

Invest Tax Credit (%)	0
RETC Calculation (\$/kWh)	0
Production Incentive-Investor (¢/kWh)	0
REPI Tier II Proportion Paid (%)	10

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

<b>Employees</b>	<b>Full Time Employees</b>	<b>Hours/Year</b>	<b>Compensation per Employee</b>
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  
Operations & Maintenance Costs (Other)**

Fixed O&M (\$/kW-yr)	10.0
O&M Escalation (%)	0.5
Insurance (%)	1.5
Labor Escalation Cost (%)	0.5
Overhead Multiplier	1.6
Other Operating Costs	
Make-up water (\$)	
Reservoir management (\$)	
Plant Scheduling Costs	
Transmission Service (\$)	

**Table L-10  
Cost Summary**

Financing Costs (\$/kW-yr)	198
Fixed Operational Costs (\$/kW-yr)	42
Tax (w/Credits) (\$/kW-yr)	12
<b>Fixed Costs (\$/kW-yr)</b>	<b>251</b>
Fuel Costs (\$/kW-yr)	0
Variable O&M (\$/kW-yr)	0
<b>Variable Costs (\$/kW-yr)</b>	<b>0</b>
<b>Total Levelized Costs (\$/kW-yr)</b>	<b>251</b>
Capital (\$/MWh)	72.02
Variable (\$/MWh)	0.00
<b>Total Levelized Costs (\$/MWh)</b>	<b>72.02</b>
<b>Capital Costs</b>	
Instant Cost (\$/kW)	1,323
Installed Cost (\$/kW)	1,483
<b>In-service Cost in 2005 (\$/kW)</b>	<b>1,637</b>

**Table L-11  
Capital Cost Detail**

<b>Total Capital Cost (\$)</b>	<b>132,200,000</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>Land Cost (\$)</b>	<b>11,200,000</b>
Acreage/Plant	1,400
Cost (\$)	5,000
Acquisition Cost (\$)	7,000,000
Land Preparation Costs (\$/acre)	3,000
Total Land Preparation Costs (\$)	4,200,000
<b>Permitting Costs (\$)</b>	<b>5,000,000</b>
Local Building Permits (\$)	
Environmental Permits (\$)	5,000,000
<b>Interconnection Costs (\$)</b>	<b>7,000,000</b>
Transmission Lines (\$)	4,000,000
Substation (\$)	3,000,000
Induction Equipment (\$)	
<b>Environmental Controls (\$)</b>	<b>0</b>
Installation Costs (\$)	0
Replacement Costs (\$)	

**Table L-12  
Maintenance Cost Detail**

<b>Cost Category</b>	<b>Parameter</b>	<b>Cost (\$/year)</b>
<b>Routine Maintenance Costs</b>		
Filter Replacement Interval (hours)	1	
Filter Price (\$/unit)	0.00	0.00
Oil Change Interval (hours)	1	
Oil Filter Price (\$/unit)	0.00	0.00
Oil Price (\$/gallon)	3.40	
Oil Capacity (gallons)	0	0.00
Oil Added (gallons/day)	0.00	0.00
Fuel Filter Interval (hours)	1,000	
Fuel Filter Price (\$/unit)	0.00	0.00
Labor (hours/day)	0.00	
Labor price (\$/hour)	48.00	0.00
<b>Total Annual Routine Maintenance</b>		<b>0</b>
<b>Major Overhauls</b>		
Time to Major Overhaul (hours)	43,800	
Major Overhaul Labor (man-hours)	600	
Labor Cost (\$/hour)	48.00	
Major Overhaul Labor Cost (\$)	28,800	
Major Overhaul Parts Cost (\$)	2,300,000	92,780.83
NPV Cost (\$)		
<b>Minor Overhauls</b>		
Annual Cost Item 1 (\$)	0	
Time to Item 1 Job (hours)	8,760	
Annual Cost Item 2 (\$)	0	
Time to Item 2 Job	0	
<b>Annualized Overhauls</b>		<b>0</b>
<b>Unscheduled Maintenance</b>		
Forced Outage (hours/year)	120	
Labor Rate (\$/hour)	48	
Labor Time per event (hours)	120	
Parts Costs (\$)	0	
Total Cost	5,760	
<b>Total Annual Maintenance</b>		<b>98,541</b>
Maintenance (\$/kW-yr)	0.99	
Maintenance (\$/MWh)	0.28	

**Table L-13  
Environmental Control Costs**

<b>Total Annual Costs (\$)</b>	<b>29,680</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 (\$/year)	0
Annual Consumables (\$)	0
Replacement Cost (\$/kW)	0
Component Life (hours)	141,760
Annualized Cost (\$)	
<b>Water Discharge</b>	
Control Technology (e.g., wastewater)	
Installation Cost (\$/kW)	0
Annual Labor (hours/year)	0
Loaded Labor Rate (\$)	48
Labor Cost (\$)	0
Annual Consumables (\$)	0
Replacement Cost (\$/kW)	0
Component Life (hours)	141,760
Annualized Cost (\$)	
<b>Solid Waste Disposal</b>	
<b>Non-hazardous Material</b>	
Tons per Year	0
Collection and Hauling (\$/ton)	10
Landfill Tipping Fees (\$/ton)	30
Total Costs (\$)	0
<b>Hazardous Materials</b>	
Tons per Year	0
Collection and Hauling (\$/ton)	10
Landfill Tipping Fees (\$/ton)	30
Total Disposal Costs (\$)	0

# **Appendix M**

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

**Table M-1  
Plant Information**

Technology Type	Solar
Fuel	None
Owner/Investor	Merchant
Base Year	2002
Inservice Year	2003

**Table M-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 M-3  
Capital Costs**

Escalation in Capital Costs	0.0%
AFUDC Rate	10.8%
Cash Cost	100.0%

**Table M-4  
Construction Costs by Year**

	Years Out from On-Line Date				
	0	-1	-2	-3	-4
Cost (%/Year)	100%	0%	0%	0%	0%
Carry Over	\$2,657	\$0	\$0	\$0	\$0

**Table M-5  
Fuel Use**

Heat Rate (MMBtu/kWh)	0
Fuel Consumption (MMBtu/Hour)	0
Start up fuel use (MMBtu/Start)	0
No. of annual starts	346
Annual Fuel Use (MMbtu)	0

**Table M-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 (Hours)	3,210
Capacity Factor(%)	22
Annual Net Energy (GWh)	193

**Table M-7  
Renewable Tax Benefits**

Invest Tax Credit (%)	10
RETC Calculation (\$/kWh)	292
Production Incentive-Investor (¢/kWh)	0
REPI Tier II Proportion Paid (%)	10

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

Employees	Full Time Employees	Hours/Year	Compensation per Employee
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  
Operations & Maintenance Costs (Other)**

Fixed O&M (\$/kW-yr)	26.0
O&M Escalation (%)	0.5
Insurance (%)	1.5
Labor Escalation Cost (%)	0.5
Overhead Multiplier	1.6
Other Operating Costs	
Make-up water (\$)	
Reservoir management (\$)	
Plant Scheduling Costs	
Transmission Service (\$)	

**Table M-10  
Cost Summary**

Financing Costs (\$/kW-yr)	368
Fixed Operational Costs (\$/kW-yr)	81
Tax (w/Credits) (\$/kW-yr)	(50)
<b>Fixed Costs (\$/kW-yr)</b>	<b>399</b>
Fuel Costs (\$/kW-yr)	0
Variable O&M (\$/kW-yr)	40
<b>Variable Costs (\$/kW-yr)</b>	<b>40</b>
<b>Total Levelized Costs (\$/kW-yr)</b>	<b>439</b>
Capital (\$/MWh)	207.39
Variable (\$/MWh)	20.52
<b>Total Levelized Costs (\$/MWh)</b>	<b>227.91</b>
<b>Capital Costs</b>	
Instant Cost (\$/kW)	2,657
Installed Cost (\$/kW)	2,861
<b>In-service Cost in 2005 (\$/kW)</b>	<b>2,918</b>

**Table M-11  
Capital Cost Detail**

<b>Total Capital Cost (\$)</b>	<b>265,693,383</b>
<b>Component Cost (\$)</b>	<b>254,212,164</b>
Structures & Improvements (\$)	2,720,813
Collector System (\$)	147,795,374
Thermal Storage System (\$)	0
Steam Generator or HX System (\$)	10,764,670
Auxiliary Heater/Boiler (\$)	0
EPGS (\$)	47,651,991
Master Control System (\$)	0
Balance of Plant (\$)	27,706,701
Engineering, Construction, Project Management (\$)	17,572,616
<b>Land Cost (\$)</b>	<b>6,831,219</b>
Acreage/MW	5
Acreage/Plant	550
Cost per Acre (\$)	5,000
Acquisition Cost (\$)	2,750,000
Land Preparation Costs (\$/acre)	7,420
Total Land Preparation Costs (\$)	4,081,219
<b>Permitting Costs (\$)</b>	<b>150,000</b>
Local Building Permits (\$)	50,000
Environmental Permits (\$)	100,000
<b>Interconnection Costs (\$)</b>	<b>4,500,000</b>
Transmission Lines (\$)	3,500,000
Substation (\$)	1,000,000
Induction Equipment (\$)	
<b>Environmental Controls (\$)</b>	<b>0</b>
Installation Costs (\$)	0
Replacement Costs (\$)	

**Table M-12  
Maintenance Cost Detail**

<b>Cost Category</b>	<b>Parameter</b>	<b>Cost (\$/year)</b>
<b>Routine Maintenance Costs</b>		
Filter Replacement Interval (hours)	1	
Filter Price (\$/unit)	0.00	0.00
Oil Change Interval (hours)	1	
Oil Filter Price (\$/unit)	0.00	0.00
Oil Price (\$/gallon)	3.40	
Oil Capacity (gallons)	0	0.00
Oil Added (gallons/day)	0.00	0.00
Fuel Filter Interval (hours)	1,000	
Fuel Filter Price (\$/unit)	0.00	0.00
Labor (hours/day)	0.00	
Labor price (\$/hour)	48.00	0.00
<b>Total Annual Routine Maintenance</b>		<b>0</b>
<b>Major Overhauls</b>		
Time to Major Overhaul (hours)	35,000	
Major Overhaul Labor (man-hours)	125	
Labor Cost (\$/hour)	48.00	
Major Overhaul Labor Cost (\$)	6,000	
Major Overhaul Parts Cost (\$)	0	236.82
NPV Cost (\$)		
<b>Minor Overhauls</b>		
Annual Cost Item 1 (\$)	925,019	
Time to Item 1 Job (hours)	3,210	
Annual Cost Item 2 (\$)	0	
Time to Item 2 Job	0	
<b>Annualized Overhauls</b>		<b>885,870</b>
<b>Unscheduled Maintenance</b>		
Forced Outage (hours/year)	200	
Labor Rate (\$/hour)	48	
Labor Time per event (hours)	200	
Parts Costs (\$)	0	
Total Cost	9,600	
<b>Total Annual Maintenance</b>		<b>895,707</b>
Maintenance (\$/kW-yr)	8.96	
Maintenance (\$/MWh)	4.65	

**Table M-13  
Environmental Control Costs**

<b>Total Annual Costs (\$)</b>	<b>0</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 (\$/year)	0
Annual Consumables (\$)	0
Replacement Cost (\$/kW)	0
Component Life (hours)	141,760
Annualized Cost (\$)	
<b>Water Discharge</b>	
Control Technology (e.g., wastewater)	
Installation Cost (\$/kW)	0
Annual Labor (hours/year)	0
Loaded Labor Rate (\$)	48
Labor Cost (\$)	0
Annual Consumables (\$)	0
Replacement Cost (\$/kW)	0
Component Life (hours)	141,760
Annualized Cost (\$)	
<b>Solid Waste Disposal</b>	
<b>Non-hazardous Material</b>	
Tons per Year	0
Collection and Hauling (\$/ton)	10
Landfill Tipping Fees (\$/ton)	30
Total Costs (\$)	0
<b>Hazardous Materials</b>	
Tons per Year	0
Collection and Hauling (\$/ton)	10
Landfill Tipping Fees (\$/ton)	30
Total Disposal Costs (\$)	0

# Appendix N

## Solar Parabolic with Gas Only

**Table N-1  
Plant Information**

Technology Type	Solar
Fuel	Natural Gas
Owner/Investor	Merchant
Base Year	2002
Inservice 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	10.8%
Cash Cost	100.0%

**Table N-4  
Construction Costs by Year**

	Years Out from On-Line Date				
	0	-1	-2	-3	-4
Cost (%/Year)	100%	0%	0%	0%	0%
Carry Over	\$2,883	\$0	\$0	\$0	\$0

**Table N-5  
Fuel Use**

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

**Table N-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 (Hours)	3,483
Capacity Factor(%)	39.8
Annual Net Energy (GWh)	348

**Table N-7  
Renewable Tax Benefits**

Invest Tax Credit (%)	0
RETC Calculation (\$/kWh)	317
Production Incentive-Investor (¢/kWh)	0
REPI Tier II Proportion Paid (%)	10

**Table N-8  
Operations & 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  
Operations & Maintenance Costs (Other)**

Fixed O&M (\$/kW-yr)	29.0
O&M Escalation (%)	0.5
Insurance (%)	1.5
Labor Escalation Cost (%)	0.5
Overhead Multiplier	1.6
Other Operating Costs	
Make-up water (\$)	
Reservoir management (\$)	
Plant Scheduling Costs	
Transmission Service (\$)	

**Table N-10  
Cost Summary**

Financing Costs (\$/kW-yr)	399
Fixed Operational Costs (\$/kW-yr)	89
Tax (w/Credits) (\$/kW-yr)	(54)
<b>Fixed Costs (\$/kW-yr)</b>	<b>434</b>
Fuel Costs (\$/kW-yr)	42
Variable O&M (\$/kW-yr)	75
<b>Variable Costs (\$/kW-yr)</b>	<b>117</b>
<b>Total Levelized Costs (\$/kW-yr)</b>	<b>551</b>
Capital (\$/MWh)	118.06
Variable (\$/MWh)	31.81
<b>Total Levelized Costs (\$/MWh)</b>	<b>149.87</b>
<b>Capital Costs</b>	
Instant Cost (\$/kW)	2,883
Installed Cost (\$/kW)	3,104
<b>In-service Cost in 2005 (\$/kW)</b>	<b>3,166</b>

**Table N-11  
Capital Cost Detail**

<b>Total Capital Cost (\$)</b>	<b>405,377,733</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 Generator 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>Land Cost (\$)</b>	<b>9,025,716</b>
Acreage/MW	7
Acreage/Plant	770
Cost per Acre (\$)	5,000
Acquisition Cost (\$)	3,850,000
Land Preparation Costs (\$/acre)	6,722
Total Land Preparation Costs (\$)	5,175,716
<b>Permitting Costs (\$)</b>	<b>150,000</b>
Local Building Permits (\$)	50,000
Environmental Permits (\$)	100,000
<b>Interconnection Costs (\$)</b>	<b>4,500,000</b>
Transmission Lines (\$)	3,500,000
Substation (\$)	1,000,000
Induction Equipment (\$)	
<b>Environmental Controls (\$)</b>	<b>0</b>
Installation Costs (\$)	0
Replacement Costs (\$)	

**Table N-12  
Maintenance Cost Detail**

<b>Cost Category</b>	<b>Parameter</b>	<b>Cost (\$/year)</b>
<b>Routine Maintenance Costs</b>		
Filter Replacement Interval (hours)	1	
Filter Price (\$/unit)	0.00	0.00
Oil Change Interval (hours)	1	
Oil Filter Price (\$/unit)	0.00	0.00
Oil Price (\$/gallon)	3.40	
Oil Capacity (gallons)	0	0.00
Oil Added (gallons/day)	0.00	0.00
Fuel Filter Interval (hours)	1,000	
Fuel Filter Price (\$/unit)	0.00	0.00
Labor (hours/day)	0.00	
Labor price (\$/hour)	48.00	0.00
<b>Total Annual Routine Maintenance</b>		<b>0</b>
<b>Major Overhauls</b>		
Time to Major Overhaul (hours)	35,000	
Major Overhaul Labor (man-hours)	125	
Labor Cost (\$/hour)	48.00	
Major Overhaul Labor Cost (\$)	6,000	
Major Overhaul Parts Cost (\$)	0	997.18
NPV Cost (\$)		
<b>Minor Overhauls</b>		
Annual Cost Item 1 (\$)	925,019	
Time to Item 1 Job (hours)	6,130	
Annual Cost Item 2 (\$)	0	
Time to Item 2 Job	0	
<b>Annualized Overhauls</b>		<b>1,173,553</b>
<b>Unscheduled Maintenance</b>		
Forced Outage (hours/year)	200	
Labor Rate (\$/hour)	48	
Labor Time per event (hours)	200	
Parts Costs (\$)	0	
Total Cost	9,600	
<b>Total Annual Maintenance</b>		<b>1,184,150</b>
Maintenance (\$/kW-yr)	11.84	
Maintenance (\$/MWh)	3.22	

**Table N-13  
Environmental Control Costs**

<b>Total Annual Costs (\$)</b>	<b>0</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 (\$/year)	0
Annual Consumables (\$)	0
Replacement Cost (\$/kW)	0
Component Life (hours)	141,760
Annualized Cost (\$)	
<b>Water Discharge</b>	
Control Technology (e.g., wastewater)	
Installation Cost (\$/kW)	0
Annual Labor (hours/year)	0
Loaded Labor Rate (\$)	48
Labor Cost (\$)	0
Annual Consumables (\$)	0
Replacement Cost (\$/kW)	0
Component Life (hours)	141,760
Annualized Cost (\$)	
<b>Solid Waste Disposal</b>	
<b>Non-hazardous Material</b>	
Tons per Year	0
Collection and Hauling (\$/ton)	10
Landfill Tipping Fees (\$/ton)	30
Total Costs (\$)	0
<b>Hazardous Materials</b>	
Tons per Year	0
Collection and Hauling (\$/ton)	10
Landfill Tipping Fees (\$/ton)	30
Total Disposal Cost (\$)	0

# Appendix O

## Solar Thermal-Stirling Dish

**Table O-1  
Plant Information**

Technology Type	Solar
Fuel	None
Owner/Investor	Merchant
Base Year	2002
Inservice Year	2003

**Table O-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 O-3  
Capital Costs**

Escalation in Capital Costs	0.0%
AFUDC Rate	10.8%
Cash Cost	100.0%

**Table O-4  
Construction Costs by Year**

	Years Out from On-Line Date				
	0	-1	-2	-3	-4
Cost (%/Year)	100%	0%	0%	0%	0%
Carry Over	\$3,435	\$0	\$0	\$0	\$0

**Table O-5  
Fuel Use**

Heat Rate (MMBtu/kWh)	0
Fuel Consumption (MMBtu/Hour)	0
Start up fuel use (MMBtu/Start)	0
No. of annual starts	0
Annual Fuel Use (MMbtu)	0

**Table O-6  
Operational Information**

Availability/Year (%)	40
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 (Hours)	3,184
Capacity Factor(%)	36.3
Annual Net Energy (GWh)	96

**Table O-7  
Renewable Tax Benefits**

Invest Tax Credit (%)	0
RETC Calculation (\$/kWh)	377
Production Incentive-Investor (¢/kWh)	0
REPI Tier II Proportion Paid (%)	10

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

Employees	Full Time Employees	Hours/Year	Compensation per Employee
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 O-9  
Operations & Maintenance Costs (Other)**

Fixed O&M (\$/kW-yr)	48.0
O&M Escalation (%)	0.5
Insurance (%)	1.5
Labor Escalation Cost (%)	0.5
Overhead Multiplier	1.6
Other Operating Costs	
Make-up water (\$)	
Reservoir management (\$)	
Plant Scheduling Costs	
Transmission Service (\$)	

**Table O-10  
Cost Summary**

Financing Costs (\$/kW-yr)	476
Fixed Operational Costs (\$/kW-yr)	122
Tax (w/Credits) (\$/kW-yr)	(65)
<b>Fixed Costs (\$/kW-yr)</b>	<b>533</b>
Fuel Costs (\$/kW-yr)	0
Variable O&M (\$/kW-yr)	0
<b>Variable Costs (\$/kW-yr)</b>	<b>0</b>
<b>Total Levelized Costs (\$/kW-yr)</b>	<b>533</b>
Capital (\$/MWh)	167.35
Variable (\$/MWh)	0.00
<b>Total Levelized Costs (\$/MWh)</b>	<b>167.35</b>
<b>Capital Costs</b>	
Instant Cost (\$/kW)	3,435
Installed Cost (\$/kW)	3,698
<b>In-service Cost in 2005 (\$/kW)</b>	<b>3,772</b>

**Table O-11  
Capital Cost Detail**

<b>Total Capital Cost (\$)</b>	<b>288,317,006</b>
<b>Component Cost (\$)</b>	<b>276,835,787</b>
Structures & Improvements (\$)	2,720,813
Collector System (\$)	147,795,374
Thermal Storage System (\$)	0
Steam Generator or HX System (\$)	11,251,870
Auxiliary Heater/Boiler (\$)	20,597,257
EPGS (\$)	47,651,991
Master Control System (\$)	0
Balance of Plant (\$)	27,706,701
Engineering, Construction, Project Management (\$)	19,111,781
<b>Land Cost (\$)</b>	<b>6,831,219</b>
Acres/MW	5
Acres/Plant	550
Cost per Acre (\$)	5,000
Acquisition Cost (\$)	2,750,000
Land Preparation Costs (\$/acre)	7,420
Total Land Preparation Costs (\$)	4,081,219
<b>Permitting Costs (\$)</b>	<b>150,000</b>
Local Building Permits (\$)	50,000
Environmental Permits (\$)	100,000
<b>Interconnection Costs (\$)</b>	<b>4,500,000</b>
Transmission Lines (\$)	3,500,000
Substation (\$)	1,000,000
Induction Equipment (\$)	
<b>Environmental Controls (\$)</b>	<b>0</b>
Installation Costs (\$)	0
Replacement Costs (\$)	

**Table O-12  
Maintenance Cost Detail**

<b>Cost Category</b>	<b>Parameter</b>	<b>Cost (\$/year)</b>
<b>Routine Maintenance Costs</b>		
Filter Replacement Interval (hours)	1	
Filter Price (\$/unit)	0.00	0.00
Oil Change Interval (hours)	1	
Oil Filter Price (\$/unit)	0.00	0.00
Oil Price (\$/gallon)	3.40	
Oil Capacity (gallons)	0	0.00
Oil Added (gallons/day)	0.00	0.00
Fuel Filter Interval (hours)	1,000	
Fuel Filter Price (\$/unit)	0.00	0.00
Labor (hours/day)	0.00	
Labor price (\$/hour)	48.00	0.00
<b>Total Annual Routine Maintenance</b>		<b>0</b>
<b>Major Overhauls</b>		
Time to Major Overhaul (hours)	35,000	
Major Overhaul Labor (man-hours)	125	
Labor Cost (\$/hour)	48.00	
Major Overhaul Labor Cost (\$)	6,000	
Major Overhaul Parts Cost (\$)	0	997.18
NPV Cost (\$)		
<b>Minor Overhauls</b>		
Annual Cost Item 1 (\$)	925,019	
Time to Item 1 Job (hours)	6,130	
Annual Cost Item 2 (\$)	0	
Time to Item 2 Job	0	
<b>Annualized Overhauls</b>		<b>1,173,553</b>
<b>Unscheduled Maintenance</b>		
Forced Outage (hours/year)	200	
Labor Rate (\$/hour)	48	
Labor Time per event (hours)	200	
Parts Costs (\$)	0	
Total Cost	9,600	
<b>Total Annual Maintenance</b>		<b>1,184,150</b>
Maintenance (\$/kW-yr)	11.84	
Maintenance (\$/MWh)	3.22	

**Table O-13  
Environmental Control Costs**

<b>Total Annual Costs (\$)</b>	<b>0</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 (\$/year)	0
Annual Consumables (\$)	0
Replacement Cost (\$/kW)	0
Component Life (hours)	141,760
Annualized Cost (\$)	
<b>Water Discharge</b>	
Control Technology (e.g., wastewater)	
Installation Cost (\$/kW)	0
Annual Labor (hours/year)	0
Loaded Labor Rate (\$)	48
Labor Cost (\$)	0
Annual Consumables (\$)	0
Replacement Cost (\$/kW)	0
Component Life (hours)	141,760
Annualized Cost (\$)	
<b>Solid Waste Disposal</b>	
<b>Non-hazardous Material</b>	
Tons per Year	0
Collection and Hauling (\$/ton)	10
Landfill Tipping Fees (\$/ton)	30
Total Costs (\$)	0
<b>Hazardous Materials</b>	
Tons per Year	0
Collection and Hauling (\$/ton)	10
Landfill Tipping Fees (\$/ton)	30
Total Disposal Costs (\$)	0

# **Appendix P**

## **Solar Parabolic w/ Thermally-Enhanced Storage Only**

**Table P-1  
Plant Information**

Technology Type	Solar
Fuel	None
Owner/Investor	Merchant
Base Year	2002
Inservice Year	2003

**Table P-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 P-3  
Capital Costs**

Escalation in Capital Costs	0.0%
AFUDC Rate	10.8%
Cash Cost	100.0%

**Table P-4  
Construction Costs by Year**

	Years Out from On-Line Date				
	0	-1	-2	-3	-4
Cost (%/Year)	100%	0%	0%	0%	0%
Carry Over	\$4,054	\$0	\$0	\$0	\$0

**Table P-5  
Fuel Use**

Heat Rate (MMBtu/kWh)	0
Fuel Consumption (MMBtu/Hour)	0
Start up fuel use (MMBtu/Start)	0
No. of annual starts	346
Annual Fuel Use (MMbtu)	0

**Table P-6  
Operational Information**

Availability/Year (%)	75
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 (Hours)	6,130
Capacity Factor(%)	42
Annual Net Energy (GWh)	368

**Table P-7  
Renewable Tax Benefits**

Invest Tax Credit (%)	0
RETC Calculation (\$/kWh)	445
Production Incentive-Investor (¢/kWh)	0
REPI Tier II Proportion Paid (%)	10

**Table P-8  
Operations & 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 P-9  
Operations & Maintenance Costs (Other)**

Fixed O&M (\$/kW-yr)	29.0
O&M Escalation (%)	0.5
Insurance (%)	1.5
Labor Escalation Cost (%)	0.5
Overhead Multiplier	1.6
Other Operating Costs	
Make-up water (\$)	
Reservoir management (\$)	
Plant Scheduling Costs	
Transmission Service (\$)	

**Table P-10  
Cost Summary**

Financing Costs (\$/kW-yr)	562
Fixed Operational Costs (\$/kW-yr)	111
Tax (w/Credits) (\$/kW-yr)	(76)
<b>Fixed Costs (\$/kW-yr)</b>	<b>597</b>
Fuel Costs (\$/kW-yr)	0
Variable O&M (\$/kW-yr)	75
<b>Variable Costs (\$/kW-yr)</b>	<b>75</b>
<b>Total Levelized Costs (\$/kW-yr)</b>	<b>672</b>
Capital (\$/MWh)	162.21
Variable (\$/MWh)	20.52
<b>Total Levelized Costs (\$/MWh)</b>	<b>182.73</b>
<b>Capital Costs</b>	
Instant Cost (\$/kW)	4,054
Installed Cost (\$/kW)	4,365
<b>In-service Cost in 2005 (\$/kW)</b>	<b>4,452</b>

**Table P-11  
Capital Cost Detail**

<b>Total Capital Cost (\$)</b>	<b>103,039,800</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>Land Cost (\$)</b>	<b>5,782,500</b>
Acres/MW	5
Acreage/Plant	158
Cost (\$/per Acre)	5,000
Acquisition Cost (\$)	787,500
Land Preparation Costs (\$/acre)	31,714
Total Land Preparation Costs (\$)	4,995,000
<b>Permitting Costs (\$)</b>	<b>150,000</b>
Local Building Permits (\$)	50,000
Environmental Permits (\$)	100,000
<b>Interconnection Costs (\$)</b>	<b>4,500,000</b>
Transmission Lines (\$)	3,500,000
Substation (\$)	1,000,000
Induction Equipment (\$)	
<b>Environmental Controls (\$)</b>	<b>0</b>
Installation Costs (\$)	0
Replacement Costs (\$)	

**Table P-12  
Maintenance Cost Detail**

<b>Cost Category</b>	<b>Parameter</b>	<b>Cost (\$/year)</b>
<b>Routine Maintenance Costs</b>		
Filter Replacement Interval (hours)	1	
Filter Price (\$/unit)	0.00	0.00
Oil Change Interval (hours)	1	
Oil Filter Price (\$/unit)	0.00	0.00
Oil Price (\$/gallon)	3.40	
Oil Capacity (gallons)	0	0.00
Oil Added (gallons/day)	0.00	0.00
Fuel Filter Interval (hours)	1,000	
Fuel Filter Price (\$/unit)	0.00	0.00
Labor (hours/day)	0.00	
Labor price (\$/hour)	48.00	0.00
<b>Total Annual Routine Maintenance</b>		<b>0</b>
<b>Major Overhauls</b>		
Time to Major Overhaul (hours)	3,000	
Major Overhaul Labor (man-hours)	36	
Labor Cost (\$/hour)	48.00	
Major Overhaul Labor Cost (\$)	1,728	
Major Overhaul Parts Cost (\$)	0	5,473
NPV Cost (\$)		
<b>Minor Overhauls</b>		
Annual Cost Item 1 (\$)	484,000	
Time to Item 1 Job (hours)	3,184	
Annual Cost Item 2 (\$)	0	
Time to Item 2 Job	0	
<b>Annualized Overhauls</b>		<b>476,256</b>
<b>Unscheduled Maintenance</b>		
Forced Outage (hours/year)	200	
Labor Rate (\$/hour)	48	
Labor Time per event (hours)	200	
Parts Costs (\$)	0	
Total Cost	9,600	
<b>Total Annual Maintenance</b>		<b>491,329</b>
Maintenance (\$/kW-yr)	16.38	
Maintenance (\$/MWh)	5.14	

**Table P-13  
Environmental Control Costs**

<b>Total Annual Costs (\$)</b>	<b>0</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 (\$/year)	0
Annual Consumables (\$)	0
Replacement Cost (\$/kW)	0
Component Life (hours)	141,760
Annualized Cost (\$)	
<b>Water Discharge</b>	
Control Technology (e.g., wastewater)	
Installation Cost (\$/kW)	0
Annual Labor (hours/year)	0
Loaded Labor Rate (\$)	48
Labor Cost (\$)	0
Annual Consumables (\$)	0
Replacement Cost (\$/kW)	0
Component Life (hours)	141,760
Annualized Cost (\$)	
<b>Solid Waste Disposal</b>	
<b>Non-hazardous Material</b>	
Tons per Year	0
Collection and Hauling (\$/ton)	10
Landfill Tipping Fees (\$/ton)	30
Total Costs (\$)	0
<b>Hazardous Materials</b>	
Tons per Year	0
Collection and Hauling (\$/ton)	10
Landfill Tipping Fees (\$/ton)	30
Total Disposal Costs (\$)	0

# Appendix Q

## Wind Farm

**Table Q-1  
Plant Information**

Technology Type	Wind
Fuel	None
Owner/Investor	Merchant
Base Year	2002
Inservice Year	2004

**Table Q-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 Q-3  
Capital Costs**

Escalation in Capital Costs	0.0%
AFUDC Rate	10.8%
Cash Cost	100.0%

**Table Q-4  
Construction Costs by Year**

	Years Out from On-Line Date				
	0	-1	-2	-3	-4
Cost (%/Year)	100%	0%	0%	0%	0%
Carry Over	\$983	\$0	\$0	\$0	\$0

**Table Q-5  
Fuel Use**

Heat Rate (MMBtu/kWh)	0
Fuel Consumption (MMBtu/Hour)	0.1
Start up fuel use (MMBtu/Start)	0
No. of annual starts	0
Annual Fuel Use (MMbtu)	533

**Table Q-6  
Operational Information**

Availability/Year (%)	70
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
Hours per Year Operation (Hours)	5,336
Capacity Factor(%)	40.2
Annual Net Energy (GWh)	352

**Table Q-7  
Renewable Tax Benefits**

Invest Tax Credit (%)	0
RETC Calculation (\$/kWh)	0
Production Incentive-Investor (¢/kWh)	1,695
REPI Tier II Proportion Paid (%)	10

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

<b>Employees</b>	<b>Full Time Employees</b>	<b>Hours/Year</b>	<b>Compensation per Employee</b>
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 Q-9  
Operations & Maintenance Costs (Other)**

Fixed O&M (\$/kW-yr)	39.0
O&M Escalation (%)	0.5
Insurance (%)	1.5
Labor Escalation Cost (%)	0.5
Overhead Multiplier	1.6
Other Operating Costs	
Make-up water (\$)	
Reservoir management (\$)	
Plant Scheduling Costs	
Transmission Service (\$)	156,000

**Table Q-10  
Cost Summary**

Financing Costs (\$/kW-yr)	139
Fixed Operational Costs (\$/kW-yr)	\$4
Tax (w/Credits) (\$/kW-yr)	(12)
<b>Fixed Costs (\$/kW-yr)</b>	<b>191</b>
Fuel Costs (\$/kW-yr)	0
Variable O&M (\$/kW-yr)	0
<b>Variable Costs (\$/kW-yr)</b>	<b>0</b>
<b>Total Levelized Costs (\$/kW-yr)</b>	<b>191</b>
Capital (\$/MWh)	54.36
Variable (\$/MWh)	0.00
<b>Total Levelized Costs (\$/MWh)</b>	<b>54.37</b>
<b>Capital Costs</b>	
Instant Cost (\$/kW)	983
Installed Cost (\$/kW)	1,059
<b>In-service Cost in 2005 (\$/kW)</b>	<b>1,101</b>

**Table Q-11  
Capital Cost Detail**

<b>Total Capital Cost (\$)</b>	<b>98,232,365</b>
<b>Development Costs (\$)</b>	<b>13,208,365</b>
Predevelopment Expenses (\$)	3,621,775
Construction Insurance (\$)	444,550
Interest during Construction (\$)	1,618,685
Commitment Fee (\$)	70,605
Legal Closing (\$)	2,118,150
Banking Due Diligence Expenses (\$)	261,500
Insurance Consultant Fee (\$)	65,375
Initial Working Capital (\$)	575,300
Equity Fee (\$)	1,307,500
Title Insurance (\$)	509,925
SR Debt Arrangement Fee (\$)	2,615,000
<b>Land Costs (\$)</b>	<b>1,750,000</b>
Acreage/Plant	100
Cost (\$/per Acre)	2,500
Acquisition Cost (\$)	250,000
Land Preparation Costs (\$/acre)	15,000
Total Land Preparation Costs (\$)	1,500,000
<b>Permitting Costs (\$)</b>	<b>375,000</b>
Local Building Permits (\$)	40,000
Environmental Permits (\$)	85,000
Bird Kill Mitigation (\$)	250,000
<b>Interconnection Costs (\$)</b>	<b>0</b>
<b>Component Cost</b>	<b>82,899,000</b>

**Table Q-12  
Maintenance Cost Detail**

<b>Cost Category</b>	<b>Parameter</b>	<b>Cost (\$/year)</b>
<b>Routine Maintenance Costs</b>		
Maintenance (\$)		1,260,430
Independent Engineer (\$)		81,065.00
Electricity Usage (\$)		41,840
Transmission Service (\$)		156,000.00
<b>Annual Routine Maintenance (\$)</b>		<b>1,539,335</b>
<b>Major Overhauls</b>		
Time to Major Overhaul (hours)	66,700	
Major Overhaul Labor (man-hours)	1,250	
Labor Cost (\$/hour)	48.00	
Major Overhaul Labor Cost (\$)	60,000	
Major Overhaul Replacement (\$)	6,970,000	
NPV Cost (\$)		<b>286,721.10</b>
<b>Minor Overhauls</b>		
Forced Outage (hours/year)	60	
Labor Rate (\$)	48	
Labor Time (man-hours)	0	
Parts Costs	0	
<b>Annualized Overhauls</b>		<b>5,975</b>
<b>Unscheduled Maintenance</b>		
Forced Outage (hours/year)	700	
Labor Rate (\$/hour)	48	
Labor time (hours)	350	
Parts Costs (\$)	707,200	
Total Cost	724,000	
<b>Total Annual Maintenance (\$)</b>		<b>2,556,031</b>
Maintenance/kW-yr (\$)	25.59	
Maintenance/MWh (\$)	7.27	

**Table Q-13  
Environmental Control Costs**

<b>Total Annual Costs (\$)</b>	<b>60</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 (\$/year)	0
Annual Consumables (\$)	0
Replacement Cost (\$/kW)	0
Component Life (hours)	141,760
Annualized Cost (\$)	
<b>Water Discharge</b>	
Control Technology (e.g., wastewater)	
Installation Cost (\$/kW)	0
Annual Labor (hours/year)	0
Loaded Labor Rate (\$)	48
Labor Cost (\$)	0
Annual Consumables (\$)	0
Replacement Cost (\$/kW)	20
Component Life (hours)	141,760
Annualized Cost (\$)	
<b>Solid Waste Disposal</b>	
<b>Non-hazardous Material</b>	
Tons per Year	1
Collection and Hauling (\$/ton)	0
Landfill Tipping Fees (\$/ton)	30
Total Costs (\$)	30
<b>Hazardous Materials</b>	
Tons per Year	1
Collection and Hauling (\$/ton)	0
Landfill Tipping Fees (\$/ton)	30
Total Disposal Costs (\$)	30