



COMPARATIVE COSTS OF CALIFORNIA CENTRAL STATION ELECTRICITY GENERATION TECHNOLOGIES

2007 IEPR Workshop

Joel Klein & Anitha Rednam

Date: June 12, 2007



TODAY

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



TODAY

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



COST OF GENERATION MODEL

- COG models.
 - What do they do?
 - Who uses them?
- CEC Model Structure.
- Model Demonstration.



WHAT DO THEY DO?

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



WHO USES THEM?

- **Within the Energy Commission**
 - Scenario Project 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.
 - 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

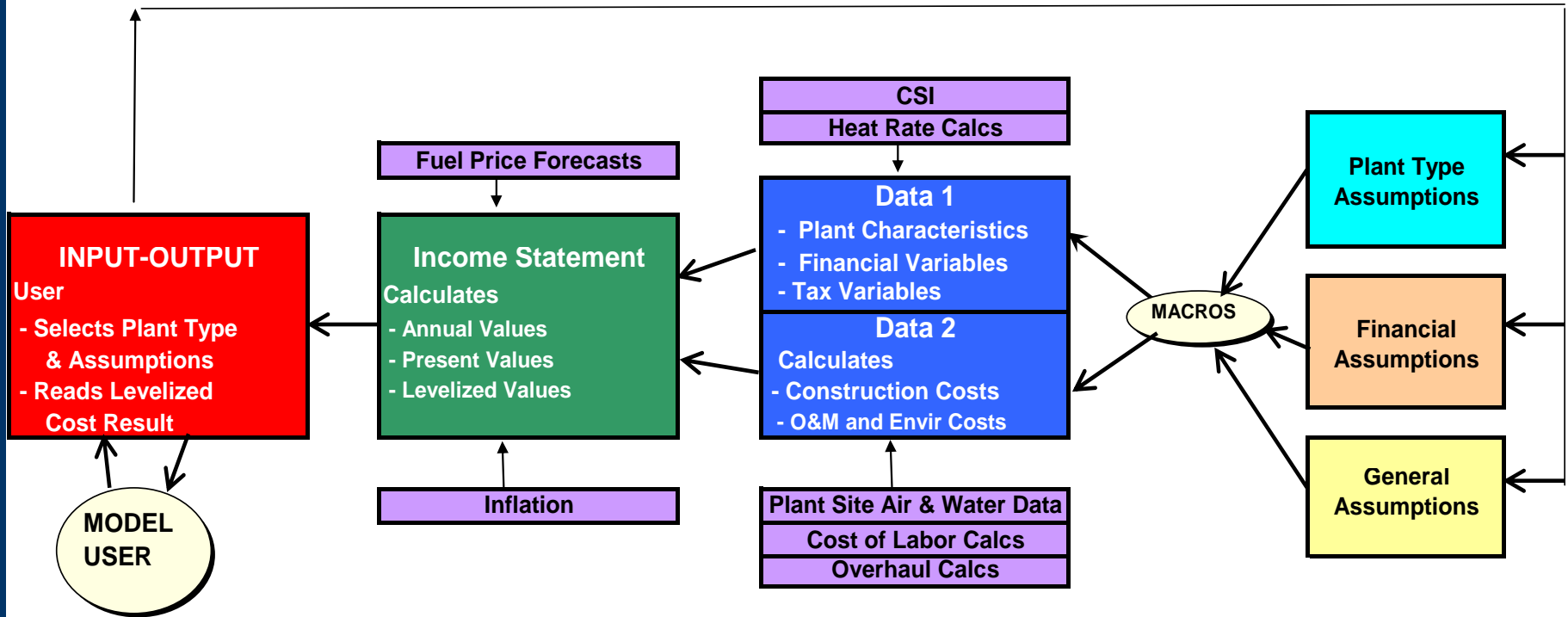
Wholesale Electricity Prices

(\$/MW h)

- Fixed Cost
- Variable Cost - Marketsym
- Total Cost



CEC MODEL STRUCTURE





INPUT

Plant Type Assumptions (Select)	Combined Cycle Standard - 2 Turbines, No Duct Firing
Financial (Ownership) Assumptions (Select)	Default-Merchant
Ownership Type For Scenarios	Merchant
General Assumptions (Select)	Default
Base Year (All Costs In 2005 Dollars)	2005
Fuel	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

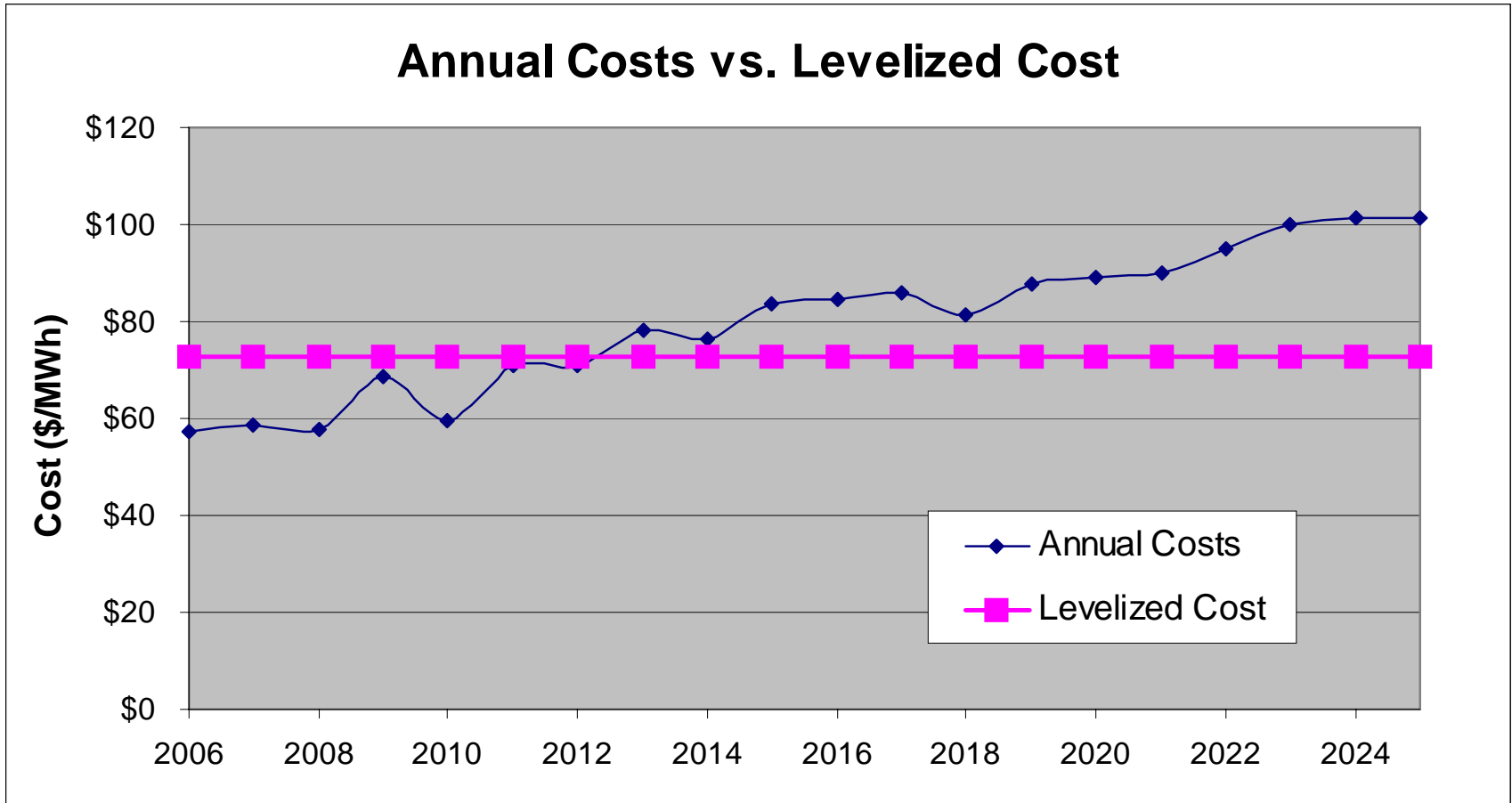
SUMMARY OF LEVELIZED COSTS

Combined Cycle Standard - 2 Turbines, No Duct Firing

Start Year = 2007 (2007 Dollars)	\$/kW-Yr	\$/MWh
Capital & Financing - Construction	\$115.66	\$22.78
Insurance	\$5.77	\$1.14
Ad Valorem Costs	\$7.36	\$1.45
Fixed O&M Costs	\$11.58	\$2.28
Corporate Taxes (w/Credits)	\$39.00	\$7.68
Fixed Costs	\$179.38	\$35.33
Fuel Costs	\$309.57	\$60.98
Variable O&M	\$26.27	\$5.17
Variable Costs	\$335.85	\$66.15
Total Levelized Costs	\$515.22	\$101.48



WHAT IS LEVELIZED COST?





MODEL DEMONSTRATION



INCOME STATEMENT

	COST CATEGORY	Merchant	IOU	POU
1	Capital & Financing	Debt Payment * %Debt + Levelized Total Equity Return * % Equity	Debt Payment * % Debt + (Return on Book Value + Depreciation) * % Equity	Debt Payment * 100% Debt + Equity Return * 0% Equity
2	Insurance	InsRate * Installed Cost	InsRate * BookValue	InsRate * Installed Cost
3	Ad Valorem	AdValRate * Installed Cost * Depreciation Factor	AdValRate * BookValue	0 or In Lieu
4	Fixed O&M	Labor + Capitalized Maintenance + Fixed O&M		
5a	State Taxes & Incentives	StateTaxRate*StateTaxInc-CSI-SGIP	StateTaxRate*StateTaxInc-CSI-SGIP	0-CSI-SGIP
5b	Federal Taxes & Incentives	FedTaxRate*FedTaxInc-BETC-REPTC	FedTaxRate*FedTaxInc-BETC-REPTC	0-REPI
5	Corporate Taxes	5a + 5b		
6	Total Fixed Costs	SUM 1-5		
7	Fuel Cost	Annualized PV(Fuel Price Forecast * Heat Rate)		
8	Variable O&M	Annualized PV(Variable O&M * MWH)		
9	Total Variable Costs	SUM 7-8		
10	Total New Generation Costs	SUM 6,9		

Notes

Solution Target: BeforeTaxIncome = Capital & Financing or Total Levelized Return

FedTaxIncome= BeforeTaxIncome-Interest-Depreciation-StateTaxes&Incentives

StateTaxIncome= BeforeTaxIncome-Interest-Depreciation

BeforeTaxIncome = $\frac{\text{AfterTaxIncome} - \text{StateTaxDed} * \text{StateTaxRate} * (1 - \text{FedTaxRate}) - \text{FedDed} * \text{FedTaxRate} - \text{SateTaxCredits} * (1 - \text{FedTaxRate}) - \text{FedTaxCredits}}{[1 - \text{StateTaxRate} - \text{FedTaxRate} * (1 - \text{StateTaxRate})]}$

[1-StateTaxRate-FedTaxRate*(1-StateTaxRate)]



TODAY

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



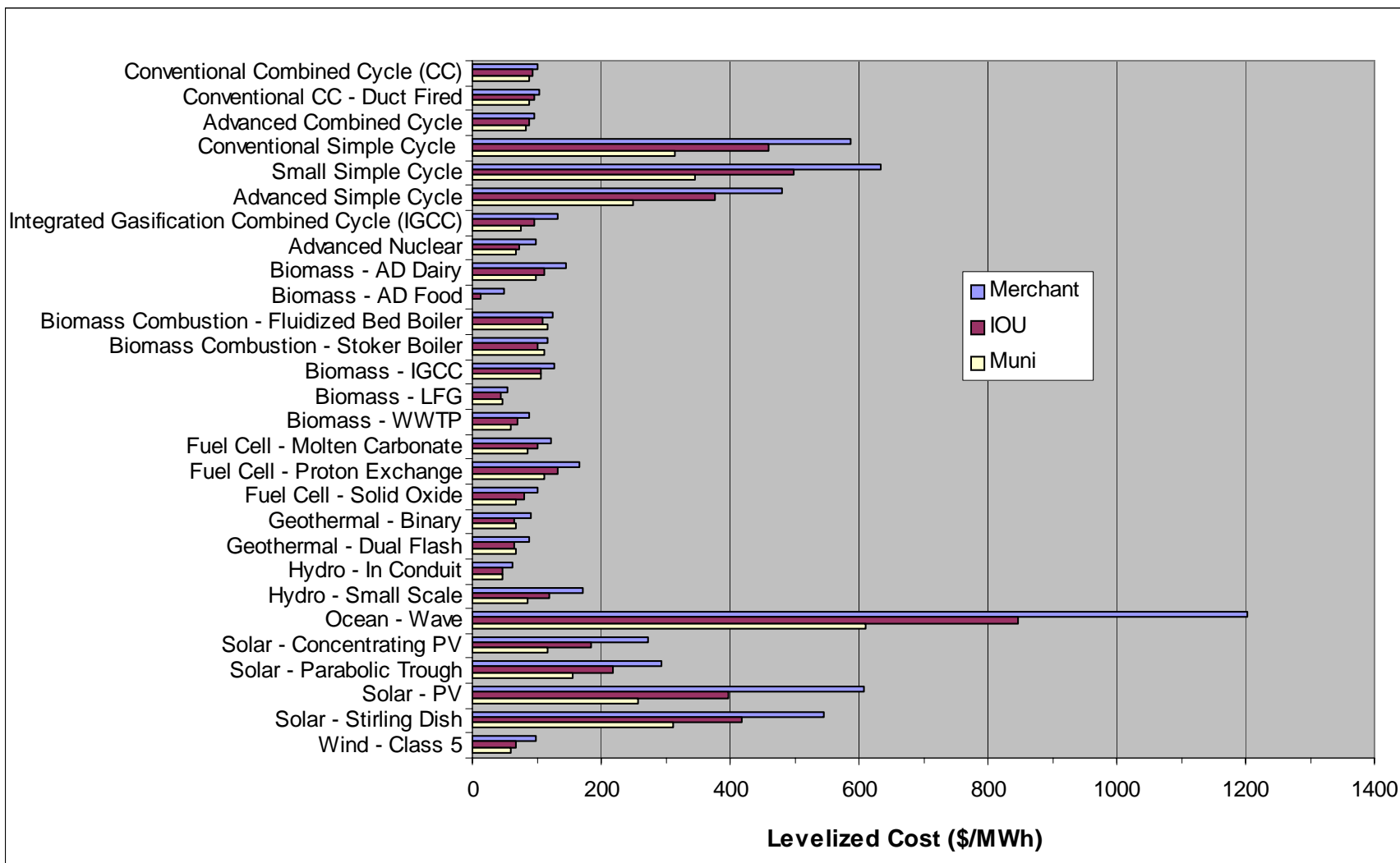
LEVELIZED COST ESTIMATES

In-Service Year =2007 (Nominal 2007\$)	Size	Merchant		IOU		Muni	
	MW	\$/kW-Yr	\$/MWh	\$/kW-Yr	\$/MWh	\$/kW-Yr	\$/MWh
Conventional Combined Cycle (CC)	500	514.57	101.35	476.31	93.97	443.68	87.79
Conventional CC - Duct Fired	550	521.49	102.72	482.14	95.12	448.59	88.77
Advanced Combined Cycle	800	485.30	95.59	447.16	88.22	413.91	81.90
Conventional Simple Cycle	100	250.81	586.36	196.68	460.01	133.90	313.42
Small Simple Cycle	50	270.85	633.21	213.36	499.02	147.98	346.37
Advanced Simple Cycle	200	205.06	479.40	160.83	376.17	106.18	248.52
Integrated Gasification Combined Cycle (IGCC)	575	678.11	131.66	492.79	95.68	384.74	74.70
Advanced Nuclear	1000	728.50	99.86	538.03	73.75	488.88	67.01
Biomass - AD Dairy	0.25	937.69	145.65	723.65	112.41	636.95	98.94
Biomass - AD Food	2	323.64	50.27	80.72	12.54	-51.00	-7.92
Biomass Combustion - Fluidized Bed Boiler	25	915.59	125.49	793.72	108.78	855.28	117.22
Biomass Combustion - Stoker Boiler	25	854.32	117.09	745.23	102.14	814.95	111.69
Biomass - IGCC	21.25	929.64	127.41	781.13	107.06	771.37	105.72
Biomass - LFG	2	370.07	54.49	294.14	43.66	317.72	47.86
Biomass - WWTP	0.5	458.23	87.35	361.82	70.59	296.38	60.36
Fuel Cell - Molten Carbonate	2	933.83	120.84	774.10	100.17	672.03	86.96
Fuel Cell - Proton Exchange	0.03	1289.91	166.91	1026.94	132.89	858.56	111.10
Fuel Cell - Solid Oxide	0.25	776.26	100.45	615.21	79.61	531.28	68.75
Geothermal - Binary	50	573.15	91.82	400.34	66.10	384.60	67.18
Geothermal - Dual Flash	50	542.03	88.67	383.07	64.58	375.70	67.01
Hydro - In Conduit	1	256.67	63.36	183.90	46.09	185.71	48.01
Hydro - Small Scale	10	700.93	171.03	480.62	119.06	338.23	86.43
Ocean - Wave	0.75	1440.72	1201.48	1006.79	846.40	716.79	611.59
Solar - Concentrating PV	15	495.96	271.96	334.48	185.55	204.88	116.23
Solar - Parabolic Trough	63.5	671.03	294.54	497.90	219.23	349.47	154.86
Solar - PV	1	1117.12	608.42	723.14	396.30	461.81	256.29
Solar - Stirling Dish	15	1121.75	544.27	859.49	417.02	643.25	312.10
Wind - Class 5	50	289.10	99.03	195.24	66.88	177.44	60.78



GRAPHICALLY

Start Year = 2007 (2007 Nominal\$)





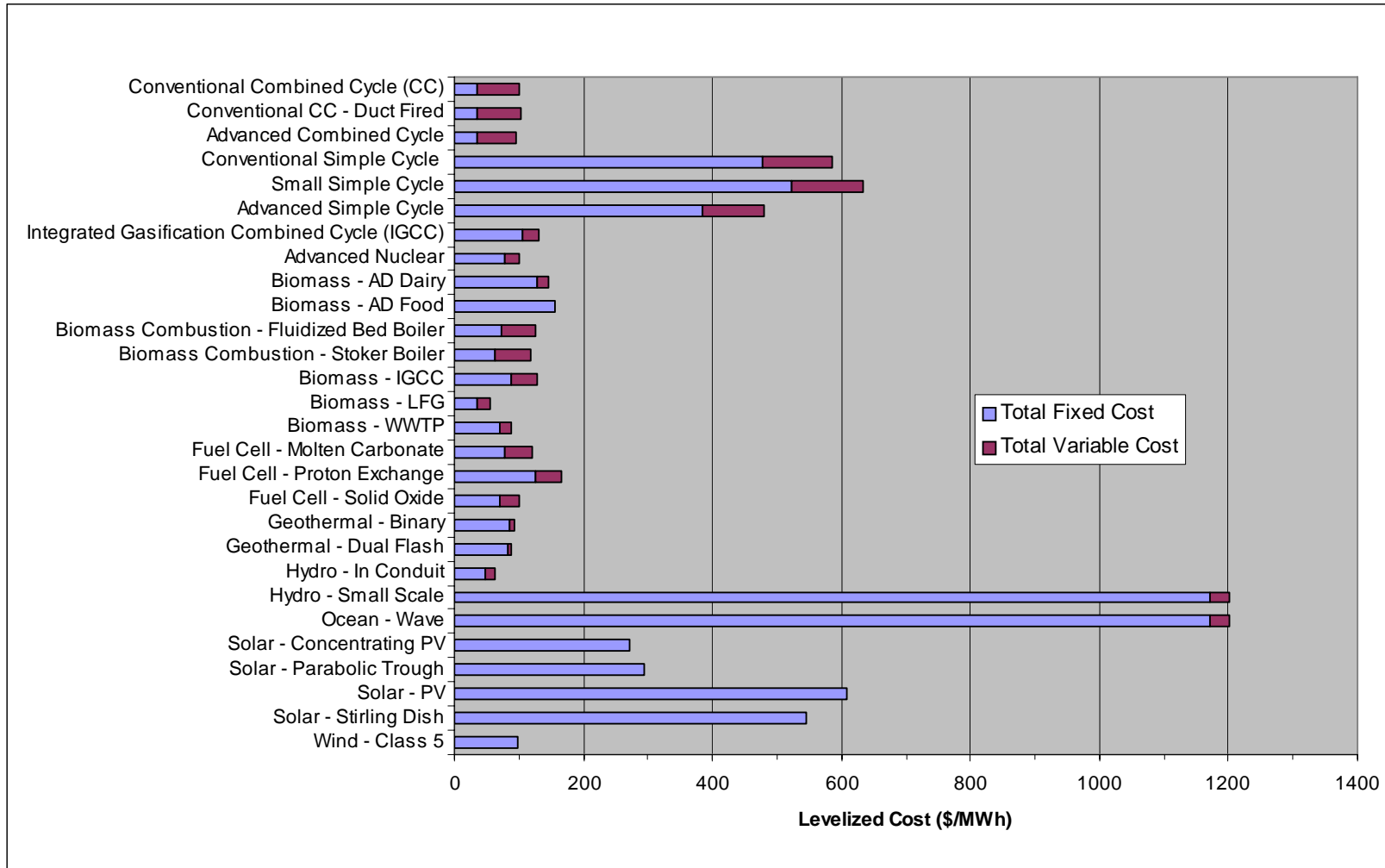
MERCHANT BY COMPONENT

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	22.69	1.13	1.44	2.28	7.65	35.20	60.98	5.17	66.15	101.35
Conventional CC - Duct Fired	550	23.27	1.16	1.48	2.20	7.85	35.96	61.76	5.00	66.76	102.72
Advanced Combined Cycle	800	22.33	1.11	1.42	1.94	7.53	34.34	56.79	4.46	61.25	95.59
Conventional Simple Cycle	100	318.41	15.86	20.27	30.08	91.94	476.56	79.70	30.10	109.80	586.36
Small Simple Cycle	50	338.72	16.87	21.57	48.27	97.55	522.97	79.70	30.54	110.24	633.21
Advanced Simple Cycle	200	260.16	12.96	16.56	19.43	75.21	384.32	65.20	29.88	95.08	479.40
Integrated Gasification Combined Cycle (IGCC)	575	68.03	3.95	6.20	8.84	18.04	105.06	22.69	3.90	26.60	131.66
Advanced Nuclear	1000	54.83	3.18	5.00	9.81	4.67	77.49	20.81	1.56	22.37	99.86
Biomass - AD Dairy	0.25	122.96	6.28	8.03	9.43	-19.53	127.17	0.00	18.48	18.48	145.65
Biomass - AD Food	2	123.60	6.28	8.04	28.28	-10.32	155.87	0.00	-105.61	-105.61	50.27
Biomass Combustion - Fluidized Bed Boiler	25	55.67	3.12	4.48	25.21	-16.57	71.92	49.76	3.81	53.57	125.49
Biomass Combustion - Stoker Boiler	25	51.13	2.86	4.12	22.60	-17.19	63.52	49.76	3.81	53.57	117.09
Biomass - IGCC	21.25	58.23	3.24	4.67	26.06	-4.93	87.28	36.33	3.80	40.13	127.41
Biomass - LFG	2	45.55	2.32	2.96	3.57	-18.12	36.28	0.00	18.21	18.21	54.49
Biomass - WWTP	0.5	71.82	3.65	4.67	4.63	-15.63	69.14	0.00	18.21	18.21	87.35
Fuel Cell - Molten Carbonate	2	81.71	4.15	5.31	0.33	-13.16	78.35	0.00	42.48	42.48	120.84
Fuel Cell - Proton Exchange	0.03	131.80	6.70	8.57	2.83	-25.47	124.43	0.00	42.48	42.48	166.91
Fuel Cell - Solid Oxide	0.25	89.37	4.54	5.81	1.57	-29.98	71.31	0.00	29.13	29.13	100.45
Geothermal - Binary	50	79.77	4.00	5.12	13.61	-16.14	86.36	0.00	5.46	5.46	91.82
Geothermal - Dual Flash	50	75.49	3.78	4.84	15.89	-16.70	83.30	0.00	5.37	5.37	88.67
Hydro - In Conduit	1	49.70	2.82	4.06	0.00	-9.71	46.88	0.00	16.48	16.48	63.36
Hydro - Small Scale	10	895.99	44.11	56.44	30.37	144.23	1171.14	0.00	30.35	30.35	1201.48
Ocean - Wave	0.75	894.17	44.24	56.48	30.47	145.40	1170.76	0.00	30.44	30.44	1201.20
Solar - Concentrating PV	15	378.55	20.60	0.00	30.69	-157.88	271.96	0.00	0.00	0.00	271.96
Solar - Parabolic Trough	63.5	229.78	13.05	0.00	33.39	18.33	294.54	0.00	0.00	0.00	294.54
Solar - PV	1	665.07	37.06	0.00	16.57	-110.28	608.42	0.00	0.00	0.00	608.42
Solar - Stirling Dish	15	390.76	22.19	0.00	100.26	31.06	544.27	0.00	0.00	0.00	544.27
Wind - Class 5	50	86.77	4.84	6.96	13.03	-12.57	99.03	0.00	0.00	0.00	99.03



MERCHANT GRAPHICALLY

Start Year = 2007 (2007 Nominal\$)



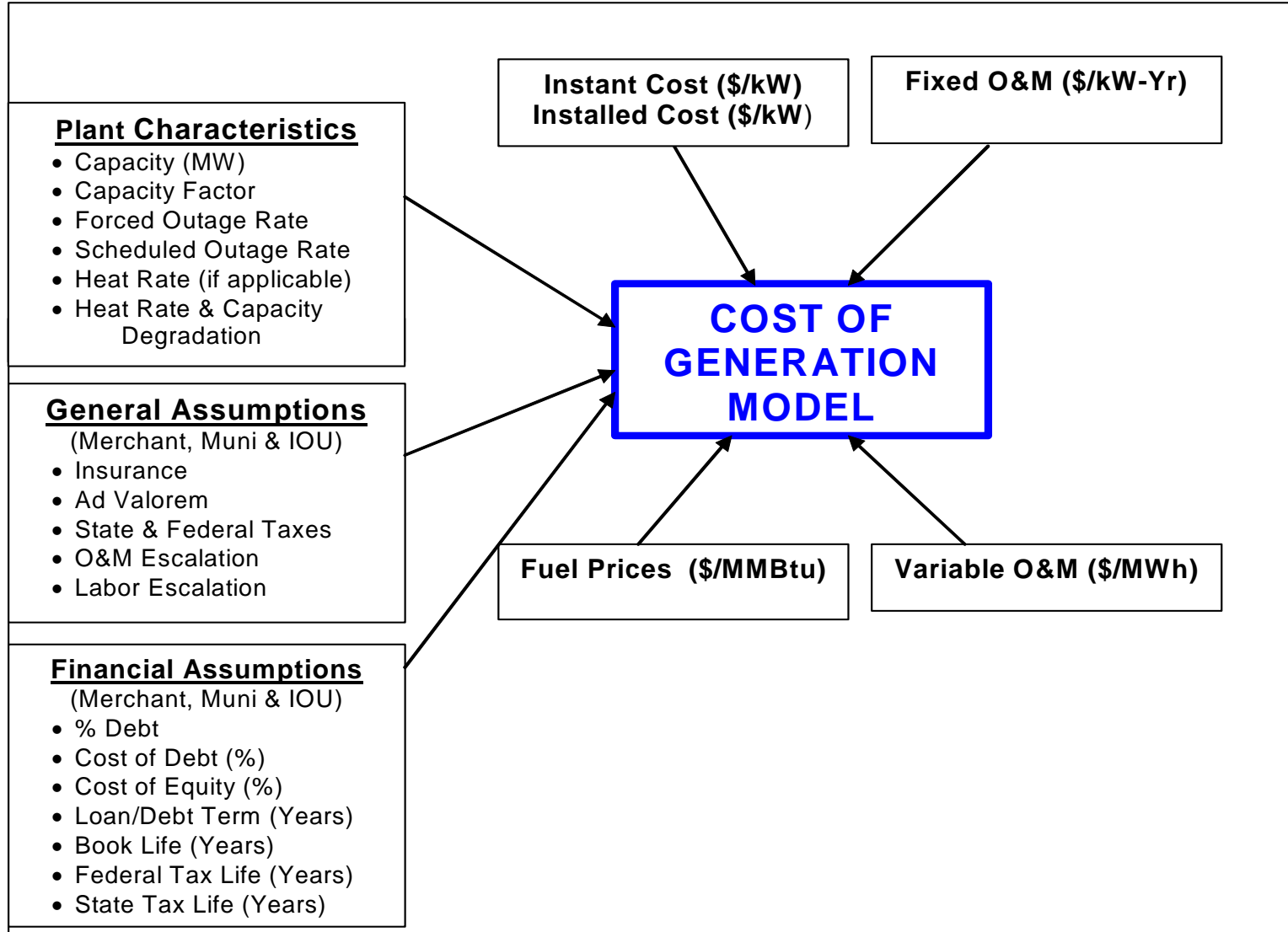


TODAY

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



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	500	60.00%	6990	784	847	852	782	9.86	4.42
Conventional Combined Cycle - Duct Fired	550	60.00%	7080	803	868	873	803	9.53	4.28
Advanced Combined Cycle	800	60.00%	6510	771	833	838	768	8.42	3.83
Conventional Simple Cycle	100	5.00%	9266	925	1000	1000	793	11.00	25.72
Small Simple Cycle	50	5.00%	9266	984	1064	1064	857	17.65	26.10
Advanced Simple Cycle	200	5.00%	7580	756	817	817	610	7.13	25.57
Integrated Gasification Combined Cycle (IGCC)	575	60.00%	8979	2198	2845	2645	2341	36.27	3.11
Nuclear	1000	85.00%	10400	2509	3247	3019	2672	57.00	1.24
Biomass - AD Dairy	0.25	75.00%	12407	5800	5955	5911	5837	51.81	15.77
Biomass - AD Food	2	75.00%	17060	5803	5958	5913	5840	155.44	-102.59
Biomass Combustion - Fluidized Bed Boiler	25	85.00%	15509	3156	3241	3217	3177	150.26	3.11
Biomass Combustion - Stoker Boiler	25	85.00%	15509	2899	2976	2954	2917	134.72	3.11
Biomass - IGCC	21.25	85.00%	10663	3121	3374	3301	3181	155.44	3.11
Biomass - LFG	2	85.00%	11566	2248	2316	2296	2263	20.73	15.54
Biomass - WWTP	0.5	75.00%	12407	2730	2821	2794	2748	20.70	15.52
Fuel Cell - Molten Carbonate	2	90.00%	8322	4488	4728	4659	4546	2.18	36.27
Fuel Cell - Proton Exchange	0.03	90.00%	13127	7239	7626	7515	7332	18.65	36.27
Fuel Cell - Solid Oxide	0.25	90.00%	8530	4908	5171	5096	4972	10.36	24.87
Geothermal - Binary	50	95.00%	N/A	3093	3673	3498	3227	72.54	4.66
Geothermal - Dual Flash	50	93.00%	N/A	2867	3404	3241	2988	82.90	4.58
Hydro - In Conduit	1	51.40%	N/A	1547	1629	1605	1567	0.00	13.47
Hydro - Small Scale	10	52.00%	N/A	4125	4345	4281	4178	13.47	3.11
Ocean : Wave	0.75	15.00%	N/A	7203	7788	7617	7342	38.63	32.19
Solar - PV	1	17.30%	N/A	9611	9697	9472	9632	24.87	0.00
Solar - Parabolic Trough	63.5	27.00%	N/A	4021	4236	4174	4073	62.18	0.00
Solar - Stirling Dish	15	24.00%	N/A	6187	6517	6422	6266	168.92	0.00
Solar - Concentrating PV	15	23.00%	N/A	5156	5432	5352	5222	46.63	0.00
Wind - Class 5	50	34.00%	N/A	1959	2012	1997	1972	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



NUCLEAR, CLEAN COAL & ALTERNATIVE TECHNOLOGIES

Technology (All costs in Nominal 2006\$)	Gross Capacity (MW)	Navigant Instant Cost (\$/kW)	CEC Total Instant Cost
Integrated Geofication Combined Cycle (IGCC)	675	2060	2129
Nuclear	1000	2400	2433
Biomass AD Dairy	0.25	6300	6861
Biomass AD Food	2	6300	6880
Biomass Combustion - Fluidized Bed Boiler	25	2760	3074
Biomass Combustion - Stoker Boiler	25	2500	2824
Biomass IGCC	21.25	2800	3036
Biomass LFG	2	1860	2198
Biomass WWTP	0.6	2400	2884
Fuel Cell - Molten Carbonate	2	4360	4362
Fuel Cell - Proton Exchange	0.03	7000	7020
Fuel Cell - Solid Oxide	0.25	4760	4780
Geothermal - Binary	60	3000	3000
Geothermal - Dual Flash	60	2760	2780
Hydro - In Conduit	1	1500	1500
Hydro - Small Scale	10	4000	4000
Ocean : Wave	0.75	8985	8985
Solar - PV	1	6000	6000
Solar - Parabolic Trough	63.6	3900	3900
Solar - Stirling Dish	16	6000	6000
Solar - Concentrating PV	16	6000	6000
Wind - Class 5	60	1900	1900



TODAY

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



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 ²	San Diego	2001
Sutter	Sutter	2001	Wildflower Indigo ²	Riverside	2001
Delta	Contra Costa	2002	Drews Alliance ²	San Bernardino	2001
Moss Landing	Monterey	2002	Century Alliance ²	San Bernardino	2001
La Paloma	Kern	2003	Hanford ²	Kings	2001
High Desert	San Bernardino	2003	Calpeak Escondido ²	San Diego	2001
MID Woodland ^{1,2}	Stanislaus	2003	Calpeak Border ²	San Diego	2001
Sunrise	Kern	2003	Gilroy ²	Santa Clara	2002
Blythe I	Riverside	2003	King City ²	Monterey	2002
Elk Hills	Kern	2003	Henrietta	Kings	2002
Von Raesfeld ¹	Santa Clara	2005	Los Esteros	Santa Clara	2003
Metcalf	Santa Clara	2005	Tracy Peaker	San Joaquin	2003
Magnolia ¹	Los Angeles	2005	Kings River Peaker ^{1,2}	Fresno	2005
Malburg ¹	Los Angeles	2005	Ripon	San Joaquin	2006
Pastoria	Kern	2005	Riverside	Riverside	2006
Mountainview ³	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

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



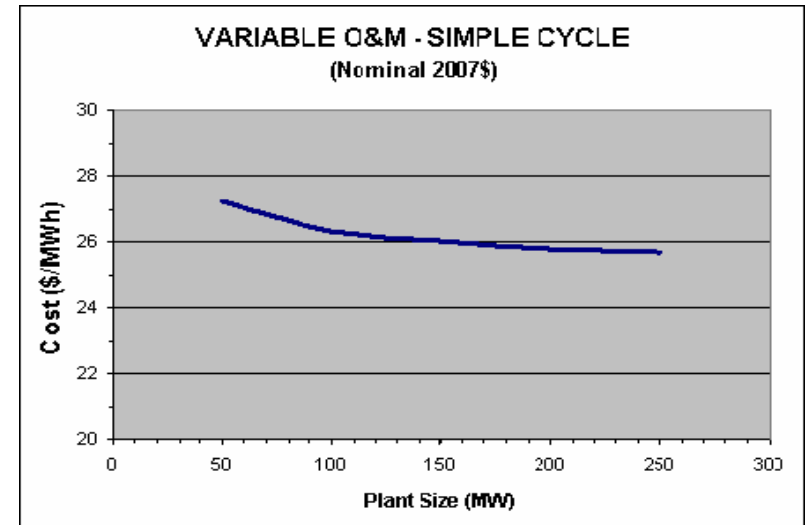
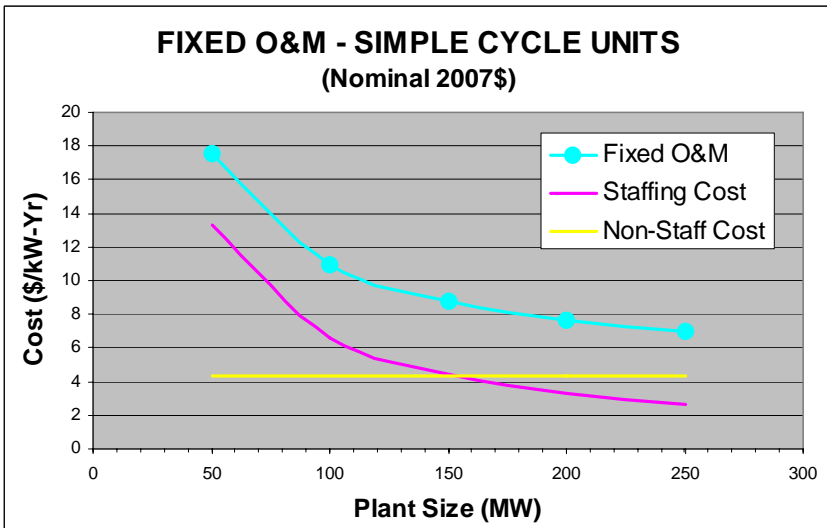
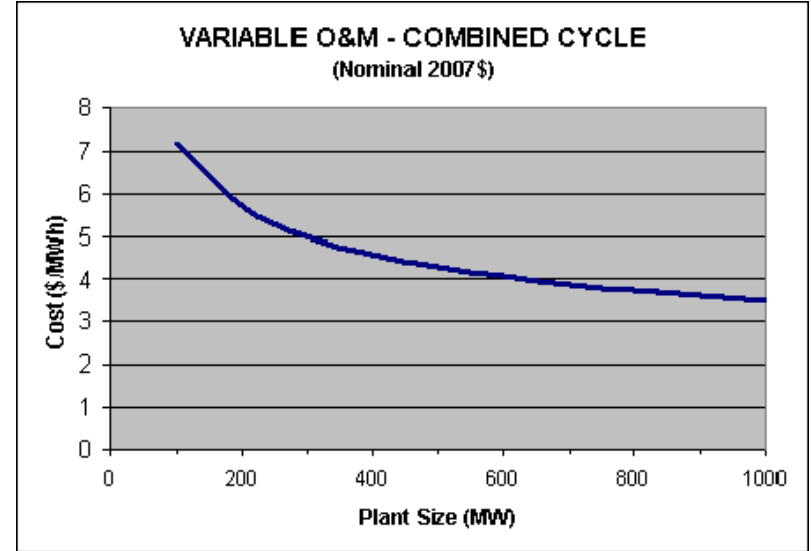
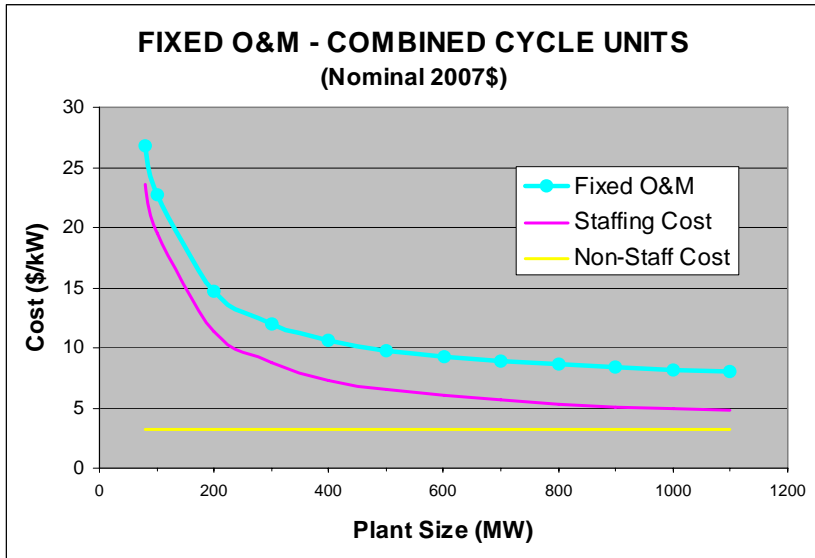
SIMPLE CYCLE INSTALLED COSTS

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

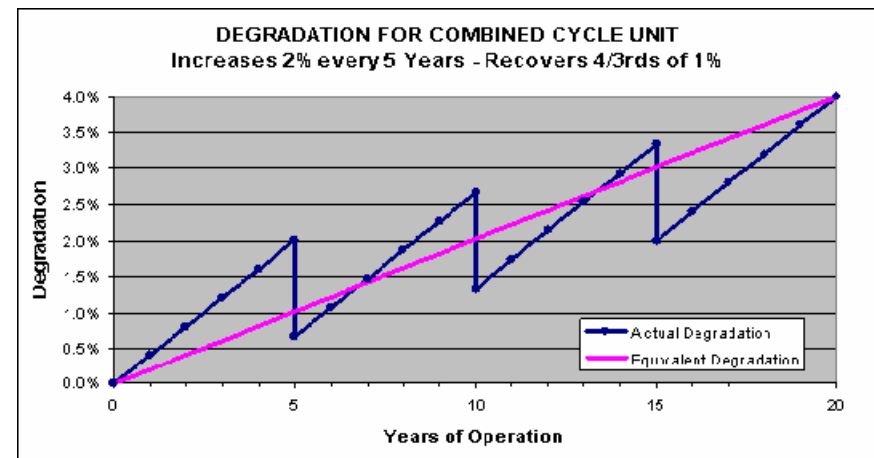
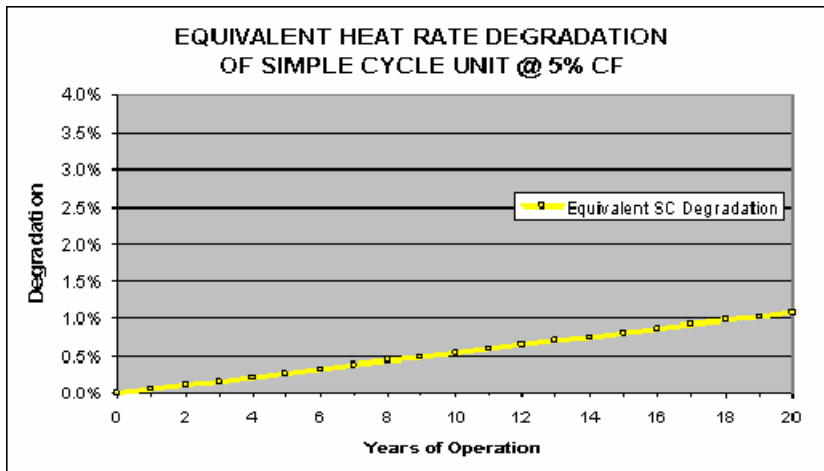


FIXED & VARIABLE O&M





HEAT RATE DEGRADATION





ASSUMED LOSSES (CPUC MPR PROCEEDINGS)

LOCATION	LOSSES (%)	POWER (MW)	ENERGY (GWh)
Busbar	--	1.0000	8.059200
High-side of Transformer	0.5%	0.9950	8.018904
Load Center	1.43%	0.9808	7.904234

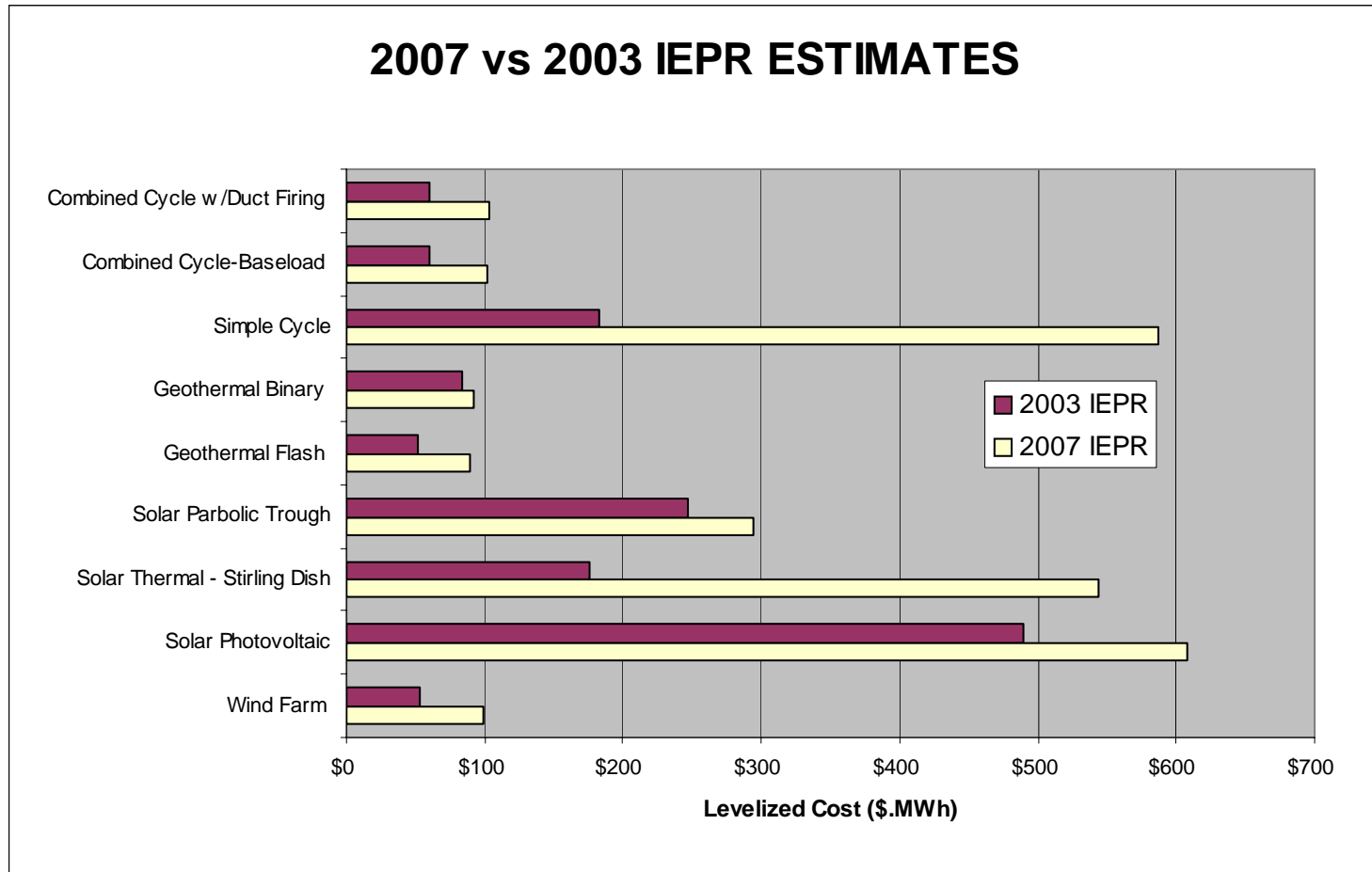


COMPARISON TO 2003 IEPR

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)
Combined Cycle w/Duct Firing	550	\$59.73	91.6	550	\$102.72	60.0	608	691	803	868
Combined Cycle-Baseload	500	\$59.50	91.6	500	\$101.35	60.0	620	677	784	847
Simple Cycle	100	\$182.62	9.4	100	\$586.36	5.0	477	544	925	1000
Geothermal Binary	35	\$83.40	98.5	50	\$91.82	95.0	3673	4140	3089	3668
Geothermal Flash	50	\$51.85	96.0	50	\$88.67	93.0	2435	2758	2863	3399
Solar Parabolic Trough	110	\$246.40	22.0	63.5	\$294.54	27.0	2975	3203	4015	4230
Solar Thermal - Stirling Dish	15	\$175.86	36.3	15	\$544.27	24.0	3742	4028	6178	6507
Solar Photovoltaic	50	\$488.84	23.8	1	\$608.42	22.2	7614	8197	8237	5424
Wind Farm	100	\$52.93	36.3	50	\$99.03	34.0	1015	1093	1956	2009



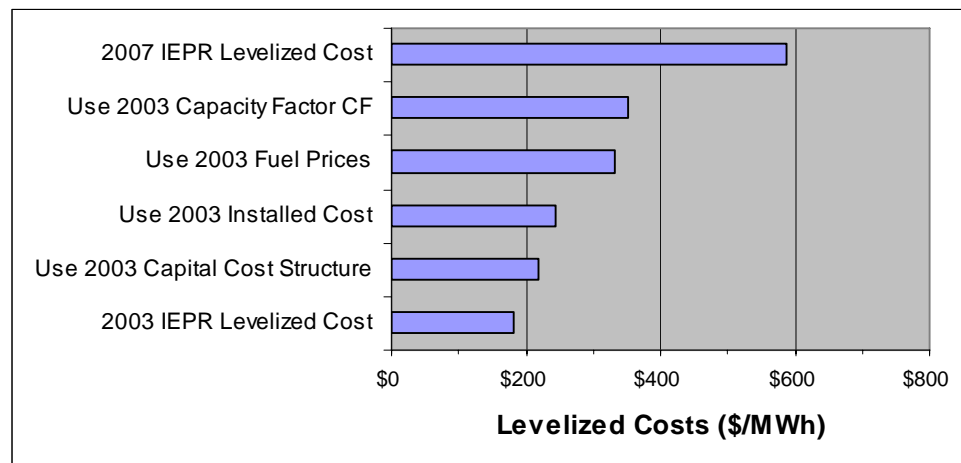
LEVELIZED COST COMPARISON





2007 IEPR vs. 2003 IEPR SIMPLE CYCLE UNIT

Effect of Change (2007\$)	\$/MWh
2007 IEPR Levelized Cost	\$586.36
Use 2003 Capacity Factor CF (5% --> 9.4%)	\$350.48
Use 2003 Fuel Prices	\$331.39
Use 2003 Installed Cost (\$1003 --> \$522/kW)	\$243.56
Use 2003 Capital Cost Structure	\$219.65
2003 IEPR Levelized Cost	\$182.62



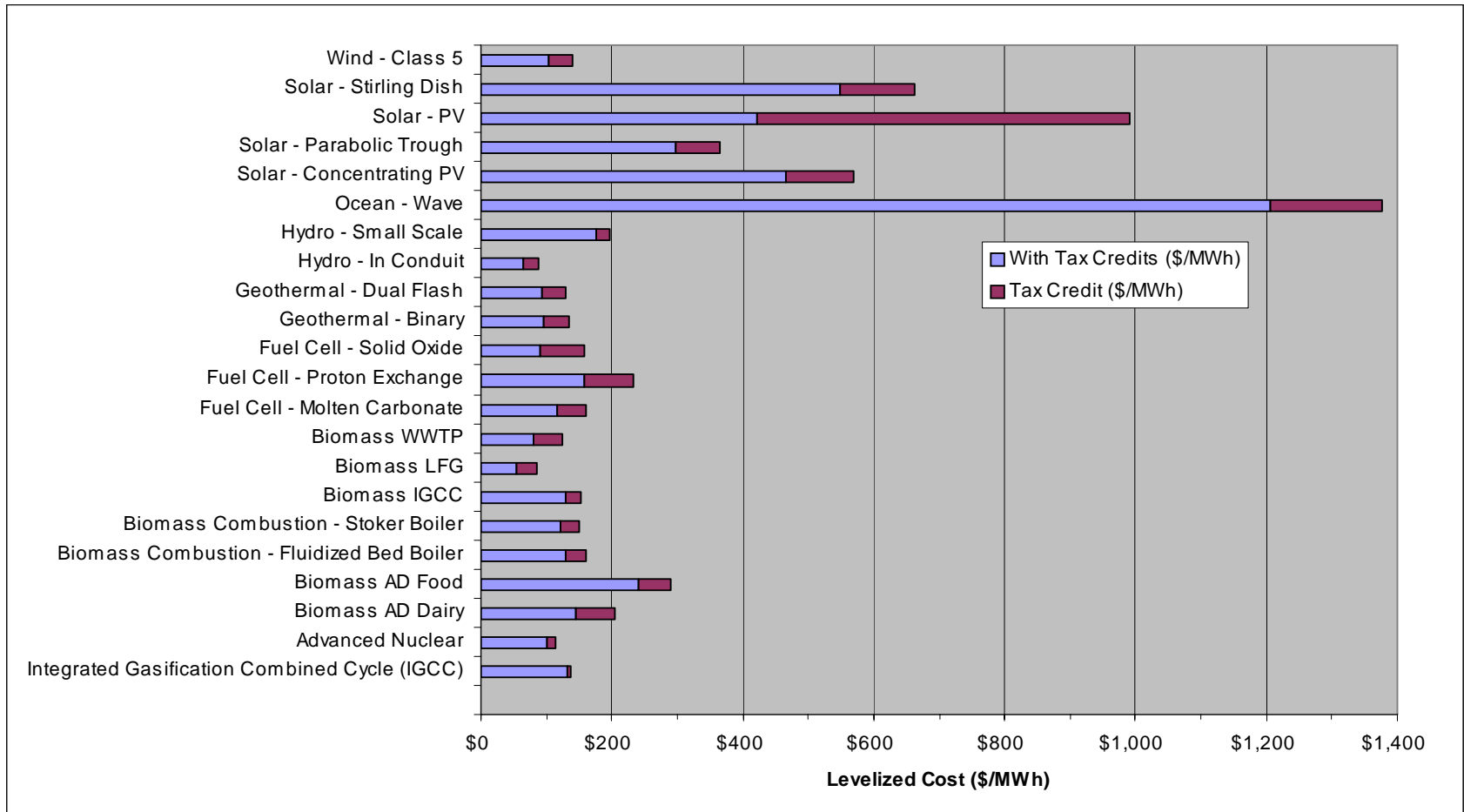


COMPARISON TO EIA ASSUMPTIONS

Technology (Nominal ZIP\$)	Size (Gross MW)		Instant Cost (\$/MW)			Fixed O&M (\$/MW/yr)			Variable O&M (\$/MWh)			Capacity Factor (%)		Heat Rate (Btu/MWh)	
	CEC	EIA	CEC	EIA	Ratio	CEC	EIA	Ratio	CEC	EIA	Ratio	CEC	EIA	CEC	EIA
Combined Cycle (CC)	500	250	784	841	1.22	8.91	12.48	0.79	4.42	2.07	2.91	80%	87%	8,980	8,800
Advanced CC	800	400	771	832	1.22	8.47	11.70	0.72	3.89	2.00	2.70	80%	87%	8,510	8,339
Simple Cycle (SC)	100	180	925	447	2.07	11.08	12.12	0.9	25.76	3.57	13.5	5%	30%	9,288	10,450
Advanced SC	200	280	768	429	1.79	7.13	10.69	0.7	26.67	3.17	13.8	5%	30%	7,680	8,850
IGCC	575	550	2192	1585	1.38	38.22	38.89	0.2	3.10	2.92	14.5	80%	89%	8,979	8,800
Adv Nuclear	1000	1350	2505	2213	1.13	58.91	87.82	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	38.22	47.85	0.8	80%		8,322	8,632
Geothermal - Binary	50	50	3088	1998	1.55	72.43	134.72	0.4	4.86	0.00	-	95%	90%		
Conventional Hydropower	10	10	4118	1605	2.69	13.45	13.07	1.0	3.10	3.61	0.0	62%			
Wind	50	50	1958	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	11.89	1.1	0.00	0.00	-	17.3%			



EFFECT OF TAX CREDITS





MISUSE OF COG ESTIMATES

- For one set of assumptions:
 - Equipment Cost.
 - Capacity Factor.
 - Location.
 - Linears.
 - ERCs.
- Can not predict how the unit will operate in the system or how it will affect the system.



OTHER CONCERNS

- Comparing levelized cost is problematic:
 - Units with different capacity factors are not comparable.
 - Risk factors can justify a more expensive unit (volatile gas prices).
 - Ignores environmental and other factors.
- CEC Model has screening curve and cost sensitivity function, but these both fall short of using a production cost or market model.



DATA LIMITATIONS CEC EFFORTS

COG models are inherently limited because they must make a number of assumptions. The most serious of these are:

- Capital Costs (Instant & Installed Cost)
- Fuel Costs
- Capacity Factors
- Heat Rates – for thermal plants



CAPITAL COSTS

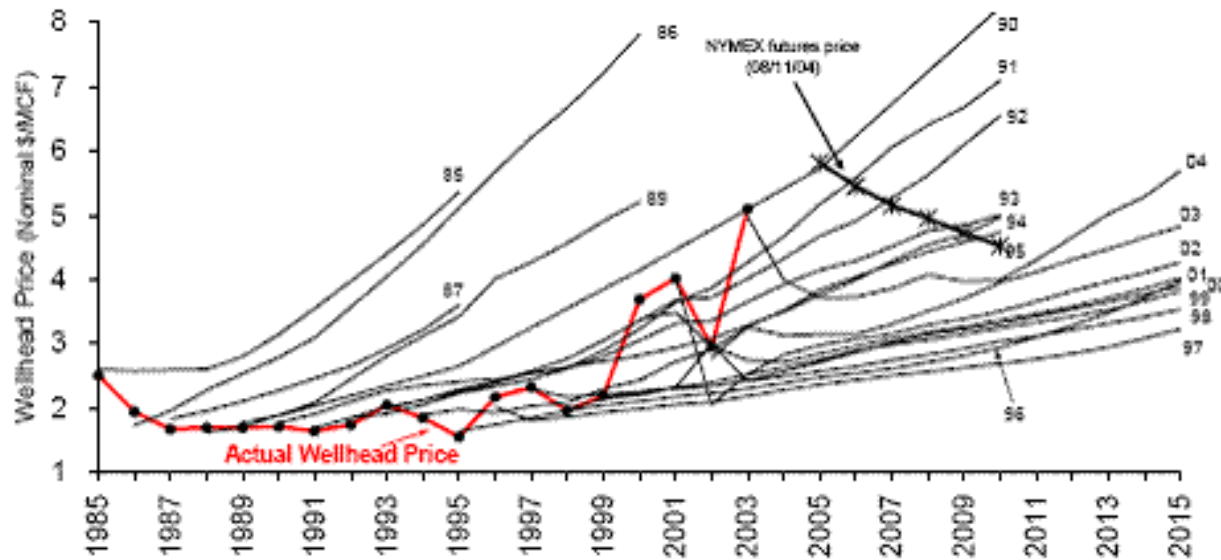
INSTANT & INSTALLED COSTS

- Difficult to estimate:
 - Change due to technological improvements and competition.
 - Vary with location and situation.
 - Competition tends to keep these costs confidential.
- CEC forecast is based on as-built survey.



FUEL COST

- Costs are highly variable.
- All gas price forecasts are wrong.



Source: EIA

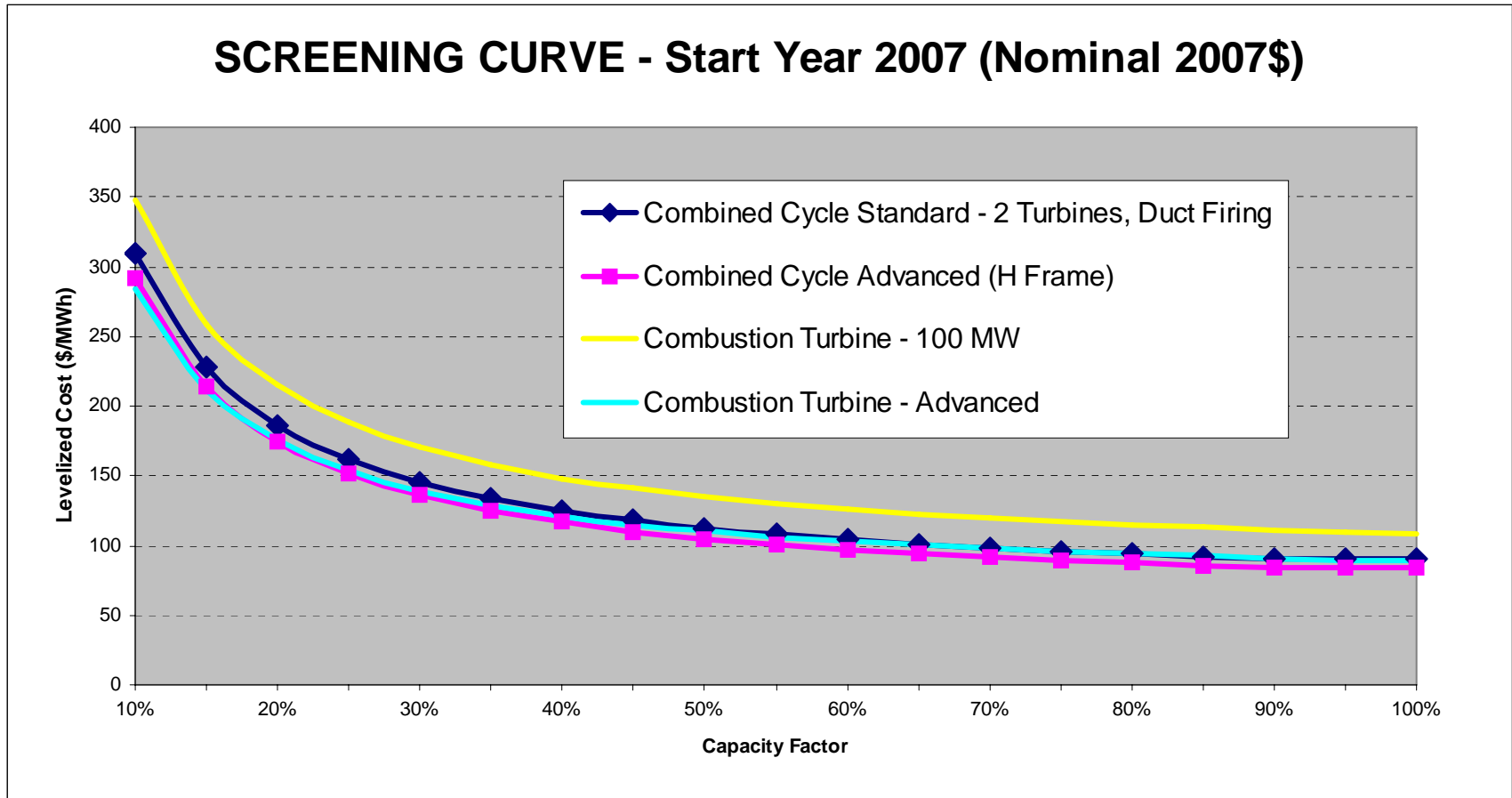


CAPACITY FACTORS

- Costs vary dramatically with Capacity Factors.
For example:
 - Combined Cycle Units: 90%; should be 60%.
 - Simple Cycle Units: 10%; should be <5%.
- CEC COG Model:
 - More realistic Capacity Factors.
 - Provides Screening Curves.



SOME CAPACITY FACTORS





COMBINED CYCLE UNITS HISTORICAL VALUES

Power Plant	QFER 2004	QFER 2005
Moss Landing Power Plant	55.5%	52.6%
Los Medanos	74.3%	74.7%
Sunrise Power	62.1%	65.7%
Elk Hills Power, LLC	79.9%	72.4%
High Desert Power Project	51.9%	50.3%
Sutter	72.0%	51.3%
Delta Energy Center	72.6%	69.5%
Blythe Energy LLC	26.8%	19.6%
La Paloma Generating	57.2%	46.4%
Von Raesfeld	nd	31.6%
Woodland	nd	51.5%
Average	61.3%	53.2%



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%



HEAT RATES (HHV)

- COG Models are typically limited because:
 - They assume a singular heat rate.
 - Estimates are often theoretical.
- CEC Model's heat rate is:
 - Is based on actual (QFER) data.
 - Adjusts heat rate as a function of CF.



NEXT STEPS

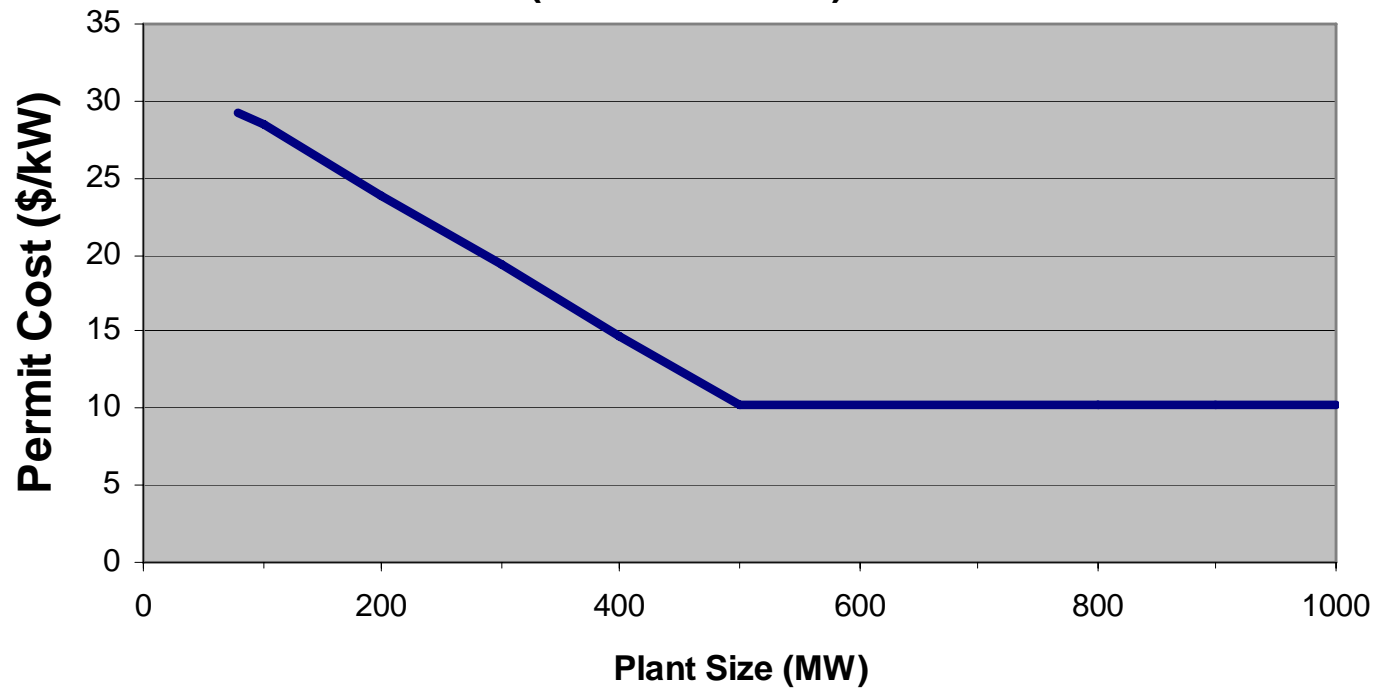
- Written comments must be submitted by June 22, 2007.
- Consider stakeholder comments for model and input modifications.
- Final staff report by end of July.
- Post Levelized Cost of Generation Model and User's Guide for public use.



END



COMBINED CYCLE PERMIT COST (Nominal 2007\$)





CAPACITY DEGRADATION

