

Utility Scale Solar PV

Generating Resource Advisory Committee
November 7, 2014

Steven Simmons

Purpose of Today's Meeting

- Utility Scale Solar PV Reference Plant for the Draft Seventh Power Plan – includes a 20 year forecast of overnight capital, O&M and levelized costs
- Assumptions may be re-visited between the Draft Plan and Final Plan – should a significant change to the solar landscape occur

Agenda

1. Background on Solar PV
2. Cost Estimates
 - a. Overnight Capital Cost
 - b. Fixed O&M Cost
 - c. Levelized Cost of Energy from Microfin
3. Detailed breakout of Levelized Costs
4. Reference Plant

Background Information

Assessment Timeline

- Generating Resource Assessment work for the Draft Seventh Plan began in 2013 – utility scale solar pv was a prominent topic early

- As the work progressed, results were brought to the GRAC for discussion
 1. June 20 2013
 2. October 16 2013
 3. May 28 2014

- Staff has analyzed and normalized solar pv data, and utilized GRAC feedback to synthesize a reference plant

Definition

- Utility Scale PV – ground mounted systems 5 MW or larger in size
- Typically high up-front capital costs; but free from the risk of fuel supply disruptions and price volatility

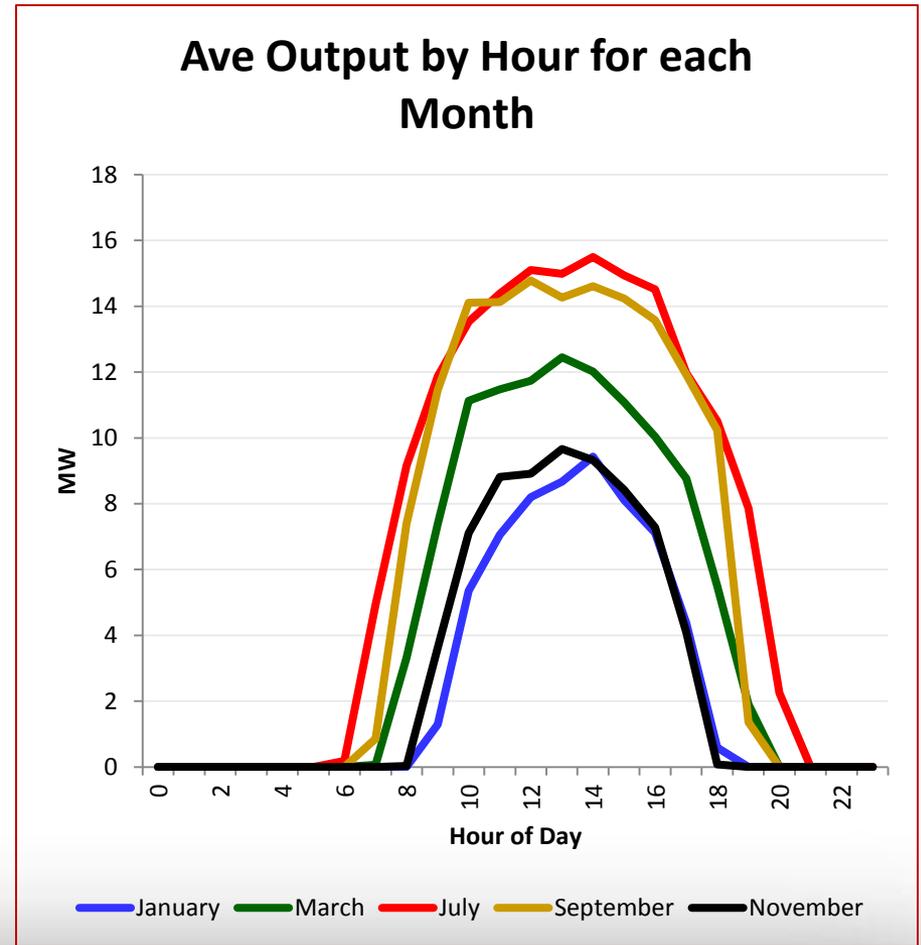
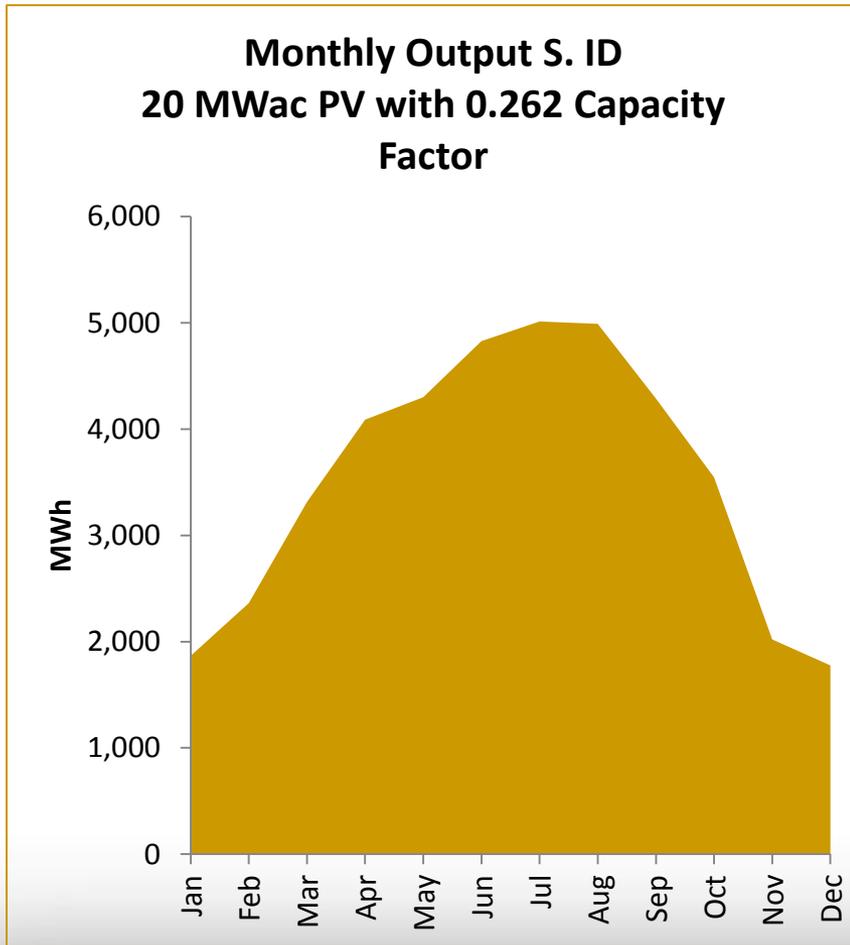
Solar PV System Components

PV Modules	Power Electronics	Balance of System
Conventional silicon like c-Si	Inverters	Land and permitting
Thin film like CdTe (First Solar)	Other control electronics	Foundation, mounts, tracking system
		Fixed mount
		Single axis tracker
		Dual axis tracker

Recent Activity and Trends

- Large projects – such as
 - Agua Caliente in Yuma Co Arizona – 290 MW – largest operating PV plant in the US
 - Topaz Solar Project in SLO California – under construction, on line in 2015 – will supplant Agua Caliente as the biggest at 550 MW
- Majority of projects are much smaller – typically around 20 MW size
- Some large projects in strong solar resource areas have been thin film and fixed mount systems. Most others are c-Si with single axis trackers
- Two announced projects in Southern Idaho
 - Grand View PV Solar Two - 80MW, slated to be in service in 2016
 - Boise City Solar - 40MW, in service 2016

Solar PV Energy Production Example for Southern Idaho



CAPITAL, O&M, and LEVELIZED COSTS

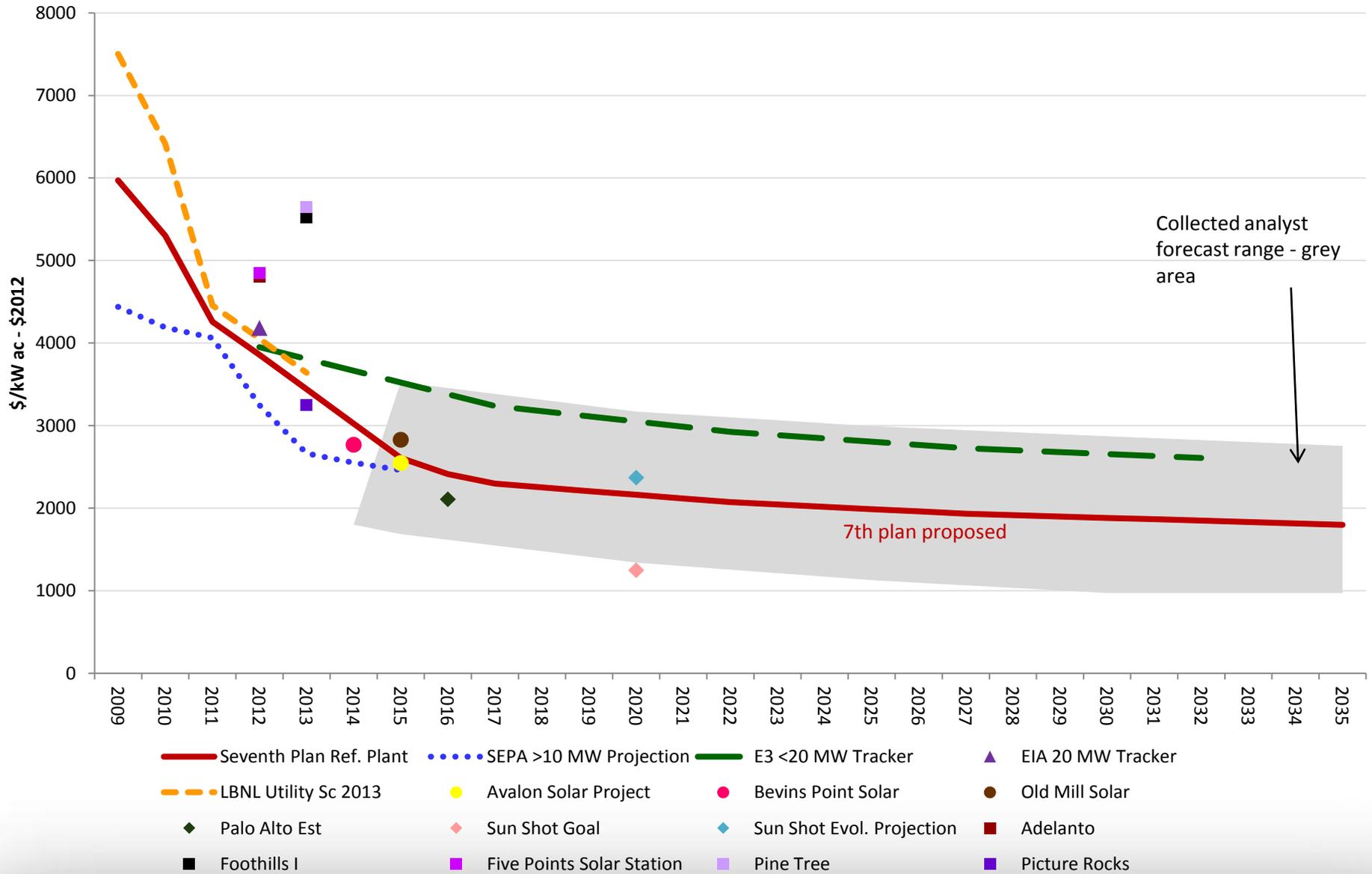
SunShot Initiative

- 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 – to reduce costs across all components and increase efficiencies
- A less aggressive Evolutionary (incremental) cost reduction goal also stated

Capital Cost Projections

- Solar costs are declining rapidly – requiring a forecast of future costs
- Informed forecast – with emphasis on c-Si, single axis tracking systems
 - Estimates from completed and planned projects plotted by year
 - Information gleaned from reports
 - Data normalized to 2012 dollars, and AC rating
 - GRAC discussion and feedback – Jun ‘13, Oct ‘13, May ‘14
 - PPA announcements of future projects – back calculated for estimates of capital costs using MicroFin
 - Sunshot vision
 - Independent comparison of forecast to other analyst estimates – hits the center

Utility Scale Solar PV Capital Cost Estimate - \$/kWac 2012 dollars



Estimate & Forecast of Capital Costs - \$/kW ac 2012\$

Year	Capital Cost \$/kW _{ac} *
2012	3,859
2016	2,413
2020	2,162
2024	2,016
2028	1,915
2032	1,848
2035	1,799

* All \$ in 2012 dollars

O&M and Levelized Cost Estimates

- Fixed O&M Estimates
 - Estimate from SunShot 2012
 - 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 0.262 (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
 - First Solar suggests a LCOE from \$70 to \$150 per MWh

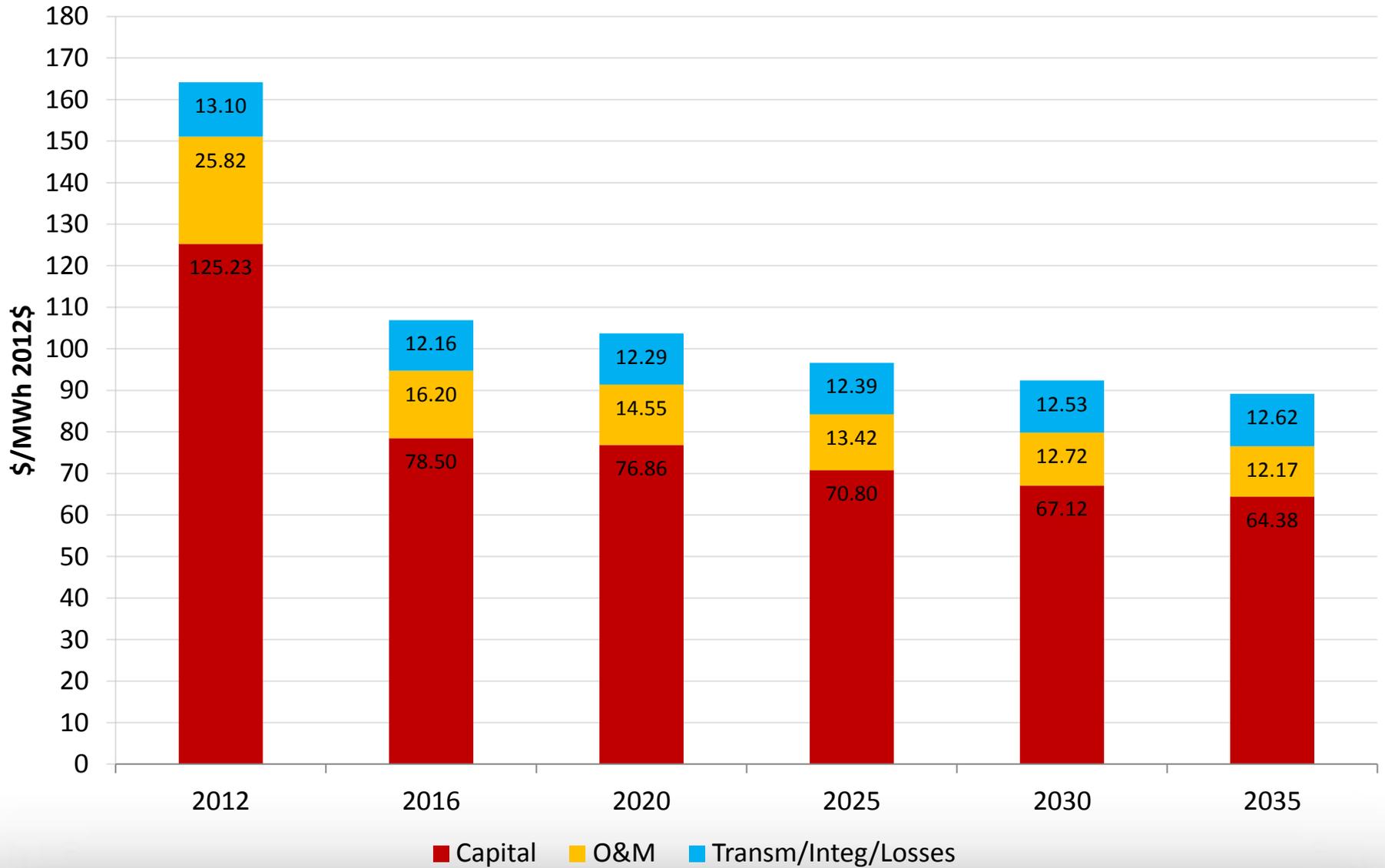
MicroFin Financials	Municipal/PUD	Investor Owned Utility	Indep. Power Producer
Federal Tax - %	0	35	35
State Tax - %	0	5	5
Fed Tax Inv Credit - %	0	30/10*	30/10*
Property Tax - %	0	1.4	1.4
Insurance - %	0.25	0.25	0.25

Debt Fraction - %	100	50	60
Debt Interest Rate (not tax adjusted)	5.24	6.69	6.69
Debt payment Period**	25	25	20
Return on Equity	0	10	13.7
Equity Payment Period	0	25	20
Discount Rate	4	4	4
Inflation Rate	1.64	1.64	1.64

* Solar only – 30% thru 2016, 10% after

**Solar PV

Levelized Cost of Energy - Utility Scale Solar PV



Levelized Cost Components & Breakout – 2016 in service, 26.2 capacity factor, All Costs in 2012\$ Total LCOE = 106.87 \$/MWh

Capital LCOE Component	78.50	\$/MWh
<u>Key input data</u>		
Capital cost estimate	2,413	\$/kW ac
Debt/Equity Mix	50/50	%
Debt int rate	6.69	%
Equity return	10	%
Discount rate	4	%
Federal tax rate	35	%
State tax rate	5	%
ITC	30	%

Capital breakout	LCOE	
Debt Service (payment & interest)	32.94	\$/MWh
Equity Service (payment & return)	41.31	\$/MWh
Federal Taxes	3.25	\$/MWh
State Taxes	1.01	\$/MWh
TTL	78.50	\$/MWh

Without ITC		
Federal Taxes	13.63	\$/MWh
State Taxes	1.47	\$/MWh

O&M LCOE Component	16.20	\$/MWh
<u>Key data</u>		
Fixed O&M estimate	16.63	\$/kW-yr
Property tax	1.4	%
Insurance	0.25	%

O&M breakout	LCOE	
O&M fixed	7.17	\$/MWh
Property Tax	7.66	\$/MWh
Insurance	1.37	\$/MWh
TTL	16.20	\$/MWh

Transmission LCOE component	12.16	\$/MWh
<u>Key input data</u>		
Fixed Transmission Cost Point to Point	20	\$/kW-yr
Variable Transmission cost	0.1	\$/MWh
Solar Integration cost	0.21	\$/kW-mo
	1.15 and up	\$/MWh
Transmission Losses	1.9	%

Transmission breakout	LCOE	
Transm. Fixed	8.62	\$/MWh
Transm. Variable	0.10	\$/MWh
Transm. Integration	1.44	\$/MWh
Cost of Losses	2.00	\$/MWh
TTL	12.16	\$/MWh

REFERENCE PLANT

REFERENCE PLANT UTILITY SCALE SOLAR PV

Plant	Characteristics	Year	Capital Cost \$/kW _{ac}	Fixed O&M \$/kW _{ac} - year	Levelized Cost of Energy \$/MW _{ac} h	Fixed Levelized Costs \$/kW _{ac} - year
<u>Technology</u> Crystalline silicon, single axis tracker <u>Location</u> S. Idaho <u>Dev. & Constr.</u> 3 years <u>Economic life</u> 30 years	<u>Capacity</u> 20 MW _{ac} <u>Capacity factor</u> (S. Idaho) 0.262 <u>Annual degradation</u> 1 %	2016	2,413	16.63	106.87	241.75
		2020	2,162	14.90	103.70	234.12
		2025	1,988	13.70	96.61	217.37
		2030	1,882	12.97	92.37	207.16
		2035	1,799	12.40	89.17	199.41
		All in 2012 \$				