



COMPARATIVE COSTS OF CALIFORNIA CENTRAL STATION ELECTRICITY GENERATION TECHNOLOGIES (COST OF GENERATION MODEL)

**ISO Stakeholders Meeting
Interim Capacity Procurement Mechanism**

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Date: October 15, 2007



TODAY

- Overview of the Cost of Generation Model.
- Summary of Levelized Costs – Output.
 - Has not yet received final approval.
- Summary of Assumptions – Input.
- Data Collection, Processing & Results.



FIRST ITEM

- Overview of the Cost of Generation Model.
- Summary of Levelized Costs - Output.
- Review the Assumptions – Input.
- Data Collection , Processing & Results.



OVERVIEW OF MODEL

- Cost of Generation (COG) models.
 - What do they do?
 - Who uses them?
- CEC Model Structure.
- Model Demonstration.



WHAT DO THEY DO?

- Estimate the levelized cost of a technology.
- Compare cost of one technology to another – commonly misused.
- CEC Model also generates:
 - Annual Costs.
 - Screening Curves.
 - Sensitivity Curves.
 - Wholesale Electricity Prices.



WHO USES THEM?

- **Within the Energy Commission**
 - Scenario & Portfolio Projects of the IEPR.
 - Retail Electricity Prices.
 - Technology summaries (Renewables Energy Office).
 - Transmission studies (Engineering Office).
 - Title 24: Value of conservation measures (Buildings and Appliances Office).
- **Outside the Energy Commission**
 - Requests from Legislature.
 - Board of Equalization (Property Taxes).
 - CPUC – Provide Modeling, Model Evaluation Or Data:
 - Computation of the Market Price Referent (MPR).
 - Computation of Qualifying Facilities (QF) Payments.
 - Valuing IOU Conservation Programs.
 - Requests from consultants and graduate students.



INPUTS

Plant Characteristics

- Capacity (MW)
- Capacity Factor
- Forced Outage Rate
- Scheduled Outage Rate
- Heat Rate (if applicable)
- Heat Rate & Capacity Degradation

Deflator Series

- Fuel Prices (\$/MMBtu)

- Instant Cost (\$/kW)
- Installed Cost (\$/kW)

Fixed O&M (\$/kW -Yr)

Variable O&M (\$/MW h)

General Assumptions

(Merchant, Muni & IOU)

- Insurance
- Ad Valorem
- State & Federal Taxes
- O&M Escalation
- Labor Escalation

Financial Assumptions

(Merchant, Muni & IOU)

- % Debt
- Cost of Debt (%)
- Cost of Equity (%)
- Loan/Debt Term (Years)
- Book Life (Years)
- Federal Tax Life (Years)
- State Tax Life (Years)

COST OF GENERATION MODEL

OUTPUTS

Levelized Fixed Costs

(\$/kW -Yr & \$/MW h)

- Capital & Financing
- Insurance
- Ad Valorem
- Fixed O&M
- Corporate Taxes

Levelized Variable Costs

(\$/kW -Yr & \$/MW h)

- Fuel
- Variable O&M

Total Levelized Costs

(\$/kW -Yr & \$/MW h)

- Levelized Fixed Costs
- Levelized Variable Costs

Annual Costs

(\$/MW h)

- Fixed Cost
- Variable Cost
- Total Cost

Screening Curves

(\$/kW -Yr & \$/MW h)

- Fixed Cost
- Variable Cost
- Total Cost

Sensitivity Curves

(%)

- Fuel Price
- Capacity Factor
- Installed Cost
- Discount Rate
- Cost of Equity
- Cost of Dept

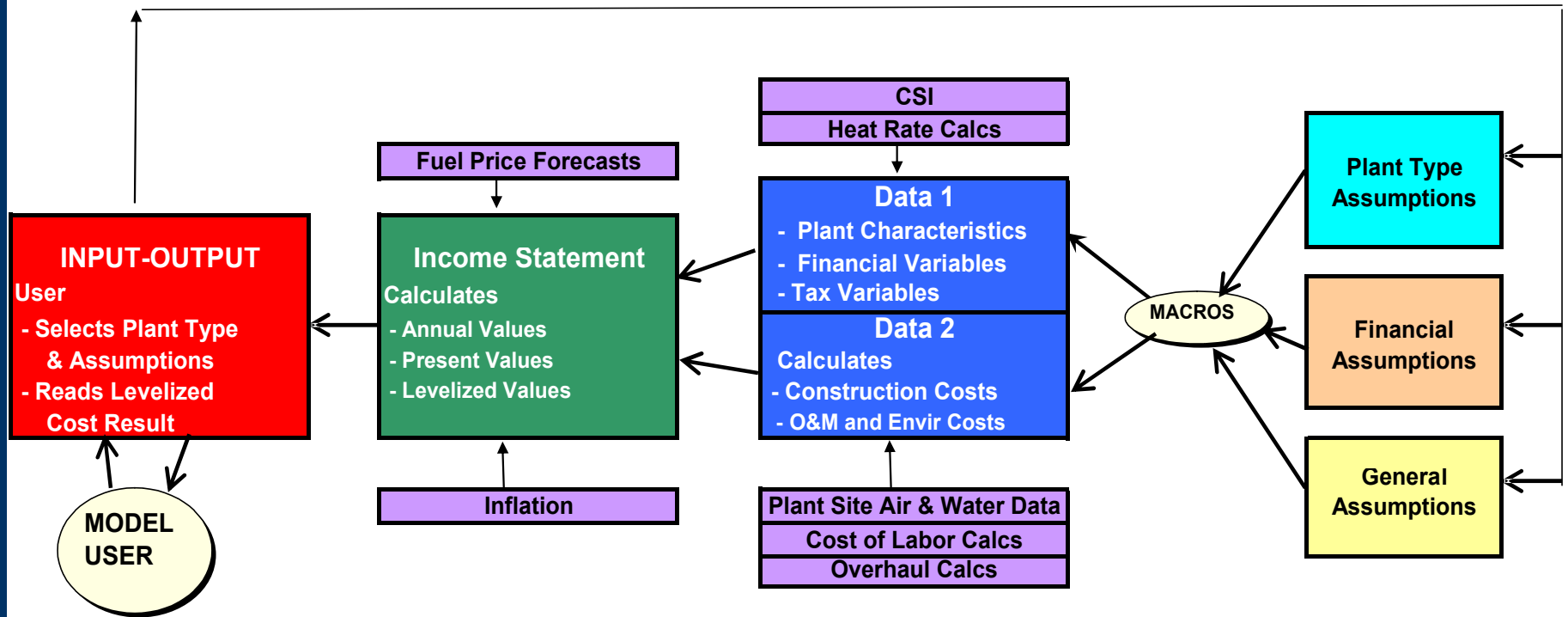
Wholesale Electricity Prices

(\$/MW h)

- Fixed Cost
- Variable Cost - Marketsym
- Total Cost



CEC MODEL STRUCTURE





INPUT SELECTION

Plant Type Assumptions (Select)	Combustion Turbine - 50 MW
Financial (Ownership) Assumptions (Select)	Merchant Gas-Fired
Ownership Type For Scenarios	Merchant
General Assumptions (Select)	Default
Base Year (All Costs In 2005 Dollars)	2005
Fuel Type	Natural Gas
<i>Data Source</i>	<i>CEC 2007 IEPR Survey (Will Walters, Aspen)</i>
Start (Inservice) Year (Enter)	2007
Fuel Price Forecast (Select)	CA - Avg.
Plant Site Region (Air & Water) (Select)	CA - Avg.
Study Perspective (Select)	At Load Center
Reported Construction Cost Basis (Select)	Installed
Turbine Configuration (Select)	2



OUTPUT RESULTS

Merchant Plant

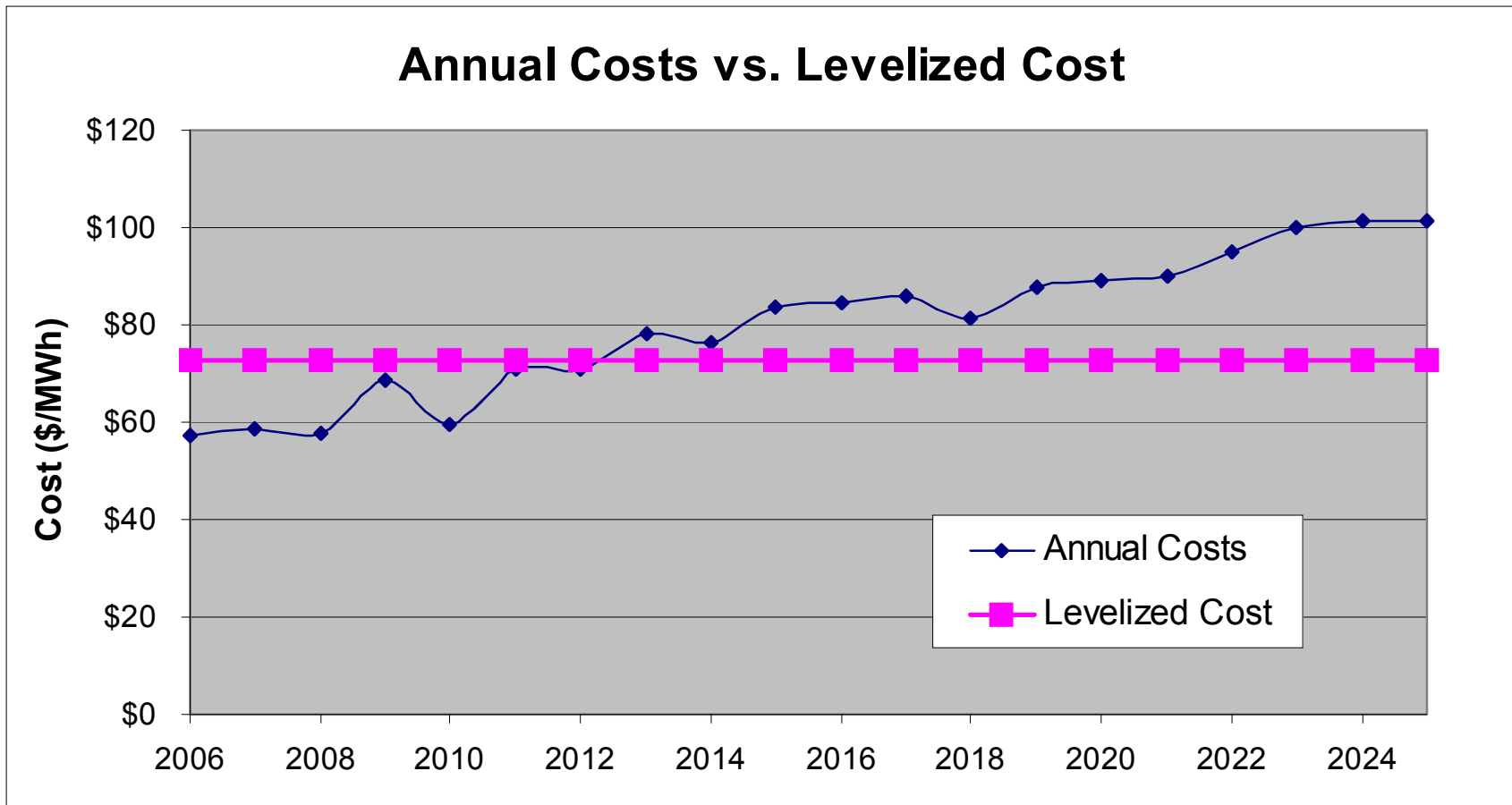
SUMMARY OF LEVELIZED COSTS

Combustion Turbine - 50 MW

Start Year = 2007 (2007 Dollars)	\$/kW-Yr	\$/MWh
Capital & Financing - Construction	\$145.30	\$347.88
Insurance	\$9.25	\$22.15
Ad Valorem Costs	\$7.25	\$17.35
Fixed O&M Costs	\$20.36	\$48.75
Corporate Taxes (w/Credits)	\$41.85	\$100.20
Fixed Costs	\$224.01	\$536.33
Fuel Costs	\$33.27	\$79.66
Variable O&M	\$13.07	\$31.29
Variable Costs	\$46.34	\$110.96
Total Levelized Costs	\$270.36	\$647.28



WHAT IS LEVELIZED COST?





MODEL DEMONSTRATION



NEXT ITEM

- Overview of the Cost of Generation Model.
- Summary of Levelized Costs – Output (Not Yet Approved).
 - Overview Including Fixed and Variable Costs
 - Focus on CT Fixed Costs in \$/kW-Yr
 - Comparison to 2003 IEPR
- Review the Assumptions – Input.
- Data Collection ,Processing & Results.



LEVELIZED COST ESTIMATES

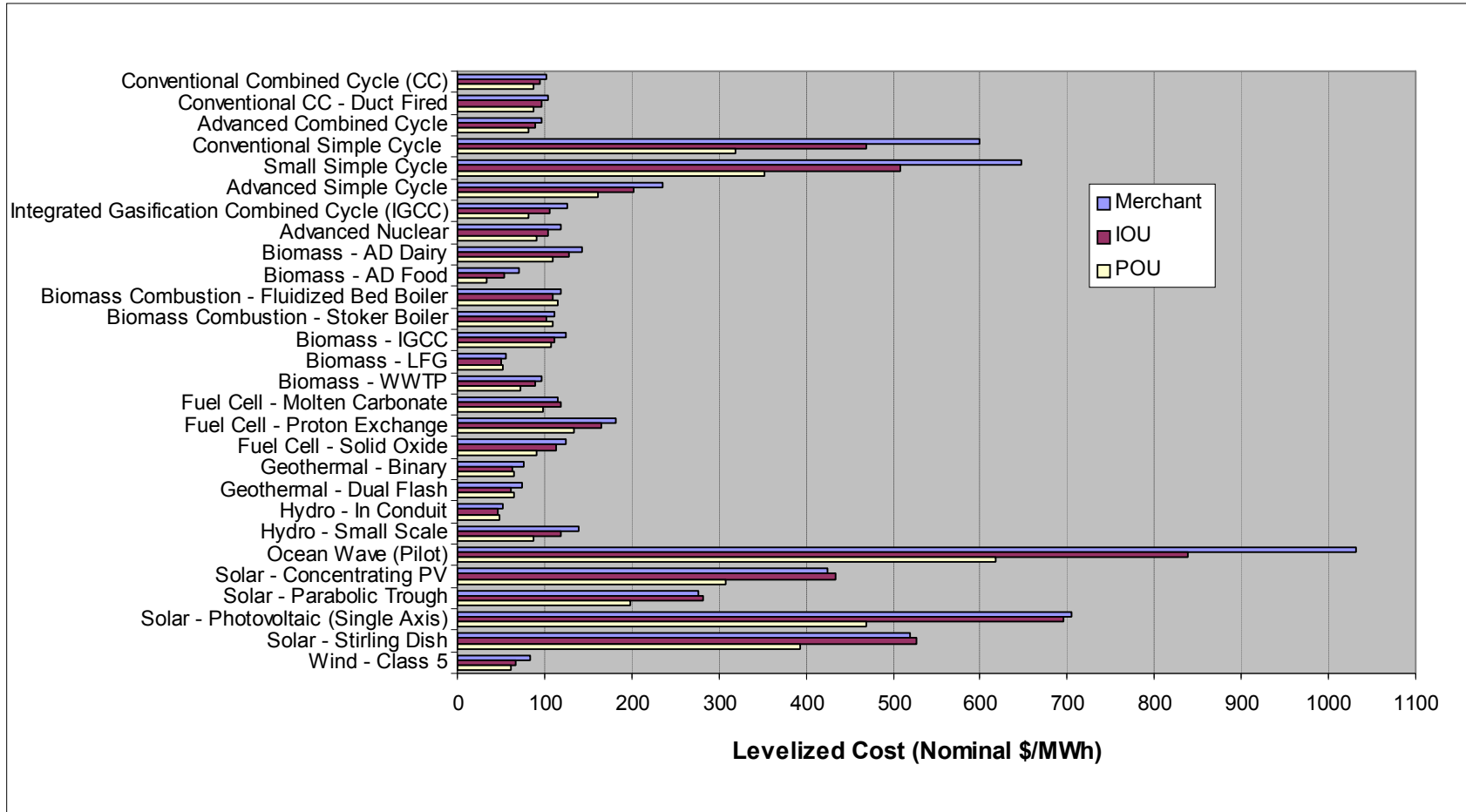
Fixed and Variable Cost

In-Service Year =2007 (Nominal 2007\$)	Size	Merchant		IOU		POU	
	MW	\$/kW-Yr	\$/MWh	\$/kW-Yr	\$/MWh	\$/kW-Yr	\$/MWh
Conventional Combined Cycle (CC)	500	505.82	102.19	466.86	94.47	428.32	86.84
Conventional CC - Duct Fired	550	512.39	103.52	472.40	95.59	432.97	87.78
Advanced Combined Cycle	800	476.97	96.36	438.22	88.68	399.62	81.02
Conventional Simple Cycle	100	250.43	599.57	195.59	468.46	132.84	318.33
Small Simple Cycle	50	270.36	647.28	212.08	507.98	146.70	351.55
Advanced Simple Cycle	200	295.96	236.12	253.22	202.10	201.13	160.60
Integrated Gasification Combined Cycle (IGCC)	575	566.58	126.51	476.15	106.32	361.52	80.72
Advanced Nuclear	1000	862.70	118.25	757.78	103.87	664.78	91.12
Biomass - AD Dairy	0.25	924.52	143.61	826.57	128.39	800.93	109.77
Biomass - AD Food	2	450.97	70.05	350.30	54.41	218.82	33.99
Biomass Combustion - Fluidized Bed Boiler	25	866.25	118.72	793.99	108.82	839.92	115.12
Biomass Combustion - Stoker Boiler	25	810.99	111.15	745.45	102.17	799.74	109.61
Biomass - IGCC	21.25	849.18	123.66	768.58	111.92	744.82	108.46
Biomass - LFG	2	382.50	56.11	345.95	50.86	352.73	52.36
Biomass - WWTP	0.5	514.65	97.34	466.63	88.84	366.54	71.78
Fuel Cell - Molten Carbonate	2	886.11	114.66	910.60	117.83	754.94	97.69
Fuel Cell - Proton Exchange	0.03	1409.63	182.41	1281.28	165.80	1025.67	132.72
Fuel Cell - Solid Oxide	0.25	955.64	123.66	868.61	112.40	695.29	89.97
Geothermal - Binary	50	477.23	75.85	396.31	63.53	394.23	65.55
Geothermal - Dual Flash	50	453.91	73.66	379.23	62.07	384.36	65.26
Hydro - In Conduit	1	213.72	52.84	183.96	45.68	188.71	47.78
Hydro - Small Scale	10	567.71	138.74	481.05	118.08	347.96	87.09
Ocean Wave (Pilot)	0.75	1239.92	1030.50	1005.64	837.65	733.96	617.12
Solar - Concentrating PV	15	620.48	424.84	631.79	434.00	442.11	308.09
Solar - Parabolic Trough	63.5	497.33	277.30	504.17	281.37	355.71	199.31
Solar - Photovoltaic (Single Axis)	1	1035.07	704.98	1019.48	695.59	681.74	468.87
Solar - Stirling Dish	15	855.55	518.89	868.93	527.00	648.77	393.47
Wind - Class 5	50	245.94	84.24	196.08	67.16	179.19	61.38



GRAPHICALLY

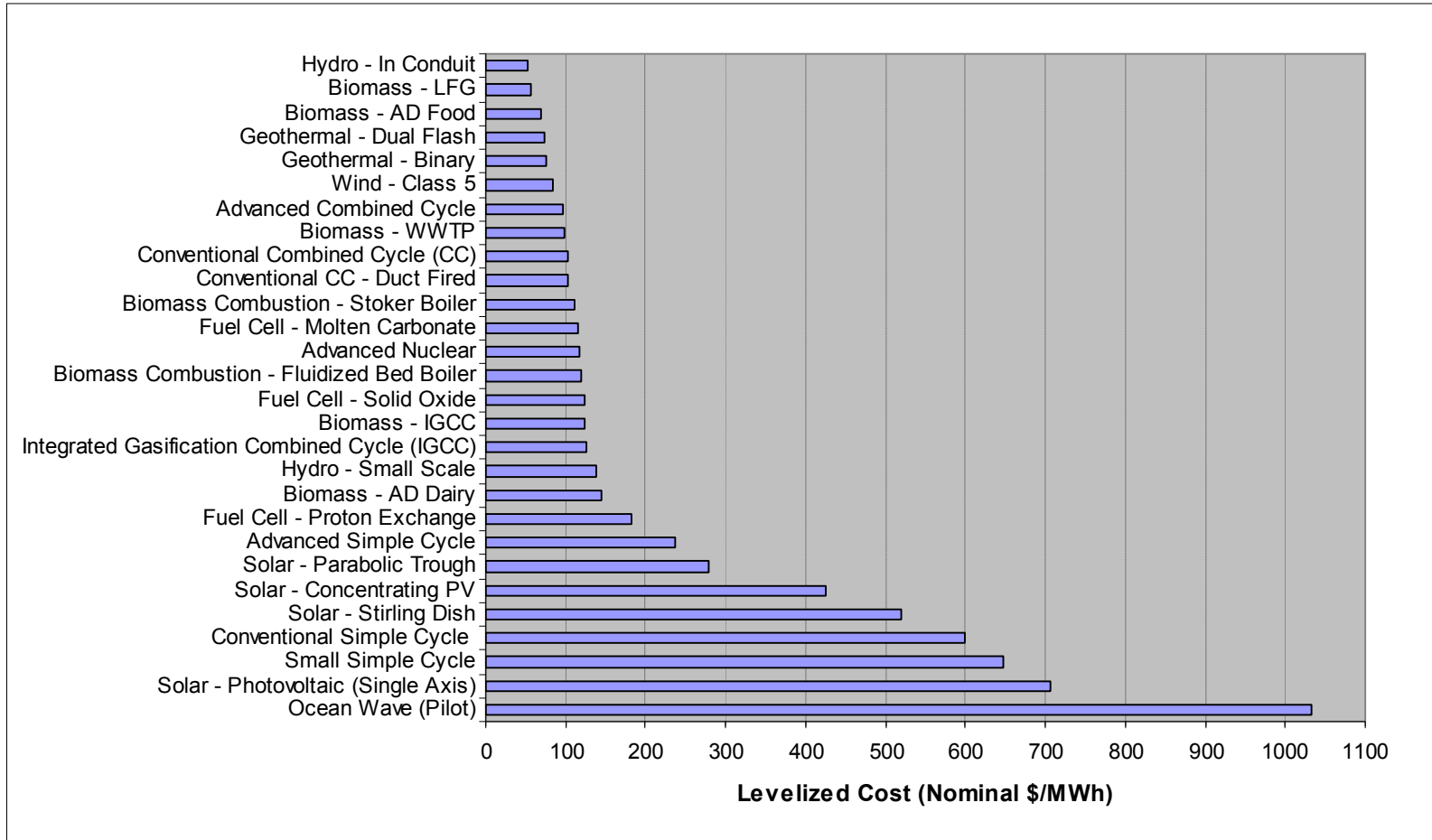
Start Year = 2007 (2007 Nominal\$)





MERCHANT DESCENDING ORDER

Start Year = 2007 (2007 Nominal\$)





MERCHANT

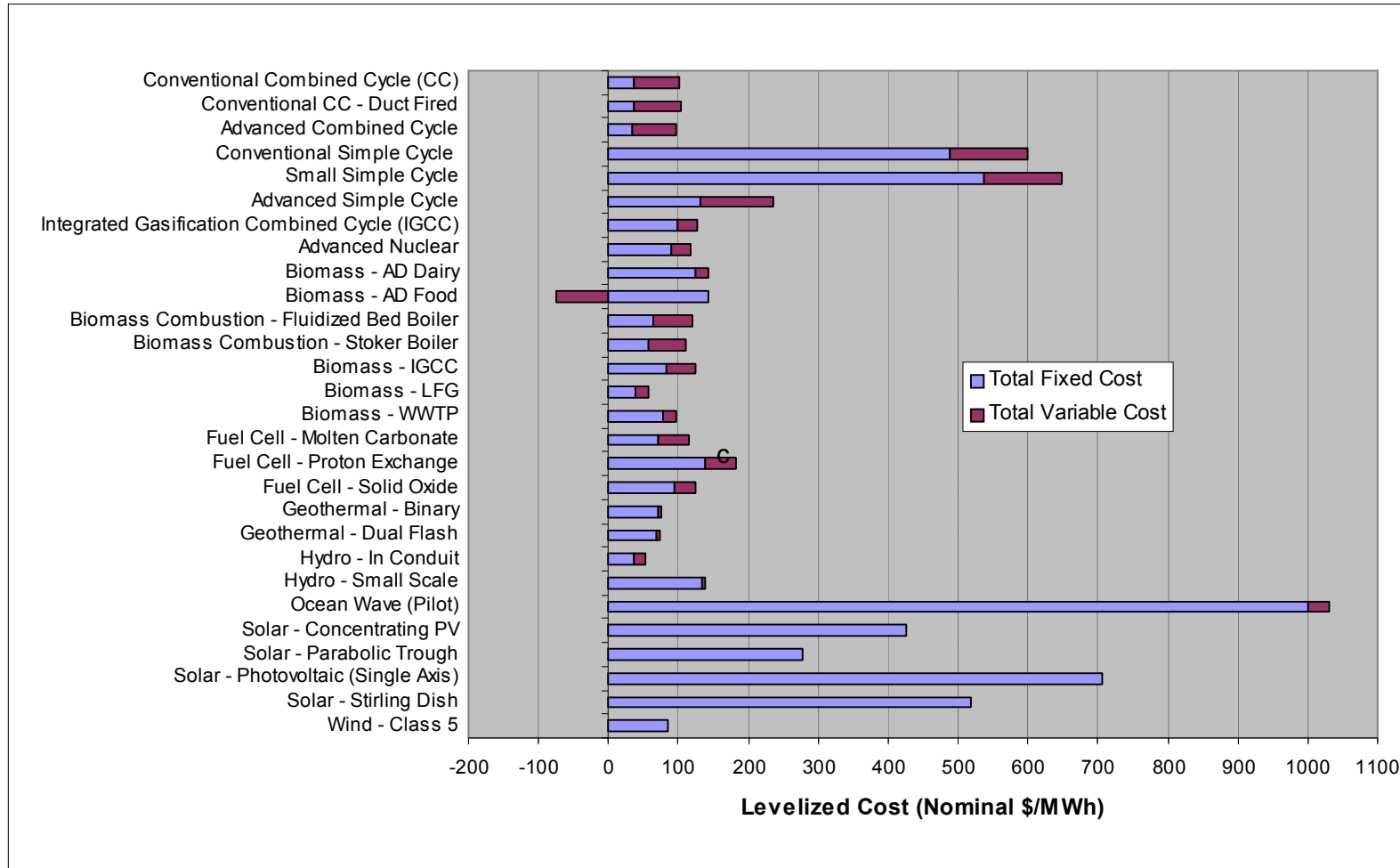
BY COMPONENT (\$/MWh)

In-Service Year =2007	Size MW	\$/MWh (Nominal 2007\$)									
		Capital & Financing	Insurance	Ad Valorem	Fixed O&M	Taxes	Total Fixed Cost	Fuel	Variable O&M	Total Variable Cost	Total Levelized Cost
Conventional Combined Cycle (CC)	500	\$23.28	\$1.48	\$1.16	\$2.30	\$7.85	\$36.07	\$60.86	\$5.27	\$66.12	\$102.19
Conventional CC - Duct Fired	550	23.81	1.52	1.19	2.22	8.03	36.77	61.64	5.11	66.75	103.52
Advanced Combined Cycle	800	22.85	1.46	1.14	1.96	7.71	35.13	56.68	4.56	61.24	96.36
Conventional Simple Cycle	100	327.02	20.82	16.31	30.49	94.43	489.08	79.66	30.83	110.49	599.57
Small Simple Cycle	50	347.88	22.15	17.35	48.75	100.20	536.33	79.66	31.29	110.96	647.28
Advanced Simple Cycle	200	89.52	5.70	4.46	6.59	25.88	132.15	73.51	30.46	103.97	236.12
Integrated Gasification Combined Cycle (IGCC)	575	64.47	6.79	4.44	10.58	12.15	98.44	24.00	4.06	28.07	126.51
Advanced Nuclear	1000	56.79	5.14	3.70	24.18	0.64	90.45	21.50	6.30	27.80	118.25
Biomass - AD Dairy	0.25	110.17	7.82	6.33	9.58	-9.05	124.84	0.00	18.77	18.77	143.61
Biomass - AD Food	2	110.21	7.82	6.33	28.74	-9.05	144.05	0.00	-74.00	-74.00	70.05
Biomass Combustion - Fluidized Bed Boiler	25	48.67	4.40	3.17	25.91	-18.44	63.72	51.09	3.91	55.00	118.72
Biomass Combustion - Stoker Boiler	25	44.70	4.04	2.91	23.23	-18.74	56.15	51.09	3.91	55.00	111.15
Biomass - IGCC	21.25	53.27	4.82	3.47	28.48	-7.62	82.42	37.32	3.91	41.23	123.66
Biomass - LFG	2	\$40.49	\$2.87	\$2.33	\$3.62	(\$11.70)	\$37.61	\$0.00	\$18.50	\$18.50	\$56.11
Biomass - WWTP	0.5	63.60	4.51	3.65	4.67	2.41	78.84	0.00	18.50	18.50	97.34
Fuel Cell - Molten Carbonate	2	72.48	5.14	4.16	0.34	-10.63	71.50	0.00	43.17	43.17	114.66
Fuel Cell - Proton Exchange	0.03	116.92	8.30	6.71	2.87	4.44	139.24	0.00	43.17	43.17	182.41
Fuel Cell - Solid Oxide	0.25	79.28	5.63	4.55	1.60	3.01	94.06	0.00	29.60	29.60	123.66
Geothermal - Binary	50	67.75	4.78	3.87	13.73	-19.84	70.30	0.00	5.55	5.55	75.85
Geothermal - Dual Flash	50	64.12	4.53	3.67	16.02	-20.12	68.21	0.00	5.45	5.45	73.66
Hydro - In Conduit	1	43.02	3.97	2.86	0.00	-13.97	35.88	0.00	16.96	16.96	52.84
Hydro - Small Scale	10	113.39	10.47	7.54	4.14	-0.71	134.83	0.00	3.91	3.91	138.74
Ocean Wave (Pilot)	0.75	777.27	54.07	43.81	30.77	93.75	999.65	0.00	30.85	30.85	1030.50
Solar - Concentrating PV	15	414.12	0.00	25.88	39.14	-54.30	424.84	0.00	0.00	0.00	424.84
Solar - Parabolic Trough	63.5	252.23	0.00	16.77	43.65	-35.34	277.30	0.00	0.00	0.00	277.30
Solar - Photovoltaic (Single Axis)	1	726.35	0.00	47.29	21.31	-89.97	704.98	0.00	0.00	0.00	704.98
Solar - Stirling Dish	15	422.09	0.00	28.06	128.97	-60.23	518.89	0.00	0.00	0.00	518.89
Wind - Class 5	50	75.51	6.83	4.92	13.40	-16.41	84.24	0.00	0.00	0.00	84.24



MERCHANT GRAPHICALLY

Start Year = 2007 (2007 Nominal\$)





FIXED PORTION OF COSTS (\$/kW-Yr)

Merchant		\$/kW-Yr (Nominal 2007\$)					
In-Service Year =2007	Size MW	Capital & Financing	Insurance	Ad Valorem	Fixed O&M	Taxes	Total Fixed Cost
Conventional Simple Cycle	100	136.59	8.70	6.81	12.74	39.44	204.28
Small Simple Cycle	50	145.30	9.25	7.25	20.36	41.85	224.01
Advanced Simple Cycle	200	112.21	7.14	5.60	8.25	32.44	165.64

IOU		\$/kW-Yr (Nominal 2007\$)					
In-Service Year =2007	Size MW	Capital & Financing	Insurance	Ad Valorem	Fixed O&M	Taxes	Total Fixed Cost
Conventional Simple Cycle	100	106.14	6.87	3.85	13.00	18.40	148.26
Small Simple Cycle	50	112.91	7.30	4.10	20.78	19.47	164.55
Advanced Simple Cycle	200	87.19	5.64	3.17	8.42	15.16	119.58

POU		\$/kW-Yr (Nominal 2007\$)					
In-Service Year =2007	Size MW	Capital & Financing	Insurance	Ad Valorem	Fixed O&M	Taxes	Total Fixed Cost
Conventional Simple Cycle	100	60.14	5.04	5.59	13.30	0.00	84.08
Small Simple Cycle	50	64.98	5.45	6.04	21.27	0.00	97.74
Advanced Simple Cycle	200	46.60	3.91	4.33	8.62	0.00	63.46



50 MW CTs ONLY

(Updated But Not Yet Approved)

In-Service Year =2007	Size MW	\$/kW-Yr (Nominal 2007\$)					Total Fixed Cost
		Capital & Financing	Insurance	Ad Valorem	Fixed O&M	Taxes	
Merchant	50	145.30	9.25	7.25	20.36	41.85	224.01
IOU	50	112.91	7.30	4.10	20.78	19.47	164.55
POU	50	64.98	5.45	6.04	21.27	0.00	97.74
Average	50	107.73	7.33	5.79	20.80	20.44	162.10



CONVERSION \$/MWh TO \$/kW-Yr

- $\$/kW\text{-Yr} = \$/MWh * \text{Energy (GWh)} / \text{Gross Capacity (MW)}$
- $\$/kW\text{-Yr} = \$/MWh * \text{Total } \$/kW\text{-Yr} / \text{Total } \$/MWh$



EFFECT OF LOCATION 50 MW MERCHANT CT

Plant Site Region	Fixed Cost	Explanation for
	\$/KW-Yr	High Value
CA Average	\$224.01	
Bay Area	\$427.64	Urban Adder
Imperial County	\$227.98	Chiller Adder
San Joaquin	\$223.91	
Kern	\$223.91	
Mohave	\$227.98	Chiller Adder
Central Coast	\$223.91	
Sacramento	\$223.91	
San Diego	\$223.91	
San Luis	\$223.91	
Santa Barbara	\$223.91	
South Coast	\$225.15	High ERC Cost
Ventura	\$223.90	



CHANGING START YEAR Cannot Use Nominal Inflation

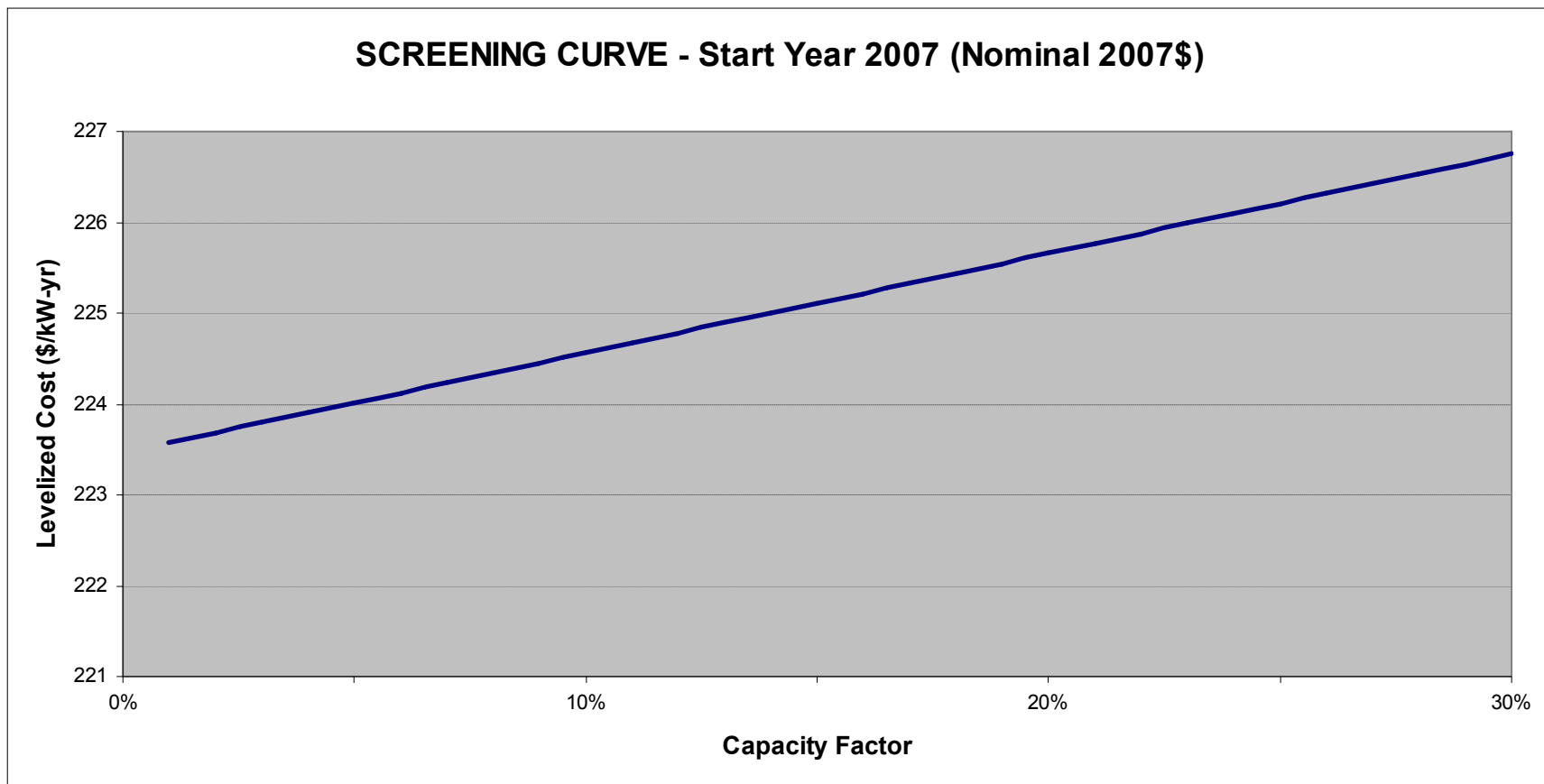
START YEAR	FIXED LEVELIZED COST (\$/kW-Yr)	CEC DEFLATOR	USING CEC DEFLATORS (\$/kW-Yr)	NECESSARY DEFLATOR
2007	\$224.01	1.000	\$224.01	1.000
2008	\$231.08	1.023	\$236.44	1.032
2009	\$238.38	1.044	\$248.96	1.064
2010	\$245.90	1.066	\$262.02	1.098
2011	\$253.67	1.087	\$275.84	1.132
2012	\$261.69	1.109	\$290.16	1.168



SCREENING CURVE

50 MW Merchant Plant

Fixed Costs Only (\$/kW-Year)





COMPARISON TO 2003 IEPR

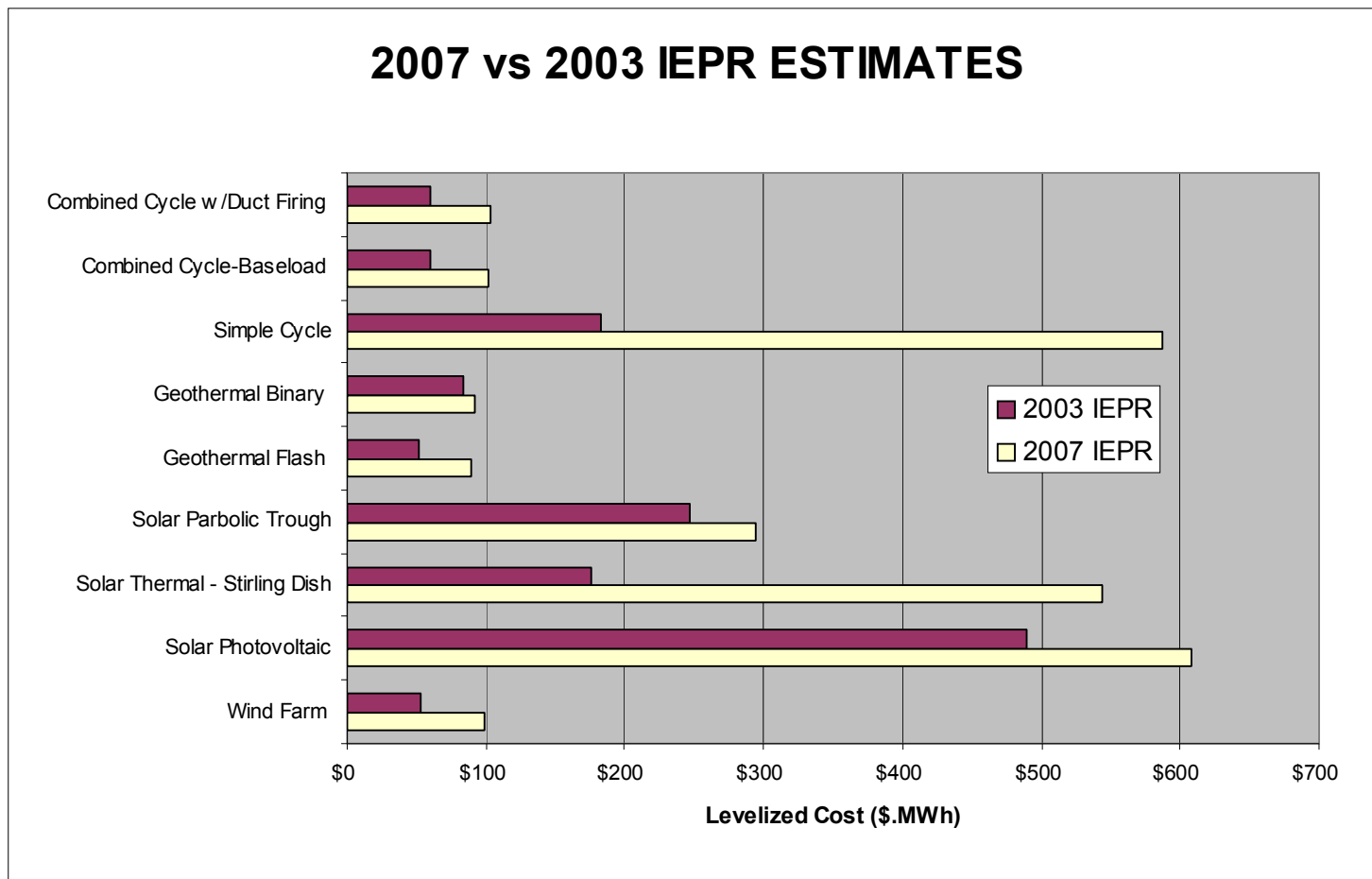
(No 50 MW Unit for Comparison)

Technology (Costs in Nominal 2007\$)	2003 IEPR			2007 IEPR			2003 IEPR		2007 IEPR	
	Gross Capacity (MW)	Levelized Cost (\$/MWh)	Capacity Factor (%)	Gross Capacity (MW)	Levelized Cost (\$/MWh)	Capacity Factor (%)	Instant Cost (\$/kW)	Installed Cost (\$/kW)	Instant Cost (\$/kW)	Installed Cost (\$/kW)
Conventional CC - Duct Fired	550	\$59.73	91.6	550	\$103.52	60.0	608	664	798	863
Conventional Combined Cycle (CC)	500	\$59.50	91.6	500	\$102.19	60.0	620	677	781	844
Conventional Simple Cycle	100	\$182.62	9.4	100	\$599.57	5.0	477	522	925	1000
Geothermal - Binary	35	\$83.40	98.5	50	\$75.85	95.0	3673	4140	3089	3562
Geothermal - Dual Flash	50	\$51.85	96.0	50	\$73.66	93.0	2435	2758	3093	3548
Solar - Parabolic Trough	110	\$246.40	22.0	63.5	\$277.30	27.0	2975	3203	4021	4190
Solar - Stirling Dish	15	\$175.86	36.3	15	\$518.89	24.0	3742	4028	6187	6446
Solar - Photovoltaic (Single Axis)	50	\$488.84	23.8	1	\$704.98	22.2	7614	8197	9611	9678
Wind - Class 5	100	\$52.93	36.3	50	\$84.24	34.0	1015	1093	1959	2000

- 2007 Levelized cost is much higher.
- 2007 Capacity Factor is much lower.
- 2007 Installed cost is much higher.



TOTAL (FIXED + VARIABLE) LEVELIZED COST COMPARISON

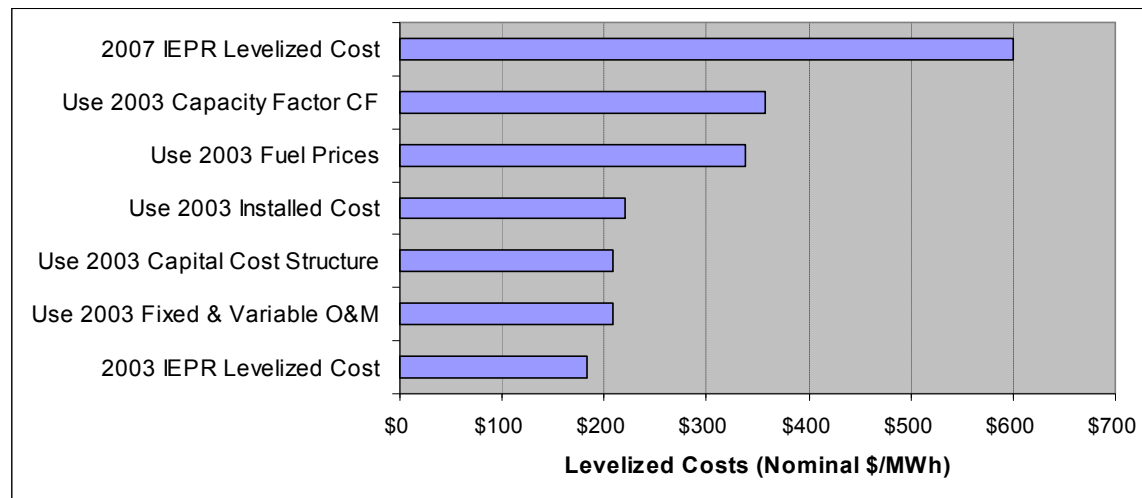




2007 IEPR vs. 2003 IEPR

100 MW SIMPLE CYCLE UNIT

Effect of Change (2007\$)	\$/MWh
2007 IEPR Levelized Cost	599.57
Use 2003 Capacity Factor CF	357.01
Use 2003 Fuel Prices	337.94
Use 2003 Installed Cost	220.67
Use 2003 Capital Cost Structure	208.67
Use 2003 Fixed & Variable O&M	207.92
2003 IEPR Levelized Cost	182.62



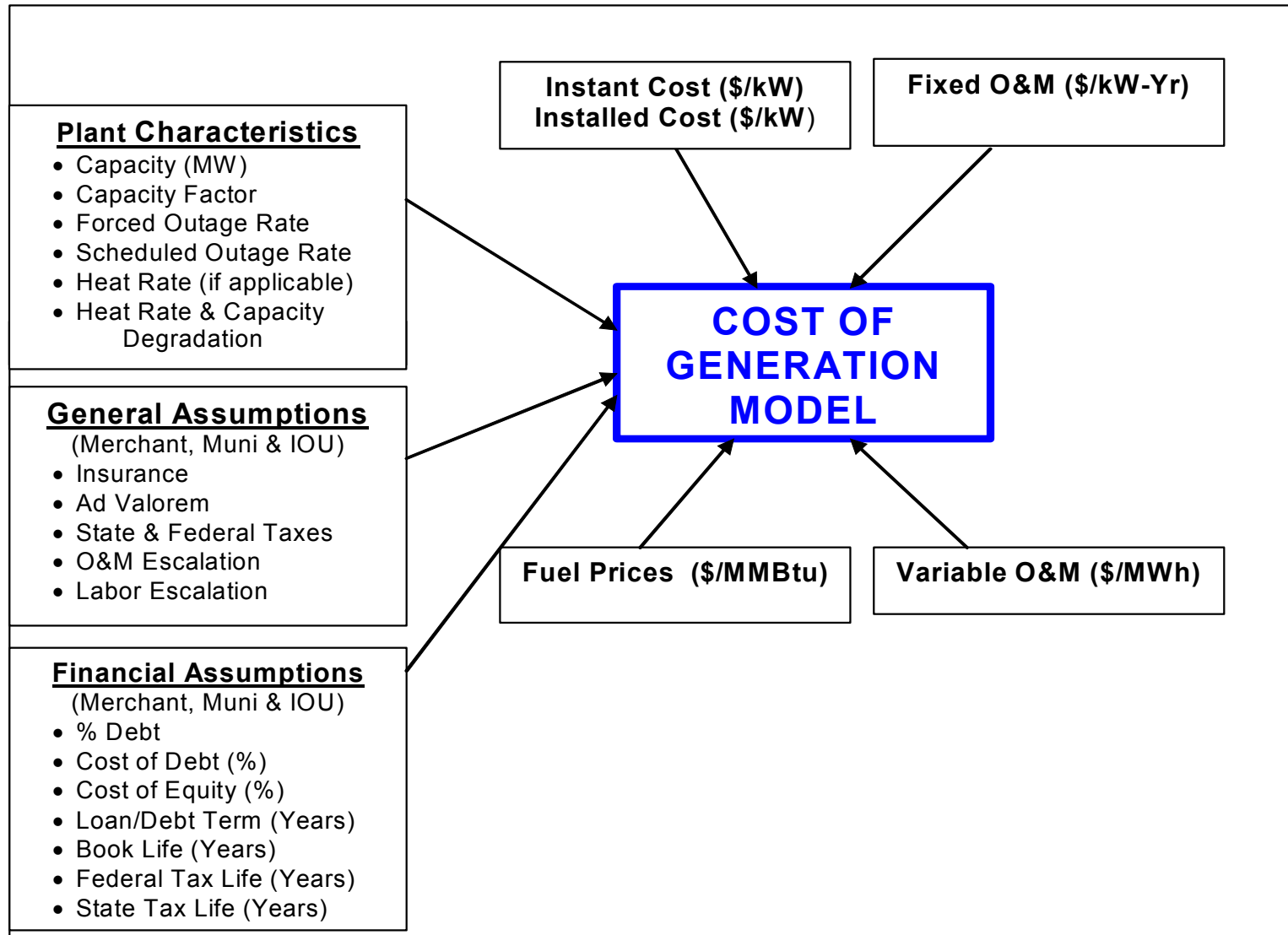


THIRD ITEM

- Overview of the Cost of Generation Model.
- Summary of Levelized Costs - Output.
- **Review the Assumptions – Input.**
 - Comparison to EIA Assumptions
- Data Collection, Processing & Results.



COG ASSUMPTIONS





ASSUMPTIONS

Technology (All costs in Nominal 2007\$)	Gross Capacity (MW)	Capacity Factor (%)	HHV Heat Rate (Btu/kWh)	Instant Cost (\$/kW)	Installed Cost (\$/kW)			Fixed O&M (\$/kW-Yr)	Variable O&M (\$/MWh)
					Merchant	IOU	Muni		
Conventional Combined Cycle (CC)	500	60.00%	6,990	781	844	849	779	9.86	4.42
Conventional CC - Duct Fired	550	60.00%	7,080	798	863	868	798	9.53	4.28
Advanced Combined Cycle	800	60.00%	6,510	766	828	834	763	8.42	3.83
Conventional Simple Cycle	100	5.00%	9,266	925	1000	1000	793	11.00	25.72
Small Simple Cycle	50	5.00%	9,266	974	1053	1053	846	17.65	26.10
Advanced Simple Cycle	200	5.00%	8,550	756	817	817	610	7.13	25.57
Integrated Gasification Combined Cycle (IGCC)	575	60.00%	8,979	2,198	3,007	2,941	2,569	36.27	3.11
Advanced Nuclear	1000	85.00%	10,400	2,950	3,754	3,662	3,177	140.00	5.00
Biomass - AD Dairy	0.25	75.00%	12,407	5,800	5,923	5,911	5,837	51.81	15.77
Biomass - AD Food	2	75.00%	17,060	5,803	5,925	5,913	5,840	155.44	-62.18
Biomass Combustion - Fluidized Bed Boiler	25	85.00%	15,509	3,156	3,223	3,217	3,177	150.26	3.11
Biomass Combustion - Stoker Boiler	25	85.00%	15,509	2,899	2,960	2,954	2,917	134.72	3.11
Biomass - IGCC	21.25	85.00%	10,663	3,121	3,320	3,301	3,181	155.44	3.11
Biomass - LFG	2	85.00%	11,566	2,254	2,302	2,296	2,263	20.73	15.54
Biomass - WWTP	0.5	75.00%	12,407	2,743	2,801	2,794	2,748	20.73	15.54
Fuel Cell - Molten Carbonate	2	90.00%	8,322	4,488	4,678	4,659	4,546	2.18	36.27
Fuel Cell - Proton Exchange	0.03	90.00%	13,127	7,239	7,545	7,515	7,332	18.65	36.27
Fuel Cell - Solid Oxide	0.25	90.00%	8,530	4,908	5,116	5,096	4,972	10.36	24.87
Geothermal - Binary	50	95.00%	N/A	3,093	3,548	3,501	3,227	72.54	4.66
Geothermal - Dual Flash	50	93.00%	N/A	2,866	3,287	3,244	2,988	82.90	4.58
Hydro - In Conduit	1	51.40%	N/A	1,547	1,612	1,606	1,567	0.00	13.47
Hydro - Small Scale	10	52.00%	N/A	4,125	4,299	4,282	4,178	13.47	3.11
Ocean Wave (Pilot)	0.75	15.00%	N/A	7,203	7,662	7,617	7,342	31.09	25.91
Solar - Concentrating PV	15	23.00%	N/A	5,156	5,372	5,352	5,222	46.63	0.00
Solar - Parabolic Trough	63.5	27.00%	N/A	4,021	4,190	4,175	4,073	62.18	0.00
Solar - Photovoltaic (Single Axis)	1	22.14%	N/A	9,611	9,678	9,672	9,632	24.87	0.00
Solar - Stirling Dish	15	24.00%	N/A	6,187	6,446	6,423	6,266	168.92	0.00
Wind - Class 5	50	34.00%	N/A	1,959	2,000	1,997	1,972	31.09	0.00



EMISSION FACTORS

Technology	Emission Factors (Lbs/MWh)					
	NOx	VOC	CO	CO2	SOx	PM10
Conventional Combined Cycle	0.056	0.017	0.049	817.62	0.007	0.035
Conventional Combined Cycle - Duct Fired	0.064	0.018	0.050	828.14	0.007	0.028
Advanced Combined Cycle	0.046	0.016	0.046	761.47	0.007	0.026
Conventional Simple Cycle	0.093	0.023	0.093	1083.84	0.009	0.065
Small Simple Cycle	0.093	0.023	0.093	1083.84	0.009	0.065
Advanced Simple Cycle	0.076	0.019	0.053	886.63	0.008	0.053
Integrated Gasification Combined Cycle (IGCC)	0.530	0.000	0.000	1928.00	0.300	0.000
Nuclear	0.000	0.000	0.000	0.000	0.000	0.000
Biomass - AD Dairy	1.700	0.000	0.000	0.000	0.390	0.000
Biomass - AD Food	1.700	0.000	0.000	0.000	0.420	0.000
Biomass Combustion - Fluidized Bed Boiler	1.240	0.000	0.000	0.000	0.700	0.000
Biomass Combustion - Stoker Boiler	1.240	0.000	0.000	0.000	0.700	0.000
Biomass - IGCC	0.850	0.000	0.000	0.000	0.700	0.000
Biomass - LFG	1.700	0.000	0.000	0.000	0.340	0.000
Biomass - WWTP	1.700	0.000	0.000	0.000	0.390	0.000
Fuel Cell - Molten Carbonate	0.010	0.000	0.000	0.000	0.003	0.000
Fuel Cell - Proton Exchange	0.100	0.000	0.000	0.000	0.000	0.000
Fuel Cell - Solid Oxide	0.050	0.000	0.000	0.000	0.000	0.000
Geothermal - Binary	0.000	0.000	0.000	0.000	0.000	0.000
Geothermal - Dual Flash	0.000	0.000	0.000	60.000	0.350	0.000
Hydro - In Conduit	0.000	0.000	0.000	0.000	0.000	0.000
Hydro - Small Scale	0.000	0.000	0.000	0.000	0.000	0.000
Ocean - Wave	0.000	0.000	0.000	0.000	0.000	0.000
Solar - PV	0.000	0.000	0.000	0.000	0.000	0.000
Solar - Parabolic Trough	0.000	0.000	0.000	0.000	0.000	0.000
Solar - Stirling Dish	0.000	0.000	0.000	0.000	0.000	0.000
Solar - Concentrating PV	0.000	0.000	0.000	0.000	0.000	0.000
Wind - Class 5	0.000	0.000	0.000	0.000	0.000	0.000



FINANCIAL ASSUMPTIONS

	Merchant Gas-Fired	Merchant Non Gas-Fired	IOU	POU
Percent Debt	40.0%	60.0%	50.0%	100.0%
Percent Equity	60.0%	40.0%	50.0%	0.0%
Cost of Debt	6.5%	6.5%	5.73%	4.35%
Cost of Equity	15.9%	15.9%	11.74%	0.0%
Discount Rate (LARR)	10.65%	8.39%	7.57%	4.35%

Term/Life Assumptions	CCs	CTs
Loan/Debt Term	12	12
Equipment Life	20	20
Economic Book Life	20	20
Federal Tax Life	20	15
State Tax Life	20	15



TAX ASSUMPTIONS

Tax	Rate
Federal Tax	35.0%
CA State Tax	8.84%
Total Tax Rate	40.7%



ASSUMED LOSSES (CPUC MPR PROCEEDINGS)

Location	Losses
On Site	2.40%
Transformer	0.5%
Transmission	1.49%



Deflator Series 2007=1	Year	Natural Gas Prices (Nominal \$/MMBtu)							Misc (Nominal \$/MMBtu)		
		PG&E	SCE	SDG&E	SMUD	LADWP	IID	CA - Avg.	Uranium	Coal	Biomass
1.00	2007	8.30	8.23	8.74	8.50	8.50	8.50	8.34	0.63	1.47	2.57
1.02	2008	6.72	6.76	7.32	6.81	7.07	7.07	6.82	0.75	1.68	2.63
1.04	2009	6.80	6.80	7.11	6.92	7.06	7.06	6.87	0.89	1.70	2.69
1.07	2010	5.46	5.71	6.20	5.42	6.09	6.09	5.69	1.05	1.72	2.74
1.09	2011	7.04	7.25	7.74	7.05	7.66	7.66	7.26	1.26	1.71	2.80
1.11	2012	6.69	6.84	7.25	6.72	7.22	7.22	6.87	1.50	1.83	2.85
1.13	2013	8.08	8.28	8.59	8.04	8.57	8.57	8.26	1.77	1.90	2.91
1.15	2014	7.39	7.57	7.88	7.36	7.86	7.86	7.56	2.11	1.97	2.97
1.17	2015	8.52	8.61	8.65	8.57	8.90	8.90	8.63	2.58	2.04	3.02
1.20	2016	8.58	8.72	8.82	8.59	9.01	9.01	8.72	2.63	2.12	3.08
1.22	2017	8.63	8.82	8.99	8.60	9.12	9.12	8.80	2.68	2.19	3.14
1.24	2018	9.16	9.42	9.62	9.12	9.77	9.77	9.38	2.73	2.27	3.20
1.26	2019	9.71	10.04	10.28	9.65	10.45	10.45	9.98	2.78	2.35	3.25
1.29	2020	9.91	10.21	10.41	9.87	10.60	10.60	10.16	2.83	2.43	3.32
1.31	2021	10.12	10.38	10.54	10.09	10.75	10.75	10.34	2.89	2.52	3.38
1.34	2022	10.58	10.91	11.10	10.54	11.33	11.33	10.86	2.94	2.59	3.44
1.36	2023	11.06	11.47	11.69	11.00	11.94	11.94	11.39	3.00	2.70	3.51
1.39	2024	11.53	11.87	12.01	11.47	12.28	12.28	11.81	3.05	2.73	3.57
1.41	2025	12.01	12.28	12.35	11.95	12.63	12.63	12.23	3.11	2.83	3.64
1.44	2026	12.44	12.72	12.80	12.37	13.09	13.09	12.67	3.17	2.94	3.71
1.47	2027	12.91	13.21	13.28	12.83	13.58	13.58	13.15	3.23	3.02	3.78
1.49	2028	13.44	13.75	13.79	13.35	14.12	14.12	13.68	3.29	3.12	3.85
1.52	2029	13.96	14.28	14.30	13.87	14.65	14.65	14.21	3.35	3.23	3.92
1.55	2030	14.48	14.80	14.78	14.38	15.16	15.16	14.73	3.41	3.33	3.99
1.58	2031	15.05	15.36	15.31	14.94	15.71	15.71	15.28	3.48	3.44	4.07
1.61	2032	15.65	15.97	15.89	15.53	16.31	16.31	15.89	3.54	3.56	4.14
1.64	2033	16.27	16.59	16.47	16.15	16.92	16.92	16.50	3.61	3.67	4.22
1.67	2034	16.91	17.21	17.05	16.78	17.52	17.52	17.13	3.67	3.77	4.30
1.70	2035	17.57	17.87	17.66	17.43	18.16	18.16	17.78	3.74	3.90	4.38
1.73	2036	18.26	18.55	18.30	18.10	18.83	18.83	18.46	3.81	3.97	4.46
1.77	2037	18.97	19.26	18.96	18.80	19.52	19.52	19.16	3.88	4.04	4.54
1.80	2038	19.72	20.00	19.65	19.53	20.25	20.25	19.90	3.96	4.12	4.63
1.83	2039	20.49	20.77	20.36	20.29	20.99	20.99	20.66	4.03	4.20	4.72
1.87	2040	21.29	21.56	21.09	21.08	21.76	21.76	21.44	4.11	4.27	4.80
1.90	2041	22.12	22.38	21.86	21.90	22.56	22.56	22.26	4.18	4.35	4.89
1.94	2042	22.99	23.24	22.65	22.75	23.39	23.39	23.12	4.26	4.44	4.99
1.97	2043	23.90	24.13	23.47	23.64	24.25	24.25	24.00	4.34	4.52	5.08
2.01	2044	24.83	25.05	24.31	24.56	25.13	25.13	24.92	4.42	4.60	5.17
2.05	2045	25.80	26.01	25.19	25.51	26.06	26.06	25.87	4.51	4.69	5.27



COMPARISON TO EIA ASSUMPTIONS

Technology (Nominal 2007\$)	Size (Gross MW)		Instant Cost (\$/kW)			Fixed O&M (\$/kW-Yr)			Variable O&M (\$/MWh)			Capacity Factor (%)		Heat Rate (Btu/kWh)	
	CEC	EIA	CEC	EIA	Ratio	CEC	EIA	Ratio	CEC	EIA	Ratio	CEC	EIA	CEC	EIA
Combined Cycle (CC)	500	250	784	641	1.22	9.91	12.49	0.79	4.42	2.07	2.91	60%	87%	6,990	6,800
Advanced CC	800	400	771	632	1.22	8.47	11.70	0.72	3.83	2.00	2.70	60%	87%	6,510	6,333
Simple Cycle (SC)	100	160	925	447	2.07	11.06	12.12	0.9	25.76	3.57	13.5	5%	30%	9,266	10,450
Advanced SC	200	230	756	423	1.79	7.13	10.53	0.7	25.57	3.17	13.8	15%	30%	8,550	8,550
IGCC	575	550	2192	1585	1.38	36.22	38.68	0.2	3.10	2.92	14.5	60%	85%	8,979	6,800
Adv Nuclear	1000	1350	2505	2213	1.13	56.91	67.92	0.8	1.24	0.49	2.5	85%		10,400	10,400
Fuel Cell (Molten Carbonate)	2	10	4481	5085	0.88	2.17	5.65	0.4	36.22	47.95	0.8	90%		8,322	8,832
Geothermal - Binary	50	50	3089	1999	1.55	72.43	164.72	0.4	4.66	0.00	-	95%	90%		
Conventional Hydropower	10	10	4118	1595	2.58	13.45	13.97	1.0	3.10	3.51	0.9	52%			
Wind	50	50	1956	1282	1.53	31.04	30.31	1.0	0.00	0.00	-	34%	34.1%		
Photovoltaic	1	5	8237	5051	1.63	12.42	11.68	1.1	0.00	0.00	-	17.3%			

- CEC Instant cost much higher
- Fixed O&Ms are comparable.
- CEC Variable O&M much higher
- CEC Capacity Factor much lower.
- CEC Heat Rate significantly lower.



SIMPLE CYCLE UNITS

Power Plant	QFER 2002	QFER 2003	QFER 2004	QFER 2005
Calpeak Border	7.77%	2.71%	2.28%	1.86%
Calpeak Enterprise	7.53%	2.18%	2.35%	1.55%
Century Alliance	4.76%	1.80%	1.34%	0.39%
Drews Alliance	4.80%	1.83%	1.46%	0.34%
King City	4.10%	4.24%	5.24%	3.95%
Wildflower Indigo	0.33%	5.86%	6.39%	4.71%
Wildflower Larkspur	1.18%	4.01%	4.74%	3.85%
Gilroy	5.15%	5.69%	5.94%	4.34%
Henrietta	3.57%	2.34%	1.31%	1.55%
Los Esteros	nd	9.62%	16.42%	16.26%
Hanford	4.74%	2.17%	1.16%	3.83%
Tracy Peaker	nd	0.71%	0.77%	0.66%
Average	4.39%	3.60%	4.12%	3.61%



LAST ITEM

- Overview of the Cost of Generation Model.
- Summary of Levelized Costs - Output.
- Review the Assumptions – Input.
- **Data Collection, Processing & Results**



DATA COLLECTION

- Combined and Simple Cycle Units – Aspen.
 - Survey of CC and CT units constructed 2001 - 2006.
- Nuclear, IGCC and Alternative Technologies – NCI.
 - Survey of actual costs and experts in the field.



POWER PLANTS SURVEYED

Combined Cycle Plants (19)			Simple Cycle Plants (15)		
Plant Name	County	Operating	Plant Name	County	Operating
Los Medanos	Contra Costa	2001	Wildflower Larkspur	San Diego	2001
Sutter	Sutter	2001	Wildflower Indigo	Riverside	2001
Delta	Contra Costa	2002	Drews Alliance	San Bernardino	2001
Moss Landing	Monterey	2002	Century Alliance	San Bernardino	2001
La Paloma	Kern	2003	Hanford	Kings	2001
High Desert	San Bernardino	2003	Calpeak Escondido	San Diego	2001
MID Woodland	Stanislaus	2003	Calpeak Border	San Diego	2001
Sunrise	Kern	2003	Gilroy	Santa Clara	2002
Blythe	Riverside	2003	King City	Monterey	2002
Elk Hills	Kern	2003	Henrietta	Kings	2002
Von Raesfeld	Santa Clara	2005	Los Esteros	Santa Clara	2003
Metcalf	Santa Clara	2005	Tracy Peaker	San Joaquin	2003
Magnolia	Los Angeles	2005	Kings River Peaker	Fresno	2005
Malburg	Los Angeles	2005	Ripon	San Joaquin	2006
Pastoria	Kern	2005	Riverside	Riverside	2006
Mountainview	San Bernardino	2006			
Palomar	Kern	2006			
Cosumnes	Sacramento	2006			
Walnut	Stanislaus	2006			



SURVEY PARAMETERS

Capital Cost Parameters

Gas Turbine and Combustor Make/Models
Steam Turbine Make/Model
Total Capital Cost of Facility
Gas Turbine Cost
Steam Turbine Cost
Air Inlet Treatment Cost
Cooling Tower/Air Cooled Condenser Cost
Water Treatment Facilities
Site Footprint and Land Cost
Total Construction Costs (Labor/Equipment/etc.)
Cost of Site Grading
Cost of Pipeline Linear Construction
Cost of Transmission Linear Construction
Cost of Licensing/Permitting Project
Air Pollution Control Costs
Cost of Air Quality Offsets

Operating & Maintenance Cost Parameters

Total Annual Operating Costs
Operating Hours
Startup/Shutdown Hours
Natural Gas Sources
Duct Burner Natural Gas Use
Water Supply Source/Cost/Consumption
Labor (Staffing and Cost)
Non-Fuel Annual Operating Costs (Consumables, etc.)
Annual Regulatory Costs (Filings, Consumables, etc.)
Major Scheduled Overhaul Frequency/Cost
Normal Annual Maintenance Costs
Reconciliation of QFER data (MW generation and total fuel use)



COMBINED CYCLE BASE CASE CONFIGURATION

1) 500 MW Plant W/O Duct Firing
2) 2 Turbines W/ 1 Steam Generator
3) GE 7F Gas Turbines
4) Wet Cooling
5) Greenfield Site
6) Non-Urban Land Cost
7) Reclaimed Water Source
8) Evaporative Coolers/Foggers
9) Selective Catalytic Reduction (SCR) & Oxidation Catalyst
10) Zero Liquid Discharge (ZLD)
11) Not Co-Located W/ Other Power Facilities
12) 12-Month Licensing Process



COMBINED CYCLE INSTALLED COSTS

500 MW Combined Cycle Unit (Nominal 2007\$)	Merchant (\$/kW)	IOU (\$/kW)	Muni (\$/kW)
Base Installed Cost	747	753	716
Linears	66	66	33
Permits	11	11	11
ERCs (California Average)	23	23	23
Total Installed Cost	847	852	782

Various Combined Cycle Units (Nominal 2007\$)	Merchant (\$/kW)	IOU (\$/kW)	Muni (\$/kW)
Conventional 500 MW CC without Duct Firing	847	852	782
Conventional 550 MW CC with Duct Firing	868	873	803
Advanced 800 MW CC without Duct Firing	833	838	768



COMBINED CYCLE ADDERS To Be Used Exogenously

Combined Cycle Units (Nominal 2007\$)	\$/kW
Dry Cooling	48
Chillers	11
Plume Abated Cooling Tower	6
No Oxidation Catalyst	-4
Urban Site	11
Co-located facility (Muni only)	-43
Alternative Gas Turbine Type	
SW 501	-32
Alstom GT-24	21
GE 7E	48
Alstom GTX100	53
GE LM6000	16



SIMPLE CYCLE BASE CASE CONFIGURATION

1) 100 MW Merchant Plant
2) 2 LM6000 Turbines
3) Wet Cooling Or Dry Cooling
4) Brownfield Site
5) Non-Urban Land Cost
6) Potable Water Source
7) Evaporative Coolers/Foggers
8) SCR and Oxidation Catalyst Used
9) ZLD
10) Not Co-Located W/ Other Power Facilities



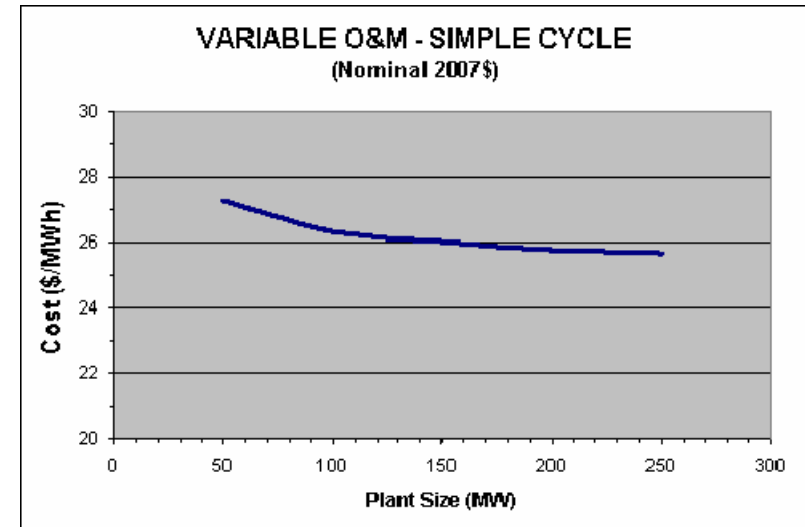
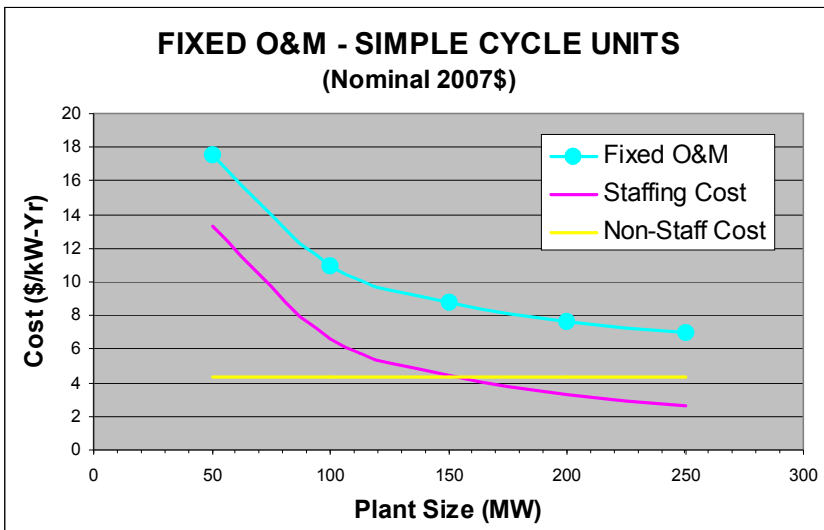
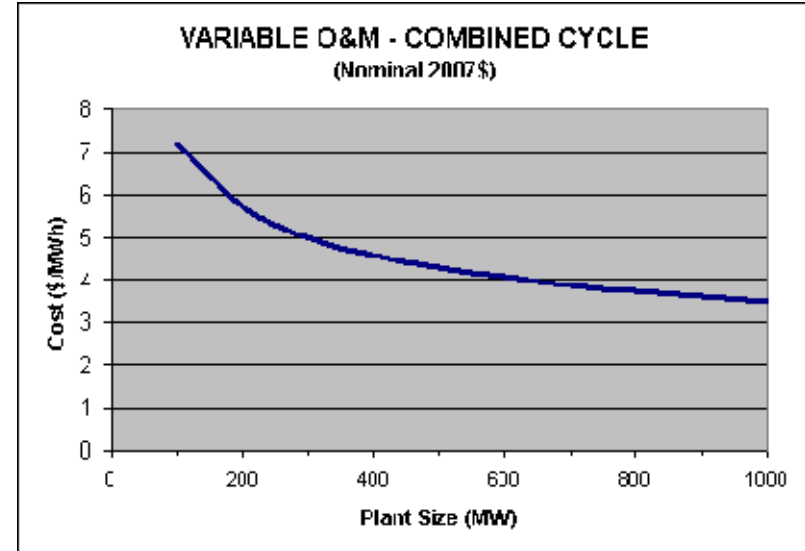
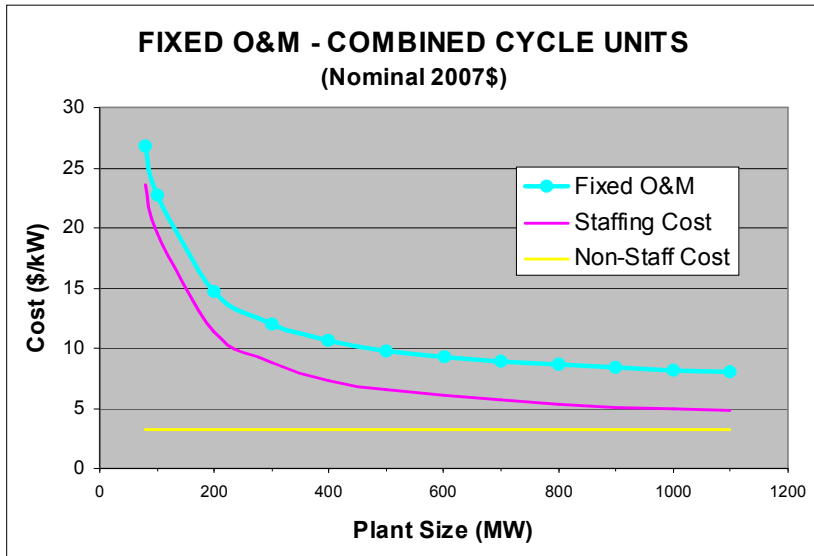
SIMPLE CYCLE INSTALLED COSTS

100 MW Simple Cycle Unit (Nominal 2007\$)	Merchant (\$/kW)	IOU (\$/kW)	Muni (\$/kW)
Base Installed Cost	942	942	735
Linears	34	34	34
Permits	21	21	21
ERCs (California Average)	3	3	3
Total Installed Cost	1000	1000	793

Various Simple Cycle Units (Nominal 2007\$)	Merchant (\$/kW)	IOU (\$/kW)	Muni (\$/kW)
Conventional 50 MW SC	1064	1064	857
Conventional 100 MW SC	1000	1000	793
Advanced 200 MW SC	817	817	610



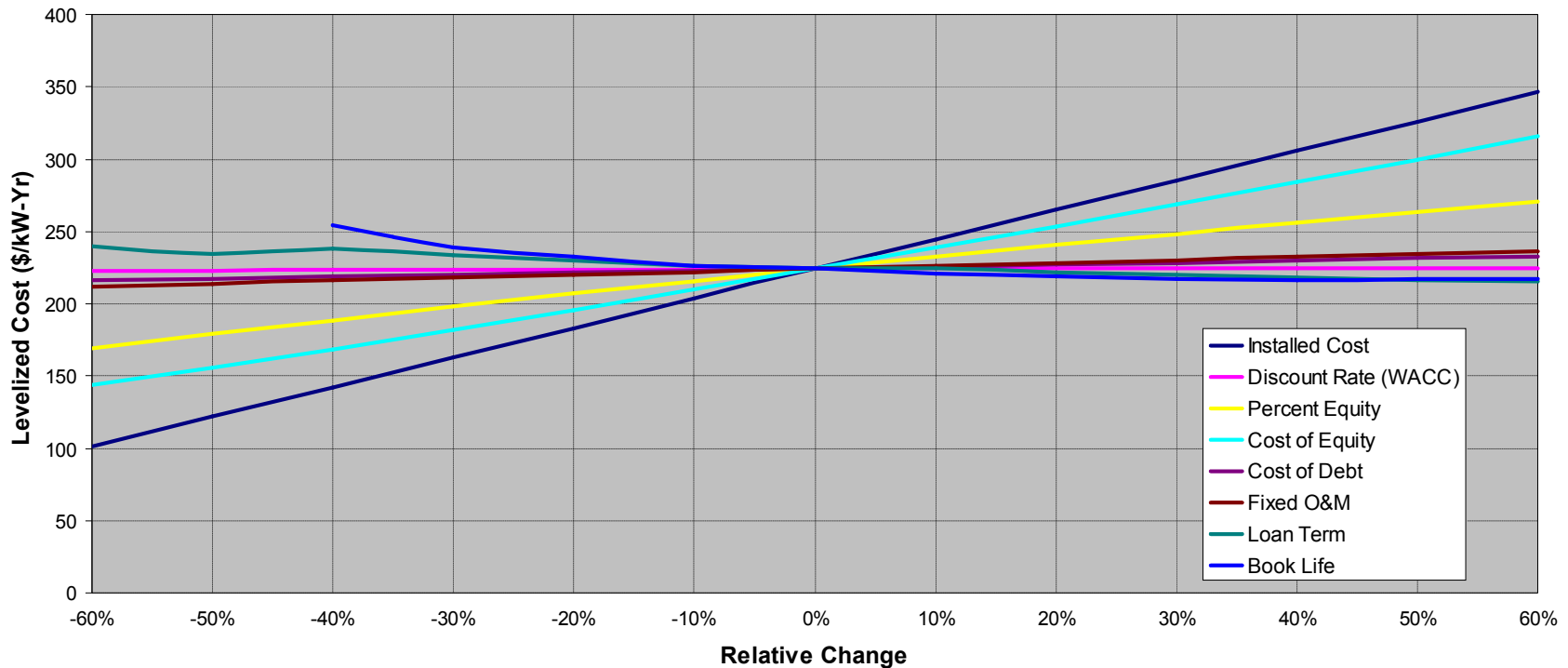
FIXED & VARIABLE O&M





EFFECT OF ASSUMPTIONS

Effect on Levelized Cost of Input Assumptions
Start Year 2007 (Nominal 2007\$)
50 MW CT with ZERO Variable Cost





SUMMARY OF VULNERABILITIES

- Model Logic – Reviewed by four inside CEC and 30 outside CEC.
- Installed Cost – Survey of As-Built Costs.
- Fixed O&M – Survey of As-Built Costs.
- Financial Assumptions – Provided by consultant.
 - Cost of Equity
 - Percent Equity



STATUS

- Had workshop on June 12, 2007.
- Have incorporated comments and redrafted Report.
- Awaiting approval by Director and Commission.
- Hope to post Final Report for second review by end of October and issue Final Report by first part of November.
- Post Cost of Generation Model and User's Guide for public use in November.



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Report, Model and User's Guide available at:

http://www.energy.ca.gov/2007_energypolicy/documents/index.html#061207



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