Generating Resources

Combined Cycle Combustion Turbine

Utility Scale Solar PV

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November 18, 2014

Purpose of Today's Webinar

- Communicate results from the work Council staff (with aid from the GRAC) has been doing recently around two key supply-side resource technologies
  1. Combined Cycle Combustion Turbine (CCCT)
  2. Utility Scale Solar Photovoltaic (Solar PV)
- This includes cost and performance estimates, along with definition of new resource reference plants for use in the Regional Portfolio Model

4 Key Points for CCCT

1. Technology	Mature technology, with continued improvements in efficiency and performance – resulting in better use of natural gas and more flexibility
2. In the Northwest	Significant presence in the region. Dispatchable baseload power, but annual generation (capacity factor) is variable, depends on hydro conditions. Plentiful natural gas supply from diverse sources and robust gas infrastructure.
3. Cost and Uncertainty	Stable capital cost estimate, but the levelized cost over 20 year planning horizon is highly uncertain – depends on future natural gas supply, price and hydro conditions
4. Emissions	Emits CO2 when generating, and related methane emissions from natural gas production and transportation - but are within proposed EPA regulations for CO2 emissions from new plants

4 Key Points for Solar PV

1. Technology	Evolving and improving both in efficiency and cost. Strong US focus on solar power; rapidly growing power source in California and the Southwest.
2. In the Northwest	Limited presence in the region, though activity is picking up significantly in Southern Idaho – which is probably the best solar resource area in the region. Non dispatchable, variable resource – output varies seasonally and daily, requires integration.
3. Cost and Uncertainty	High up-front capital costs, but costs have been declining rapidly, requiring a forecast of future cost declines. Levelized costs free from fuel related uncertainty.
4. Emissions	Does not emit CO2.

GRAC Meetings To Date

GRAC Meeting	Solar PV	CCCT	Hydro Scoping	Gas Peakers	Wind
1) Jun 20 2013	1				
2) Oct 16 2013	2	1	1		
3) Feb 27 2014		2		1	
4) May 28 2014	3	3	2	2	1
5) Oct 2 2014			3	3	2
6) Nov 7 2014	4				

Reference Plant Basics

- Potential technology and configuration
- Likely location
- Capacity (MW)
- Normalized overnight capital cost ($/kW)
- O&M costs fixed ($/kW-yr) and variable ($/MWh)
- Levelized cost fixed ($/kW-yr) and full ($/MWh)– annualized cost of capital and operation across the lifecycle
- Heat rate if applicable
- Note: all $ in 2012 dollars

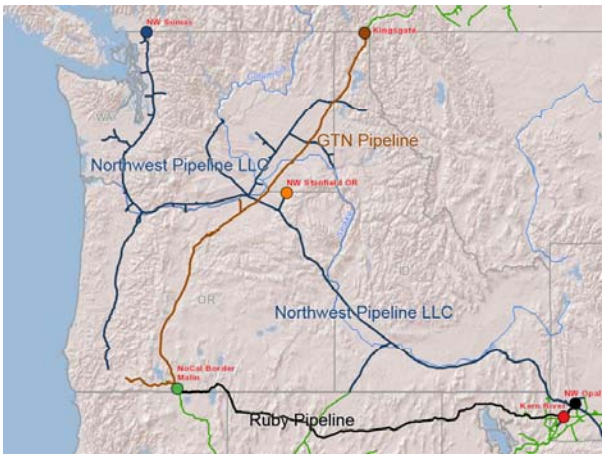
Combined Cycle Combustion Turbine

Background

Primary Components

- Gas-fired combustion turbine (s)
- Heat recovery steam generator (s) - HRSG with or without duct firing
- Natural gas supply
- Water supply with or without dry cooling

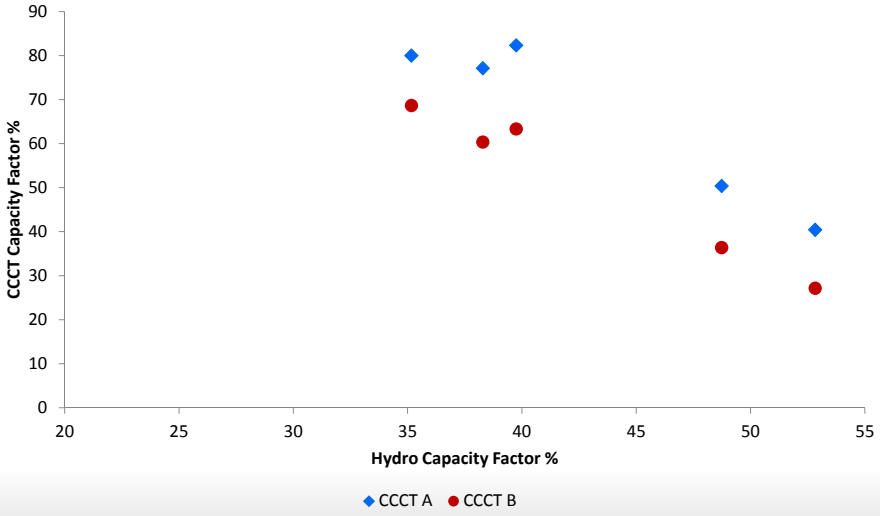
Fuel



Natural Gas infrastructure in the Northwest can tap supply from BC and Alberta Canada, and US Rockies

Draft Natural Gas forecast prices average from from $3.80 to $7.5 per mmbtu in 2012 dollars

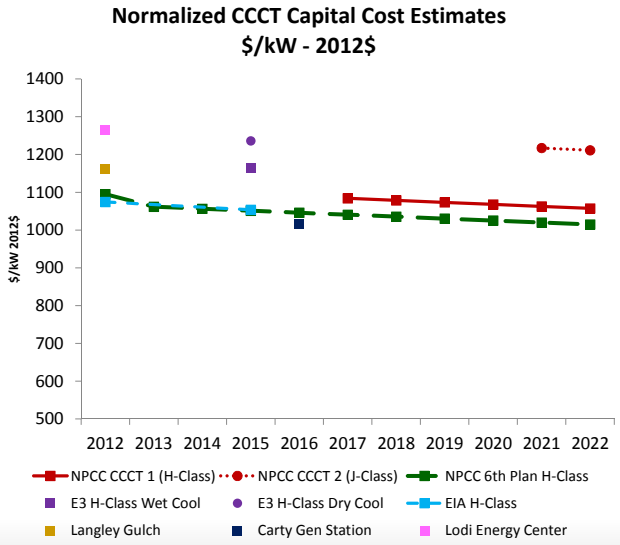
Annual Capacity Factors for 2 CCCT plants in the Northwest by Hydro Capacity Factor (2008 – 2012)

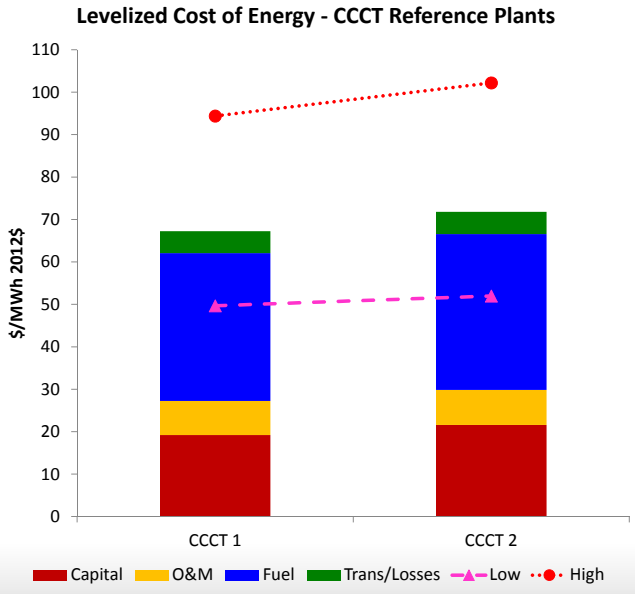


Worked up two reference plants for Draft Seventh Plan

CCCT1 H-Class with wet cooling
Based on Siemens SCC6-8000H

CCCT J-Class with dry cooling based on MHI 501J





LCOE
Capacity Factor 60%
Mid Fuel Price PNWE

Low Case:
Capacity Factor 80%
Low Fuel Price PNWE

HIgh Case:
Capacity Factor 40%
High Fuel Price PNWE

Reference Plants

	CCCT 1 Siemens H-Class 1x1, Wet Cooled	CCCT 2 MHI J-Class 501J 1x1, Dry Cooled	
Location	PNW East	PNW East	
Earliest In –Service	2017	2021	
Construction Per. Years	3	3	
Economic Life Years	30	30	
Capacity MW	392	449	
Capital Cost $/kW	$1,084	$1,217	
Fuel	Natural Gas	Natural Gas	
Heat Rate btu/kWh	6,471	6,408	
Max Capacity Factor %	89	89	
Inv. Tax Credit	-	-	
O&M Fixed ($/kW-yr), Variable ($/MWh)	15.37, 3.27	15.37, 3.27	
CO2 lb/MWh	792	784	

Utility Scale Solar PV

Solar PV Components

PV Modules	Power Electronics	Balance of System
Silicon based c-Si	Inverters	Land and permitting
Thin Film CdTe	Control electronics	Foundation, mounts, tracking systems
		Fixed mount
		Single-axis tracker
		Duel-axis tracker

SunShot Initiative

- DOE launched SunShot as a way to drive R&D advances and provide market stimulation for Solar PV
- Cost goal for utility scale solar PV – $\$1/W_{dc}$ by 2020 which would represent a 75% drop in capital costs since 2010
- Revolutionary advances required – reducing costs across all components and increased efficiencies
- A less aggressive Evolutionary (incremental) cost reduction goal also stated

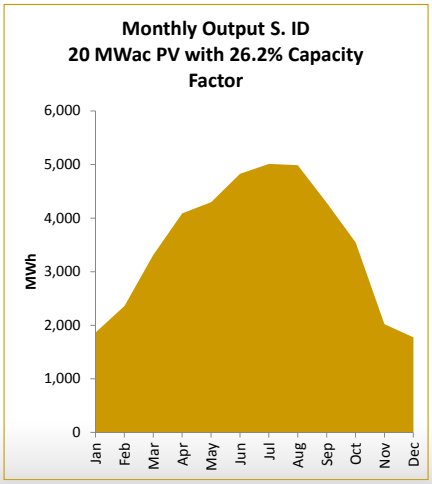
Solar PV in the PNW

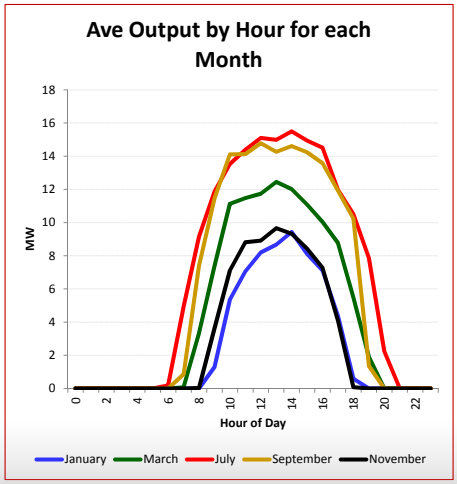
Courtesy of Constellation Energy

- **Outback Solar**, Christmas Valley, OR – largest solar PV project installed to-date in PNW at 5 MW

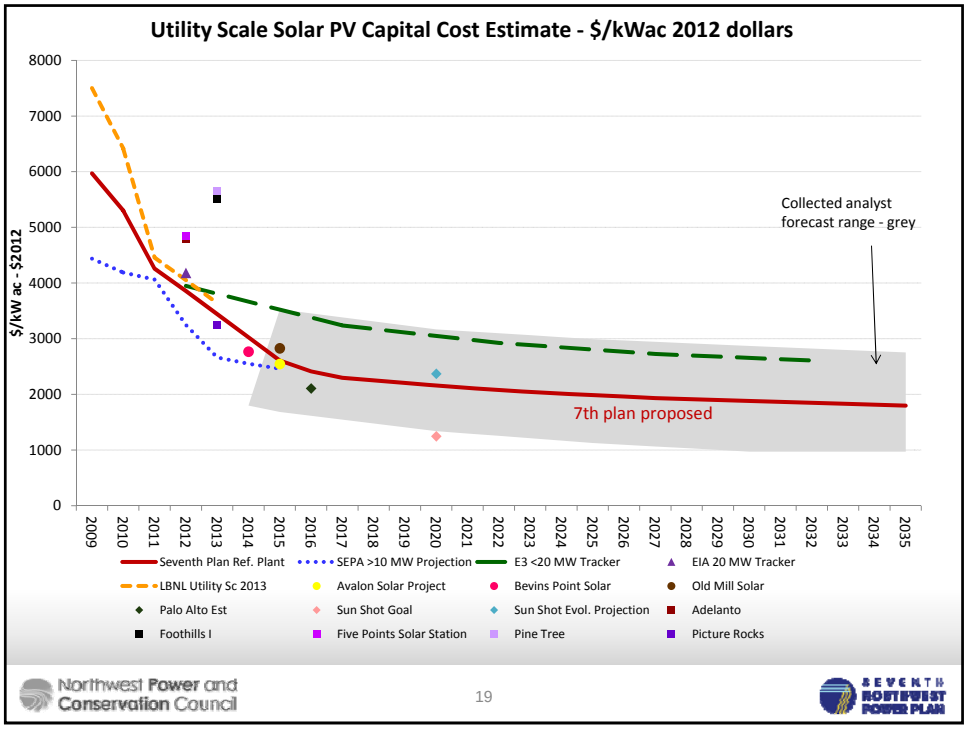
- **Solar in Southern Idaho ~500 MW**
  - Grand View Solar Two (80 MW) and Boise City Solar (40 MW) - 20 year sales agreements approved by IPUC 11/14/14
  - 11 additional projects in IPUC queue (380 MW)

Solar PV Energy Production Example for Southern Idaho



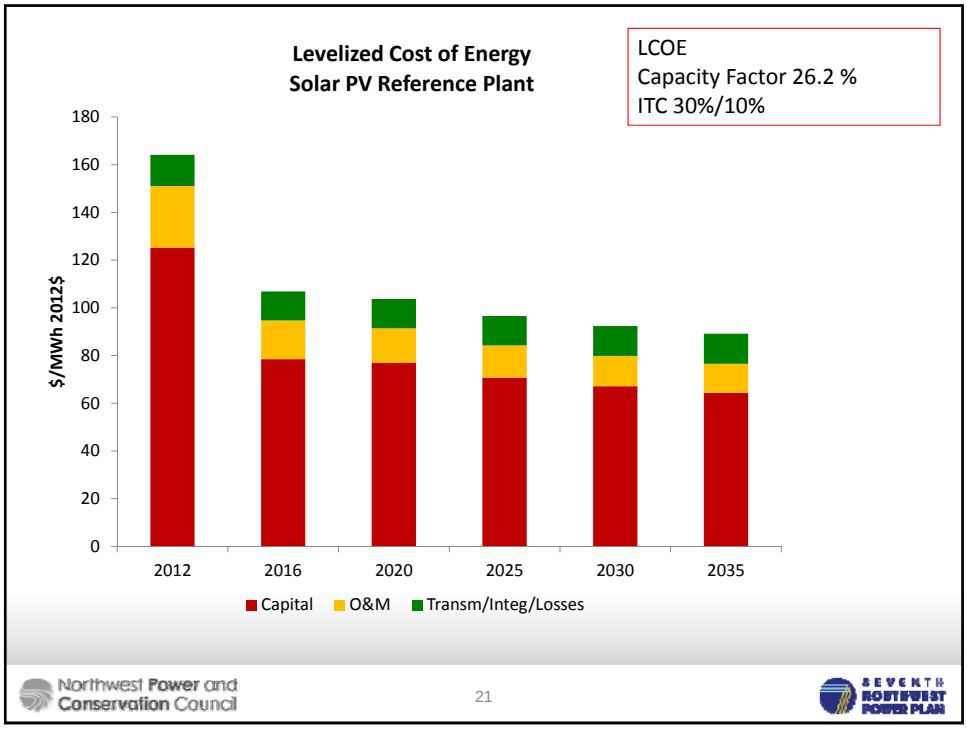


Source: NREL PV Watts



O&M and Levelized Cost Estimates

- Fixed O&M Estimates
  - PV panel washing & replacement due to loss
  - Inverter replacement at 15 years
  - Costs decline with capital cost estimate
  - 30 year life
- Levelized Cost Calculation
  - Capacity Factor 26.2% (S ID)
  - Investment Tax Credit 30% through 2016, then 10%
  - Microfin cost calculator: includes cost of capital, insurance and property tax, O&M, transmission, integration, and cost of losses



Reference Plants

	CCCT 1 Siemens H-Class 1x1, Wet Cooled	CCCT 2 MHI J-Class 501J 1x1, Dry Cooled	Solar PV c-Si Single Axis Tracker
Location	PNW East	PNW East	ID South
Earliest In –Service	2017	2021	2016
Construction Per. Years	3	3	1
Economic Life Years	30	30	30
Capacity MW	392	449	20
Capital Cost $/kW	$1,084	$1,217	$2,413 (2016)
Fuel	Natural Gas	Natural Gas	-
Heat Rate btu/kWh	6,471	6,408	-
Max Capacity Factor %	89	89	26.2
Inv. Tax Credit	-	-	30% /10% 2017 and later
O&M Fixed ($/kW-yr), Variable ($/MWh)	15.37, 3.27	15.37, 3.27	16.63 (2016)
CO2 lb/MWh	792	784	-

Wrap Up

Levelized Costs – Reference Plants

	Fixed Levelized Cost $/kW-yr			LCOE $/MWh		
Year	CCCT 1	CCCT 2	Solar PV	CCCT 1	CCCT 2	Solar PV
2016	163.27		241.75	67.23		106.87
2020		177.38	234.12		71.80	103.70
2025			217.37			96.61
2030			207.16			92.37
2035			199.41			89.17

CCCT Cap Factor 60%
Solar Cap Factor 26%