COMBUSTION TURBINE LEVELIZED COSTS

BRIEFING FOR THE CAISO

Date: August 23, 2010

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Electricity Analysis Office

California Energy Commission

TODAY

- Short History of COG Model and Report.
- 2009 IEPR LCOE and Comparison to 2007 IEPR.
- Overview of Cost of Generation Model.
- Overview of the Cost of Generation Report.

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SHORT HISTORY

- The COG Model is used to produce the IEPR report: **COMPARATIVE COSTS OF CALIFORNIA CENTRAL STATION ELECTRICITY GENERATION**
  http://www.energy.ca.gov/2009publications/CEC-200-2009-017/CEC-200-2009-017-SF.PDF
- The Model was first developed in 2003 and then updated in 2007 and 2009.
- The Model, its data, and its outputs are fundamental to many electricity generation and transmission planning studies.
- The COG Model and Report are made available for State, Federal and public use.

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CHANGE IN LCOE FOR 49.9 MW COMBUSTION TURBINE

		Levelized Costs ($/kW-Yr)					
Scenarios	Size MW	Capital & Financing	Insurance	Ad Valorem	Fixed O&M	Taxes	**Total Fixed Cost**
2007 IEPR (2007 Start Year & $)	50	145.30	7.25	9.25	20.36	41.85	**224.01**
2007 IEPR (Escalated to 2009$)	50	156.29	7.79	9.95	21.90	45.01	**240.95**
2007 IEPR (2009 Start Year & $)	50	151.76	7.55	9.66	21.43	43.69	**234.09**
2009 IEPR (2009 Start Year & $)	49.9	198.11	9.63	13.09	27.45	55.13	**303.42**
Apparent increase in Levelized Cost		35%					
Inflating 2007 dollars to 2009 dollars		26%					
Running 2007 Model for 2009 Start Year		30%					

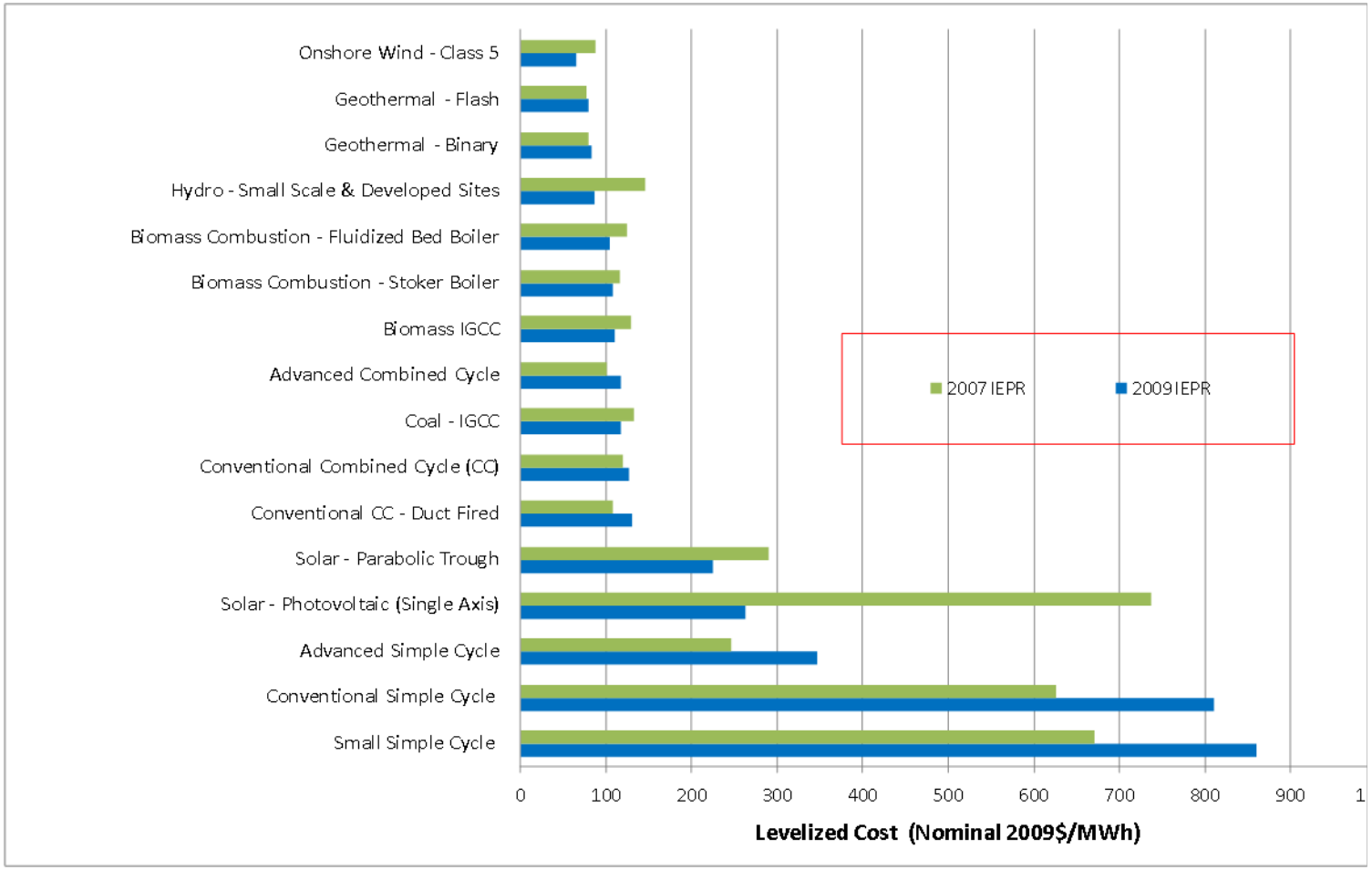
CHANGE IN ASSUMPTIONS
49.9 MW COMBUSTION TURBINE

Plant Type Assumptions	2007 IEPR (2009$)	2009 IEPR (2009$)	Increase
Capacity (MW)	50.00	49.90	0%
Instant Cost	$1,017	$1,292	**27%**
Installed Cost	$1,111	$1,449	**30%**
Fixed O&M ($/kW-Yr)	$18.28	$23.94	**31%**
Capacity Factor	5%	5%	0%
Insurance	0.6%	0.6%	0%
Ad Valorem	1.07%	1.10%	3%
Site Losses	2.40%	2.40%	0%
Capacity Degradation	0.05%	0.05%	0%
Heat Rate (Btu/kWh)	9,266	9,266	0%
Heat Rate Degradation	0.05%	0.05%	0%
Plant Losses	2.40%	3.40%	**42%**
Transformer Losses	0.50%	0.50%	0%
Transmission Losses	1.49%	2.09%	**40%**

Finance Assumptions	2007 IEPR (2009$)	2009 IEPR (2009$)	Increase
% Equity	60%	60%	0%
Cost of Equity	15.19%	14.47%	**-5%**
Cost of Debt	6.50%	7.49%	**15%**
WACC	10.65%	10.46%	**-2%**
Debt Term	12 Years	12 Years	0%
Average Inflation	1.90%	1.56%	**-18%**
Real Labor Escalation	0.50%	0.50%	0%
Real O&M Escalation	0.50%	0.50%	0%
Book Life	20 Years	20 Years	0%
Federal Tax Rate	35.0%	35.0%	0%
State Tax Rate	8.84%	8.84%	0%
Total Tax Rate	40.7%	40.7%	0%
Federal Tax Life	15 Years	15 Years	0%
State Tax Life	15 Years	15 Years	0%

COMPARISON TO 2007 IEPR

Start Year = 2009 (2009 Nominal$/MWh)



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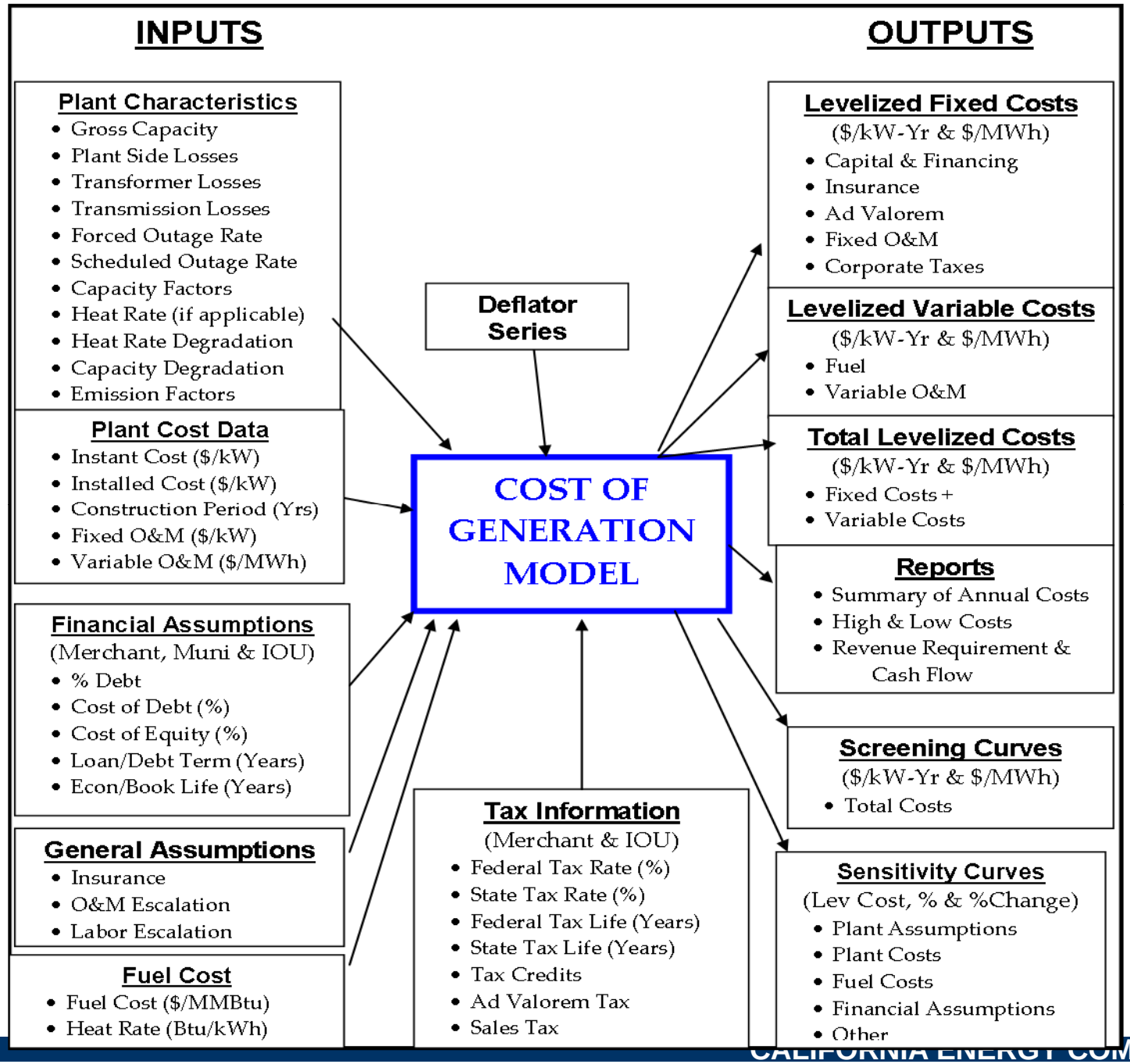
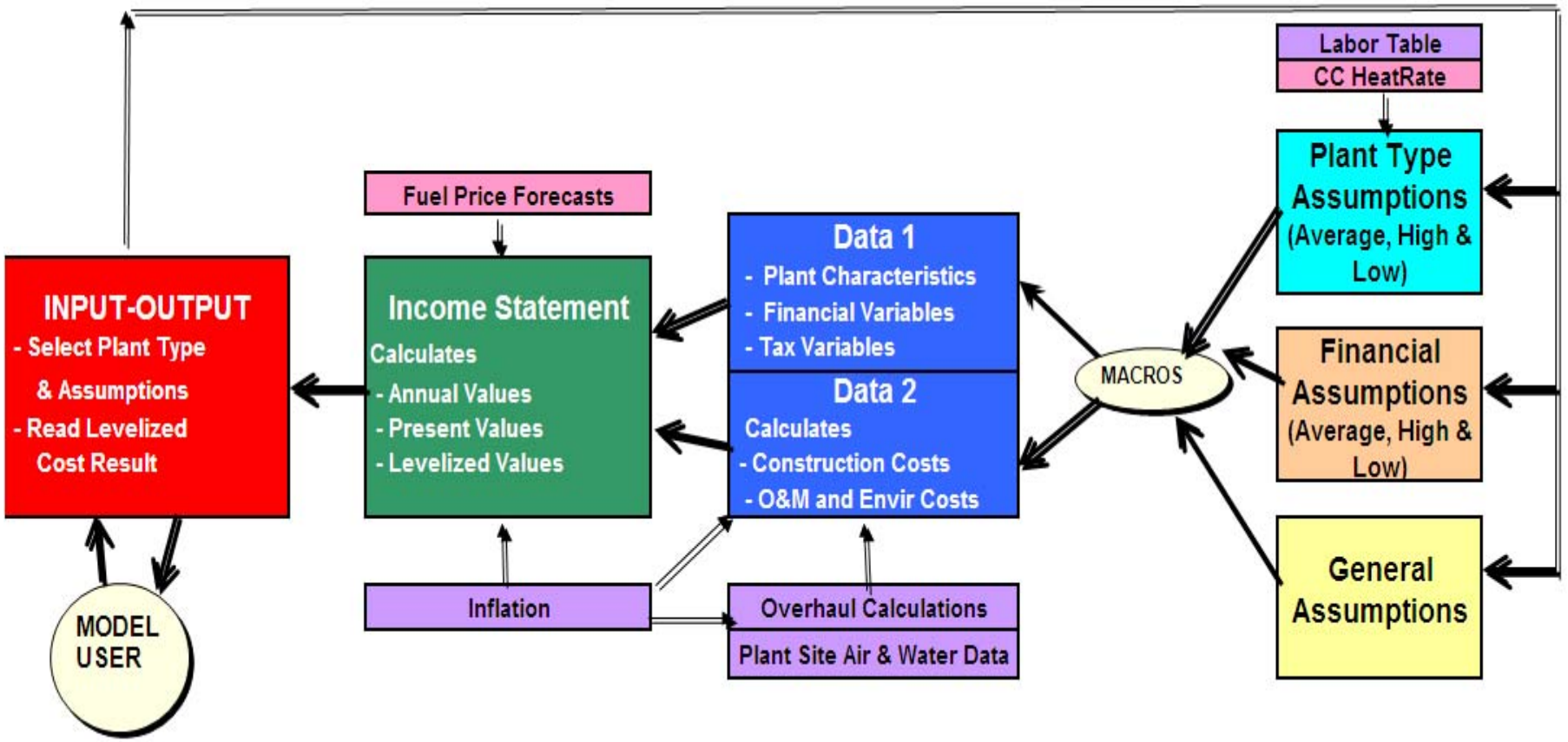
WHAT DOES IT DO?

- Estimates the levelized costs for technologies.
- Compares cost of one technology to another.
- CEC Model also generates:
  - Annual Costs
  - Stores Scenarios
  - Screening Curves
  - Sensitivity Curves
  - Wholesale Electricity Prices


INPUTS
OUTPUTS
Plant Characteristics
• Gross Capacity
• Plant Side Losses
• Transformer Losses
• Transmission Losses
• Forced Outage Rate
• Scheduled Outage Rate
• Capacity Factors
• Heat Rate (if applicable)
• Heat Rate Degradation
• Capacity Degradation
• Emission Factors
Plant Cost Data
• Instant Cost ($/kW)
• Installed Cost ($/kW)
• Construction Period (Yrs)
• Fixed O&M ($/kW)
• Variable O&M ($/MWh)
Financial Assumptions
(Merchant, Muni & IOU)
• % Debt
• Cost of Debt (%)
• Cost of Equity (%)
• Loan/Debt Term (Years)
• Econ/Book Life (Years)
General Assumptions
• Insurance
• O&M Escalation
• Labor Escalation
Fuel Cost
• Fuel Cost ($/MMBtu)
• Heat Rate (Btu/kWh)
Deflator Series
COST OF GENERATION MODEL
Tax Information
(Merchant & IOU)
• Federal Tax Rate (%)
• State Tax Rate (%)
• Federal Tax Life (Years)
• State Tax Life (Years)
• Tax Credits
• Ad Valorem Tax
• Sales Tax
Levelized Fixed Costs
($/kW-Yr & $/MWh)
• Capital & Financing
• Insurance
• Ad Valorem
• Fixed O&M
• Corporate Taxes
Levelized Variable Costs
($/kW-Yr & $/MWh)
• Fuel
• Variable O&M
Total Levelized Costs
($/kW-Yr & $/MWh)
• Fixed Costs +
• Variable Costs
Reports
• Summary of Annual Costs
• High & Low Costs
• Revenue Requirement & Cash Flow
Screening Curves
($/kW-Yr & $/MWh)
• Total Costs
Sensitivity Curves
(Lev Cost, % & %Change)
• Plant Assumptions
• Plant Costs
• Fuel Costs
• Financial Assumptions
• Other

COG MODEL STRUCTURE



INPUT SELECTION

Plant Type Assumptions (Select)	Combustion Turbine - 49.9 MW
Financial (Ownership) Assumptions (Select)	Merchant Fossil
Ownership Type For Scenarios	Merchant
General Assumptions (Select)	Default
Base Year (All Costs In 2009 Dollars)	2009
Fuel Type (Accept Default)	Natural Gas
Data Source	*Aspen 5-23-09*
Start (Inservice) Year (Enter)	2009
Natural Gas Price Forecast (Select)	CA Average
Plant Site Region (Air & Water) (Select)	CA - Avg.
Study Perspective (Select)	To Delivery Point
Reported Construction Cost Basis (Select)	Instant
Turbine Configuration (Select)	2
Carbon Price Forecast(Select)	No Carbon Price
Cost Scenario(Select)	Mid-range
Tax Loss Treatment (Select)	Loss Recovered in Single Year

OUTPUT RESULTS

SUMMARY OF LEVELIZED COSTS
Combustion Turbine - 49.9 MW

Start Year = 2009 (2009 Dollars)	$/kW-Yr	$/MWh
Capital & Financing - Construction	$198.11	$482.17
Insurance	$9.63	$23.44
Ad Valorem Costs	$13.09	$31.87
Fixed O&M	$27.46	$66.82
Corporate Taxes (w/Credits)	$55.13	$134.18
Fixed Costs	**$303.42**	**$738.47**
Fuel & GHG Emissions Costs	$39.25	$95.54
Variable O&M	$2.09	$5.08
Variable Costs	**$41.34**	**$100.62**
Transmission Service Costs	$2.15	**$5.24**
Total Levelized Costs	**$346.92**	**$844.32**

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DEVELOPMENT PHASES

- 2003 IEPR – First version of the COG Model consisting of 25 separate workbooks.
- 2005 IEPR – Model under development.
- 2007 IEPR – Condensed into one workbook, made more transparent, improved data inputs, improved the internal and external documentation, and added a number of special features.
- 2009 IEPR – Added high & low scenarios, transmission costs, options in tax credits, and cash-flow accounting.

MERCHANT LEVELIZED COSTS

By Component ($/MWh)

		$/MWh (Nominal $)										¢/kWh
In-Service Year = 2009 (Nominal 2009 $)	Size MW	Capital & Financing	Insurance	Ad Valorem	Fixed O&M	Taxes	Total Fixed Cost	Fuel	Variable O&M	Total Variable Cost	Transmission Cost	Total Levelized Cost	Total Levelized Cost
Small Simple Cycle	49.9	494.12	24.02	32.66	66.82	137.52	**755.14**	95.54	4.80	**100.34**	5.24	**860.71**	**86.07**
Conventional Simple Cycle	100	471.38	22.91	31.15	48.57	131.48	**705.49**	95.54	4.80	**100.34**	5.24	**811.07**	**81.11**
Advanced Simple Cycle	200	164.86	8.01	10.90	18.81	46.01	**248.59**	88.15	4.34	**92.50**	5.24	**346.32**	**34.63**
Conventional Combined Cycle (CC)	500	30.20	1.46	1.98	1.61	9.93	**45.18**	71.87	3.86	**75.73**	5.21	**126.12**	**12.61**
Conventional CC - Duct Fired	550	31.93	1.54	2.10	1.66	10.51	**47.74**	73.01	3.86	**76.87**	5.21	**129.82**	**12.98**
Advanced Combined Cycle	800	27.47	1.33	1.80	1.33	9.04	**40.98**	67.00	3.54	**70.54**	5.21	**116.73**	**11.67**
Coal - IGCC	300	72.98	3.83	5.21	9.38	-11.33	**80.08**	19.38	11.98	**31.36**	5.38	**116.83**	**11.68**
Biomass IGCC	30	59.97	3.84	5.08	29.12	-26.40	**71.62**	26.75	5.08	**31.84**	6.54	**109.99**	**11.00**
Biomass Combustion - Fluidized Bed Boiler	28	60.92	3.78	5.00	17.56	-23.00	**64.26**	27.35	5.83	**33.18**	6.58	**104.02**	**10.40**
Biomass Combustion - Stoker Boiler	38	48.64	3.02	4.00	27.66	-18.49	**64.83**	28.06	8.91	**36.97**	6.45	**108.25**	**10.83**
Geothermal - Binary	15	84.76	6.52	9.85	11.15	-48.94	**63.33**	0.00	5.94	**5.94**	13.83	**83.11**	**8.31**
Geothermal - Flash	30	74.41	5.74	8.67	13.19	-43.22	**58.79**	0.00	6.61	**6.61**	13.51	**78.91**	**7.89**
Hydro - Small Scale & Developed Sites	15	93.65	7.03	10.62	11.10	-46.78	**75.62**	0.00	4.85	**4.85**	6.00	**86.47**	**8.65**
Hydro - Capacity Upgrade of Existing Site	80	43.98	2.97	4.48	7.53	-0.84	**58.12**	0.00	3.16	**3.16**	5.68	**66.96**	**6.70**
Solar - Parabolic Trough	250	257.53	16.58	0.00	47.03	-114.69	**206.45**	0.00	0.00	**0.00**	18.26	**224.70**	**22.47**
Solar - Photovoltaic (Single Axis)	25	317.91	20.47	0.00	47.03	-141.44	**243.96**	0.00	0.00	**0.00**	18.26	**262.21**	**26.22**
Onshore Wind - Class 3/4	50	74.66	5.53	8.36	5.90	-36.18	**58.28**	0.00	6.97	**6.97**	7.16	**72.41**	**7.24**
Onshore Wind - Class 5	100	65.77	4.87	7.37	5.20	-31.88	**51.34**	0.00	6.97	**6.97**	7.16	**65.47**	**6.55**

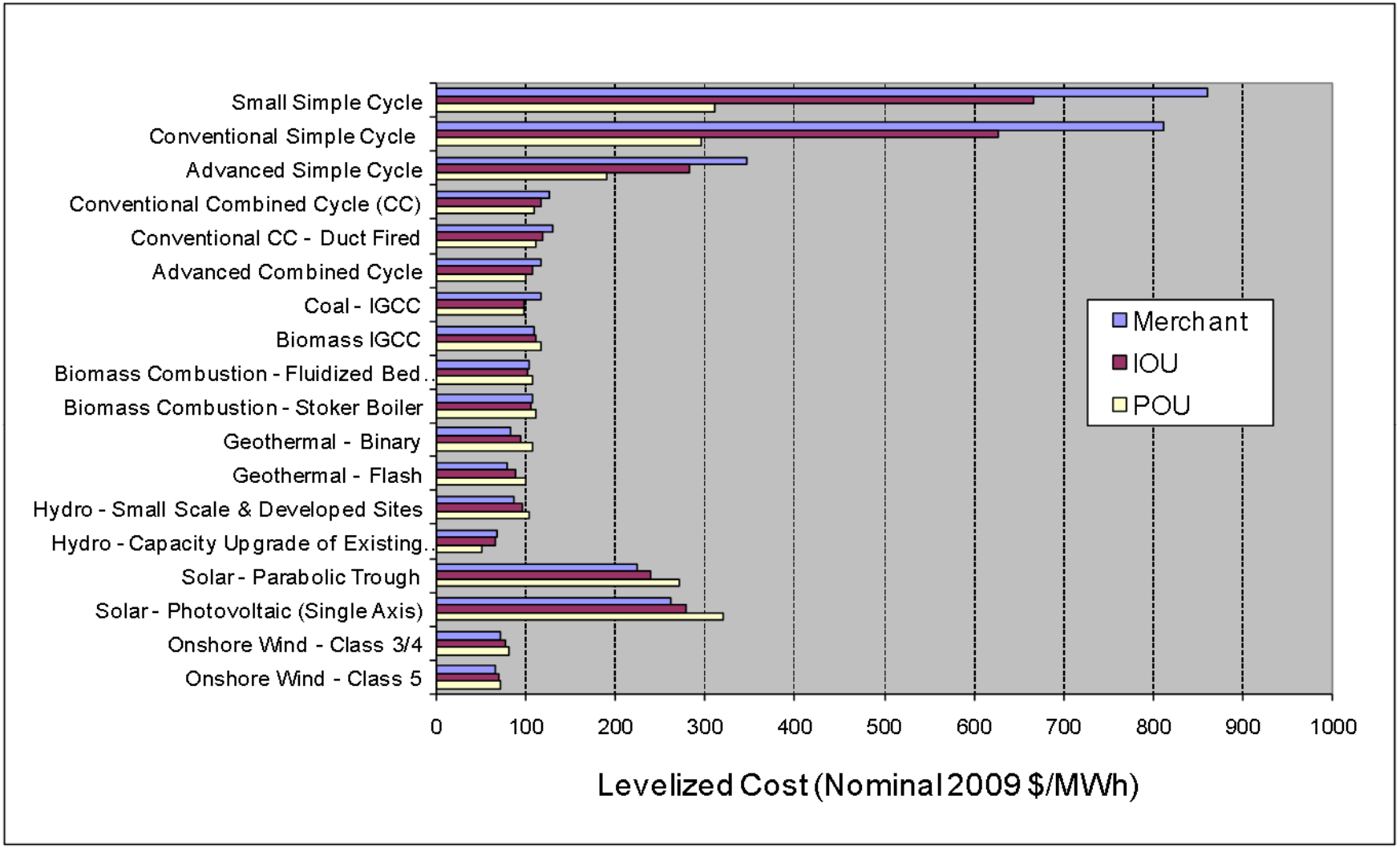
AVERAGE LEVELIZED COST

Start Year = 2009 (2009 Nominal$)

In-Service Year = 2009 (Nominal 2009 $)	Size	Merchant			IOU			POU		
	MW	$/kW-Yr	$/MWh	¢/kWh	$/kW-Yr	$/MWh	¢/kWh	$/kW-Yr	$/MWh	¢/kWh
Small Simple Cycle	49.9	353.65	860.71	86.07	274.07	667.28	66.73	255.88	311.63	31.16
Conventional Simple Cycle	100	333.25	811.07	81.11	257.29	626.43	62.64	242.00	294.73	29.47
Advanced Simple Cycle	200	284.59	346.32	34.63	232.40	282.92	28.29	234.08	190.06	19.01
Conventional Combined Cycle (CC)	500	773.91	126.12	12.61	712.74	116.32	11.63	662.70	108.35	10.83
Conventional CC - Duct Fired	550	743.48	129.82	12.98	682.37	119.32	11.93	632.03	110.71	11.07
Advanced Combined Cycle	800	716.27	116.73	11.67	661.04	107.88	10.79	615.74	100.67	10.07
Coal - IGCC	300	747.38	116.83	11.68	628.75	98.32	9.83	629.53	98.49	9.85
Biomass IGCC	30	656.89	109.99	11.00	666.72	111.65	11.16	701.86	117.58	11.76
Biomass Combustion - Fluidized Bed Boiler	28	683.49	104.02	10.40	661.87	100.75	10.08	698.48	106.42	10.64
Biomass Combustion - Stoker Boiler	38	726.41	108.25	10.83	710.28	105.87	10.59	740.14	110.42	11.04
Geothermal - Binary	15	427.95	83.11	8.31	475.41	93.52	9.35	505.80	106.91	10.69
Geothermal - Flash	30	422.60	78.91	7.89	467.95	88.51	8.85	494.92	100.59	10.06
Hydro - Small Scale & Developed Sites	15	165.65	86.47	8.65	181.77	95.54	9.55	189.61	103.50	10.35
Hydro - Capacity Upgrade of Existing Site	80	135.40	66.96	6.70	131.31	65.39	6.54	99.17	51.29	5.13
Solar - Parabolic Trough	250	376.70	224.70	22.47	399.04	238.27	23.83	452.71	271.52	27.15
Solar - Photovoltaic (Single Axis)	25	439.58	262.21	26.22	466.76	278.71	27.87	533.55	320.00	32.00
Onshore Wind - Class 3/4	50	203.33	72.41	7.24	217.56	77.75	7.78	220.99	80.52	8.05
Onshore Wind - Class 5	100	208.69	65.47	6.55	222.94	70.19	7.02	225.69	72.44	7.24

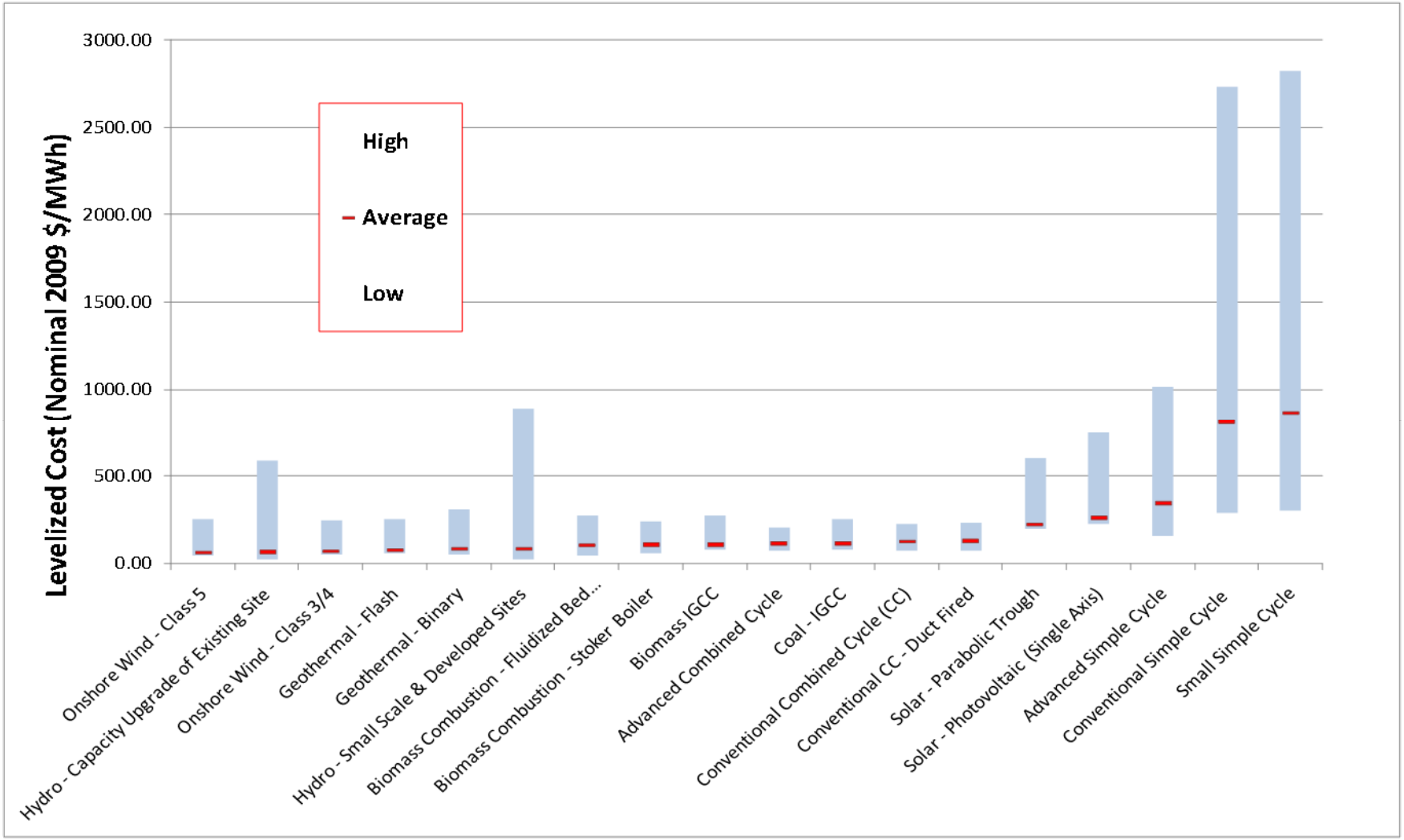
Average Cost by Technology

Start Year = 2009 (2009 Nominal$)

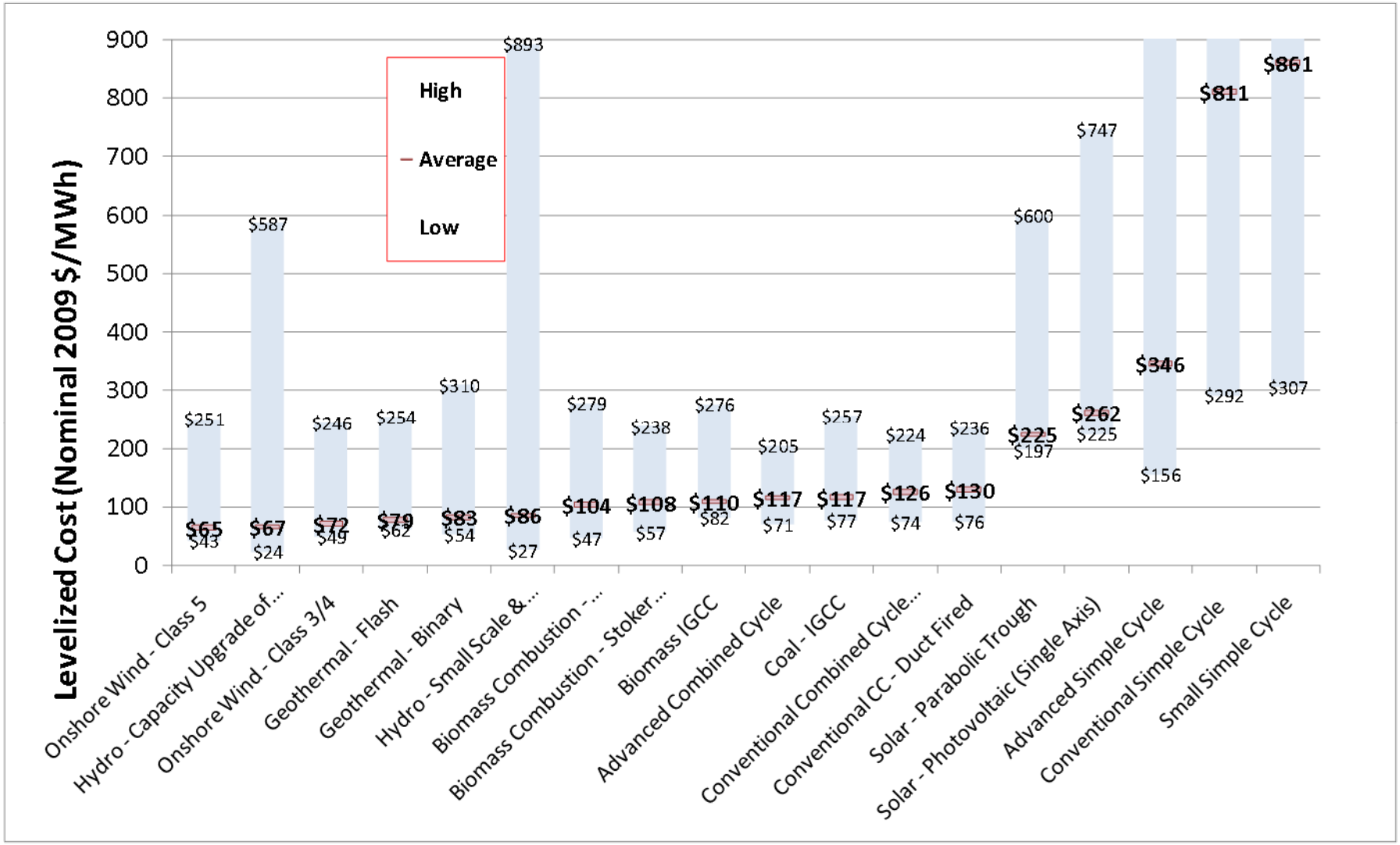


RANGE OF LEVELIZED COST

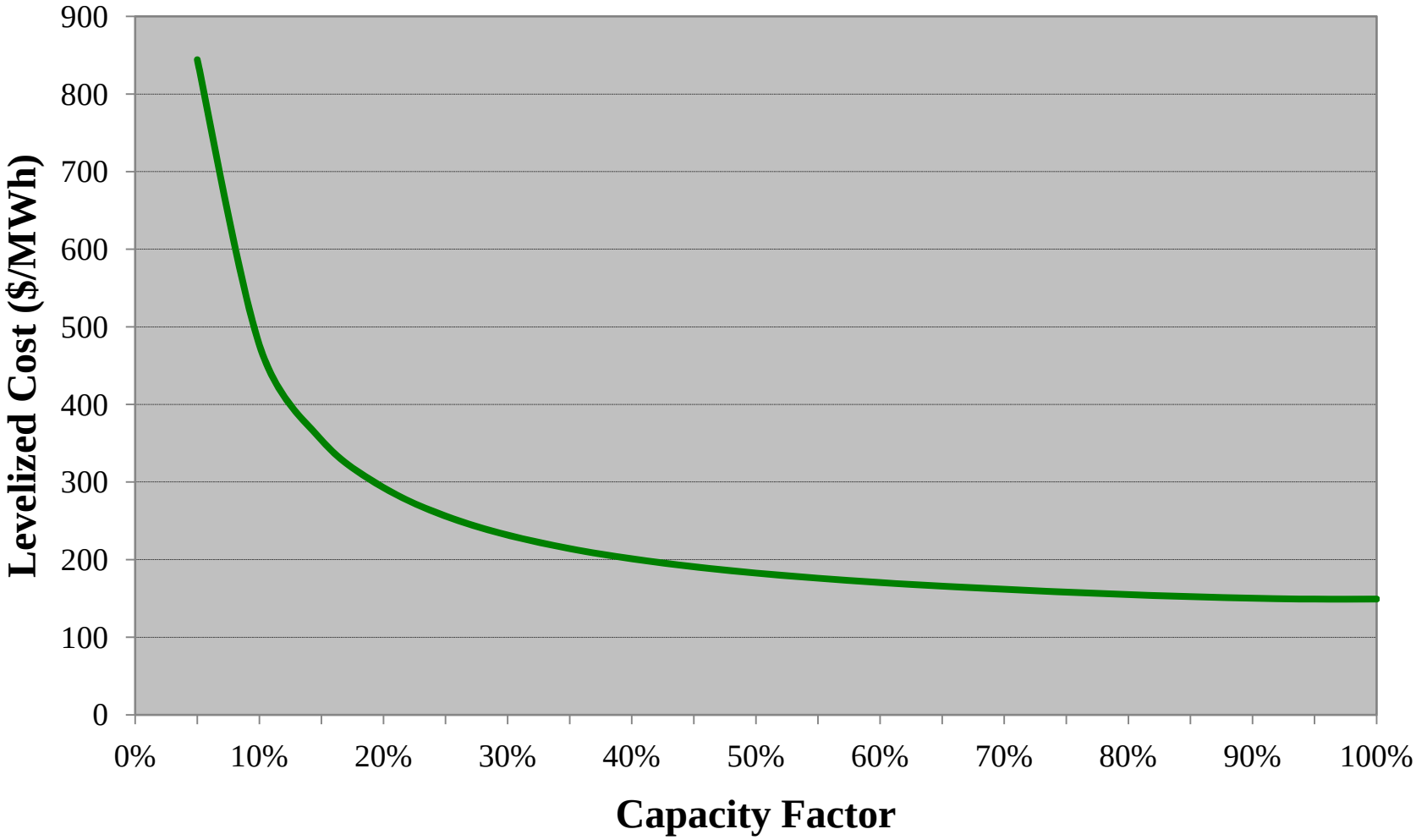
Merchant Plant In-Service in 2009



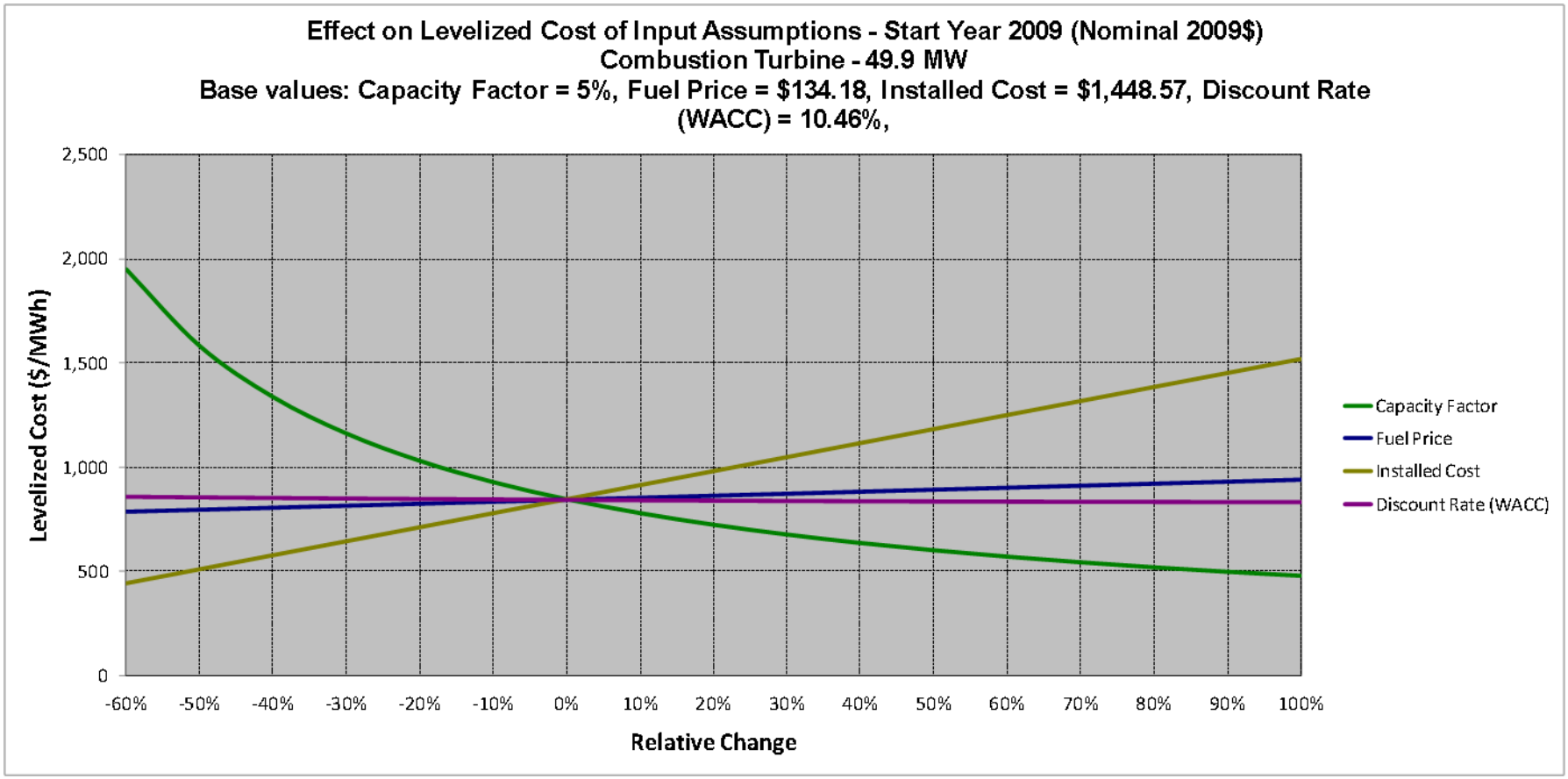
2009 EXPANDED



SCREENING CURVE 49,5 MW
-Start Year 2009 (Nominal 2009$)



SENSITIVITY CURVE



INTERNET LINKS

COST OF GENRATION MODEL AND USER'S GUIDE:
HTTP://WWW.ENERGY.CA.GOV/2010PUBLICATIONS/CEC-200-2010-002/INDEX.HTML

COMPARATIVE COSTS OF CALIFORNIA CENTRAL STATION ELECTRICITY GENERATION :
HTTP://WWW.ENERGY.CA.GOV/2010PUBLICATIONS/CEC-200-2010-002/INDEX.HTML

END