Cost of Generation Workshop: Non-solar Renewables

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Introduction

- Updated values and performance parameters for biomass, geothermal and wind.
- Less focus on these as costs forecasts are more stable and narrower than for solar
  - Ranges are more a function of location vs. different expectations
- Intended as review of 2009 COG values
  - However, found significant changes in estimates

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Methodology for Update

- Reviewed publicly available data sources
  - Relied mostly on NREL surveys and consultant studies, but compared to other less detailed studies
- Reconciled sources to be comparable
- Used 2009 values if no new information
- Only changes in wind costs were forecasted

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Wind

- Wind costs rose to 2009 then decreased
  - Mid case reflects move toward low case
- More 100m towers beyond 80m standard
- Class 5 (>16.8 mph) sites already developed, Class 3 (>14.3 mph) becoming dominant sites
- Station usage significant (~15%)
- European studies showing output degradation of 0.3% per year.

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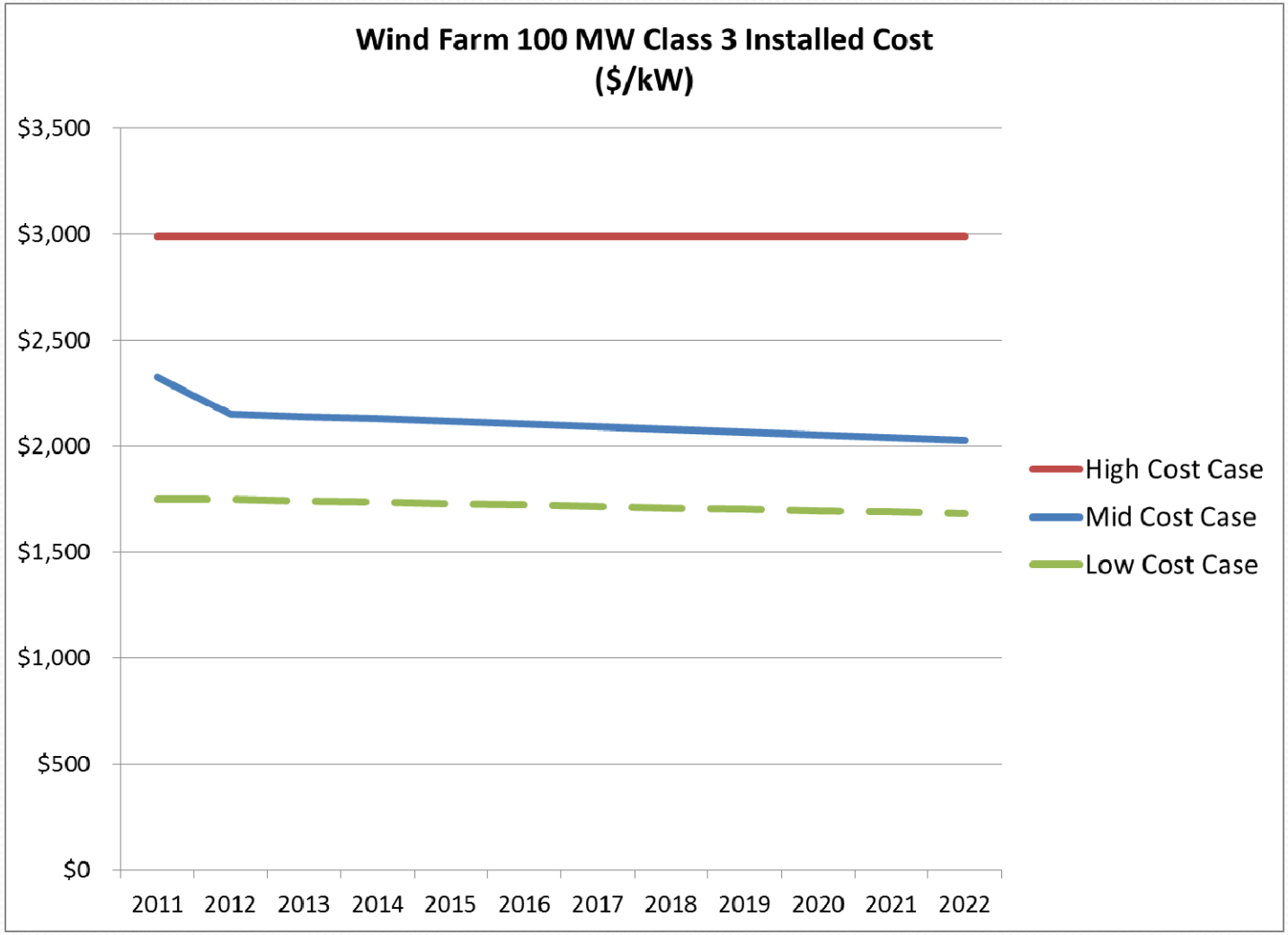
Wind Class 3 Cost Forecasts



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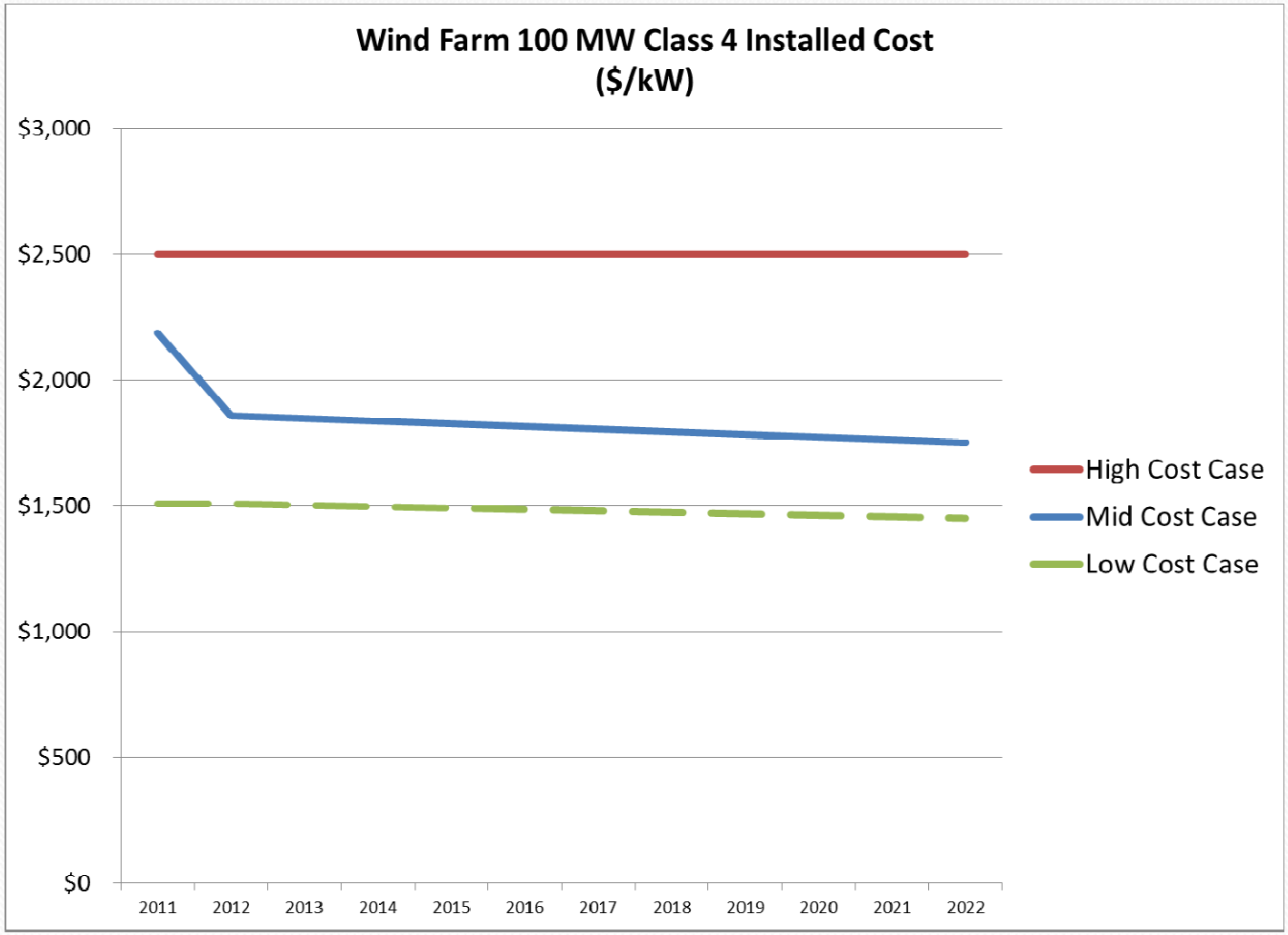
Wind Class 4 Cost Forecasts



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Biomass

- Focus on FBB systems for utility scale
  - Biogas technologies typically DG scale
- Revised values more consistent with boiler scale economies vis-à-vis mature coal plant
  - No cost changes forecasted
- Biomass typically less than 50 MW due to fuel collection & transport costs

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Geothermal

- Binary and flash technologies
  - Binary has no GHG emissions, flash amount varies but less than dry steam (e.g., Geysers)
- Well exploration and drilling costs are largest cost variable, along with long development stage
- Significant well pumping loads & O&M costs
- Geothermal typically less than 50 MW to match resource

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Summary of Renewables Factors Mid Case

Technology - Plant Costs Start Year = 2013 (2013 Dollars)	Gross Capacity (MW)	Instant Costs ($/kW)	Fixed O&M ($/kW-Yr)	Variable O&M ($/MWh)
Biomass Fluidized Bed Boiler 50 MW	50	4,985	106.26	5.29
Geothermal Binary 30 MW	30	5,227	89.79	0.00
Geothermal Flash 30 MW	30	5,933	89.79	0.00
Wind - Class 3 100 MW	100	1,934	31.72	8.46
Wind - Class 4 100 MW	100	1,673	31.72	8.46

Technology Input Parameters	Gross Capacity (MW)	Plant Side Losses	Capacity Factor	Heat Rate (Btu/kWh)	Degradation (%/Year)		CO2 Emissions (Lbs/MWh)
					Capacity	Heat Rate	
Biomass Fluidized Bed Boiler 50 MW	50	4.00%	80.7%	14,500	0.10%	0.15%	195.0
Geothermal Binary 30 MW	30	11.50%	85.0%	34,377	0.50%	3.00%	0.0
Geothermal Flash 30 MW	30	17.00%	85.0%	34,377	0.50%	3.00%	264.5
Wind - Class 3 100 MW	100	15.00%	42.0%		0.30%	0.00%	0.0
Wind - Class 4 100 MW	100	15.00%	39.0%		0.30%	0.00%	0.0

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Summary of Renewables 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)
Biomass Fluidized Bed Boiler 50 MW	50	6,427	100.44	15.86
Geothermal Binary 30 MW	30	6,557	154.78	0.00
Geothermal Flash 30 MW	30	7,888	182.58	0.00
Wind - Class 3 100 MW	100	2,506	31.72	10.57
Wind - Class 4 100 MW	100	2,095	31.72	10.57

Technology Input Parameters	Gross Capacity (MW)	Plant Side Losses	Capacity Factor	Heat Rate (Btu/kWh)	Degradation (%/Year)		CO2 Emissions (Lbs/MWh)
					Capacity	Heat Rate	
Biomass Fluidized Bed Boiler 50 MW	50	7.00%	78.20%	14,500	0.20%	0.20%	40.6
Geothermal Binary 30 MW	30	14.50%	77.09%	34,633	2.00%	5.00%	180.0
Geothermal Flash 30 MW	30	20.00%	71.81%	34,633	2.00%	5.00%	397.0
Wind - Class 3 100 MW	100	16.50%	30.00%		0.80%	0.00%	0.0
Wind - Class 4 100 MW	100	16.50%	30.00%		0.80%	0.00%	0.0

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Summary of Renewables 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)
Biomass Fludized Bed Boiler 50 MW	50	3,464	106.26	5.29
Geothermal Binary 30 MW	30	4,368	89.79	0.00
Geothermal Flash 30 MW	30	3,778	86.15	0.00
Wind - Class 3 100 MW	100	1,647	31.72	6.34
Wind - Class 4 100 MW	100	1,422	31.72	6.34

Technology Input Parameters	Gross Capacity (MW)	Plant Side Losses	Capacity Factor	HHV Heat Rate (Btu/kWh)	Degradation (%/Year)		CO2 Emissions (Lbs/MWh)
					Capacity	Heat Rate	
Biomass Fludized Bed Boiler 50 MW	50	2.00%	85.00%	13,500	0.00%	0.10%	0.0
Geothermal Binary 30 MW	30	8.50%	95.00%	34,120	0.00%	0.00%	0.0
Geothermal Flash 30 MW	30	14.00%	95.00%	34,120	0.00%	0.00%	98.9
Wind - Class 3 100 MW	100	14.00%	43.00%		0.00%		0.0
Wind - Class 4 100 MW	100	14.00%	45.00%		0.00%		0.0

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