BUILDING A WORLD OF DIFFERENCE

16 May 2011

BLACK & VEATCH'S (RETI'S) COST OF GENERATION CALCULATOR

RYAN PLETKA, PE

CALIFORNIA ENERGY COMMISSION
COST OF GENERATION WORKSHOP

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BLACK & VEATCH
Building a world of difference.

TOPICS FOR TODAY

- **Overview of Energy Economics at Black & Veatch**
- **Review of the Renewable Energy Transmission Initiative (RETI) Cost of Generation Model**
  - History
  - Features
  - Pros / Cons
  - Applications
- **Black & Veatch's GenCost Service**

Thanks to Kevin Joyce, who developed key logic for this model

OVERVIEW OF ENERGY ECONOMICS AT BLACK & VEATCH

COMMON ECONOMIC ANALYSIS PROJECTS AT BLACK & VEATCH

- **Broad, high-level studies**
  - Strategic planning (RETI, Western Renewable Energy Zones, etc.)
- **Market modeling and assessments**
  - Energy market modeling, forecasts, integrated resource planning, locational marginal pricing
- **Cost estimates**
  - Feasibility-level, EPC projects, etc.
- **Financial due diligence**
  - Project finance, mergers and acquisitions

EXAMPLE LEVEL OF DETAIL – FUEL COSTS

- **Project Due Diligence**
  - 100+ fuel contracts
  - Multiple fuel cost components indexed to different factors
    - Diesel price, labor costs, PPI, etc.
  - Monthly accounting

- **RETI Cost of Generation Model**

Fuel Cost ($/MBtu)	$10
Fuel Cost Escalation	2.5%

REVIEW OF THE RENEWABLE ENERGY TRANSMISSION INITIATIVE (RETI) COST OF GENERATION MODEL

History

Features

Pros / Cons

Applications

WHAT IS THE CALIFORNIA RENEWABLE ENERGY TRANSMISSION INITIATIVE?

RETI is a statewide planning process to identify transmission projects needed to accommodate California's renewable energy goals.

- **Premise at the time:**
  - California law required 20% renewables by 2010; the state had also adopted a goal of 33% by 2020.
  - Development of renewable generation had slowed in CA. **Transmission was recognized as a limiting factor.**
- **RETI facilitated planning and permitting for transmission to competitive renewable energy zones (CREZs)**
- **Broad stakeholder engagement**

www.energy.ca.gov/reti

HISTORY OF THE RETI COST OF GENERATION CALCULATOR

- Pre-RETI – Various B&V cost of generation models in use, each with its own shortcomings
- 2008 – RETI COG model introduced for Phase 1A and 1B of RETI
- 2009 – Adapted for use in Western Renewable Energy Zones (WREZ) project
- 2009/2010 – Updated for RETI Phase 2 to reflect tax law changes, degradation, cost changes, etc.

COST OF GENERATION IS ONE PART OF RETI RESOURCE VALUATION METHODOLOGY

Rank Cost = Costs - Value

Costs
Generation Cost + Transmission Cost + Integration Cost

Value
Energy Value + Capacity Value

OVERVIEW – COST OF GENERATION CALCULATION

- **Simple pro forma cash flow model to determine the cost of generation for individual projects**
- **Spreadsheet based tool**
- **Allows disparate renewable energy projects to be valued on similar basis**
- **Provides single levelized cost of generation ($/MWh) representing the cost of generation over the plant life**
  - Implements the PTC, the ITC, and several different depreciation schedules
  - Includes developer return on investment

KEY FEATURES OF THE RETI COG MODEL

1. Simple
2. Simple
3. Simple

DRIVER'S FOR SIMPLICITY

- Accessible to broad variety of stakeholders
- Applicable to all technologies
- Need to accommodate project structures in Mexico, Canada, and US
- Limit number of arguments for calculation efficiency
- Linear (non-iterative) – doesn't require use of Solver
- Must be able to process thousands of projects in seconds

		LCOE ($/MWh)							
Project Name	Technology	IPP w / ITC	IPP w / PTC	IPP no incent.	Muni	Mexico	Canada	LCOE Scenario	**LCOE, $/MWh**
Butte	Biomass	*$120*	$136	$151	$129	$149	$147	IPP w / ITC	**$120**
Colusa	Biomass	*$115*	$129	$144	$123	$142	$140	IPP w / ITC	**$115**
El Dorado	Biomass	*$129*	$144	$159	$138	$157	$155	IPP w / ITC	**$129**
Fresno	Biomass	*$112*	$125	$140	$120	$138	$136	IPP w / ITC	**$112**
Glenn	Biomass	*$120*	$136	$151	$129	$149	$147	IPP w / ITC	**$120**
Humboldt 1	Biomass	*$118*	$131	$146	$126	$144	$142	IPP w / ITC	**$118**
Kern East 1	Biomass	*$120*	$134	$149	$128	$147	$144	IPP w / ITC	**$120**
Kings	Biomass	*$124*	$140	$155	$133	$153	$150	IPP w / ITC	**$124**
Lassen	Biomass	*$125*	$139	$154	$134	$152	$150	IPP w / ITC	**$125**
Los Angeles NE 1	Biomass	*$93*	$105	$120	$100	$118	$116	IPP w / ITC	**$93**

SCREENSHOT OF MODEL

Black & Veatch
Renewable Energy Transmission Initiative
Cost of Generation Calculator

All inputs are in blue.

Technology Assumptions	
Project Capacity (MW)	1
Capital Cost ($/kW)	$1,000
Fixed O&M ($/kW)	$50
Fixed O&M Escalation	2.5%
Variable O&M ($/MWh)	$10
Variable O&M Escalation	2.5%
Fuel Cost ($/MBtu)	$10
Fuel Cost Escalation	2.5%
Heat Rate (Btu/kWh)	0
Capacity Factor	22%
Misc Revenue ($/MWh)	$5
Misc Escalation	2.5%
Degradation	2%

Financial/Economic Assumptions	
Debt Percentage	60%
Debt Rate	6.50%
Debt Term (years)	15
Economic Life (years)	25
Percent 5-year MACRS	100%
Percent 7-year MACRS	0%
Percent 15-year MACRS	0%
Percent 20-year MACRS	0%
Energy Price Escalation	2.5%
Tax Rate	40%
Cost of Equity	7.75%
Discount Rate	6.982%

Incentives	
PTC ($/MWh)	$0
PTC Escalation	0.0%
PTC Term (years)	10
ITC	30%
ITC Depr Basis	85%

Outputs	
NPV Equity Return	$0
LCOE	$76.47

Calculation		
Cap Cost		$700,000
	0	
	0	-740272.78
	5	-679493.32
slope		12155.891

Year		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Annual Generation (MWh)		1,927	1,889	1,851	1,814	1,778	1,742	1,707	1,673	1,640	1,607	1,575	1,543	1,512	1,482	1,452	1,423	1,395	1,367	1,340	1,313
Power Price		$60.90	$62.42	$63.98	$65.58	$67.22	$68.90	$70.62	$72.39	$74.20	$76.05	$77.95	$79.90	$81.90	$83.95	$86.05	$88.20	$90.40	$92.66	$94.98	$97.36
Misc Revenue		$5.00	$5.13	$5.25	$5.38	$5.52	$5.66	$5.80	$5.94	$6.09	$6.24	$6.40	$6.56	$6.72	$6.89	$7.06	$7.24	$7.42	$7.61	$7.80	$7.99
Total Operating Revenues		**$126,999**	**$127,571**	**$128,145**	**$128,721**	**$129,301**	**$129,882**	**$130,467**	**$131,054**	**$131,644**	**$132,236**	**$132,831**	**$133,429**	**$134,029**	**$134,633**	**$135,238**	**$135,847**	**$136,458**	**$137,072**	**$137,689**	**$138,309**
Fixed O&M		$50,000	$51,250	$52,531	$53,845	$55,191	$56,570	$57,985	$59,434	$60,920	$62,443	$64,004	$65,604	$67,244	$68,926	$70,649	$72,415	$74,225	$76,081	$77,983	$79,933
Variable O&M		$19,272	$19,359	$19,446	$19,533	$19,621	$19,710	$19,798	$19,887	$19,977	$20,067	$20,157	$20,248	$20,339	$20,430	$20,522	$20,615	$20,707	$20,801	$20,894	$20,988
Fuel Cost		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Operating Expenses		**$69,272**	**$70,609**	**$71,977**	**$73,378**	**$74,812**	**$76,280**	**$77,783**	**$79,322**	**$80,897**	**$82,510**	**$84,161**	**$85,852**	**$87,583**	**$89,356**	**$91,171**	**$93,030**	**$94,933**	**$96,882**	**$98,877**	**$100,921**
Interest Payment		$27,300	$26,171	$24,969	$23,688	$22,325	$20,872	$19,326	$17,678	$15,924	$14,056	$12,066	$9,947	$7,690	$5,286	$2,726	$0	$0	$0	$0	$0
Principal Payment		$17,368	$18,497	$19,699	$20,980	$22,344	$23,796	$25,343	$26,990	$28,744	$30,613	$32,602	$34,722	$36,979	$39,382	$41,942	$0	$0	$0	$0	$0
Debt Service		**$44,668**	**$44,668**	**$44,668**	**$44,668**	**$44,668**	**$44,668**	**$44,668**	**$44,668**	**$44,668**	**$44,668**	**$44,668**	**$44,668**	**$44,668**	**$44,668**	**$44,668**	**$0**	**$0**	**$0**	**$0**	**$0**
Tax Depreciation - 5		$170,000	$272,000	$163,200	$97,920	$97,920	$48,960	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Tax Depreciation - 7		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Tax Depreciation - 15		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Tax Depreciation - 20		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Taxable Income		($139,573)	($241,209)	($132,001)	($66,265)	($65,756)	($16,230)	$33,358	$34,054	$34,823	$35,671	$36,604	$37,630	$38,756	$39,991	$41,341	$42,817	$41,526	$40,191	$38,812	$37,388
PTC		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Taxes		**($55,829)**	**($96,484)**	**($52,800)**	**($26,506)**	**($26,302)**	**($6,492)**	**$13,343**	**$13,622**	**$13,929**	**$14,268**	**$14,642**	**$15,052**	**$15,503**	**$15,996**	**$16,536**	**$17,127**	**$16,610**	**$16,076**	**$15,525**	**$14,955**
Total	***(280,000)***	***68,888***	***108,777***	***64,300***	***37,181***	***36,123***	***15,426***	***(5,328)***	***(6,557)***	***(7,851)***	***(9,210)***	***(10,640)***	***(12,143)***	***(13,725)***	***(15,388)***	***(17,137)***	***25,690***	***24,915***	***24,114***	***23,287***	***22,433***

MACRS Depreciation Schedules																					
5	0.2	0.32	0.192	0.1152	0.1152	0.0576	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0.1429	0.2449	0.1749	0.1249	0.0893	0.0892	0.0893	0.0446	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0.05	0.095	0.0855	0.077	0.0693	0.0623	0.059	0.059	0.0591	0.059	0.0591	0.059	0.0591	0.059	0.0591	0.059	0.0591	0.0295	0	0	0
20	0.0375	0.07219	0.06677	0.06177	0.05713	0.05285	0.04888	0.04522	0.04462	0.04461	0.04462	0.04461	0.04462	0.04461	0.04462	0.04461	0.04462	0.04461	0.04462	0.04461	0.04462

MODEL INPUTS - 1

Technology Assumptions	
Project Capacity (MW)	1
Capital Cost ($/kW)	$1,000
Fixed O&M ($/kW)	$50
Fixed O&M Escalation	2.5%
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MODEL INPUTS - 1

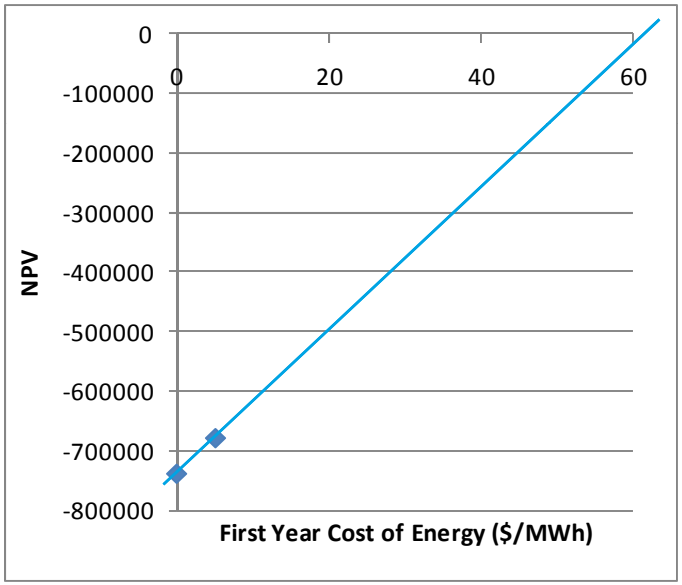
Incentives	
PTC ($/MWh)	$0
PTC Escalation	0.0%
PTC Term (years)	10
ITC	30%
ITC Depr Basis	85%

CASH FLOW STATEMENT

Year		1	2	3	
Annual Generation (MWh)		1,927	1,889	1,851	1,
Power Price		$60.90	$62.42	$63.98	$6
Misc Revenue		$5.00	$5.13	$5.25	$
Total Operating Revenues		**$126,999**	**$127,571**	**$128,145**	**$128,**
Fixed O&M		$50,000	$51,250	$52,531	$53,
Variable O&M		$19,272	$19,359	$19,446	$19,
Fuel Cost		$0	$0	$0	
Operating Expenses		**$69,272**	**$70,609**	**$71,977**	**$73,**
Interest Payment		$27,300	$26,171	$24,969	$23,
Principal Payment		$17,368	$18,497	$19,699	$20,
Debt Service		**$44,668**	**$44,668**	**$44,668**	**$44,**
Tax Depreciation - 5		$170,000	$272,000	$163,200	$97,
Tax Depreciation - 7		$0	$0	$0	
Tax Depreciation - 15		$0	$0	$0	
Tax Depreciation - 20		$0	$0	$0	
Taxable Income		($139,573)	($241,209)	($132,001)	($66,2
PTC		$0	$0	$0	
Taxes		**($55,829)**	**($96,484)**	**($52,800)**	**($26,**
Total	***(280,000)***	***68,888***	***108,777***	***64,300***	***37,1***

THE MODEL USES A "TRICK" TO AVOID ITERATIVE CALCULATION

- **The spreadsheet takes advantage of the fact that the NPV of cash flows is linear with year 1 cost.***
  - The TABLE() function runs two year 1 cost scenarios and finds the associated NPVs. This defines the line that relates the two variables.
  - The line is solved for NPV = 0, which gives the year 1 cost to populate the pro forma.
  - LCOE is calculated from the energy costs over the life of the project.



*This linear relationship is not always true, but is for this model due to its simple, constrained design

MODEL PROS

- **Simple, non-iterative, fast**
- **Has been vetted in RETI and WREZ processes**
- **Can be used for nearly any energy technology**
  - So long as the technology can be characterized by the inputs
- **Good for screening and relative comparisons of different options**

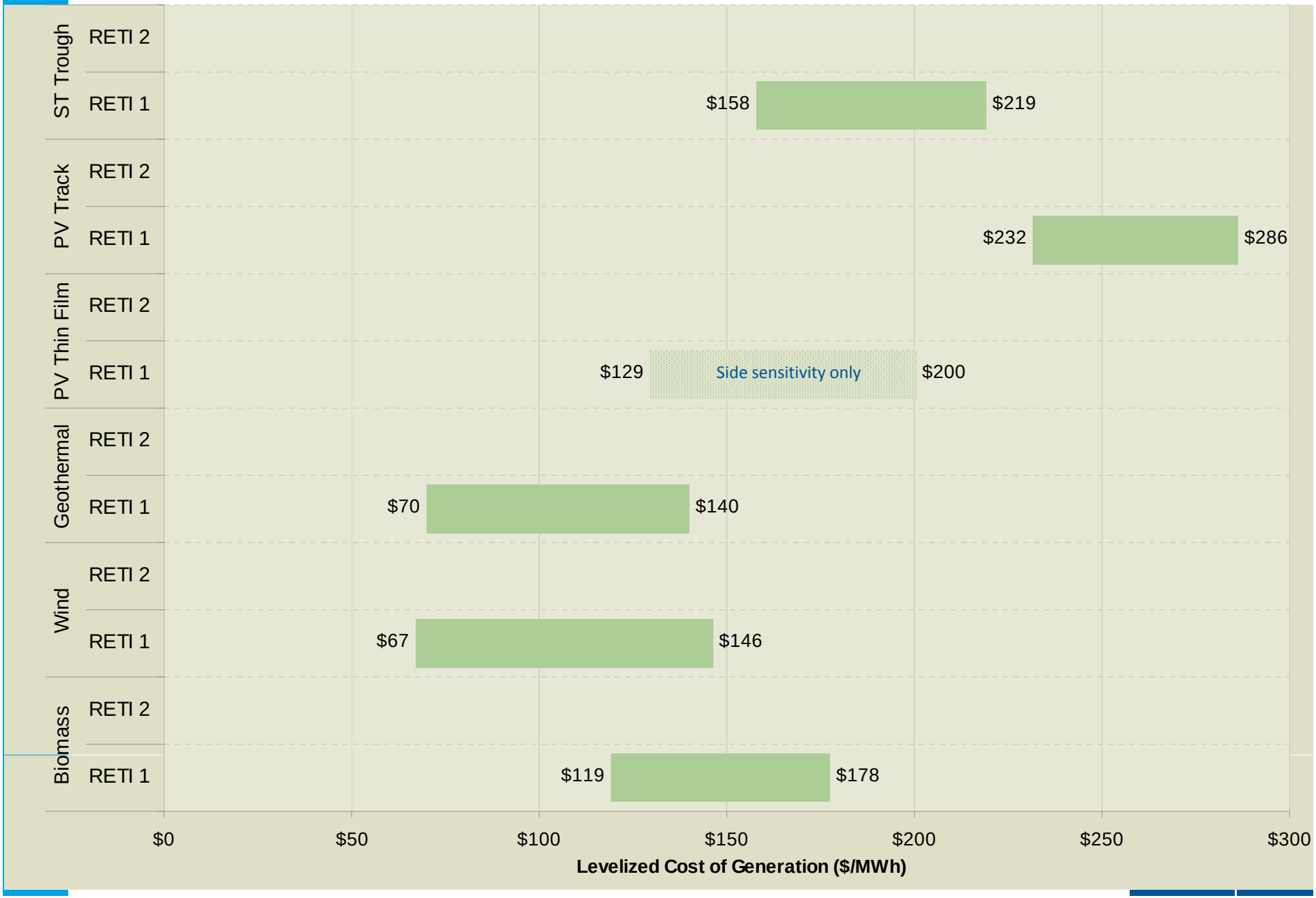
MODEL CONS

- This model was designed for use by Black & Veatch only
- Very little documentation
- Input assumptions are sparse and require knowledgeable user (for example: we lump property tax into O&M)
- Simplified approach to timing issues
- Not a realistic “simulation” of project finance

EXAMPLE APPLICATIONS

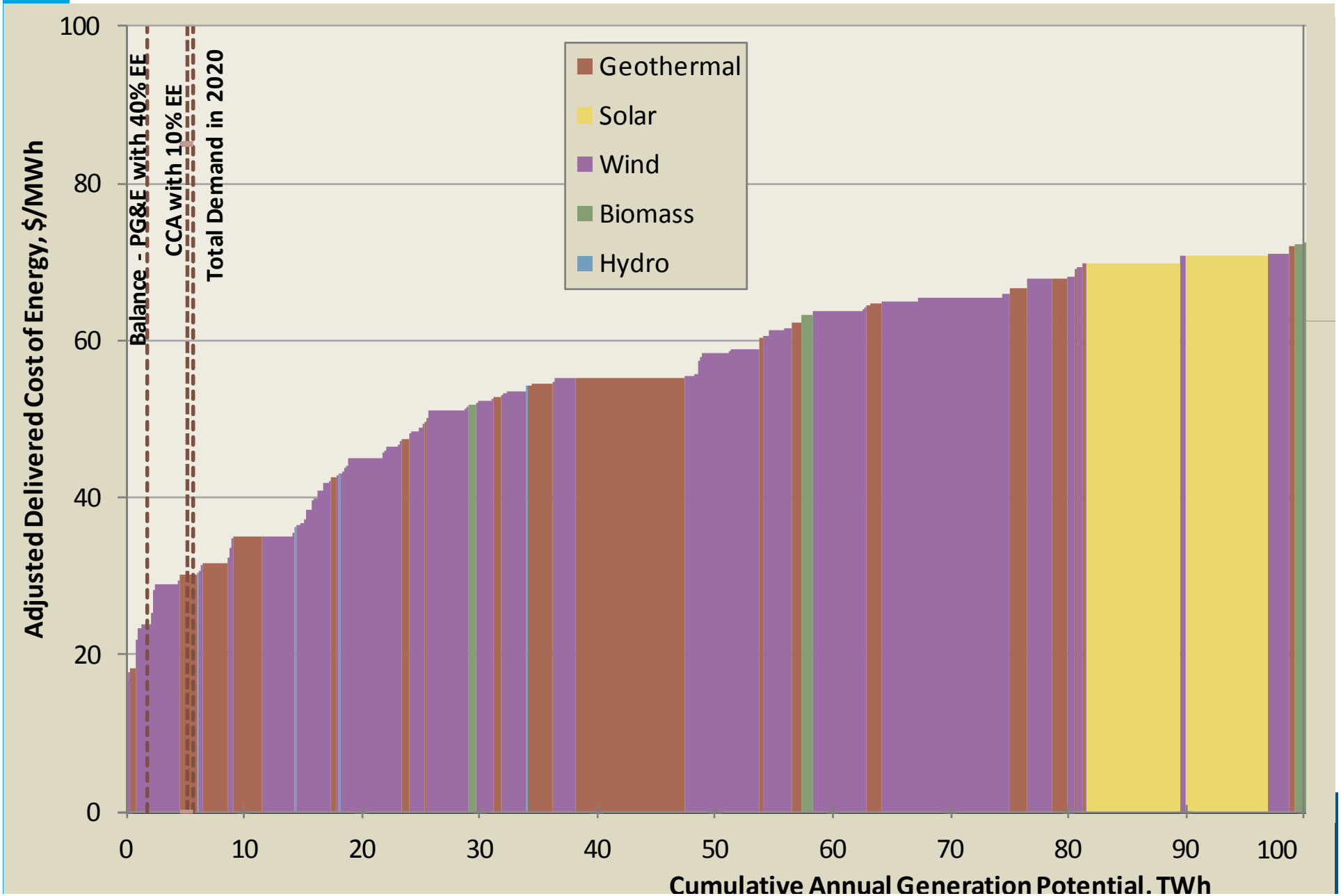
- The power of the RETI cost of generation model is not its simulation of economics for single projects, rather it is ability to make quick comparisons of many projects

RETI PHASE 1 VIEW OF RENEWABLE ECONOMICS (2008)

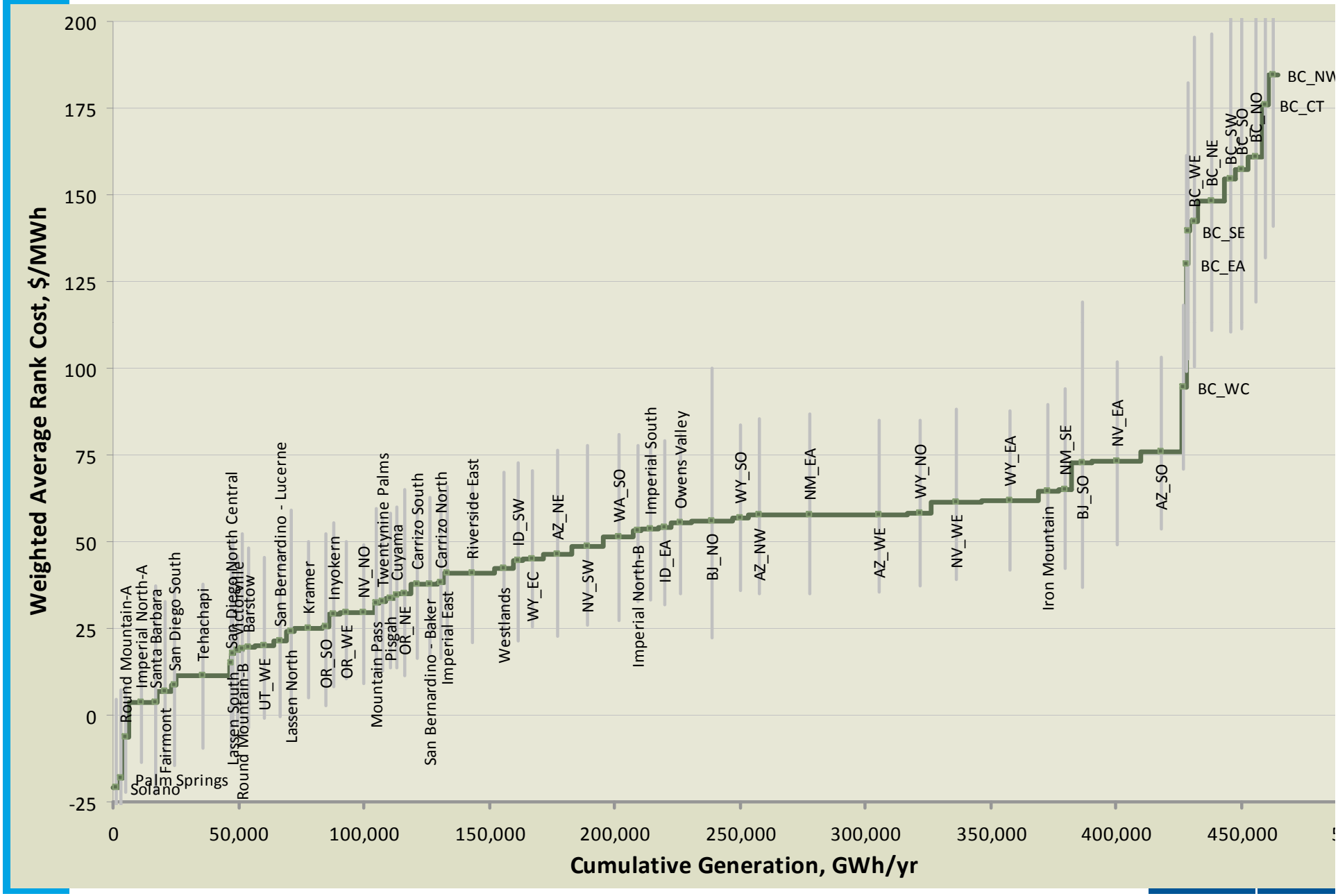


RETI PHASE 2 VIEW OF RENEWABLE ECONOMICS (2010)

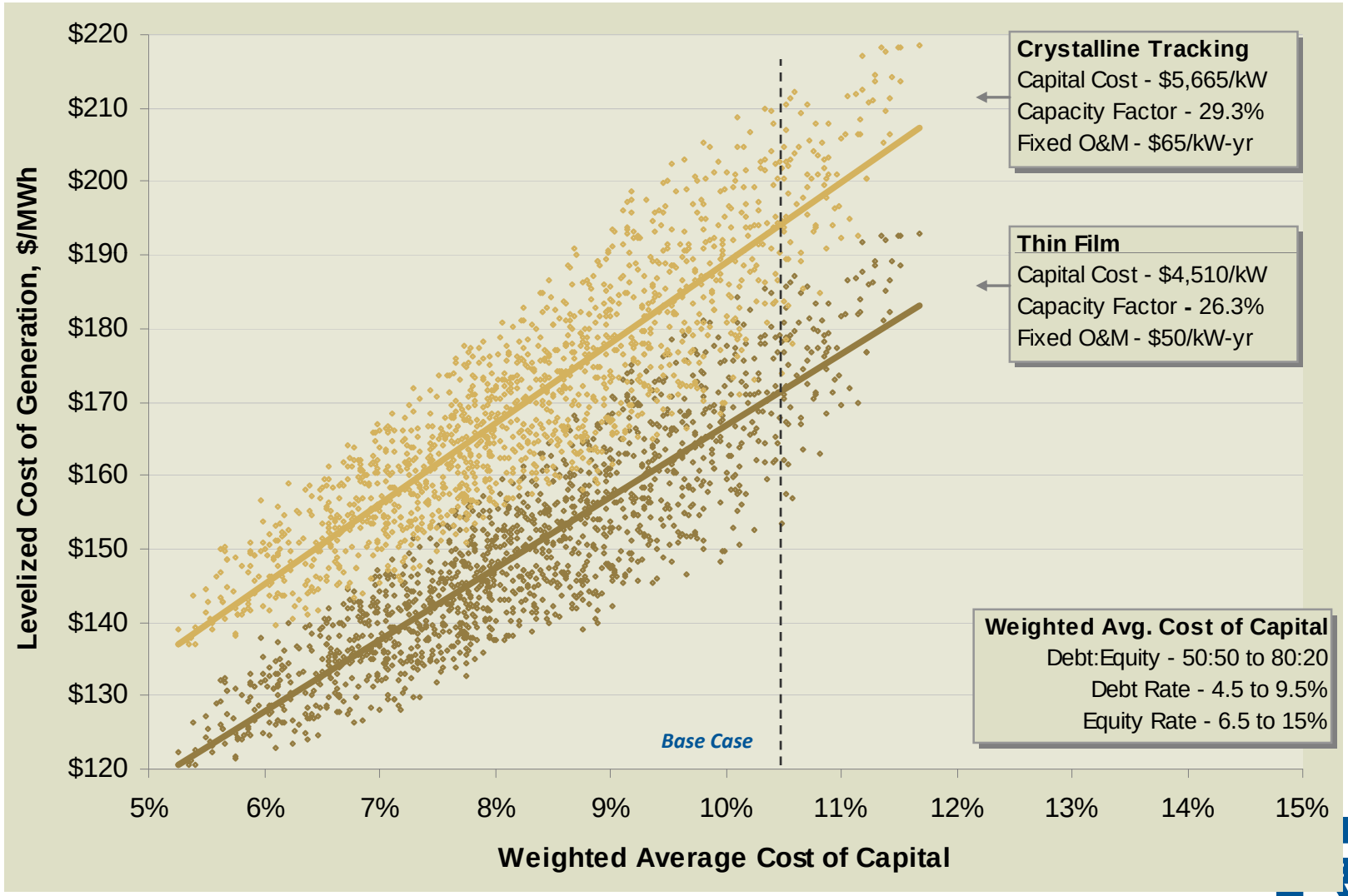
SUPPLY CURVES (SAN FRANCISCO 100% RE)



RETI PHASE 2B CREZ RANKING, WITH UNCERTAINTY BANDS



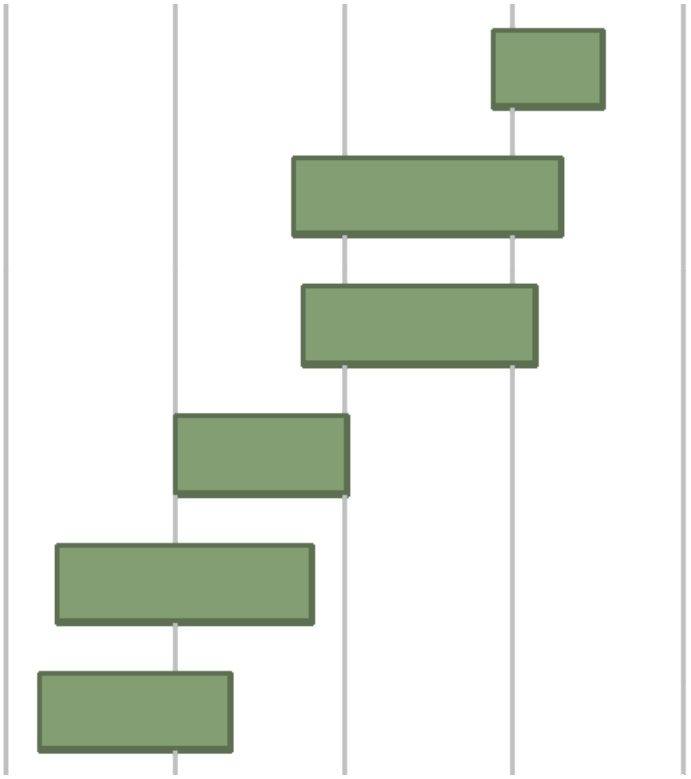
EXAMPLE MONTE CARLO SIMULATION: SOLAR COST OF CAPITAL STUDY



BLACK & VEATCH'S GENCOST™ SERVICE

THE GENCOST SERVICE

- Supplement to B&V's Energy Market Perspective Product
- Reference for capital costs, operating costs and characteristics, and levelized cost of energy for a wide range of electric generation technologies
- Updated every 6 months to capture changing market dynamics



GENCOST: KEY CHARACTERISTICS

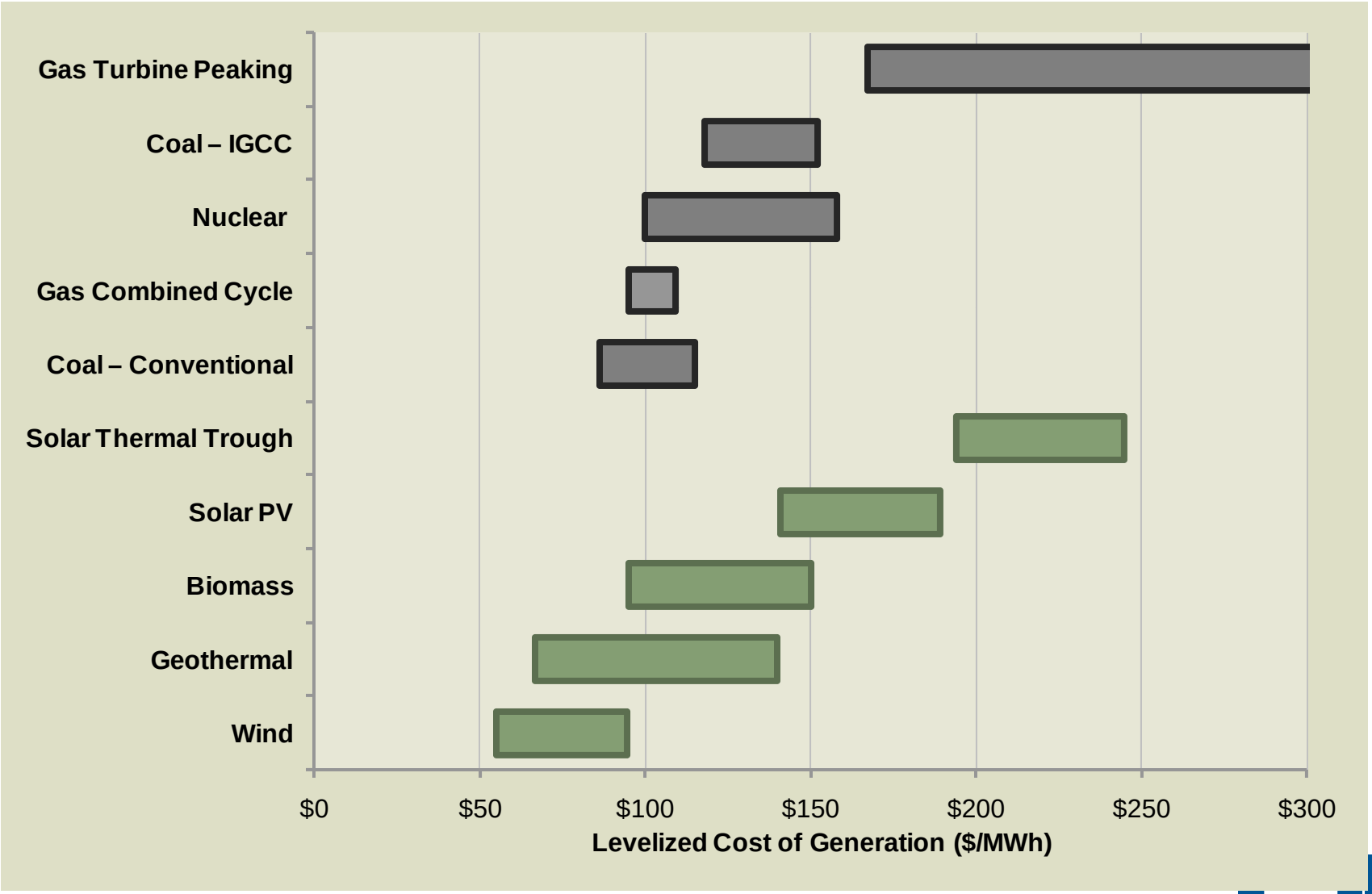
	Capacity Factor (%)	Capital Cost (U.S. $ / kW)	Levelized Cost of Generation (U.S. $ / MWh)
Solid Biomass	70 to 90	3,500 to 5,000	95 to 150
Wind	32 to 42	2,000 to 2,500	55 to 95
Geothermal	80 to 90	4,000 to 6,000	67 to 140
Solar Thermal	22 to 27	5,300 to 5,600	194 to 245
Solar PV	22 to 27	3,600 to 4,000	141 to 189
Coal – Conventional	70 to 90	3,000 to 4,000	86 to 115
Coal – IGCC	70 to 90	4,500 to 5,500	118 to 152
Nuclear	70 to 90	6,000 to 8,000	100 to 158
Natural Gas CCCT	70 to 90	1,000 to 1,600	95 to 109
Natural Gas SCCT	5 to 25	600 to 900	167 to 361

Source: B&V estimates from various projects. 2010 assumptions

Notes: Includes current incentives, but does not include any carbon costs (either for capture or incentives). Levelized cost of generation reflect life-cycle cost estimates at the output of the power plant (the "busbar"). Transmission costs and system integration costs excluded. Capacity factors based on local resource availability and can vary outside of the ranges here. Variable energy resources (wind, solar), do not include storage to firm the resource. Values shown are for typical commercial projects, subject to resource availability described below.

Resource availability: Landfill gas and biomass resources generally available in much of the U.S. Onshore wind (class 3+) available in many areas of the country except the Southeast; offshore wind available in coastal areas, but substantially more expensive. Geothermal limited to Western U.S. Highest quality (capacity factor) solar resource is in Southwest U.S. Costs elsewhere will be significantly higher.

GENCOST: COMPARATIVE ECONOMICS



THANK YOU!

RYAN PLETKA, PE

BLACK & VEATCH

DIRECTOR, RENEWABLES STRATEGIC PLANNING

650 CALIFORNIA, FIFTH FLOOR

SAN FRANCISCO, CA 94108

PLETKARJ@BV.COM

TEL: 415-693-9552 X14