

CALIFORNIA
ENERGY
COMMISSION

COMPARATIVE COST OF CALIFORNIA CENTRAL STATION ELECTRICITY GENERATION TECHNOLOGIES

STAFF REPORT

Prepared in support of the *Electricity and Natural
Gas Assessment Report* under the Integrated Energy
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DISCLAIMER

This paper was prepared by the California Energy Commission staff. Opinions, conclusions, and findings expressed in this report are those of the authors. This report does not represent the official position of the California Energy Commission until adopted at an Energy Commission Business Meeting.

Errata to Generation Cost Model Spreadsheets

In response to public comments to *Comparative Cost of California Central Station Electricity Generation Technologies*, Final Staff Report number 100-03-001F, Energy Commission staff has prepared this *errata* to the report's cost spreadsheets. For most technologies, levelized cost did not change. Of the seven technologies for which staff modified its levelized cost estimates, only two displayed movements of over one mill per kilowatt hour. The following paragraphs describe the modifications staff made in its analysis, and the resultant changes in levelized costs.

Gas-fired Combined Cycle and Combustion Turbines

Labor wage rates were adjusted from (1) \$17/hour to \$30/hour for plant operators, (2) \$18/hour to \$30/hour for mechanics, (3) \$12/hour to \$20/hour for laborers, and (4) \$13/hour to \$20/hour for support staff to be consistent with those used for renewable and alternative generation technologies. Due to the range of wages across the state and the lack of a specific survey for the industry, proxy costs were derived from State of California data for petroleum refining and electric utility workers, and a survey of petroleum production workers' wages.¹ The overhead multiplier remains the same based on calculations using data from the U.S. Bureau of Labor Statistics.² Note that the managers' salary is a weighted average for all managers.

Renewable Generation Tax Credits and Incentives

The treatment of tax incentives and production credits were corrected for solar, geothermal and wind generation. The following items were changed:

- The investment tax credit under Internal Revenue Code Section 48 for geothermal and solar is only available to merchant owned power plants, and excludes utility-owned properties.³
- A missing link for the renewable energy production incentive under Internal Revenue Code Section 45 for investor-owned plants, both merchant and utility, was corrected, and the inflation calculation for the production credit was corrected to match the base year of the model (2001).

The references for each provision of the renewable energy subsidies are provided below:

Investment Tax Credit	solar, geothermal: 1992 EPAct, Sec 1916; IRC Sec 48
Production Incentive-Investor	wind, closed loop biomass: 1992 EPAct, Sec 1916; IRC Sec 45
Geothermal Depletion Allowance	IRC Sec 613
RE Production Incentive Tier I	solar, wind, geothermal, closed-loop biomass; only state subdivisions or cooperatives: 1992 EPAct, Sec 1212; DOE 10 CFR Part 451
RE Production Incentive Tier II	landfill methane, open loop biomass, prorated among pool: 1992 EPAct, Sec 1212; DOE 10 CFR Part 451
REPI Tier II Proportion Paid	DOE, Office of Power Technologies, REPI, January 15, 2003

- The municipal-owned renewable energy production incentive inflation calculation available under Section 1212 of the 1992 Energy Policy Act for solar, geothermal and wind generation also was corrected.

Geothermal

Transmission scheduling costs were inadvertently included only for this technology, and this cost item was deleted.

Levelized Costs

The changes described in this *errata* changed the levelized cost estimates for seven of the seventeen technologies that staff studied. As indicated previously, the resultant changes were minute in the vast majority of cases. The levelized cost estimate for wind decreased the most, from \$49.33/MWh to \$46.25/MWh, while the estimate for a combustion turbine rose from \$157.11 to 159.58/MWh. All other changes were less than one mill per kWh. Modifications to levelized cost estimates are shown in the table below.

Technology	Original Cost (\$/MWh)	Revised Cost (\$/MWh)	Change (\$/MWh)
Combined Cycle-Baseload	51.84	51.99	+0.15
Combustion Turbine	157.11	159.58	+2.47
Fuel Cell – Molten Carbonate	101.47	100.88	-0.59
Geothermal Binary 35 MW	73.65	72.88	-0.77
Geothermal Flash 50 MW	45.21	45.31	+0.10
Wind Farm	49.33	46.25	-3.08
Combined Cycle w/Duct Firing	52.04	52.19	+0.15

¹ California 2002 Statistical Abstract, *Average Hours And Earnings Of Production Workers, By Industry, California 2001*, Table C-9; and California Independent Producers' Association, *2003 Wage Survey*.

² U.S. Census Bureau, *2002 U.S. Statistical Abstract*, "Employer Costs for Employee Compensation per Hour Worked: 2002," Table No. 618.

³ Federal Register Vol. 60 No. 138 at 36960.

Table of Contents

	Page
Introduction.....	iii
Overview.....	1
Purpose	2
Technology Costs	2
Applicability of Levelized Costs	4
Methodology.....	6
Wind.....	8
Solar	8
Geothermal.....	8
Caveats.....	9
Emerging Technologies	11
Appendix A Natural Gas Price Forecast.....	A-1
Appendix B Financial Information.....	B-1
Appendix C Combine Cycle-Baseload (No Duct Firing) .C-1	Error! Bookmark not defined.
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 Photovoltaics	M-1
Appendix N Solar Parabolic w/o Thermally-Enhanced Storage or Gas	N-1
Appendix O Solar Parabolic with Gas Only	O-1
Appendix P Solar Thermal-Stirling Dish.....	P-1
Appendix Q Solar Parabolic w/ Thermally-Enhanced Storage Only	Q-1
Appendix R Wind Farm.....	R-1
Appendix S Combine Cycle-Baseload (With Duct Firing)	S-1

Introduction

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

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

Overview

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

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

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

Based on comments received on the February, 11, 2003 draft, staff has made numerous changes to its preliminary report. The original study focused on capital, rather than developmental costs. The current study includes development, land acquisition, and permitting costs for all technologies. Certain parties also expressed concern that staff had systematically understated several costs associated with fossil-fired plants. In response to this latter set of comments, staff has

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

Purpose

As part of the Integrated Energy Resource Plan, the California Energy Commission staff has developed cost estimates for central-station electricity generation technologies. These cost estimations are intended to provide general guides about expected costs of different technologies for policy makers and the public, and to assist resource planners in screening generation options.

Technology Costs

Table 1 shows the results of cost analyses for various technologies. Expected levelized costs, constant annual payments made over the life of the plants, are shown to provide a common basis of measurement. By construction, *levelized costs are given in constant, or real, dollars*. This report uses a base year of 2002. 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 as general estimates of ownership costs for different technologies. They are not intended to be the sole criterion used in an investment decision, which necessarily involves an evaluation of many other factors.

Estimates of levelized costs are provided for power plants that use natural gas as an energy source and for plants that use renewable energy sources. The costs for these technologies are listed below in **Table 1**. Gas-fired plant costs are derived from Energy Commission staff analyses. The expected levelized cost for a generic new baseload combined cycle plant is 5.18 cents per kWh. As shown in **Table 4**, however, this estimate jumps to 5.34 cents per

kWh for a unit located in the South Coast Air Quality Management District. When one adds duct firing at the above-mentioned unit, this cost rises further to 5.37 cents per kWh. Energy Commission staff estimates show that a combustion turbine, with an in-service year of 2004 and used for peaking service with a 10 percent capacity factor, can be expected to deliver this peak capacity and energy at a cost of 15.71 cents per kWh. Geothermal flash technology has the lowest levelized costs at 4.52 cents per kWh, with wind next at 4.93 cents per kWh. Hydropower is projected to provide load-following power at 6.04 cents per kWh. Geothermal binary plants have an expected cost of 7.37 cents per kWh. Solar thermal parabolic trough units have expected levelized costs ranging from 13.52 to 21.53 ¢ per kWh.

**Table 1
Levelized Costs by Technology**

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

In considering these figures, it is important to note the relationship between the expected economic (or “book”) life of a project and levelized cost. In this report, the standard loan period is 12 years. For project finance, this means that the entire dollar outlay associated with completing the project (or the “instant cost”) is allocated during years one through twelve of the project. A levelized cost calculation acts as if these costs are incurred across *all* years of a project’s operation. The levelized cost of a highly capital intensive project, such as hydroelectric, will depend greatly on the project life assumed. If an economic lifetime of say, 50 years were assumed, staff’s estimate of the levelized cost for hydroelectric generation would fall precipitously. This greater economic lifetime would allow the relatively large capital cost to spread over a greater number of years, decreasing its contribution to levelized

cost. The study's figures would then overestimate, perhaps substantially, the levelized cost of a hydroelectric project with an economic lifetime of more than 30 years.

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

Applicability of Levelized Costs

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

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

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

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

price contracts, generators will charge a premium above the expected average market price for power to compensate for the shift in risk from ratepayers to generators.

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

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

Methodology

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

Debt financing usually has fairly rigid conditions related to the term of the loan, the required periodic payments and the security of repayment, much like a home mortgage. Equity financing is usually repaid from the residual revenues remaining after paying all other costs and, as a result, has a higher risk of not being fully repaid compared to debt financing. For purposes of cost comparisons, the assumption is made that these investments are recovered on a relatively constant annual basis without regard to the amount of generation output. This annual expenditure is then divided over the annual generation to derive the average cost per kWh for the investment or “capital” component.

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

Table 2
Assumptions for Equity Return and Debt Interest Rates

Type of Owner	Return on Equity	Debt by Term (November, 2001) ⁴					
		1	5	10	12	20	30
Merchant	16.0%	7.4%	7.4%	7.4%	7.4%	7.8%	8.0%
IOU	10.6%	6.3%	6.3%	6.3%	6.3%	7.1%	7.4%
Muni/Coop	NA	3.9%	3.9%	3.9%	3.9%	4.7%	4.8%

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

The third category is the variable costs that are derived from fuel consumption, maintenance expenditures for forced outages, and other input costs driven directly by hourly plant operations. For a natural gas-fired plant, the largest component of these costs is the consumption of natural gas. Fuel costs can represent two-thirds or more of total average costs. Fuel usage, by technology, is shown in **Table 5** of **Appendices C through S**. Renewable resources typically have quite low variable costs because their fuel, other than biomass, or other energy sources have low or zero costs.

Variable input costs, particularly fuel costs, change over time. The fuel costs are often relatively unpredictable compared to other cost components. The staff’s December 2002 projection of the price of natural gas for the years 2003-2013 is found in **Table 1, Appendix A**. After 2013, an average escalation factor of 5.60 percent is used to project natural gas price. This is the value of the predicted increase in fuel cost from 2012 to 2013.

Variable costs also change directly with plant output and thus can vary substantially from year to year. However, they vary little, if at all, on an average cost basis. On the other hand, capital and O&M costs per kWh are inversely related to plant output—higher output means lower average costs for these components, and vice versa. Assumptions concerning annual plant operation are provided in **Table 6** of **Appendices C** through **S**.

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

**Table 3
Federal and State Tax Programs**

	Merchant	IOU	Muni/Coop
Combustion Turbine			
Federal Depreciation	MACRS ⁵ 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
Wind			
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
Solar			
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
Geothermal			
Federal Depreciation	MACRS 5 year	MACRS 5 year	N/A
CA Depreciation	Plant Life	Plant Life	N/A
Investment Tax Credit	Yes	Yes	N/A
Renewable Production Credit	No	No	Tier I

The federal corporate income tax rate is assumed to be 34 percent, and 8.84 percent is assumed for the California tax rate. The average property tax rate is 1.069 percent, and the average sales tax is 7.67 percent.⁶ In addition, **Table 7** of **Appendices C** through **S** lists the renewable tax benefits applicable to each of the technologies.

To estimate operating and maintenance costs, common assumptions for salaries and associated benefits were developed but most other costs are technology specific. Assumptions for each technology are shown in **Tables 8 and 9 of Appendices C** through **S**. Based on the technological and financial data contained in this report, staff obtained cost summaries for each of the technologies studied. These summaries are provided in **Table 10 of Appendices C** through **S**. Staff analyzed the impact of the emission mitigation and the cost of adding the duct firing to gas-fired facilities in different air quality management districts and summarized the results in **Table 4**. The emission cost used in the staff analysis was extracted from “Regional Cost Differences Siting New Power Generation in California Report” dated December, 2002.

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

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

Caveats

The analysis presents the costs in terms of levelized costs. Levelized costs can be interpreted as a constant level of revenue necessary each year to recover all expenses over the expected economic life of the project, assuming all costs are known. Levelized costs for any power plant are a function of all the fixed and varying annual costs (e.g., financing, operations and maintenance, and fuel).

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

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

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

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

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

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

Natural gas variability is an important factor that can affect the cost of the gas-fired technologies. Hedging natural gas prices and hedging cost could be an important element in determining the actual cost. However, in this analysis, staff did not consider the hedging impact.⁷ One must also note that the intermittent nature of wind and run-of-river hydro projects decreases their value relative to dispatchable units.

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

Emerging Technologies

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

**Table 5
Levelized Costs for Emerging Technologies**

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

⁴ Staff has not updated these values from when they were derived because doing so would not be cost effective. Additionally, and more current values will not likely be representative of future market conditions

⁵ Modified Accelerated Cost Recovery System.

⁶ Elizabeth G. Hill, *California's Tax System: A Primer* (Sacramento, California: Legislative Analyst's Office, State of California, January 2001).

⁷ For an estimate of the hedging cost associated with natural-gas-fired plants, see Bolinger, Wisner and Golove, *Quantifying the Value that Wind Power Provides as a Hedge Against Volatile Natural Gas Prices*, (Berkeley, Lawrence Berkeley National Laboratory, June 2002).

Appendices A-S

Appendix A

Natural Gas Price Forecast

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

Year	Price
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

Category	Capital Structure	Capital Cost
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	SoCal
Air Quality Management District	Kern County

**Table C-2
Plant Size**

Gross Capacity (MW)	500.0
Parasitic Load (MW)	0.0
Net Capacity (MW)	500
Derate Factor (%)	100.0
Firm Capacity (MW)	500
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 (%)	0.15

**Table C-3
Capital Costs**

Escalation in Capital Costs (%)	0
AFUDC Rate (%)	10.3
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%	20%	5%	0%	0%
Carry Over	\$550.0	\$137.0	\$27.0	\$0.0	\$0.0

**Table C-5
Fuel Use**

Heat Rate (MMBtu/kWh)	7,100
Fuel Consumption (MMBtu/hour)	3,550
Start-up Fuel Use (MMBtu/start)	1,850
Number of Annual Starts	50
Annual Fuel Use (MMBtu)	28,577,700

**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)	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 (\$)	0
Production Incentive-Investor (¢/kWh)	0
Geothermal Depletion Allowance	N/A
RE Production Incentive Tier I	0
RE Production Incentive Tier II	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	4	1,800	\$77,031 per year
Plant Operators	12	1,800	\$30 per hour
Mechanics	4	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-year)	4.33
Fixed O&M/Instant Cost (%)	0.80
O&M Escalation (%)	0.5
Insurance (%)	1.5
Labor Escalation Cost (%)	0.5
Overhead Multiplier	1.6
Other Operating Costs	
Water Supply (\$/AF)	197
Consumption (AF/YR)	2,600
Water Supply Costs (\$/MWh)	0.13
Plant Scheduling Costs	
Transmission Service (\$/MW)	
Wheeling Charges (\$/kWh)	
Scheduler Costs	
Variable Operating Costs (\$/MWh)	1.21
Environmental Control Costs (\$/MWh)	0.68
Variable O&M (\$/MWh)	2.02

**Table C-10
Cost Summary**

Financing Costs (\$/kW-year)	75
Fixed Operational Costs (\$/kW-year)	16
Tax (w/Credits) (\$/kW-year)	1
Fixed Costs (\$/kW-year)	91
Fuel Costs (\$/kW-year)	307
Variable O&M (\$/kW-year)	19.16
Variable Costs (\$/kW-year)	326
Total Levelized Costs (\$/kW-year)	417
Capital (\$/MWh)	11.39
Variable (\$/MWh)	40.60
Total Levelized Costs (\$/MWh)	51.99
Capital Costs	
Instant Cost (\$/kW)	542
Installed Cost (\$/MWh)	592
Inservice Cost in 2004 (\$/kW)	616

**Table C-11
Capital Cost Detail**

Total (\$)	270,896,567
Component Cost (\$)	239,289,126
Turbine/Engine [Not itemized] (\$)	234,597,182
Generator/Gearhead	
Boiler/HRSG	
Fuel Pipeline/Tank	
Slab & Engine Mount	
Miscellaneous fitting & hoses, spare parts (\$)	4,691,944
Office space	
Control Room	
Financial Transaction Costs (%)	0.0
Land Costs (\$)	1,477,941
Acreage/Plant	15
Cost per Acre (\$)	100,000
Acquisition Cost (\$)	1,470,588
Land Prep Costs per Acre (\$)	500
Total Land Prep Costs (\$)	7,353
Permitting Costs (\$)	5,129,500
Local Building Permits (\$)	
Environmental Permits (\$)	
Air Emission Permits (\$)	5,129,500
Interconnection Costs (\$)	0
Transmission Lines (\$)	
Substation (\$)	
Induction Equipment (\$)	
Environmental Controls (\$)	25,000,000
Installation Costs (\$)	25,000,000
Replacement Costs (\$)	

**Table C-12
Maintenance Cost Detail**

Routine Maintenance Costs		Annual Costs
Replacement Interval (hours)	8,024	
Replacement Parts (\$/unit)	400,000	400,000
Maintenance Interval (hours)	8,024	
Materials/Supplies (\$/unit)	400,000	400,000
Interval (hours)	1,000	
Item Price (\$/unit)	0.00	0.00
Labor (hours/day)	0.00	
Labor price (\$/hour)	48.00	0.00
Total Annual Routine Maintenance		800,000
Major Overhauls		
Time to Major Overhaul (hours)	20,000	
Major Overhaul Labor (man-hours)	18,000	
Labor Cost (\$/hour)	96.00	
Major Overhaul Labor Cost (\$)	1,728,000	
Major Overhaul Replacement (\$)	3,272,000	
NPV Cost (\$)		2,250,104
Minor Overhauls		
Annual Cost Item 1	1,200,000	
Hours to Item 1 Job	8,024	
Annual Cost Item 2	0	
Hours to Item 2 Job	0	
Annualized PV Overhauls		1,401,939
Unscheduled Maintenance		
Forced Outage (hours/year)	400	
Labor Rate (\$/hour)	48	
Labor time per event (hours)	400	
Parts Costs (\$)	374,400	
Total (\$)	393,600	
Total Annual Maintenance		4,845,644
Maintenance (\$/kW-year)	9.69	
Maintenance (\$/MWh)	1.21	

**Table C-13
Environmental Control Costs**

Total Annual Costs (\$)	2,743,205
Air Emissions	
Control Technology (e.g., SCR) (\$)	15,000,000
Installation Cost (\$/kW)	30
Annual Labor (hours/year)	100
Loaded Labor Rate (\$/hour)	48
Labor Cost (\$)	4,800
Annual Consumables-Catalyst (\$)	333,333
Replacement Cost (\$/kW)	20
Component Life (hours)	141,760
Annualized Replacement Cost (\$)	1,028,436
Water Cooling	
Control Technology (e.g., wastewater) (\$)	10,000,000
Installation Cost (\$/kW)	20
Annual Labor (hours/year)	1000
Loaded Labor Rate (\$)	48
Labor Cost (\$)	48,000
Annual Consumables (\$)	300,000
Replacement Cost (\$/kW)	20
Component Life (hours)	141,760
Annualized Cost (\$)	1,028,436
Solid Waste Disposal	
Non hazardous material	
Tons per Year	1
Collection and Hauling (\$/ton)	10
Landfill Tipping Fees (\$/ton)	30
Total Costs (\$)	40
Hazardous materials	
Tons per Year	1
Collection and Hauling (\$/ton)	60
Landfill Tipping Fees (\$/ton)	100
Total Disposal Costs (\$)	160

Appendix D

Combustion Turbine

**Table D-1
Plant Information**

Technology Type	Natural Gas
Fuel	Natural Gas
Owner/Investor	Merchant
Base Year	2002
Inservice Year	2004
Utility Service Area	SoCal
Air Quality Management District	Kern County

**Table D-2
Plant Size**

Gross Capacity (MW)	100.0
Parasitic Load (MW)	0.0
Net Capacity (MW)	100
Derate Factor (%)	100.0
Firm Capacity (MW)	100
Transmission Losses (%)	5.0
Required AS/reserves (%)	7.0
Average Hourly Output Rate (%)	100
Effective Load Carry Capacity (MW)	88
Annual Capacity Degradation Rate (%)	0.15

**Table D-3
Capital Costs**

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

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

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

**Table D-5
Fuel Use**

Heat Rate (MMBtu/kWh)	9,300
Fuel Consumption (MMBtu/hour)	930
Start-up Fuel Use (MMBtu/start)	180
Number of Annual Starts	120
Annual Fuel Use (MMBtu)	785,682

**Table D-6
Operational Information**

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

**Table D-7
Renewable Tax Benefits**

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

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

Employees	Full Time Employees	Hours/Year	Compensation Per Employee
Managers	4	1,800	\$90,000 per year
Plant Operators	4	1,800	\$30 per hour
Mechanics	2	1,800	\$30 per hour
Laborers	0	1,800	\$20 per hour
Support Staff	1	1,800	\$20 per hour

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

Fixed O&M (\$/kW-year)	11.52
Fixed O&M/Instant Cost (%)	2.76
O&M Escalation (%)	0.5
Insurance (%)	1.5
Labor Escalation Cost (%)	0.5
Overhead Multiplier	1.6
Other Operating Costs	
Water Supply (\$/AF)	197
Consumption (AF/YR)	520
Water Supply Costs (\$/MWh)	1.25
Plant Scheduling Costs	
Transmission Service (\$/MW)	
Wheeling Charges (\$/kWh)	
Scheduler Costs	
Variable Operating Costs (\$/MWh)	9.15
Environmental Control Costs (\$/MWh)	5.43
Variable O&M (\$/MWh)	15.83

**Table D-10
Cost Summary**

Financing Costs (\$/kW-year)	57
Fixed Operational Costs (\$/kW-year)	22
Tax (w/Credits) (\$/kW-year)	1
Fixed Costs (\$/kW-year)	80
Fuel Costs (\$/kW-year)	42
Variable O&M (\$/kW-year)	9
Variable Costs (\$/kW-year)	51
Total Levelized Costs (\$/kW-year)	131
Capital (\$/MWh)	97.46
Variable (\$/MWh)	62.12
Total Levelized Costs (\$/MWh)	159.58
Capital Costs	
Instant Cost (\$/kW)	417
Installed Cost (\$/MWh)	456
Inservice Cost in 2004 (\$/kW)	475

**Table D-11
Capital Cost Detail**

Total (\$)	41,715,152
Component Cost (\$)	31,620,000
Turbine/Engine [Not segregated] (\$)	31,000,000
Generator/Gearhead	
Boiler/HRSG	
Fuel Pipeline/Tank	
Slab & Engine Mount	
Miscellaneous fitting & hoses, spare parts (\$)	620,000
Office space	
Control Room	
Financial Transaction Costs (%)	0.0
Land Costs (\$)	5,007,353
Acreage/Plant	50
Cost per Acre (\$)	100,000
Acquisition Cost (\$)	5,000,000
Land Prep Costs/Acre (\$)	500
Total Land Prep Costs (\$)	7,353
Permitting Costs (\$)	87,799
Local Building Permits	
Environmental Permits	
Air Emission Permits (\$)	87,799
Interconnection Costs	0
Transmission Lines	
Substation	
Induction Equipment	
Environmental Controls (\$)	5,000,000
Installation Costs (\$)	5,000,000
Replacement Costs	

**Table D-12
Maintenance Cost Detail**

Routine Maintenance Costs		Annual Costs
Replacement Interval (hours)	822	
Replacement Parts (\$/unit)	40,000	40,000
Maintenance Interval (hours)	822	
Materials/Supplies (\$/unit)	40,000	40,000
Interval (hours)	1,000	
Item Price (\$/unit)	0.00	0.00
Labor (hours/day)	0.00	
Labor price (\$/hour)	48.00	0.00
Total Annual Routine Maintenance		80,000
Major Overhauls		
Time to Major Overhaul (hours)	8,360	
Major Overhaul Labor (man-hours)	3,600	
Labor Cost (\$/hour)	96.00	
Major Overhaul Labor Cost (\$)	345,600	
Major Overhaul Replacement (\$)	3,654,400	
NPV Cost (\$)		193,253
Minor Overhauls		
Annual Cost Item 1	100,000	
Hours to Item 1 Job	822	
Annual Cost Item 2	0	
Hours to Item 2 Job	0	
Annualized PV Overhauls		102,212
Unscheduled Maintenance		
Forced Outage (hours/year)	44	
Labor Rate (\$/hour)	48	
Labor time per event (hours)	44	
Parts Costs (\$)	374,400	
Total	376,502	
Total Annual Maintenance		751,967
Maintenance (\$/kW-year)	7.52	
Maintenance (\$/MWh)	9.15	

**Table D-13
Environmental Control Costs**

Total Annual Costs (\$)	446,506
Air Emissions	
Control Technology (e.g., SCR) (\$)	3,000,000
Installation Cost (\$/kW)	30
Annual Labor (hours/year)	100
Loaded Labor Rate (\$/hour)	48
Labor Cost (\$)	4,800
Annual Consumables-Catalyst (\$)	33,333
Replacement Cost (\$/kW)	20
Component Life (hours)	141,760
Annualized Replacement Cost (\$)	169,286
Water Cooling	
Control Technology (e.g., wastewater) (\$)	2,000,000
Installation Cost (\$/kW)	20
Annual Labor (hours/year)	200
Loaded Labor Rate (\$/hour) (\$)	48
Labor Cost (\$)	9,600
Annual Consumables (\$)	60,000
Replacement Cost (\$/kW)	20
Component Life (hours)	141,760
Annualized Cost (\$)	169,286
Solid Waste Disposal	
Non hazardous material	
Tons per Year	1
Collection and Hauling (\$/ton)	10
Landfill Tipping Fees (\$/ton)	30
Total Costs (\$)	40
Hazardous materials	
Tons per Year	1
Collection and Hauling (\$/ton)	60
Landfill Tipping Fees (\$/ton)	100
Total Disposal Costs (\$)	160

Appendix E

Fuel Cell - CT Hybrid

**Table E-1
Plant Information**

Technology Type	Natural Gas
Fuel	Natural Gas
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 (%)	10.3
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	\$1,164	\$0	\$0	\$0	\$0

**Table E-5
Fuel Use**

Heat Rate (MMBtu/kWh)	5,700.0
Fuel Consumption (MMBtu/Hr)	142.5
Start-up Fuel Use (MMBtu/start)	0.0
Number of Annual Starts	0.0
Annual Fuel Use (MMBtu)	1,123,470.0

**Table E-6
Operational Information**

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

**Table E-7
Renewable Tax Benefits**

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

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

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

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

Fixed O&M (\$/kW-year)	191.0
Fixed O&M/Instant Cost (%)	16.40
O&M Escalation (%)	0.5
Insurance (%)	1.5
Labor Escalation Cost (%)	0.5
Overhead Multiplier	1.6
Other Operating Costs	
Water Supply (\$/AF)	
Consumption (AF/YR)	
Water Supply Costs (\$/MWh)	
Plant Scheduling Costs	
Transmission Service (\$/MW)	
Wheeling Charges (\$/kWh)	
Scheduler Costs	
Variable Operating Costs (\$/MWh)	5.07
Environmental Control Costs (\$/MWh)	
Variable O&M (\$/KW-year)	40

**Table E-10
Cost Summary**

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

**Table E-11
Capital Cost Detail**

Total (\$)	29,096,786
Component Cost (\$)	28,850,000
SOFC Generator Equipment (\$)	8,350,000
SOFC Power Conditioning Equipment (\$)	3,675,000
Gas Turbine Generator Equipment (\$)	5,000,000
Balance of Plant Equipment (\$)	4,450,000
Site Preparation (\$)	425,000
Project Management and Engineering (\$)	925,000
Overhead and Profit Allowance (\$)	6,025,000
Financial Transaction Costs (%)	0
Land Costs (\$)	246,786
Sq Ft/MW	4,300
Acreage/Plant	2.47
Cost per Acre (\$)	100,000
Acquisition Cost (\$)	246,786
Land Prep Costs per Acre (\$)	0
Total Land Prep Costs (\$)	0
Permitting Costs (\$)	0
Local Building Permits (\$)	
Environmental Permits (\$)	
Interconnection Costs (\$)	0
Transmission Lines (\$)	
Substation (\$)	
Induction Equipment (\$)	

**Table E-12
Maintenance Cost Detail**

Routine Maintenance Costs		Annual Costs
Replacement Interval (hours)	1	
Filter Price (\$)	0	0
Maintenance Interval (hours)	1	
Price (\$)	0	0
Oil Price (\$/gallon)	3.40	
Oil Capacity (gallons)	0	0
Oil Added per Day (gallons)	0	0
Interval (hours)	1,000	
Item Price (\$)	0	0
Labor (hours/day)	0	
Labor Price (\$/hour)	48	0
Annual Routine Maintenance		0
Major Overhauls		
Hours to Major Overhaul	0	
Major Overhaul Labor (man-hours)	0	
Labor Cost (\$/hour)	48	
Major Overhaul Labor Cost (\$)	0	
Major Overhaul Replacement (\$)	0	
NPV Cost (\$)		
Minor Overhauls		
Annual Cost Item 1 (\$)	22,925,101	
Hours to Item 1 Job	40,000	
Annual Cost Item 2 (\$)	4,585,020	
Hours to Item 2 Job	55,188	
Annualized Overhauls		4,069,350
Unscheduled Maintenance		
Forced Outage (hours/year)	438	
Labor Rate (\$/hour)	48	
Hours of Labor	438	
Parts Costs (\$)	0	
Total (\$)	21,024	
Total Annual Maintenance (\$)		4,090,374
Maintenance (\$/kW-year)	163.61	
Maintenance (\$/MWh)	20.75	

**Table E-13
Environmental Control Costs**

Total Annual Costs (\$)	0
Air Emissions	
Control Technology (e.g. SCR) (\$)	
Installation Cost (\$/kW)	0
Annual Labor (hours/year)	0
Loaded Labor Rate (\$/hour)	48
Labor Cost (\$)	0
Annual Consumables-Catalyst (\$)	0
Replacement Cost (\$/kW)	0
Component Life (hours)	141,760
Annualized Cost (\$)	
Water Cooling	
Control Technology (e.g. wastewater) (\$)	
Installation Cost (\$/kW)	0
Annual Labor (hours/year)	0
Loaded Labor Rate (\$/hour)	48
Labor Cost (\$)	0
Annual Consumables (\$)	0
Replacement Cost (\$/kW)	0
Component Life (hours)	141,760
Annualized Cost (\$)	
Solid Waste Disposal	
Non hazardous material	
Tons per Year	0
Collection and Hauling (\$/ton)	10
Landfill Tipping Fees (\$/ton)	30
Total Costs (\$)	0
Hazardous materials	
Tons per Year	0
Collection and Hauling (\$/ton)	10
Landfill Tipping Fees (\$/ton)	30
Total Disposal Costs (\$)	0

Appendix F

Fuel Cell - Molten Carbonate

**Table F-1
Plant Info**

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 (%)	10.3
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 (MMBtu/kWh)	7,511.0
Fuel Consumption (MMBtu/Hr)	187.8
Start-up Fuel Use (MMBtu/start)	0.0
Number of Annual Starts	0.0
Annual Fuel Use (MMBtu)	1,480,418.0

**Table F-6
Operational Information**

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

**Table F-7
Renewable Tax Benefits**

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

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

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
Operation & Maintenance Costs (Other)**

Fixed O&M (\$/kW-year)	120.0
Fixed O&M/Instant Cost (%)	7.99
O&M Escalation (%)	0.5
Insurance (%)	1.5
Labor Escalation Cost (%)	0.5
Overhead Multiplier	1.6
Other Operating Costs	
Water Supply (\$/AF)	
Consumption (AF/YR)	
Water Supply Costs (\$/MWh)	
Plant Scheduling Costs	
Transmission Service (\$/MW)	
Wheeling Charges (\$/kWh)	
Scheduler Costs	
Variable Operating Costs (\$/MWh)	5.07
Environmental Control Costs (\$/MWh)	
Variable O&M (\$/MWh)	40

**Table F-10
Cost Summary**

Financing Costs (\$/kW-year)	194
Fixed Operational Costs (\$/kW-year)	180
Tax (w/Credits) (\$/kW-year)	9
Fixed Costs (\$/kW-year)	383
Fuel Costs (\$/kW-year)	362
Variable O&M (\$/kW-year)	50
Variable Costs (\$/kW-year)	412
Total Levelized Costs (\$/kW-year)	795
Capital (\$/MWh)	48.64
Variable (\$/MWh)	52.24
Total Levelized Costs (\$/MWh)	100.88
Capital Costs	
Instant Cost (\$/kW)	1,509
Installed Cost (\$/MWh)	1,624
In-service Cost in 2004 (\$/kW)	1,690

**Table F-11
Capital Cost Detail**

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

**Table F-12
Maintenance Cost Detail**

Routine Maintenance Costs		Annual Costs
Replacement Interval (hours)	1	
Filter Price (\$)	0	0
Maintenance Interval (hours)	1	
Price (\$)	0	0
Oil Price (\$/gallon)	3.40	
Oil Capacity	0	0
Oil Added per Day	0	0
Interval (hours)	1,000	
Item Price (\$)	0	0
Labor (hours/day)	0	
Labor Price (\$/hour)	48	0
Annual Routine Maintenance		0
Major Overhauls		
Hours to Major Overhaul	0	
Major Overhaul Labor (man-hours)	0	
Labor Cost (\$/hour)	48	
Major Overhaul Labor Cost (\$)	0	
Major Overhaul Replacement (\$)	0	
NPV Cost (\$)		
Minor Overhauls		
Annual Cost Item 1 (\$)	10,000,000	
Hours to Item 1 Job	23,652	
Annual Cost Item 2 (\$)	0	
Hours to Item 2 Job	55,188	
Annualized Overhauls		2,991,198
Unscheduled Maintenance		
Forced Outage (hours/year)	438	
Labor Rate (\$/hour)	48	
Hours of Labor	438	
Parts Costs (\$)	0	
Total (\$)	21,024	
Total Annual Maintenance		3,012,222
Maintenance (\$/kW-year)	120.49	
Maintenance (\$/MWh)	15.28	

**Table F-13
Environmental Control Costs**

Total Annual Costs (\$)	0
Air Emissions	
Control Technology (e.g. SCR) (\$)	
Installation Cost (\$/kW)	0
Annual Labor (hours/year)	0
Loaded Labor Rate (\$/hour)	48
Labor Cost (\$)	0
Annual Consumables-Catalyst (\$)	0
Replacement Cost (\$/kW)	0
Component Life (hours)	141,760
Annualized Cost (\$)	
Water Cooling	
Control Technology (e.g. wastewater) (\$)	
Installation Cost (\$/kW)	0
Annual Labor (hours/year)	0
Loaded Labor Rate (\$/hour)	48
Labor Cost (\$)	0
Annual Consumables (\$)	0
Replacement Cost (\$/kW)	0
Component Life (hours)	141,760
Annualized Cost (\$)	
Solid Waste Disposal	
Non hazardous material	
Tons per Year	0
Collection and Hauling (\$/ton)	10
Landfill Tipping Fees (\$/ton)	30
Total Costs (\$)	0
Hazardous materials	
Tons per Year	0
Collection and Hauling (\$/ton)	10
Landfill Tipping Fees (\$/ton)	30
Total Disposal Costs (\$)	0

APPENDIX G

Fuel Cell - Phosphoric Acid

**Table G-1
Plant Information**

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

**Table G-2
Plant Size**

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

**Table G-3
Capital Costs**

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

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

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

**Table G-5
Fuel Use**

Heat Rate (MMBtu/kWh)	9,389.0
Fuel Consumption (MMBtu/hour)	234.7
Start-up Fuel Use (MMBtu/start)	0.0
Number of Annual Starts	0.0
Annual Fuel Use (MMBtu)	1,850,572.0

**Table G-6
Operational Information**

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

**Table G-7
Renewable Tax Benefits**

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

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

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
Operation & Maintenance Costs (Other)**

Fixed O&M (\$/kW-year)	271.0
Fixed O&M/Instant Cost (%)	5.99
O&M Escalation (%)	0.5
Insurance (%)	1.5
Labor Escalation Cost (%)	0.5
Overhead Multiplier	1.6
Other Operating Costs	
Water Supply (\$/AF)	
Consumption (AF/YR)	
Water Supply Costs (\$/MWh)	
Plant Scheduling Costs	
Transmission Service (\$/MW)	
Wheeling Charges (\$/kWh)	
Scheduler Costs	
Variable Operating Costs (\$/MWh)	22.20
Environmental Control Costs (\$/MWh)	
Variable O&M (\$/kW-year)	175

**Table G-10
Cost Summary**

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

**Table G-11
Capital Cost Detail**

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

**Table G-12
Maintenance Cost Detail**

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

**Table G-13
Environmental Control Costs**

Total Annual Costs (\$)	0
Air Emissions	
Control Technology (e.g. SCR) (\$)	
Installation Cost (\$/kW)	0
Annual Labor (hours/year)	0
Loaded Labor Rate (\$/hour)	48
Labor Cost (\$)	0
Annual Consumables-Catalyst (\$)	0
Replacement Cost (\$/kW)	0
Component Life (hours)	141,760
Annualized Cost (\$)	
Water Cooling	
Control Technology (e.g. wastewater) (\$)	
Installation Cost (\$/kW)	0
Annual Labor (hours/year)	0
Loaded Labor Rate (\$/hour)	48
Labor Cost (\$)	0
Annual Consumables (\$)	0
Replacement Cost (\$/kW)	0
Component Life (hours)	141,760
Annualized Cost (\$)	
Solid Waste Disposal	
Non hazardous material	
Tons per Year	0
Collection and Hauling (\$/ton)	10
Landfill Tipping Fees (\$/ton)	30
Total Costs (\$)	0
Hazardous materials	
Tons per Year	0
Collection and Hauling (\$/ton)	10
Landfill Tipping Fees (\$/ton)	30
Total Disposal Costs (\$)	0

APPENDIX H

Fuel Cell - Proton Exchange Membrane

**Table H-1
Plant Information**

Technology Type	Natural Gas
Fuel	Natural Gas
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 (%)	10.3
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 (MMBtu/kWh)	9,389.0
Fuel Consumption (MMBtu/hour)	234.7
Start-up Fuel Use (MMBtu/start)	0.0
Number of Annual Starts	0.0
Annual Fuel Use (MMBtu)	1,850,572.0

**Table H-6
Operational Information**

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

**Table H-7
Renewable Tax Benefits**

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

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

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
Operation & Maintenance Costs (Other)**

Fixed O&M (\$/kW-year)	271.0
Fixed O&M/Instant Cost (%)	17.91
O&M Escalation (%)	0.5
Insurance (%)	1.5
Labor Escalation Cost (%)	0.5
Overhead Multiplier	1.6
Other Operating Costs	
Water Supply (\$/AF)	
Consumption (AF/YR)	
Water Supply Costs (\$/MWh)	
Plant Scheduling Costs	
Transmission Service (\$/MW)	
Wheeling Charges (\$/kWh)	
Scheduler Costs	
Variable Operating Costs (\$/MWh)	22.20
Environmental Control Costs (\$/MWh)	
Variable O&M (\$/kW-year)	175

**Table H-10
Cost Summary**

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

**Table H-11
Capital Cost Detail**

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

**Table H-12
Maintenance Cost Detail**

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

**Table H-13
Environmental Control Costs**

Total Annual Costs (\$)	0
Air Emissions	
Control Technology (e.g. SCR) (\$)	
Installation Cost (\$/kW)	0
Annual Labor (hours/year)	0
Loaded Labor Rate (\$/hour)	48
Labor Cost (\$)	0
Annual Consumables-Catalyst (\$)	0
Replacement Cost (\$/kW)	0
Component Life (hours)	141,760
Annualized Cost (\$)	
Water Cooling	
Control Technology (e.g. wastewater) (\$)	
Installation Cost (\$/kW)	0
Annual Labor (hours/year)	0
Loaded Labor Rate (\$/hour)	48
Labor Cost (\$)	0
Annual Consumables (\$)	0
Replacement Cost (\$/kW)	0
Component Life (hours)	141,760
Annualized Cost (\$)	
Solid Waste Disposal	
Non hazardous material	
Tons per Year	0
Collection and Hauling (\$/ton)	10
Landfill Tipping Fees (\$/ton)	30
Total Costs (\$)	0
Hazardous materials	
Tons per Year	0
Collection and Hauling (\$/ton)	10
Landfill Tipping Fees (\$/ton)	30
Total Disposal Costs (\$)	0

APPENDIX I

Fuel Cell - Solid Oxide

**Table I-1
Plant Information**

Technology Type	Natural Gas
Fuel	Natural Gas
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 (%)	10.3
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	\$1,577	\$0	\$0	\$0	\$0

**Table I-5
Fuel Use**

Heat Rate (MMBtu/kWh)	8,345.0
Fuel Consumption (MMBtu/hour)	208.6
Start-up Fuel Use (MMBtu/start)	0.0
Number of Annual Starts	0.0
Annual Fuel Use (MMBtu)	1,644,800.0

**Table I-6
Operational Information**

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

**Table I-7
Renewable Tax Benefits**

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

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

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

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

Fixed O&M (\$/kW-year)	294.0
Fixed O&M/Instant Cost (%)	18.67
O&M Escalation (%)	0.5
Insurance (%)	1.5
Labor Escalation Cost (%)	0.5
Overhead Multiplier	1.6
Other Operating Costs	
Water Supply (\$/AF)	
Consumption (AF/YR)	
Water Supply Costs (\$/MWh)	
Plant Scheduling Costs	
Transmission Service (\$/MW)	
Wheeling Charges (\$/kWh)	
Scheduler Costs	
Variable Operating Costs (\$/MWh)	1.60
Environmental Control Costs (\$/MWh)	
Variable O&M (\$/MWh)	13

**Table I-10
Cost Summary**

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

**Table I-11
Capital Cost Detail**

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

**Table I-12
Maintenance Cost Detail**

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

**Table I-13
Environmental Control Costs**

Total Annual Costs (\$)	0
Air Emissions	
Control Technology (e.g. SCR) (\$)	
Installation Cost (\$/kW)	0
Annual Labor (hours/year)	0
Loaded Labor Rate (\$/hour)	48
Labor Cost (\$)	0
Annual Consumables-Catalyst (\$)	0
Replacement Cost (\$/kW)	0
Component Life (hours)	141,760
Annualized Cost (\$)	
Water Cooling	
Control Technology (e.g. wastewater) (\$)	
Installation Cost (\$/kW)	0
Annual Labor (hours/year)	0
Loaded Labor Rate (\$/hour)	48
Labor Cost (\$)	0
Annual Consumables (\$)	0
Replacement Cost (\$/kW)	0
Component Life (hours)	141,760
Annualized Cost (\$)	
Solid Waste Disposal	
Non hazardous material	
Tons per Year	0
Collection and Hauling (\$/ton)	10
Landfill Tipping Fees (\$/ton)	30
Total Costs (\$)	0
Hazardous materials	
Tons per Year	0
Collection and Hauling (\$/ton)	10
Landfill Tipping Fees (\$/ton)	30
Total Disposal Costs (\$)	0

Appendix J

Geothermal Binary 35 MW

**Table J-1
Plant Information**

Technology Type	Geothermal
Fuel	Geothermal
Owner/Investor	Merchant
Base Year	2001
Inservice Year	2005

**Table J-2
Plant Size**

Gross Capacity (MW)	35.0
Parasitic Load (MW)	10.0
Net Capacity (MW)	25
Derate Factor (%)	100.0
Firm Capacity (MW)	25
Transmission Losses (%)	2.0
Required AS/reserves (%)	0
Average Hourly Output Rate (%)	100.0
Effective Load Carry Capacity (MW)	25
Annual Capacity Degradation Rate (%)	0

**Table J-3
Capital Costs**

Escalation in Capital Costs (%)	0
AFUDC Rate (%)	10.3
Cash Cost (%)	100

**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	\$3,360	\$2,585	\$321	\$0	\$0

**Table J-5
Fuel Use**

Heat Rate	N/A
Fuel Consumption/Hour (MMBtu/Hour)	0.0
Start-up Fuel Use (MMBtu/Start)	0.0
Number of Annual Starts	1
Annual Fuel Use (MMBtu)	0

**Table J-6
Operational Information**

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

**Table J-7
Renewable Tax Benefits**

Invest Tax Credit (%)	10
RETC Calculation (\$)	392
Production Incentive-Investor (¢/kWh)	0
Geothermal Depletion Allowance	
RE Production Incentive Tier I	0
RE Production Incentive Tier II	0
REPI Tier II Proportion Paid (%)	10

**Table J-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	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-year)	152
Fixed O&M/Instant Cost (%)	4.73
O&M Escalation (%)	0.5
Insurance (%)	1.5
Labor Escalation Cost (%)	0.5
Overhead Multiplier	2.0
Other Operating Costs	
Water Supply (\$/AF)	250,000
Consumption (AF/YR)	25,000
Water Supply Costs (\$/MWh)	
Plant Scheduling Costs	0
Transmission Service (\$/MW)	
Wheeling Charges (\$/kWh)	
Scheduler Costs	
Variable Operating Costs (\$/MWh)	0.00
Environmental Control Costs (\$/MWh)	
Variable O&M (\$/kW-year)	0

**Table J-10
Cost Summary**

Financing Costs (\$/kW-year)	442
Fixed Operational Costs (\$/kW-year)	257
Tax (w/Credits) (\$/kW-year)	(78)
Fixed Costs (\$/kW-year)	621
Fuel Costs (\$/kW-year)	8
Variable O&M (\$/kW-year)	0
Variable Costs (\$/kW-year)	8
Total Levelized Costs (\$/kW-year)	629
Capital (\$/MWh)	71.96
Variable (\$/MWh)	0.92
Total Levelized Costs (\$/MWh)	72.88
Capital Costs	
Instant Cost (\$/kW)	3,210
Installed Cost (\$/MWh)	3,618
In-service Cost in 2004 (\$/kW)	3,839

**Table J-11
Capital Cost Detail**

Total (\$)	80,255,463
Component Cost (\$)	79,700,000
Exploration costs (\$)	3,000,000
Wellfield Development (\$)	34,700,000
Plant Equipment (\$)	42,000,000
Financial Transaction Costs (\$)	0.0
Land Costs (\$)	555,463
Occupied Acreage	40
Total Project Area (Acres)	12000
BLM Pre-dev Lease Fee (\$)	44
Total Land "Cost Burden" (\$)	531,463
Land Prep Costs per Acre	600
Total Land Prep Costs (\$)	24,000
Permitting Costs (\$)	0
Building Permits (\$)	
Environmental Permits (\$)	
Environmental Permits (\$)	300,000
Transmission Lines (\$)	
Substation (\$)	
Environmental Controls (\$)	0
Installation Costs (\$)	0
Replacement Costs (\$)	

**Table J-12
Maintenance Cost Detail**

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

**Table J-13
Environmental Control Costs**

Total Annual Costs	50,000
Media & Technology	
Air Emissions	
Control Technology (eg SCR) (\$)	
Installation Cost (\$/kW)	0
Annual Labor (hours/year)	0
Loaded Labor Rate (\$/hour)	60
Labor Cost	0
Annual Consumables	0
Replacement Cost (\$/kW)	0
Component Life (hours)	0
Annualized Cost	
Water Discharge	
Control Technology (e.g., wastewater)	
Installation Cost (\$/kW)	0
Annual Labor (hours/year)	0
Loaded Labor Rate (\$/hour)	60
Labor Cost (\$)	0
Annual Consumables (\$)	0
Replacement Cost (\$/kW)	0
Component Life (hours)	0
Annualized Cost (\$)	
Solid Waste Disposal	
Non hazardous material	
Tons per Year	0
Collection and Hauling (\$/ton)	30
Landfill Tipping Fees (\$/ton)	0
Total Costs	0
Hazardous materials	
Tons per Year	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
Inservice Year	2005

**Table K-2
Plant Size**

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

**Table K-3
Capital Costs**

Escalation in Capital Costs (%)	0
AFUDC Rate (%)	10.3
Cash Cost (%)	100

**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	\$2,239	\$1,724	\$426	\$0	\$0

**Table K-5
Fuel Use**

Heat Rate	N/A
Fuel Consumption/Hour (MMBtu/Hr)	0.0
Start-up Fuel Use (MMBtu/Start)	0.0
Number of Annual Starts	1
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	8,409
Capacity Factor (%)	96
Annual Net Energy (GWh)	378

**Table K-7
Renewable Tax Benefits**

Invest Tax Credit (%)	10
RETC Calculation (\$)	261
Production Incentive-Investor (¢/kWh)	0
Geothermal Depletion Allowance	
RE Production Incentive Tier I	0
RE Production Incentive Tier II	0
REPI Tier II Proportion Paid (%)	10

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

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

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

Fixed O&M	60
Fixed O&M/Instant Cost (%)	2.81
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
Water Supply Costs (\$/MWh)	
Plant Scheduling Costs	
Transmission Service (\$/MW)	0
Wheeling Charges (\$/kWh)	
Scheduler Costs	
Variable Operating Costs (\$/MWh)	0.10
Environmental Control Costs (\$/MWh)	
Variable O&M (\$/kW-year)	1

**Table K-10
Cost Summary**

Financing Costs (\$/kW-year)	294
Fixed Operational Costs (\$/kW-year)	120
Tax (w/Credits) (\$/kW-year)	(45)
Fixed Costs (\$/kW-year)	369
Fuel Costs (\$/kW-year)	11
Variable O&M (\$/kW-year)	1
Variable Costs (\$/kW-year)	12
Total Levelized Costs (\$/kW-year)	381
Capital (\$/MWh)	43.91
Variable (\$/MWh)	1.40
Total Levelized Costs (\$/MWh)	45.31
Capital Costs	
Instant Cost (\$/kW)	2,128
Installed Cost (\$/MWh)	2,410
In-service Cost in 2004 (\$/kW)	2,558

**Table K-11
Capital Cost Detail**

Total (\$)	95,539,694
Component Cost (\$)	95,200,000
Exploration costs (\$)	3,000,000
Wellfield Development (\$)	32,200,000
Plant Equipment (\$)	60,000,000
Financial Transaction Costs (%)	0.0
Land Costs (\$)	339,694
Occupied Acreage	40
Total Project Area (Acres)	6000
Lease Fee per Acre (\$)	53
Total Land "Cost Burden" (\$)	315,694
Land Prep Costs per Acre (\$)	600
Total Land Prep Costs (\$)	24,000
Permitting Costs (\$)	0
Building permit (\$)	
Environmental Permits (\$)	
Environmental Permits (\$)	300,000
Transmission Lines (\$)	
Substation (\$)	
Environmental Controls (\$)	0
Installation Costs (\$)	0
Replacement Costs (\$)	

**Table K-12
Maintenance Cost Detail**

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

**Table K-13
Environmental Control Costs**

Total Annual Costs (\$)	174,000
Air Emissions	
Control Technology (e.g., SCR) (\$)	
Installation Cost (\$/kW)	0
Annual Labor (hours/year)	0
Loaded Labor Rate (\$/hour)	48
Labor Cost (\$)	0
Annual Consumables (\$)	0
Replacement Cost (\$/kW)	0
Component Life (hours)	0
Annualized Cost (\$)	
Water Discharge	
Control Technology (e.g., wastewater) (\$)	
Installation Cost (\$/kW)	0
Annual Labor (hours/year)	0
Loaded Labor Rate (\$/hour)	48
Labor Cost (\$)	0
Annual Consumables (\$)	0
Replacement Cost (\$/kW)	0
Component Life (hours)	0
Annualized Cost (\$)	
Solid Waste Disposal	
Non hazardous material	
Tons per Year	5,800
Collection and Hauling (\$/ton)	30
Landfill Tipping Fees (\$/ton)	0
Total Costs (\$)	174,000
Hazardous Materials	
Tons per Year	0
Collection and Hauling (\$/ton)	0
Landfill Tipping Fees (\$/ton)	30
Total Disposal Costs (\$)	0

APPENDIX L

HYDROPOWER

**Table L-1
Plant Info**

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

**Table L-2
Plant Size**

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

**Table L-3
Capital Costs**

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

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

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

**Table L-5
Fuel Use**

Heat Rate (MMBtu/kWh)	N/A
Fuel Consumption (MMBtu/hour)	0.0
Start-up Fuel Use (MMBtu/start)	0.0
Number of Annual Starts	0.0
Annual Fuel Use (MMBtu)	0.0

**Table L-6
Operational Information**

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

**Table L-7
Renewable Tax Benefits**

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

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

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

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

Fixed O&M (\$/kW-year)	10.0
Fixed O&M/Instant Cost (%)	0.90
O&M Escalation (%)	0.5
Insurance (%)	1.5
Labor Escalation Cost (%)	0.5
Overhead Multiplier	1.6
Other Operating Costs	
Water Supply (\$/AF)	
Consumption (AF/YR)	
Water Supply Costs (\$/MWh)	
Plant Scheduling Costs	
Transmission Service (\$/MW)	
Wheeling Charges (\$/kWh)	
Scheduler Costs	
Variable Operating Costs (\$/MWh)	
Environmental Control Costs (\$/MWh)	
Variable O&M (\$/kW-year)	

**Table L-10
Cost Summary**

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

**Table L-11
Capital Cost Detail**

Total (\$)	115,188,000
Component Cost (\$)	109,000,000
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
Financial Transaction Costs (%)	0
Land Costs (\$)	6,188,000
Acreage/Plant	1,400
Cost per Acre (\$)	1,420
Acquisition Cost (\$)	1,988,000
Land Prep Costs per Acre (\$)	3,000
Total Land Prep Costs (\$)	4,200,000
Permitting Costs (\$)	0
Local Building Permits (\$)	
Environmental Permits (\$)	
Interconnection Costs (\$)	0
Transmission Lines (\$)	0
Substation (\$)	0
Induction Equipment (\$)	
Environmental Controls (\$)	0
Installation Costs (\$)	0
Replacement Costs (\$)	

**Table L-12
Maintenance Detail**

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

**Table L-13
Environmental Control Costs**

Total Annual Costs (\$)	0
Air Emissions	
Control Technology (e.g. SCR) (\$)	
Installation Cost (\$/kW)	0
Annual Labor (hours/year)	0
Loaded Labor Rate (\$/hour)	48
Labor Cost (\$)	0
Annual Consumables-Catalyst (\$)	0
Replacement Cost (\$/kW)	0
Component Life (hours)	141,760
Annualized Cost (\$)	
Water Cooling	
Control Technology (e.g. wastewater) (\$)	
Installation Cost (\$/kW)	0
Annual Labor (hours/year)	0
Loaded Labor Rate (\$/hour)	48
Labor Cost (\$)	0
Annual Consumables (\$)	0
Replacement Cost (\$/kW)	0
Component Life (hours)	141,760
Annualized Cost (\$)	
Solid Waste Disposal	
Non hazardous material	
Tons per Year	0
Collection and Hauling (\$/ton)	10
Landfill Tipping Fees (\$/ton)	30
Total Costs (\$)	0
Hazardous materials	
Tons per Year	0
Collection and Hauling (\$/ton)	10
Landfill Tipping Fees (\$/ton)	30
Total Disposal Costs (\$)	0

Appendix M

Solar Photovoltaics

**Table M-1
Plant Information**

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

**Table M-2
Plant Size**

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

**Table M-3
Capital Costs**

Escalation in Capital Costs (%)	0
AFUDC Rate (%)	10.3
Cash Cost (%)	100

**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	\$6,653	\$0	\$0	\$0	\$0

**Table M-5
Fuel Use**

Heat Rate	N/A
Fuel Consumption/Hour (MMBtu/Hr)	0.0
Start-up Fuel Use (MMBtu/Start)	0.0
Number of Annual Starts	0.0
Annual Fuel Use (MMBtu)	0

**Table M-6
Operational Information**

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

**Table M-7
Renewable Tax Benefits**

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

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

Employee Category	Full Time Employee	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-year)	10
Fixed O&M/Instant Cost (%)	0.15
O&M Escalation (%)	0.5
Insurance (%)	1.5
Labor Escalation Cost (%)	0.5
Overhead Multiplier	1.6
Other Operating Costs	
Water Supply (\$/AF)	
Consumption (AF/YR)	
Water Supply Costs (\$/MWh)	
Plant Scheduling Costs	
Transmission Service (\$/MW)	
Wheeling Charges (\$/kWh)	
Scheduler Costs	
Variable Operating Costs (\$/MWh)	0
Environmental Control Costs (\$/MWh)	
Variable O&M (\$/kW-year)	0

**Table M-10
Cost Summary**

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

**Table M-11
Capital Cost Detail**

Total (\$)	332,630,100
Component Cost (\$)	330,000,000
PV Modules (\$)	225,000,000
Structures (\$)	25,000,000
Inverter (\$)	25,000,000
Installation (\$)	37,500,000
Engineering, Construction, Project Management (\$)	17,500,000
Financial Transaction Costs (%)	0.0
Land Cost (\$)	2,630,100
Acreage/Plant	250
Cost per Acre (\$)	3,100
Acquisition Cost (\$)	775,000
Land Prep Costs/Acre (\$)	7,420
Total Land Prep Costs (\$)	1,855,100
Permitting Costs (\$)	0
Local Building Permits (\$)	
Environmental Permits (\$)	
Interconnection Costs (\$)	0
Transmission Lines (\$)	
Substation (\$)	
Induction Equipment (\$)	
Environmental Controls (\$)	0
Installation Costs (\$)	0
Replacement Costs (\$)	

**Table M-12
Maintenance Cost Detail**

Routine Maintenance Costs		Annual Costs
Replacement Interval (hours)	1	
Filter Price (\$)	0	0
Maintenance Interval (hours)	1	
Price (\$)	0	0
Oil Price (\$/gallon)	3.40	
Oil Capacity	0	0
Oil Added per Day	0	0
Interval (hours)	1,000	
Item Price (\$)	0	0
Labor (hours/day)	0	
Labor Price (\$/hour)	48	0
Annual Routine Maintenance		0
Major Overhauls		
Hours to Major Overhaul	31,290	
Major Overhaul Labor (man-hours)	1,250	
Labor Cost (\$/hour)	48	
Major Overhaul Labor Cost (\$)	60,000	
Major Overhaul Replacement (\$)	0	1,499.73
NPV Cost (\$)		
Minor Overhauls		
Annual Cost Item 1 (\$)	0	
Hours to Item 1 Job	2,086	1
Annual Cost Item 2 (\$)	0	
Hours to Item 2 Job	0	7
Annualized Overhauls		0
Unscheduled Maintenance		
Forced Outage (hours/year)	8	
Labor Rate (\$/hour)	48	
Hours of Labor	8	
Parts Costs (\$)	1,000	
Total (\$)	1,384	
Total Annual Maintenance		2,884
Maintenance (\$/kW-year)	0.06	
Maintenance (\$/MWh)	0.03	

**Table M-13
Environmental Control Costs**

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

Appendix N

Solar Parabolic w/o Thermally Enhanced Storage or Gas

**Table N-1
Plant Information**

Technology Type	Solar
Fuel	None
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
AFUDC Rate (%)	10.3
Cash Cost (%)	100

**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	\$2,600	\$0	\$0	\$0	\$0

**Table N-5
Fuel Use**

Heat Rate - N/A	N/A
Fuel Consumption/Hour (MMBtu/hour)	0.0
Start-up Fuel Use (MMBtu/Start)	0.0
Number of Annual Starts	346.0
Annual Fuel Use (MMBtu)	0

**Table N-6
Operational Information**

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

**Table N-7
Renewable Tax Benefits**

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

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

Employee Category	Full Time Employee	Hours/Year	Compensation per Employee
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-year)	26
Fixed O&M/Instant Cost (%)	1.01
O&M Escalation (%)	0.5
Insurance (%)	1.
Labor Escalation Cost (%)	0.5
Overhead Multiplier	1.6
Other Operating Costs	
Water Supply (\$/AF)	
Consumption (AF/YR)	
Water Supply Costs (\$/MWh)	
Plant Scheduling Costs	
Transmission Service (\$/MW)	
Wheeling Charges (\$/kWh)	
Scheduler Costs	
Variable Operating Costs (\$/MWh)	7.41
Environmental Control Costs (\$/MWh)	
Variable O&M (\$/kW-year)	34

**Table N-10
Cost Summary**

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

**Table N-11
Capital Cost Detail**

Total (\$)	259,998,383
Component Cost (\$)	254,212,164
Structures & Improvements (\$)	2,720,813
Collector System (\$)	147,795,374
Thermal Storage System (\$)	0
Steam Gen or HX System (\$)	10,764,670
Auxiliary Heater/Boiler (\$)	0
Electric Power Generating System (\$)	47,651,991
Master Control System (\$)	0
Balance of Plant (\$)	27,706,701
Engineering, Construction, Project Management (\$)	17,572,616
Financing Arrangement Costs (%)	0.0
Land Cost (\$)	5,786,219
Acreage/MW	5
Acreage/Plant	550
Cost per Acre (\$)	3,100
Acquisition Cost (\$)	1,705,000
Land Prep Costs per Acre (\$)	7,420
Total Land Prep Costs (\$)	4,081,219
Permitting Costs (\$)	0
Local Building Permits (\$)	
Environmental Permits (\$)	
Interconnection Costs (\$)	0
Transmission Lines (\$)	0
Substation (\$)	0
Induction Equipment (\$)	
Environmental Controls (\$)	0
Installation Costs (\$)	0
Replacement Costs (\$)	

**Table N-12
Maintenance Cost Detail**

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

**Table N-13
Environmental Control Costs**

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

Appendix O

Solar Parabolic w/Gas Only

**Table O-1
Plant Information**

Technology Type	Solar
Fuel	Natural Gas
Owner/Investor	Merchant
Base Year	2002
Inservice Year	2003

**Table O-2
Plant Size**

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

**Table O-3
Capital Costs**

Escalation in Capital Costs (%)	0
AFUDC Rate (%)	10.3
Cash Cost (%)	100

**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	\$2,841	\$0	\$0	\$0	\$0

**Table O-5
Fuel Use**

Heat Rate (MMBtu/kWh)	2,480
Fuel Consumption (MMBtu/hour)	248
Start-up Fuel Use (MMBtu/start)	0
Number of Annual Starts	346
Annual Fuel Use (MMBtu)	1,520,240

**Table O-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	6,130
Capacity Factor (%)	42
Annual Net Energy (GWh)	368

**Table O-7
Renewable Tax Benefits**

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

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

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

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

Fixed O&M (\$/kW-year)	40
Fixed O&M/Instant Cost (%)	1.42
O&M Escalation (%)	0.5
Insurance (%)	1.5
Labor Escalation Cost (%)	0.5
Overhead Multiplier	1.6
Other Operating Costs	
Water Supply (\$/AF)	462
Consumption (AF/YR)	200
Water Supply Costs (\$)	92,214
Plant Scheduling Costs	
Transmission Service (\$/MW)	
Wheeling Charges (\$/kWh)	
Scheduler Costs	
Variable Operating Costs (\$/MWh)	6.00
Environmental Control Costs (\$/MWh)	
Variable O&M (\$/kW-year)	23

**Table O-10
Cost Summary**

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

**Table O-11
Capital Cost Detail**

Total (\$)	284,065,853
Component Cost (\$)	276,835,787
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
Electric Power Generation System (\$)	47,651,991
Master Control System (\$)	0
Balance of Plant (\$)	27,706,701
Engineering, Construction, Project Management (\$)	19,111,781
Financial Transaction Costs (%)	0.0
Land Cost (\$)	5,786,219
Acreage/MW	5
Acreage/Plant	550
Cost per Acre (\$)	3,100
Acquisition Cost (\$)	1,705,000
Land Prep Costs per Acre (\$)	7,420
Total Land Prep Costs (\$)	4,081,219
Permitting Costs (\$)	343,847
Environmental & Local Building Permits (\$)	0
Air emission offset costs (\$)	343,847
Interconnection Costs (\$)	0
Transmission Lines (\$)	0
Substation (\$)	0
Induction Equipment (\$)	
Environmental Controls (\$)	1,100,000
Installation Costs (\$)	1,100,000
Replacement Costs (\$)	

**Table O-12
Maintenance Cost Detail**

Routine Maintenance Costs		Annual Costs
Replacement Interval (hours)	1	
Filter Price (\$)	0	0
Maintenance Interval (hours)	1	
Price (\$)	0	0
Oil Price (\$/gallon)	3.40	
Oil Capacity	0	0
Oil Added per Day	0	0
Interval (hours)	1,000	
Item Price (\$)	0	0
Labor (hours/day)	0	
Labor Price (\$/hour)	48	0
Annual Routine Maintenance		0
Major Overhauls		
Hours to Major Overhaul	35,000	
Major Overhaul Labor (man-hours)	125	
Labor Cost (\$/hour)	48	
Major Overhaul Labor Cost (\$)	6,000	
Major Overhaul Replacement (\$)	0	
NPV Cost (\$)		1,015.72
Minor Overhauls		
Annual Cost Item 1 (\$)	925,019	
Hours to Item 1 Job	6,130	
Annual Cost Item 2 (\$)	0	
Hours to Item 2 Job	0	
Annualized Overhauls		1,184,298
Unscheduled Maintenance		
Forced Outage (hours/year)	200	
Labor Rate (\$/hour)	48	
Hours of Labor	200	
Parts Costs (\$)	0	
Total (\$)	9,600	
Total Annual Maintenance (\$)		1,194,913
Maintenance (\$/kW-year)	11.95	

**Table O-13
Environmental Control Costs**

Total Annual Costs (\$)	1,100,000
Air Emissions	
Control Technology (eg SCR) (\$)	1,100,000
Installation Cost (\$/kW)	10
Annual Labor (hours/year)	0
Loaded Labor Rate (\$/hour)	48
Labor Cost (\$)	0
Annual Consumables (\$)	0
Replacement Cost (\$/kW)	0
Component Life (hours)	141,760
Annualized Cost (\$)	
Water Discharge	
Control Technology (eg wastewater) (\$)	
Installation Cost (\$/kW)	0
Annual Labor (hours/year)	0
Loaded Labor Rate (\$/hour)	48
Labor Cost (\$)	0
Annual Consumables (\$)	0
Replacement Cost (\$/kW)	0
Component Life (hours)	141,760
Annualized Cost (\$)	
Solid Waste Disposal	
Non hazardous material	
Tons per Year	0
Collection and Hauling (\$/ton)	10
Landfill Tipping Fees (\$/ton)	30
Total Costs (\$)	0
Hazardous materials	
Tons per Year	0
Collection and Hauling (\$/ton)	10
Landfill Tipping Fees (\$/ton)	30
Total Disposal Costs (\$)	0

Appendix P

Solar Thermal – Stirling Dish

**Table P-1
Plant Information**

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

**Table P-2
Plant Size**

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

**Table P-3
Capital Costs**

Escalation in Capital Costs (%)	0
AFUDC Rate (%)	10.3
Cash Cost (%)	100

**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	\$3,270	\$0	\$0	\$0	\$0

**Table P-5
Fuel Use**

Heat Rate (MMBtu/kWh)	0
Fuel Consumption (MMBtu/hour)	0.0
Start-up Fuel Use (MMBtu/start)	0.0
Number of Annual Starts	0.0
Annual Fuel Use (MMBtu)	0

**Table P-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	3,184
Capacity Factor (%)	36.3
Annual Net Energy (GWh)	96

**Table P-7
Renewable Tax Benefits**

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

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

Employee Category	Full Time Employee	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 P-9
Operations & Maintenance Costs (Other)**

Fixed O&M (\$/kW – Yr)	48
Fixed O&M/Instant Cost (%)	1.48
O&M Escalation (%)	0.5
Insurance (%)	1.5
Labor Escalation Cost (%)	0.5
Overhead Multiplier	1.6
Other Operating Costs	
Water Supply (\$/AF)	
Consumption (AF/YR)	
Water Supply Costs (\$)	
Plant Scheduling Costs	
Transmission Service (\$/MW)	
Wheeling Charges (\$/kWh)	
Scheduler Costs	
Variable Operating Costs (\$/MWh)	
Environmental Control Costs (\$/MWh)	
Variable O&M (\$/kW-year)	

**Table P-10
Cost Summary**

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

**Table P-11
Capital Cost Detail**

Total (\$)	98,090,550
Component Cost (\$)	92,607,300
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
Financial Transaction Costs (%)	0.0
Land Cost (\$)	5,483,250
Acres/MW	5
Acreage/Plant	157.5
Cost per Acre (\$)	3,100
Acquisition Cost (\$)	488,250
Land Prep Costs per Acre (\$)	31,714
Total Land Prep Costs (\$)	4,995,000
Permitting Costs (\$)	0
Local Building Permits (\$)	
Environmental Permits (\$)	
Interconnection Costs (\$)	0
Transmission Lines (\$)	0
Substation (\$)	0
Induction Equipment (\$)	
Environmental Controls (\$)	0
Installation Costs (\$)	0
Replacement Costs (\$)	

**Table P-12
Maintenance Cost Detail**

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

**Table P13
Environmental Control Costs**

Total Annual Costs (\$)	0
Air Emissions	
Control Technology (eg SCR) (\$)	
Installation Cost (\$/kW)	0
Annual Labor (hours/year)	0
Loaded Labor Rate (\$/hour)	48
Labor Cost (\$)	0
Annual Consumables (\$)	0
Replacement Cost (\$/kW)	0
Component Life (hours)	141,760
Annualized Cost (\$)	
Water Discharge	
Control Technology (eg wastewater) (\$)	
Installation Cost (\$/kW)	0
Annual Labor (hours/year)	0
Loaded Labor Rate (\$/hour)	48
Labor Cost (\$)	0
Annual Consumables (\$)	0
Replacement Cost (\$/kW)	0
Component Life (hours)	141,760
Annualized Cost (\$)	
Solid Waste Disposal	
Non hazardous material	
Tons per Year	0
Collection and Hauling (\$/ton)	10
Landfill Tipping Fees (\$/ton)	30
Total Costs (\$)	0
Hazardous materials	
Tons per Year	0
Collection and Hauling (\$/ton)	10
Landfill Tipping Fees (\$/ton)	30
Total Disposal Costs (\$)	0

Appendix Q

Solar Parabolic w/Thermally Enhanced Storage Only

**Table Q-1
Plant Information**

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

**Table Q-2
Plant Size**

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

**Table Q-3
Capital Costs**

Escalation in Capital Costs (%)	0
AFUDC Rate (%)	10.3
Cash Cost (%)	100

**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	\$3,993	\$0	\$0	\$0	\$0

**Table Q-5
Fuel Use**

Heat Rate (MMBtu/kWh)	0
Fuel Consumption (MMBtu/hour)	0
Start-up Fuel Use (MMBtu/start)	0
Number of Annual Starts	346
Annual Fuel Use (MMBtu)	0

**Table Q-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	6,130
Capacity Factor (%)	42
Annual Net Energy (GWh)	368

**Table Q-7
Renewable Tax Benefits**

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

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

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

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

Fixed O&M (\$/kW – Yr)	29
Fixed O&M/Instant Cost (%)	0.74
O&M Escalation (%)	0.5
Insurance (%)	1.5
Labor Escalation Cost (%)	0.5
Overhead Multiplier	1.6
Other Operating Costs	
Water Supply (\$/AF)	
Consumption (AF/YR)	
Water Supply Costs (\$)	
Plant Scheduling Costs	
Transmission Service (\$/MW)	
Wheeling Charges (\$/kWh)	
Scheduler Costs	
Variable Operating Costs (\$/MWh)	17.41
Environmental Control Costs (\$/MWh)	
Variable O&M (\$/kW-year)	64

**Table Q-10
Cost Summary**

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

**Table Q-11
Capital Cost Detail**

Total (\$)	399,264,733
Component Cost (\$)	391,702,016
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
Financial Transaction Costs (\$)	0.0
Land Cost (\$)	7,562,716
Acreage/MW	7
Acreage/Plant	770
Cost per Acre (\$)	3,100
Acquisition Cost (\$)	2,387,000
Land Prep Costs per Acre (\$)	6,722
Total Land Prep Costs (\$)	5,175,716
Permitting Costs (\$)	0
Local Building Permits (\$)	
Environmental Permits (\$)	
Interconnection Costs (\$)	0
Transmission Lines (\$)	0
Substation (\$)	0
Induction Equipment (\$)	
Environmental Controls (\$)	0
Installation Costs (\$)	0
Replacement Costs (\$)	

**Table Q-12
Maintenance Cost Detail**

Routine Maintenance Costs		Annual Costs
Replacement Interval (hours)	1	
Filter Price (\$)	0	0
Maintenance Interval (hours)	1	
Price (\$)	0	0
Oil Price (\$/gallon)	3.40	
Oil Capacity	0	0
Oil Added per Day	0	0
Interval (hours)	1,000	
Item Price (\$)	0	0
Labor (hours/day)	0	
Labor Price (\$/hour)	48	0
Annual Routine Maintenance		0
Major Overhauls		
Hours to Major Overhaul:	35,000	
Major Overhaul Labor (man-hours)	125	
Labor Cost (\$/hour)	48	
Major Overhaul Labor Cost (\$)	6,000	
Major Overhaul Replacement (\$)	0	1,015.72
NPV Cost (\$)		
Minor Overhauls		
Annual Cost Item 1 (\$)	925,019	
Hours to Item 1 Job	6,130	1
Annual Cost Item 2 (\$)	0	
Hours to Item 2 Job	0	7
Annualized Overhauls		1,184,298
Unscheduled Maintenance		
Forced Outage (hours/year)	200	
Labor Rate (\$/hour)	48	
Hours of Labor	200	
Parts Costs (\$)	0	
Total (\$)	9,600	
Total Annual Maintenance		1,194,913
Maintenance (\$/kW-year)	11.95	

**Table Q-13
Environmental Control Costs**

Total Annual Costs (\$)	0
Media & Technology	Cost
Air Emissions	
Control Technology (e.g. SCR) (\$)	
Installation Cost (\$/kW)	0
Annual Labor (hours/year)	0
Loaded Labor Rate (\$/hour)	48
Labor Cost (\$)	0
Annual Consumables-Catalyst (\$)	0
Replacement Cost (\$/kW)	0
Component Life (hours)	141,760
Annualized Cost (\$)	
Water Cooling	
Control Technology (e.g. wastewater) (\$)	
Installation Cost (\$/kW)	0
Annual Labor (hours/year)	0
Loaded Labor Rate (\$/hour)	48
Labor Cost (\$)	0
Annual Consumables (\$)	0
Replacement Cost (\$/kW)	0
Component Life (hours)	141,760
Annualized Cost (\$)	
Solid Waste Disposal	
Non hazardous material	
Tons per Year	0
Collection and Hauling (\$/ton)	10
Landfill Tipping Fees (\$/ton)	30
Total Costs (\$)	0
Hazardous materials	
Tons per Year	0
Collection and Hauling (\$/ton)	10
Landfill Tipping Fees (\$/ton)	30
Total Disposal Costs (\$)	0

Appendix R

Wind Farm

**Table R-1
Plant Information**

Technology Type	Wind
Fuel	None
Owner/Investor	Merchant
Base Year	2001
Inservice Year	2004

**Table R-2
Plant Size**

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

**Table R-3
Capital Costs**

Escalation in Capital Costs (%)	0
AFUDC Rate (%)	10.3
Cash Cost (%)	100

**Table R-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	\$887	\$0	\$0	\$0	\$0

**Table R-5
Fuel Use**

Heat Rate (MMBtu/kWh)	0
Fuel Consumption (MMBtu/hour)	0.0
Start-up Fuel Use (MMBtu/start)	0.0
Number of Annual Starts	0.0
Annual Fuel Use (MMBtu)	0

**Table R-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	5,336
Capacity Factor (%)	40.2
Annual Net Energy (GWh)	352

**Table R-7
Renewable Tax Benefits**

Invest Tax Credit (%)	0
RETC Calculation (\$)	0
Production Incentive-Investor (¢/kWh)	1.9
Geothermal Depletion Allowance	N/A
RE Production Incentive Tier I	0
RE Production Incentive Tier II	0
REPI Tier II Proportion Paid (%)	10

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

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

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

Fixed O&M (\$/kW – Yr)	39
Fixed O&M/Instant Cost (%)	4.35
O&M Escalation (%)	0.5
Insurance (%)	1.5
Labor Escalation Cost (%)	0.5
Overhead Multiplier	1.6
Other Operating Costs	
Water Supply (\$/AF)	
Consumption (AF/YR)	
Water Supply Costs (\$)	
Plant Scheduling Costs	
Transmission Service (\$/MW)	0
Wheeling Charges (\$/kWh)	
Scheduler Costs	
Variable Operating Costs (\$/MWh)	
Environmental Control Costs (\$/MWh)	
Variable O&M (\$/kW-year)	0

**Table R-10
Cost Summary**

Financing Costs (\$/kW-year)	120
Fixed Operational Costs (\$/kW-year)	63
Tax (w/Credits) (\$/kW-year)	(20)
Fixed Costs (\$/kW-year)	163
Fuel Costs (\$/kW-year)	0
Variable O&M (\$/kW-year)	0
Variable Costs (\$/kW-year)	0
Total Levelized Costs (\$/kW-year)	163
Capital (\$/MWh)	46.25
Variable (\$/MWh)	0.00
Total Levelized Costs (\$/MWh)	46.25
Capital Costs	
Instant Cost (\$/kW)	887
Installed Cost (\$/MWh)	955
In-service Cost in 2004 (\$/kW)	994

**Table R-11
Capital Cost Detail**

Total (\$)	88,644,930
Development Costs (\$)	4,136,930
Predevelopment Expenses (\$)	3,621,775
Construction Insurance (\$)	444,550
Commitment Fee (\$)	70,605
Component Cost (\$)	82,902,000
68 ENRON 1.5MW Turbines (\$)	69,700,000
Foundations (\$)	5,202,000
Electrical Installation (\$)	2,040,000
Tower Installation (\$)	2,720,000
Engineering Consultancy (\$)	1,360,000
Control Rooms (Grouped) (\$)	700,000
Other Infrastructure & Service Center (\$)	1,180,000
Financial Transaction Costs (%)	0.0
Land Costs (\$)	1,606,000
Acreage/Plant	100
Cost/Acre (\$)	1,060
Acquisition Cost (\$)	106,000
Land Prep Costs per Acre (\$)	15,000
Total Land Prep Costs (\$)	1,500,000
Permitting Costs (\$)	0
Local Building Permits (\$)	
Environmental Permits (\$)	
Bird Kill Mitigation (\$)	
Interconnection Costs (\$)	0
Acreage/Plant	
Cost per Acre (\$)	
Acquisition Cost (\$)	

**Table R-12
Maintenance Cost Detail**

Routine Maintenance Costs		Annual Costs
Maintenance (\$)	1,260,430	1,260,430
Independent Engineer (\$/unit)	81,065	81,065
Electricity Usage (\$)	41,840	41,840
Transmission Serv (\$/unit)	156,000	156,000.00
Annual Routine Maintenance (\$)		1,539,335
Major Overhauls		
Hrs 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 (\$)		295,205.45
Minor Overhauls		
Hours to Minor Overhaul	40,000	
Labor Rate (\$/hour)	48	
Hours of Labor	1,250	
Parts Cost (\$)	0	
Annualized Overhauls (\$)		6,085
Unscheduled Maintenance		
Forced Outage (hours/year)	700	
Labor Rate (\$/hour)	48	
Hours of Labor	350	
Parts Costs (\$)	707,200	
Total (\$)	724,000	
Total Annual Maintenance (\$)		2,564,628
Maintenance (\$/kW-year)	25.67	
Maintenance (\$/MWh)	7.29	

**Table R-13
Environmental Control Costs**

Total Annual Costs (\$)	60
Media & Technology	
Air Emissions	
Control Technology (e.g. SCR) (\$)	
Installation Cost (\$/kW)	0
Annual Labor (hours/year)	0
Loaded Labor Rate (\$/hour)	48
Labor Cost (\$)	0
Annual Consumables-Catalyst (\$)	0
Replacement Cost (\$/kW)	0
Component Life (hours)	141,760
Annualized Cost (\$)	
Water Cooling	
Control Technology (e.g. wastewater) (\$)	
Installation Cost (\$/kW)	0
Annual Labor (hours/year)	0
Loaded Labor Rate (\$/hour)	48
Labor Cost (\$)	0
Annual Consumables (\$)	0
Replacement Cost (\$/kW)	20
Component Life (hours)	141,760
Annualized Cost (\$)	
Solid Waste Disposal	
Non hazardous material	
Tons per Year	1
Collection and Hauling (\$/ton)	0
Landfill Tipping Fees (\$/ton)	30
Total Costs (\$)	30
Hazardous materials	
Tons per Year	1
Collection and Hauling (\$/ton)	0
Landfill Tipping Fees (\$/ton)	30
Total Disposal Costs (\$)	30

Appendix S

Combined Cycle – Duct Firing

**Table S-1
Plant Information**

Technology Type	Natural Gas
Fuel	Natural Gas
Owner/Investor	Merchant
Base Year	2002
Inservice Year	2004
Utility Service Area	SoCal
Air Quality Management District	Kern County

**Table S-2
Plant Size**

Gross Capacity (MW)	520.0
Parasitic Load (MW)	0.0
Net Capacity (MW)	520.0
Derate Factor (%)	100.0
Firm Capacity (MW)	520.0
Transmission Losses (%)	5.0
Required AS/reserves (%)	7.0
Average Hourly Output Rate (%)	100.0
Effective Load Carry Capacity (MW)	459.0
Annual Capacity Degradation Rate (%)	0.15

**Table S-3
Capital Costs**

Escalation in Capital Costs (%)	0
AFUDC Rate (%)	10.3
Cash Cost (%)	100

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

	Years Out from On-Line Date				
	0	-1	-2	-3	-4
Cost (%/Year)	75%	20%	5%	0%	0%
Carry Over	\$539	\$134	\$27	\$0	\$0

**Table S-5
Fuel Use**

Heat Rate (MMBtu/kWh)	7,100
Fuel Consumption/Hour (MMBtu/hour)	3,550.0
Start-up Fuel Use (MMBtu/Start)	1,850.0
Number of Annual Starts	50
Duct Firing Heat Rate (Btu/kWh)	12,200
Added Capacity (MW)	20
Fuel Consumption/Hour (MMBtu/hour)	244
Duct Firing Hours/Year (hours)	400
Annual Fuel Use (MMBtu)	28,675,300

**Table S-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)	4,020

**Table S-7
Renewable Tax Benefits**

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

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

Employee Category	Full Time Employee	Hours/Year	Compensation per Employee
Managers (Weighted Avg.)	4	1,800	\$77,031 per year
Plant Operators	12	1,800	\$30 per hour
Mechanics	4	1,800	\$30 per hour
Laborers	2	1,800	\$20 per hour
Support Staff	3	1,800	\$20 per hour

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

Fixed O&M (\$/kW-year)	4.16
Fixed O&M/Instant Cost (%)	0.78
O&M Escalation (%)	0.5
Insurance (%)	1.5
Labor Escalation Cost (%)	0.5
Overhead Multiplier	1.6
Other Operating Costs	
Water Supply (\$/AF)	197
Consumption (AF/YR)	2,704
Water Supply Costs (\$)	0.13
Plant Scheduling Costs	
Transmission Service (\$/MW)	
Wheeling Charges (\$/kWh)	
Scheduler Costs	
Variable Operating Costs (\$/MWh)	1.21
Environmental Control Costs (\$/MWh)	0.70
Variable O&M (\$/kW-year)	2.04

**Table S-10
Cost Summary**

Financing Costs (\$/kW-year)	73
Fixed Operational Costs (\$/kW-year)	15
Tax (w/Credits) (\$/kW-year)	1
Fixed Costs (\$/kW-year)	89
Fuel Costs (\$/kW-year)	295
Variable O&M (\$/kW-year)	18.65
Variable Costs (\$/kW-year)	314
Total Levelized Costs (\$/kW-year)	403
Capital (\$/MWh)	11.57
Variable (\$/MWh)	40.63
Total Levelized Costs (\$/MWh)	52.19
Capital Costs	
Instant Cost (\$/kW)	531
Installed Cost (\$/MWh)	580
In-service Cost in 2004 (\$/kW)	604

**Table S-11
Capital Cost Detail**

Total (\$)	275,896,567
Component Cost (\$)	243,289,126
Turbine/Engine [Not itemized] (\$)	234,597,182
Generator/Gearhead (\$)	
Boiler/HRSG (\$)	
Fuel Pipeline/Tank (\$)	
Slab & Engine Mount (\$)	
Miscellaneous fitting & hoses (\$)	4,691,944
Office space (\$)	
Control Room(\$)	
Duct Burners (\$)	4,000,000
Financial Transaction Costs (%)	0
Land Costs (\$)	1,477,941
Acreage/Plant	15
Cost per Acre (\$)	100,000
Acquisition Cost (\$)	1,470,588
Land Prep Costs (\$/Acre)	500
Total Land Prep Costs (\$)	7,353
Permitting Costs (\$)	5,129,500
Local Building Permits (\$)	
Environmental Permits (\$)	
Air Emission Permits (\$)	5,129,500
Interconnection Costs (\$)	0
Transmission Lines (\$)	
Substation (\$)	
Induction Equipment (\$)	
Environmental Controls (\$)	26,000,000
Installation Costs (\$)	26,000,000
Replacement Costs (\$)	

**Table S-12
Maintenance Cost Detail**

Routine Maintenance Costs		Annual Costs
Replacement Interval (hours)	8,024	
Replacement Parts (\$/unit)	400,000	400,000
Maintenance Interval (hours)	8,024	
Materials/Supplies (\$/unit)	400,000	400,000
Interval (hours)	1,000	
Item Price (\$/unit)	0.00	0.00
Labor hours/day	0.00	
Labor price (\$/hour)	48.00	0.00
Annual Routine Maintenance		800,000
Major Overhauls		
Hours to Major Overhaul	20,000	
Major Overhaul Labor (man-hours)	18,000	
Labor Cost (\$/hour)	96.00	
Major Overhaul Labor Cost (\$)	1,728,000	
Major Overhaul Replacement (\$)	3,272,000	
NPV Cost (\$)		2,250,104
Minor Overhauls		
Annual Cost Item 1	1,200,000	
Hours to Item 1 Job	8,024	
Annual Cost Item 2	\$0	
Hours to Item 2 Job	0	
Annualized PV Overhauls		1,401,939
Unscheduled Maintenance		
Forced Outage (hours/year)	400	
Labor Rate (\$/hour)	48	
Hours of Labor	400	
Parts Costs (\$)	374,400	
Total (\$)	393,600	
Total Annual Maintenance		4,845,644
Maintenance (\$/kW-year)	9.32	
Maintenance (\$/MWh)	1.21	

**Table S-13
Environmental Control Costs**

Total Annual Costs (\$)	2,825,480
Air Emissions	
Control Technology (e.g., SCR) (\$)	15,600,000
Installation Cost (\$/kW)	30
Annual Labor (hours/year)	100
Loaded Labor Rate (\$/hour)	48
Labor Cost (\$)	4,800
Annual Consumables-Catalyst (\$)	333,333
Replacement Cost (\$/kW)	20
Component Life (hours)	141,760
Annualized Replacement Cost (\$)	1,069,573
Water Cooling	
Control Technology (e.g., wastewater) (\$)	10,400,000
Installation Cost (\$/kW)	20
Annual Labor (hours/year)	1000
Loaded Labor Rate (\$/hour)	48
Labor Cost (\$)	48,000
Annual Consumables (\$)	300,000
Replacement Cost (\$/kW)	20
Component Life (hours)	141,760
Annualized Cost (\$)	1,069,573
Solid Waste Disposal	
Non hazardous material	
Tons per Year	1
Collection and Hauling (\$/ton)	10
Landfill Tipping Fees (\$/ton)	30
Total Costs (\$)	40
Hazardous materials	
Tons per Year	1
Collection and Hauling (\$/ton)	60
Landfill Tipping Fees (\$/ton)	100
Total Disposal Costs (\$)	160