Natural Gas Combined Cycle Combustion Turbine

Solar PV Utility-Scale

Reference Plants & Levelized Costs

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REFERENCE PLANTS

Capital Costs are Overnight and all costs in 2012 dollars

CCCT Reference Plant 1

Model & Technology Based on Siemens H-Class (SCC6 8000H – SGT6)					
Plant	Output & Costs	Output & Costs with Augmentation	Life Cycle Costs	Operation	Normalization
Location **Boardman OR**	Baseload Capacity **392 MW**	Capacity with 20MW Duct Firing Augmentation **412 MW**	Economic Life **30 years**	Ramp Rate **35 MW/min**	Capacity Adjustments • Elevation (-) • Elec./Mech. Auxiliaries (-) • Inlet & Exhaust Losses (-) • Duct Firing Aug (+)
Earliest In-Service **2014**	Heat Rate **6,471 btu/kWh**	Heat Rate with Duct Firing **6,531 btu/kWh**	Fixed O&M **15.37 $/kW/year**	CO2 Emission Rate **792 lb/MWh**	Heat Rate Adjustments • Lower Heating to Higher Heating Value (+) • Elec./Mech. Auxiliaries (-) • Inlet & Exhaust Losses (-) • Duct Firing Aug (+)
Configuration **1x1**	Capital Cost **425 $mm**	Capital Cost with Duct Firing **433 $mm**	Variable O&M **3.27 $/MWh**	Water Usage **2,629 gpm*** (*for 2x1)	Capital Cost Adjustments • Conversion to 2012 $ (-) • Cost of Labor OR (+) • Plant Accessories (+) • Duct Firing (+)
Cooling **Wet**	Capital Cost per kW **1,084 $/kW**	Capital Cost with Duct Firing per MW **1,052 $/kW**	Annual Life Cycle Degradation **0.39 % Capacity** **0.31 % Heat Rate**		
Fuel **Natural Gas – GTN pipeline**			Levelized Cost of Energy (2015) **56.88 $/MWh**		

Capital Costs are Overnight and all costs in 2012 dollars

CCCT Reference Plant 2

Model & Technology Based on Mitsubishi Heavy Industries J-Class (MPCP1 - M501J)					
Plant	Output & Costs	Output & Costs with Augmentation	Life Cycle Costs	Operation	Normalization
Location **Boardman OR**	Baseload Capacity **449 MW**	Capacity with 20MW Duct Firing Augmentation **469 MW**	Economic Life **30 years**	Ramp Rate **20 MW/min**	Capacity Adjustments • Elevation (-) • Elec./Mech. Auxiliaries (-) • Inlet & Exhaust Losses (-) • Duct Firing Aug (+)
Earliest In-Service **2018**	Heat Rate **6,408 btu/kWh**	Heat Rate with Duct Firing **6,459 btu/kWh**	Fixed O&M **15.37 $/kW/year**	CO2 Emission Rate **784 lb/MWh**	Heat Rate Adjustments • Lower Heating to Higher Heating Value (+) • Elec./Mech. Auxiliaries (-) • Inlet & Exhaust Losses (-) • Duct Firing Aug (+)
Configuration **1x1**	Capital Cost **547 $mm**	Capital Cost with Duct Firing **556 $mm**	Variable O&M **3.27 $/MWh**	Water Usage **137.2 gpm*** (*for 2x1)	Capital Cost Adjustments • Conversion to 2012 $ (-) • Cost of Labor OR (+) • Plant Accessories (+) • Duct Firing (+)
Cooling **Dry**	Capital Cost per kW **1,217 $/kW**	Capital Cost with Duct Firing per MW **1,186 $/kW**	Annual Life Cycle Degradation **0.39 % Capacity** **0.31 % Heat Rate**		
Fuel **Natural Gas – GTN pipeline**			Levelized Cost of Energy (2018) **60.32 $/MWh**		

Solar PV Update

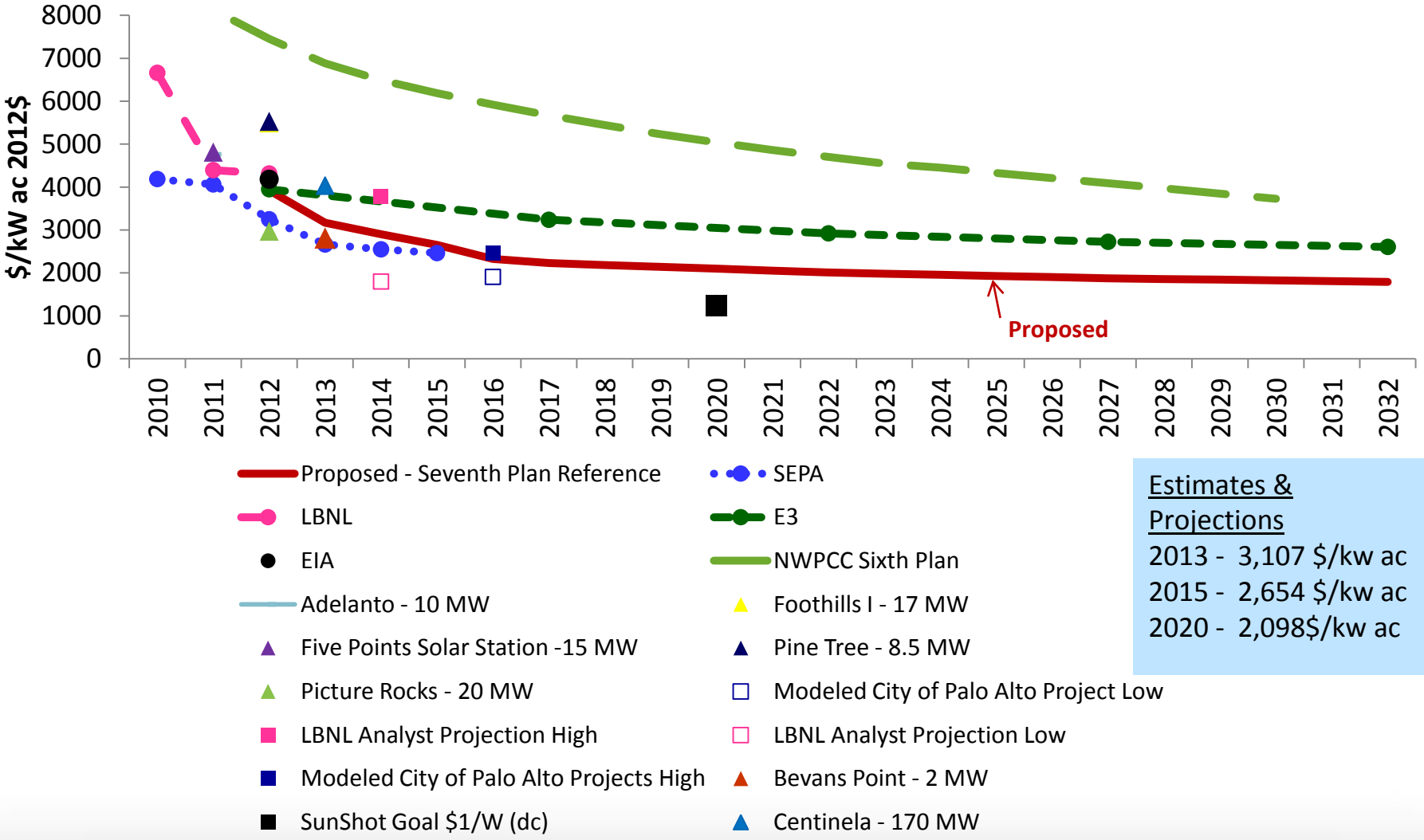
<u>Proposed Reference Utility Scale Solar PV Plant Update 05.26.14</u>

5 MW ac using flat plate single crystalline modules mounted on single-axis trackers.

individual plants at scattered locations within the better solar resource areas

8.3 acres/MW solar pv (NREL) - so around 40 acres for a 5 MW plant

Solar PV Utility Scale
Capital Cost Estimates & Projections ($/kW ac - 2012 $)



Estimates & Projections
2013 - 3,107 $/kw ac
2015 - 2,654 $/kw ac
2020 - 2,098$/kw ac

Recent Solar PV Power Purchase Agreements

1. Macho Springs Solar by First Solar
   - PPA with El Paso Electric at 57.80 $/MWh
   - Includes New Mexico Production Tax Credit (w/o is approximately 84.90 $/MWh)
   - Uses Thin Film technology
2. Recurrent Energy to build a 150MW solar pv plant in West Texas
   - PPA with Austin Energy for less than 50 $/MWh
   - 2016 operation date – would be largest solar pv plant in Texas

LEVELIZED COST OF ENERGY

Discussion

Levelized Cost of Energy (LCOE) – a measure to compare costs of different generating technologies over plant life cycles - expressed in **$/MWh** (or $/kWh).

LCOE reflects the cost per unit of electricity for building, financing, operating, and maintaining a generating plant through the life cycle.

Important assumptions include:

- Capital costs
- Financing costs
- O&M costs
- Fuel costs
- Emission costs
- Utilization

Discussion

Important factors for Solar PV LCOE estimates

1. Capital Cost estimates – the primary cost component for solar projects
2. Financing assumptions – see #1
3. Capacity Factor – based on location, how much electricity can the plant produce?
4. We see some PPA costs lower than published LCOE –why?

   - CA sites on distressed farm land
   - financing options ?
   - better locations (capacity factors)

Natural Gas Combined Cycle Combustion Turbine

1. Fuel costs are significant – 30 year foresight of natural gas prices suggests risk
2. Future emission cost?

Discussion

The Council financial model - Micro Fin – was used to calculate LCOE. The model generates annual costs for debt and equity service, taxes (income and property), expenses (O&M, fuel) based on the inputs, calculates NPV and produces a levelized cost for the cost components.

Model assumptions include:

Solar PV	**Ntrl Gas CCCT**
IOU financed – 9.8% ROE, AT WACC 5.3%	IOU financed – 9.8% ROE, AT WACC 5.3%
Capacity Factor 26.4% (Boise ID area location)	Capacity Factor 85%
Life cycle degradation	Life cycle degradation
Investment Tax Credit – 30% until 2017, then 10%	Currently no CO2 emission penalty
Transmission – point to point, BPA 2014 Trans. Rate Schedule	Transmission – point to point, BPA 2014 Trans. Rate Schedule

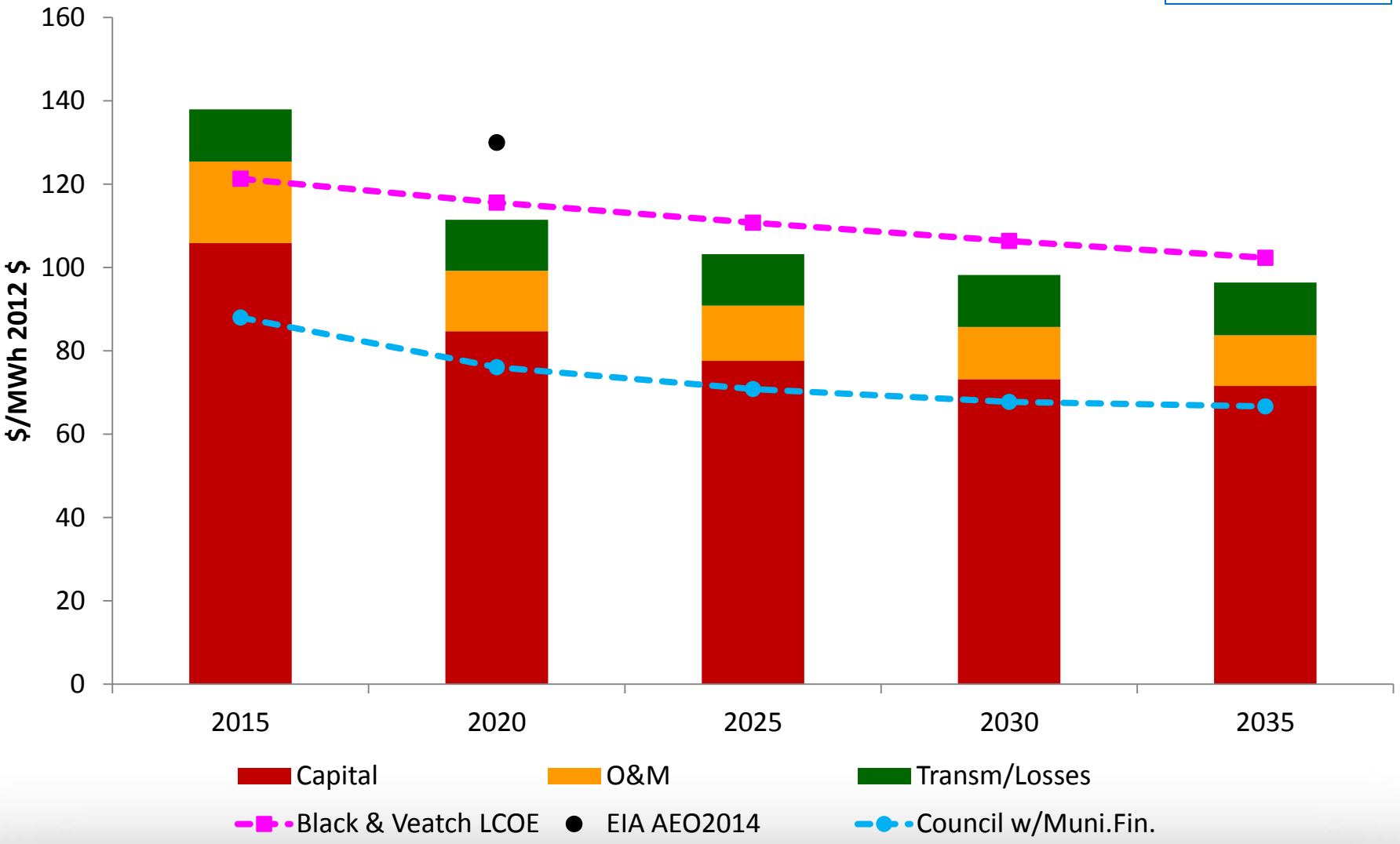
Discussion

Compared to recently released LCOE values from

- EIA Annual Energy Outlook 2014
- Black and Veatch Report for NREL (Cost & Performance Data for Power Generation Technologies)

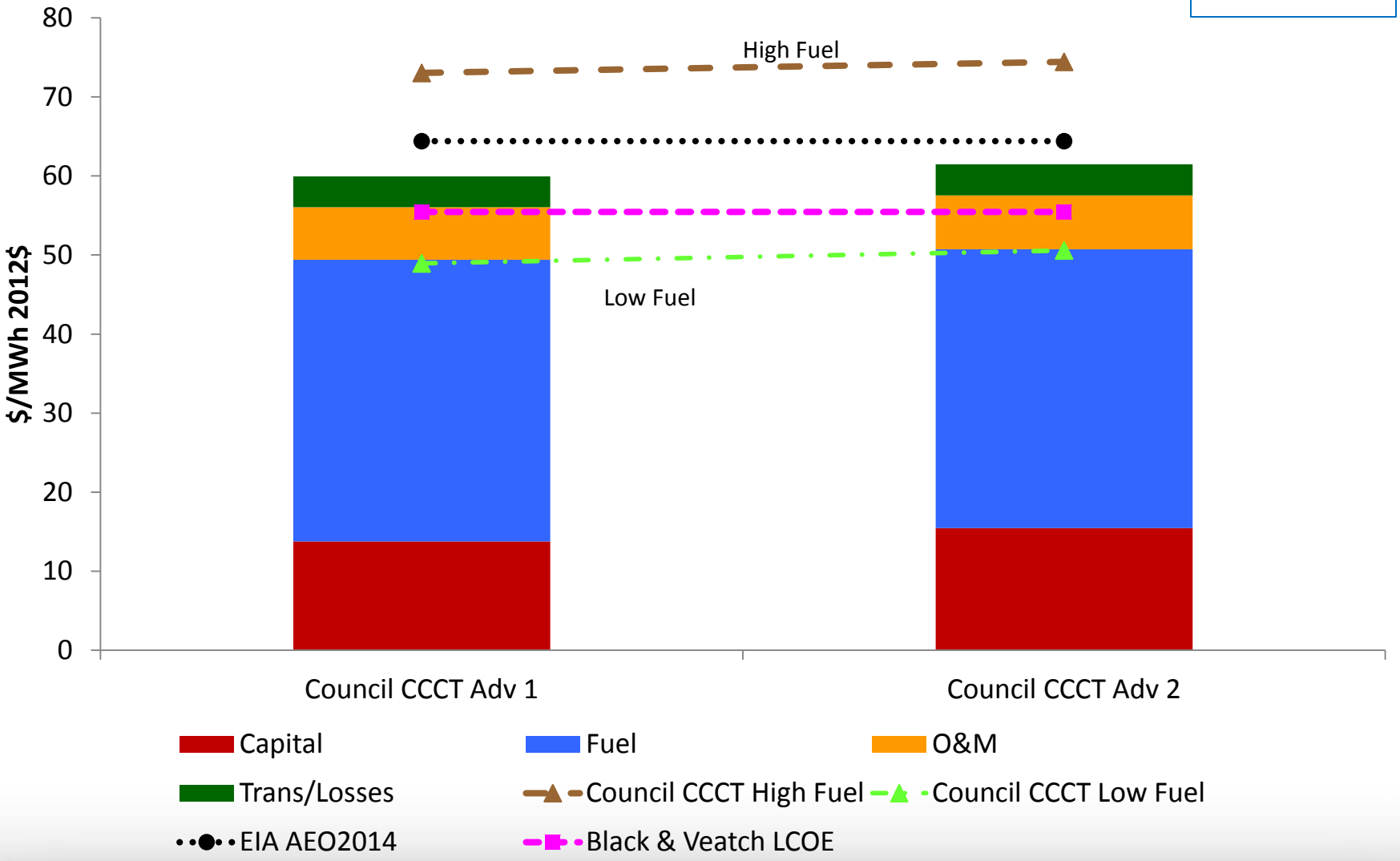
Levelized Cost of Energy $/MWh
Solar PV Utility Scale

IOU financing
Capacity factor –
Boise ID area



Levelized Cost of Energy $/MWh
Ntrl Gas Combined Cycle CT – Year 2020

No CO2 emission penalty attached



Levelized Cost of Energy $/MWh
Solar PV & Ntrl Gas CCCT – Year 2020