Cost of Generation Workshop: Natural Gas Technologies

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Gas-Fired Plants Costs Survey

- Previous Survey Completed in 2006 for 2007 IEPR
- Types of Plants Surveyed
  - CEC Jurisdictional
    - Simple Cycle
    - Combined Cycle (not Cogeneration)
  - Information Requested
    - Capital Costs (new plants since 2006 survey)
    - Operating Costs (plants ≥1 calendar year operation)

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Survey Sample Pool

- Total Projects – 47 (~16,900 MW)
- Total Project Owners - 29
- Total Simple Cycle (SC) Projects – 22 (~2,900 MW)
- Total Combined Cycle (CC) Projects – 25 (~14,000 MW)
- Total Merchant Projects – 30 (14 CC, 16 SC)
- Total IOU Projects – 4 (all CC)
- Total Muni Projects – 13 (7 CC, 6 SC)
- Operating Cost Requests SC/CC – 19 / 24
- Capital Cost Requests SC/CC – 8 / 6

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Capital Cost Requests

- Parameters Requested
  - Total Cost
  - Gas Turbine/Combustor Make/Model/Cost
  - Steam Turbine Make/Model/Cost (where applicable)
  - Inlet Air Treatment Type/Cost
  - Cooling Equipment Type/Cost
  - Water Treatment Cost/ZLD (Y/N)
  - Site Footprint/Land Cost
  - Total Construction Costs
    - Site Preparation Costs
    - Linear Connection Costs (Gas/Transmission/Water/Sewer)
    - Licensing/Permitting Costs
    - Air Pollution Control and Offsets Costs

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Capital Cost Survey Form

Power Plant Project (XX-AFC-1XX As-Built Information Request			Confidential ☒[1]
#	As-Built Capital Cost Information Request Parameter		
1	Gas Turbine Make/Models	Gas Turbine 1 Make/Model 7FA	
2	Combustor Make/Model	Turbine 1 Combustor Make/Model _____	
3	Steam Turbine/Generator Make/Model	Steam Turbine/Generator 1 Make/Model _____	
4	Total Capital Cost of Facility	$ MM _____ ($ MM = Millions of Dollars) Total capital cost value basis for the costs presented above and below: 1) Instant or overnight costs ☐ or Installed of final costs ☐ 2) Costs are provided ☐ with sales & use tax or ☐ without sales & use tax included Year basis for capital costs provided above and below -_20__	☐
	Capital Cost Details		
5	Gas Turbine/Generator Cost (installed cost each)	$ MM _____ ;If not installed cost please list basis _____	☐
6	Steam Turbine/Generator Cost (installed cost each)	$ MM _____ ;If not installed cost please list basis _____ _____	☐
7	Inlet Air Treatment (not filtering - installed cost)	Inlet Air Treatment (Y/N?) Y Type Evaporative Inlet Air Coolers Cost $ MM _____ If not installed cost please list basis _____	☐
8	Cooling Equipment Cost (installed cost)	$ MM _____ ;If not installed cost please list basis _____	☐
9	Water Treatment Facilities (installed cost)	$ MM _____ ZLD System (Y/N?) N ;If not installed cost please list basis _____	☐
10	Site Footprint and Land Cost	Acres ---_____ $ MM _____	☐
11	Total Construction Costs (Labor/Equipment/etc.)	$ MM _____	☐
12	Cost of Site Preparation	Site Grading/Earthmoving/Compaction$ MM _____ Soil Remediation $ MM _____	☐
13	Cost of Linear Connection Construction	Natural Gas $ MM _____ Transmission $ MM _____ Water $ MM _____ Sewer $ MM _____	☐
14	Cost of Licensing/Permitting Project	$ MM _____ (not including emissions offset costs requested below)	☐
15	Air Pollution Control Costs	SCR $ MM _____ Oxidation Catalyst $ MM _____	☐
16	Cost of Emission Reduction Credits (ERCs) or other Offsets	NOx $ MM _____ ___ PM10 $ MM _____ VOC $ MM _____ SOx $ MM _____ CO $ MM _____	☐
17	**Contact Person for Follow-up Questions**	**Name** _____ **Phone Number** _____	

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Operating Cost Requests

- Parameters Requested
  - Annual Cost (years 2006 – 2011 as applicable)
  - Operating Hours/Start & Stop Hours/# Starts
  - Duct Burner Fuel Use (as applicable)
  - Annualized Gas Price
  - Water Consumption/Cost
  - Staffing Personnel/Cost
  - Ongoing Costs (consumables, equipment, etc.)
  - Maintenance Costs
  - Fixed versus Variable Cost Definition

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Operating Cost Survey Form

Power Plant (XX-AFC-XX) As-Operating Information Request			Confidential ☒[1]
#	Operating Cost Information Request Parameter		
1	Total Annual Operating Costs (Cost should be inclusive of fuel and all other operating costs)	2006 - $ MM_____ 2007 - $ MM_____ 2008 - $ MM_____ 2009 - $ MM_____ 2010 - $ MM_____ 2011 - $ MM_____ Total operating cost value basis: 1) Costs are provided ☐ with sales and use tax or ☐ without sales and use tax included	☐
2	Operating hours and Startups/Shutdowns Hours (average considering number of turbines at site)	2006 – Operating Hours _____ Startup/shutdown hours _____No. of Startups _____ 2007 – Operating Hours _____ Startup/shutdown hours _____No. of Startups _____ 2008 – Operating Hours _____ Startup/shutdown hours _____No. of Startups _____ 2009 – Operating Hours _____ Startup/shutdown hours _____No. of Startups _____ 2010 – Operating Hours _____ Startup/shutdown hours _____No. of Startups _____ 2011 – Operating Hours _____ Startup/shutdown hours _____No. of Startups _____	
3	Natural Gas – Sources of Fuel.	Utility Supplier PG&E ☐ SoCalGas ☐ SDG&E ☐ Other secondary sources (describe) _____	
4	Duct Burner Natural Gas Usage (MMCuft)	Duct Burner Fuel Use 2006 _____ 2007 _____ 2008 _____2009 _____ 2010 _____ 2011 _____ Duct Burner Hours of Operation 2006 _____ 2007 _____ 2008 _____2009 _____ 2010 _____ 2011 _____	
5	Natural Gas Average Annual Price ($/MMBtu)	Utility Gas - 2006 _____2007 _____2008 _____2009 _____2010 _____2011 _____ Other source - 2006 _____2007 _____2008 _____2009 _____2010 _____2011 _____	☐
6	Water Supply Source/Cost/Consumption (2011)	Average Cost $ _____/acre-ft, Consumption _____ acre-ft	☐
7	Staffing (average annual cost – 2011 dollars) (please provide staffing in full time equivalents)	Managers ____#, Operators ____#, Mechanics ____#, Laborers ____#, Support Staff ____#, Other ____# Total Payroll _____ $/yr	☐
8	Ongoing Operating Costs (average annual cost – 2011 dollars)	Consumables Costs (Chemicals, etc) _____ $/yr, Equipment acquisition and leasing costs _____ $/yr, Regulatory Filings, etc. _____ $/yr, Ongoing Emissions Offsets Costs . _____ Other Direct Costs _____ $/yr	☐
9	Estimate of Actual Annual Maintenance Costs (2011 dollars)	Normal Annualized Maintenance Costs $ _____ (include major overhauls) Major Overhaul Frequency _____ yrs, last year of occurrence 20__, cost of last major overhaul $ MM ____	☐
10	Fixed versus Variable O&M Costs Definition	For non-fuel costs please list the items considered as fixed cost versus variable O&M cost (please attached separate sheet if needed) Fixed O&M Costs _____ _____ Variable O&M Costs _____ _____	☐
11	**Contact Person for Follow-up Questions**	**Name** _____ **Phone Number** _____	

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Survey Response Rate

- Total Projects – 85%
  - Total Project Owners – 81%
  - Total Merchant Projects – 90%
  - Total IOU Projects – 100%
  - Total Muni Projects – 69%
  - Total Simple Cycle (SC) Projects – 91%
  - Total Combined Cycle (CC) Projects – 80%
  - Total Capital Cost (SC/CC) – 75% / 83%
  - Total Operating Cost (SC/CC) – 89% / 79%
- 2007 COG Response Rate – 100%

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Raw Data Analysis

- Data completion adequate for COG purposes
- Total cost data appears to have no major flaws
- Certain minor data, such as duct firing fuel use, was found to have significant issues.
- Overall – data adequate for COG model use

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Gas-fired Plant Costs: QFER

- 2002-2011 QFER data used to derive weighted average heat rate & capacity factor estimates
- Differs from *Thermal Efficiency of Gas-Fired Generation* for two reasons
  - COG estimate drops the (partial) first year of operations
  - COG estimate uses planned rather than actual capacity
    - Planned capacity is what is used for planning purposes

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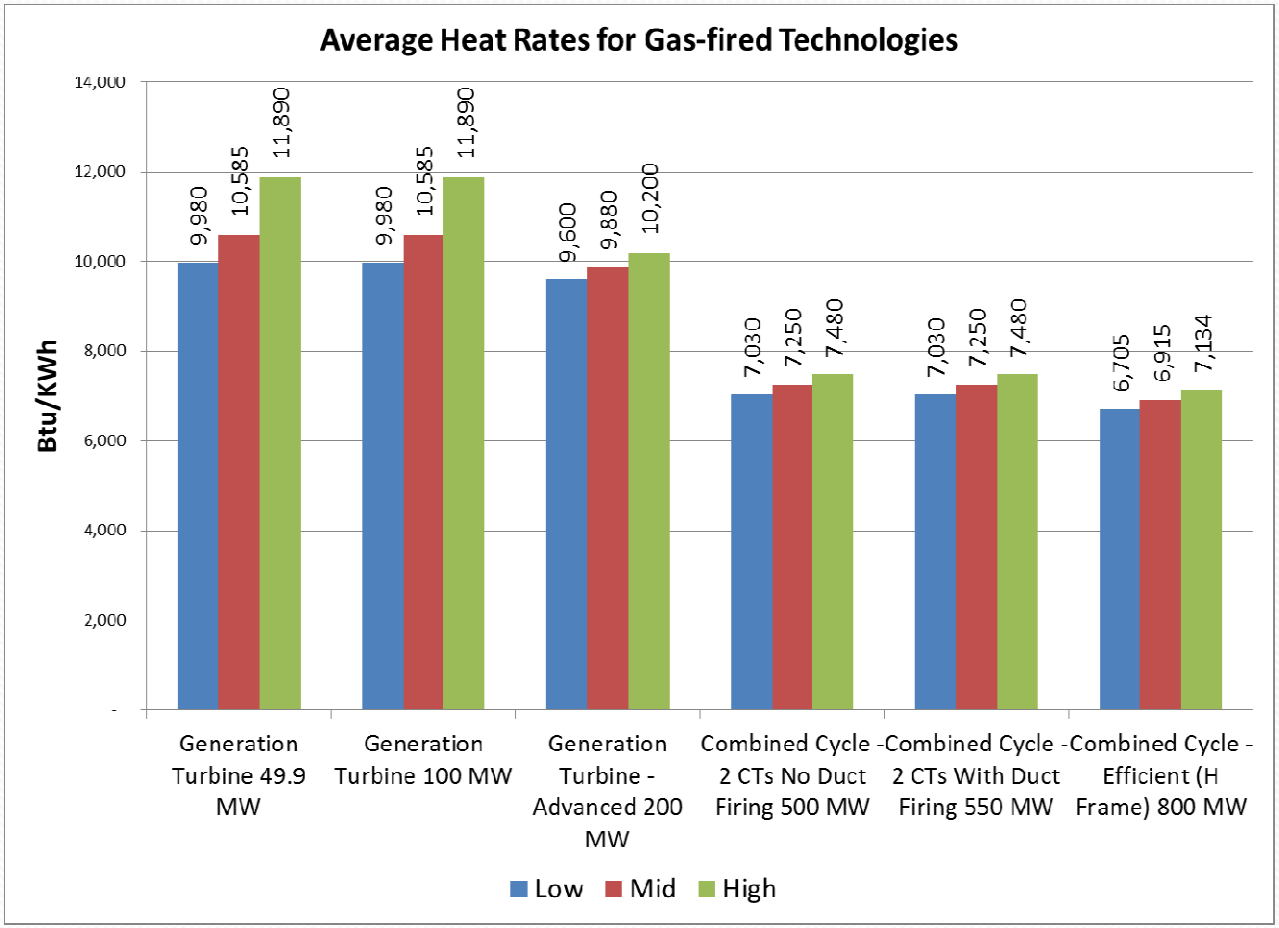
Gas-fired Plant Costs: Heat Rates



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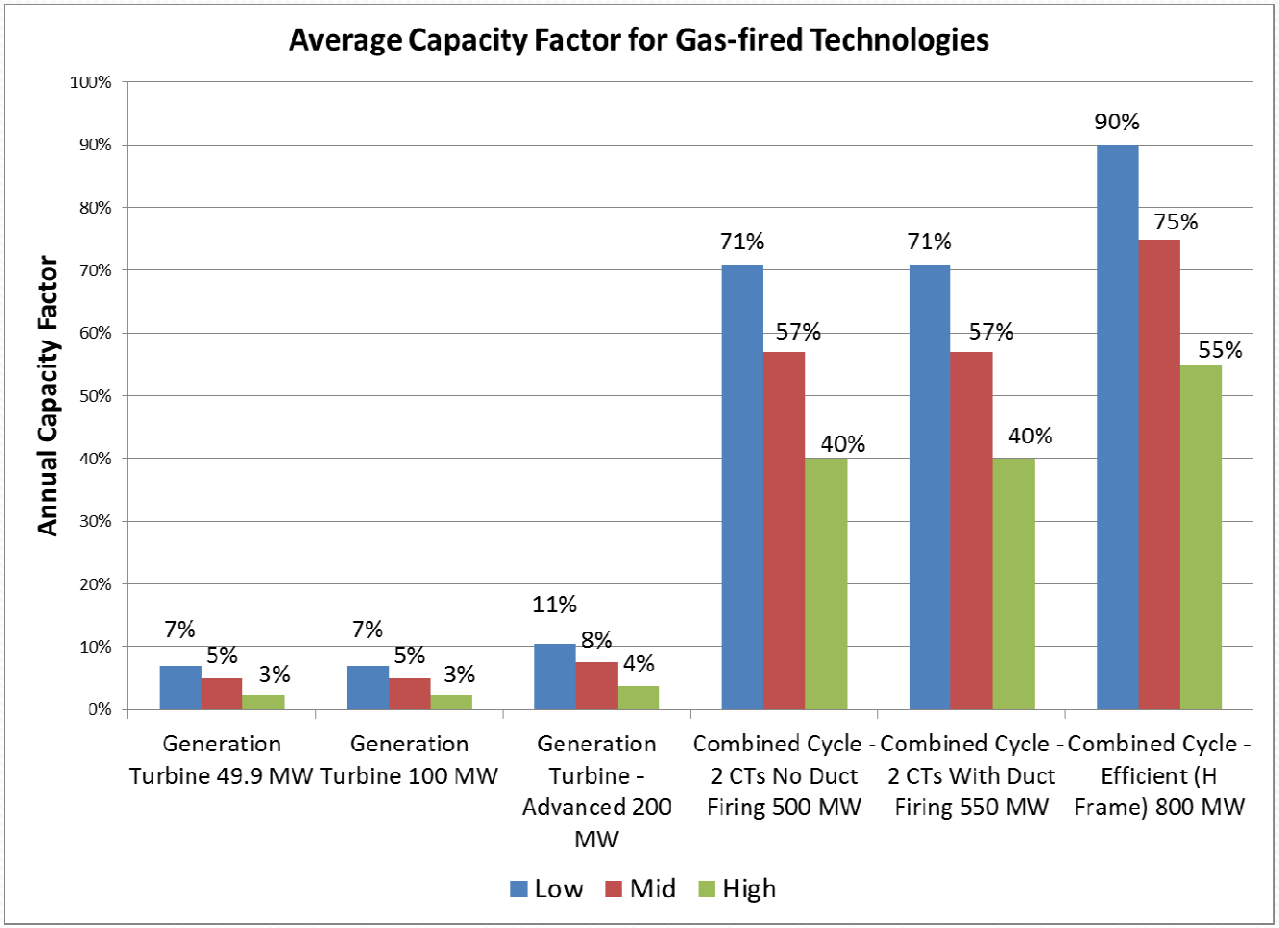
Gas-fired Plant Costs: Capacity Factors



Summary of Gas Plant Factors Survey Averages

Technology - Plant Costs Start Year = 2013 (2013 Dollars)	Gross Capacity (MW)	Instant Costs ($/kW)	Fixed O&M ($/kW-Yr)	Variable O&M ($/MWh)
Generation Turbine 49.9 MW	49.9	1,609	28.39	0.00
Generation Turbine 100 MW	100	1,569	27.44	0.00
Generation Turbine - Advanced 200 MW	200	1,151	25.24	0.00
Combined Cycle - 2 CTs No Duct Firing 500 MW	500	1,257	34.56	0.61
Combined Cycle - 2 CTs With Duct Firing 550 MW	550	1,264	34.56	0.61

Technology Input Parameters	Gross Capacity (MW)	Capacity Factor	Heat Rate (Btu/kWh)	Degradation (%/Year)		CO2 Emissions (Lbs/MWh)
				Capacity	Heat Rate	
Generation Turbine 49.9 MW	50	7.50%	10,585	0.05%	0.05%	1239.3
Generation Turbine 100 MW	100	7.50%	10,585	0.05%	0.05%	1239.3
Generation Turbine - Advanced 200 MW	200	11.25%	9,880	0.05%	0.05%	1156.8
Combined Cycle - 2 CTs No Duct Firing 500 MW	500	57.00%	7,250	0.24%	0.24%	848.8
Combined Cycle - 2 CTs With Duct Firing 550 MW	550	57.00%	7,250	0.24%	0.24%	848.8

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Summary of Gas Plant Factors
High Cost Case

Technology - Plant Costs Start Year = 2013 (2013 Dollars)	Gross Capacity (MW)	Instant Costs ($/kW)	Fixed O&M ($/kW-Yr)	Variable O&M ($/MWh)
Generation Turbine 49.9 MW	49.9	2,255	75.16	0.00
Generation Turbine 100 MW	100	2,144	73.55	0.00
Generation Turbine - Advanced 200 MW	200	1,690	69.90	0.00
Combined Cycle - 2 CTs No Duct Firing 500 MW	500	1,441	82.42	1.89
Combined Cycle - 2 CTs With Duct Firing 550 MW	550	1,454	82.42	1.89

Technology Input Parameters	Gross Capacity (MW)	Capacity Factor	Heat Rate (Btu/kWh)	Degradation (%/Year)		CO2 Emissions (Lbs/MWh)
				Capacity	Heat Rate	
Generation Turbine 49.9 MW	50	4.00%	11,890	0.05%	0.20%	1392.1
Generation Turbine 100 MW	100	4.00%	11,890	0.05%	0.20%	1392.1
Generation Turbine - Advanced 200 MW	200	6.00%	10,200	0.05%	0.20%	1194.2
Combined Cycle - 2 CTs No Duct Firing 500 MW	500	40.00%	7,480	0.24%	0.20%	875.8
Combined Cycle - 2 CTs With Duct Firing 550 MW	550	40.00%	7,480	0.24%	0.20%	875.8

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Summary of Gas Plant Factors Low Cost Case

Technology - Plant Costs Start Year = 2013 (2013 Dollars)	Gross Capacity (MW)	Instant Costs ($/kW)	Fixed O&M ($/kW-Yr)	Variable O&M ($/MWh)
Generation Turbine 49.9 MW	49.9	1,141	9.98	0.00
Generation Turbine 100 MW	100	1,132	9.66	0.00
Generation Turbine - Advanced 200 MW	200	728	8.93	0.00
Combined Cycle - 2 CTs No Duct Firing 500 MW	500	1,055	13.79	0.19
Combined Cycle - 2 CTs With Duct Firing 550 MW	550	1,054	13.79	0.19

Technology Input Parameters	Gross Capacity (MW)	Capacity Factor	Heat Rate (Btu/kWh)	Degradation (%/Year)		CO2 Emissions (Lbs/MWh)
				Capacity	Heat Rate	
Generation Turbine 49.9 MW	50	14.00%	9,980	0.05%	0.05%	1168.5
Generation Turbine 100 MW	100	14.00%	9,980	0.05%	0.05%	1168.5
Generation Turbine - Advanced 200 MW	200	21.00%	9,600	0.05%	0.05%	1124.0
Combined Cycle - 2 CTs No Duct Firing 500 MW	500	71.00%	7,030	0.24%	0.20%	823.1
Combined Cycle - 2 CTs With Duct Firing 550 MW	550	71.00%	7,030	0.24%	0.20%	823.1

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