Northwest Power and Conservation Council

July 30, 2013

MEMORANDUM

TO: Power Committee

FROM: Charlie Black

SUBJECT: Primer on Solar Power

Staff has prepared another in a series of primers designed to build up a framework for understanding power planning issues. Previously we have covered topics such as carbon emissions, generating resources, peaking capacity, power system flexibility, reserves, and levelized cost. At the Power Committee meeting on August 6, Steve Simmons and Gillian Charles will present a primer on solar power. The primer will characterize solar power and describe recent trends and issues for this generating resource type.

An overview of several types of solar power systems is provided, including utility scale photovoltaic, rooftop/distributed generation, and concentrating solar power. In addition, recent issues, cost trends, and performance are covered.

851 S.W. Sixth Avenue, Suite 1100
Portland, Oregon 97204-1348
www.nwcouncil.org

Steve Crow
Executive Director

503-222-5161
800-452-5161
Fax: 503-820-2370

Primer

Solar Power

Power Committee Meeting
Steven Simmons & Gillian Charles
August 6, 2013

Topics

1. Solar Power Introduction & In The News
2. Solar Photovoltaic Utility Scale and Rooftop
3. Concentrating Solar Power
4. Solar Photovoltaic Utility Scale Cost & Performance

Solar has a Bright Future

- Modest environmental impacts
- Avoid reliance on risky fuel
- Coincidence with peak electricity demand – at least in some areas
- Technological breakthroughs
- State renewable portfolio standards as well as federal and state grants and tax incentives
- Many projects completed and under construction – both large (Agua Caliente in AZ - 290 MW) and small (Outback Solar in S. OR - 5 MW)

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Sunny Headlines

- SunShot Initiative – goal is to reduce Solar PV cost by 75% from 2010 to 2020 (DOE - 2011)
- Energy Department Announces $12 million to Accelerate Record-Breaking Solar Cell Efficiency (DOE – Jan 2013)
- New solar panels glisten in the high desert sun (OR) – (BPA – Jan 2013)
- Power from solar nears amount lost from San Onofre (Orange Co Register – Jun 2013)
- Palo Alto Goes Solar, 80 Megawatts at 6.9 Cents per Kilowatt-Hour (GreenTech Media – Jul 2013)

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Not So Sunny Headlines

- Abound Solar files to liquidate in bankruptcy (Reuters 2012)
- Micron Owned Transform Solar Received $1.68M in State Training Grants Before Announcing Layoffs (Boise Public Radio 2012)
- SoloPower sheds jobs, auctions equipment in struggle to survive (Oregonian 2013)
- Arizona's Biggest Utility Proposes a Cut to Net Metering - APS calls it customer fairness; solar advocates call it a backdoor tax. (Greentech Media 2013)

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Solar Power Types

- Solar Photovoltaic (PV)
  - Utility Scale PV
  - Rooftop/Distributed Generation
- Concentrating Solar Power (CSP)

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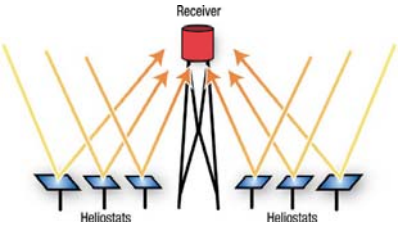
Solar Systems

Rooftop/DG



CSP

Utility Scale PV

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Utility Scale Solar PV

Systems are composed of individual solar pv cells collected into multiple solar modules which are connected to inverters and send AC power to the grid. Can range from small installations around 1 MW to large units nearly 300 MW.

- Solar cells convert sunlight directly into electricity and are typically one of two types:
  - Crystalline Silicon - more expensive to build but better efficiency (~ 25%)
  - Thin Film (can be Silicon based or other substrate, cheaper to manufacture but less efficient (~ 13 to 20 %)
- Modules are either
  - Fixed - less expensive to install but lower capacity factor
  - Trackers – will follow the sun, more expensive but better capacity factors

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Utility Scale Solar PV

Agua Caliente Solar
- Near Yuma AZ
- Around 290 MW
- Developed by First Solar
- PPA is PG&E
- Thin Film Panels – Fixed Ground Mount

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Outback Solar – Christmas Valley, OR

Courtesy of Constellation Energy

- Four years to complete – from conception to commercial service

- PNW largest solar project to date – 5.7 MW DC installed capacity
- ~ 23,000 polycrystalline ground-mount single-axis tracker solar pv panels
- $15 million in financing through tax incentives from Oregon's Business Energy Tax Credit and a grant Energy Trust of Oregon

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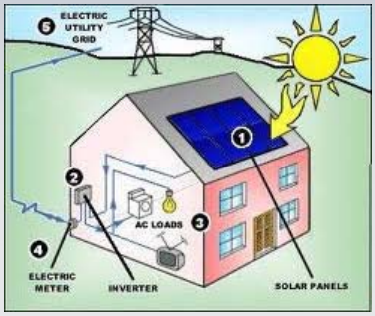
Rooftop Solar PV

Can mount pv panels on a rooftop to power your house or business and send power to the grid. The amount of power generated depends on the amount of sun light that is available, the roof angle and orientation and the amount of shading from buildings and trees. A typical residential rooftop system is around 4 kW in size; Commercial around 32 kW.



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PV Manufacturing

- PV panel manufacturing shares similarities with semiconductor manufacturing of computer chips – but with less complexity, and less stringent requirements for quality control and clean room technologies
- Silicon is often the substrate of choice – implanted with other materials such as phosphorus and boron to develop a cell that converts sunlight into electricity. Thin film can use Si, or other semiconductor materials such as CdTe or CIGS
- Costs are dropping – has been following a learning curve path – x% reduction in cost for each doubling of product made

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Solar Investment Tax Credit

- 30% investment tax credit for commercial and residential solar energy systems
- Under current law, ITC to remain in effect until end of 2016 at 30%; Post-2016, credit drops to 10% (for solar)
- Provides market certainty → increasing deployment and efficiency and lowering costs of solar energy

Concentrating Solar Power

Concentrating Solar Power (CSP) Plants use reflected sunlight as fuel to heat a transfer fluid – which can heat water to spin a turbine, and/or heat molten salt to store in a tank to generate power later. In order to be efficient, these plants must be over 100 MW in size. CSP plants can be dispatched and can provide storage – key distinguishing points.

- Trough Systems
- Power Tower Systems

Trough Systems – parabolic mirrors reflect and focus sunlight on an absorber tube with fluid which transfers heat to an engine generator. Storage may be provided with molten salt in tanks.

Power Tower Systems – heliostats (flat, sun tracking mirrors) focus sunlight onto a receiver on top of a tower to heat fluid that will spin a turbine and/or heat molten salt for storage.

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Concentrating Solar Power

Ivanpah
- Mojave Desert CA
- 377 MW
- Developed by BrightSource
- PPA is PG&E and So Cal Edison

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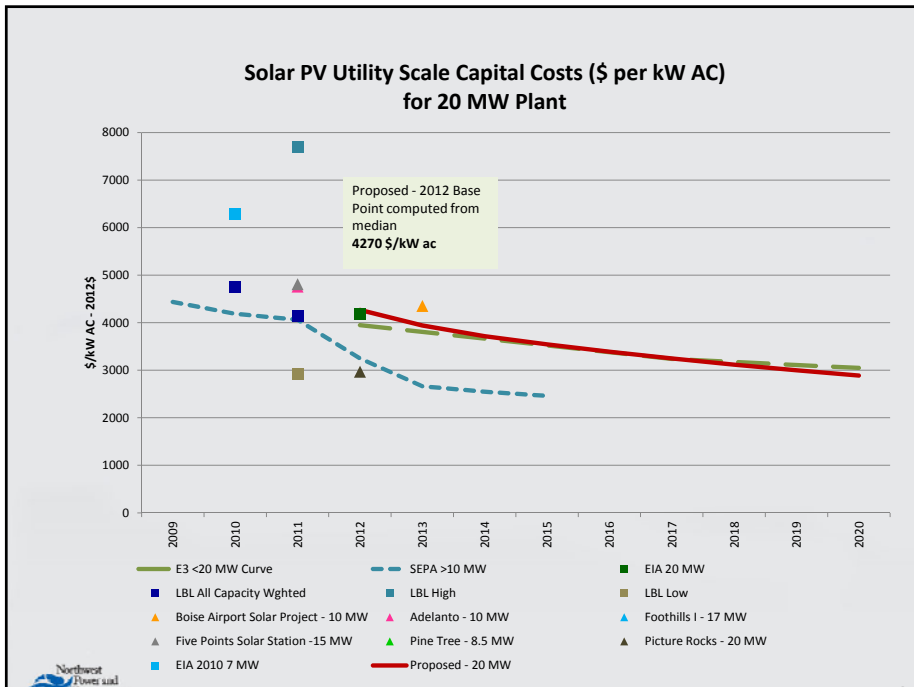
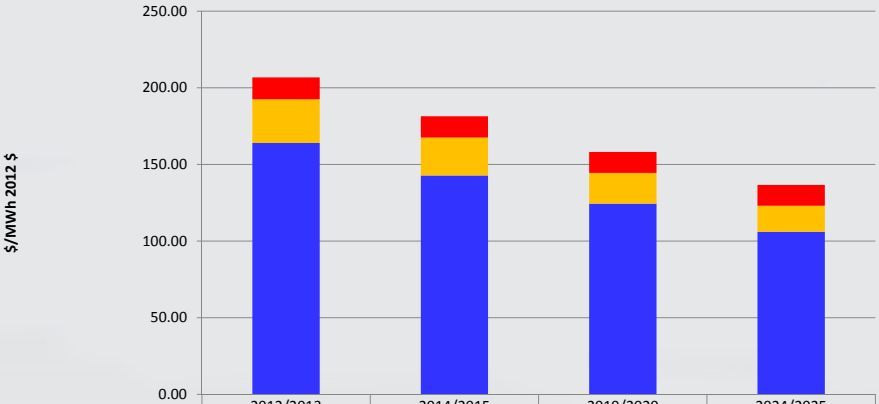
Preliminary Cost and Performance Assessments: Utility-Scale Solar PV



Levelized Cost by Year ($/MWh in 2012 dollars)
Proposed Solar PV Central Station Snapshot of 4 Years
Boise ID Location (CF ac to ac -26.9%)

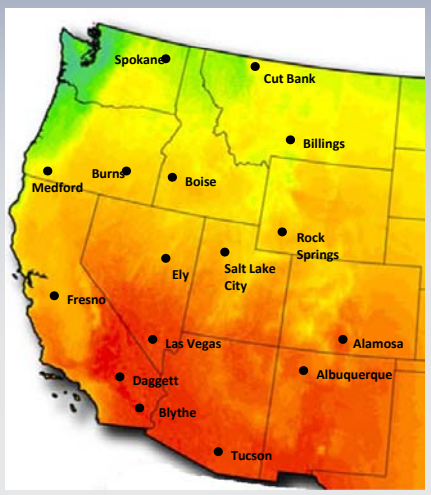


	2012/2013	2014/2015	2019/2020	2024/2025
Transmission & Integration	14.37	13.94	13.70	13.54
O&M incl tax & insur	28.41	24.74	19.99	17.05
Capital	164.02	142.75	124.42	106.03
TTL	206.80	181.42	158.11	136.62

Solar PV Performance

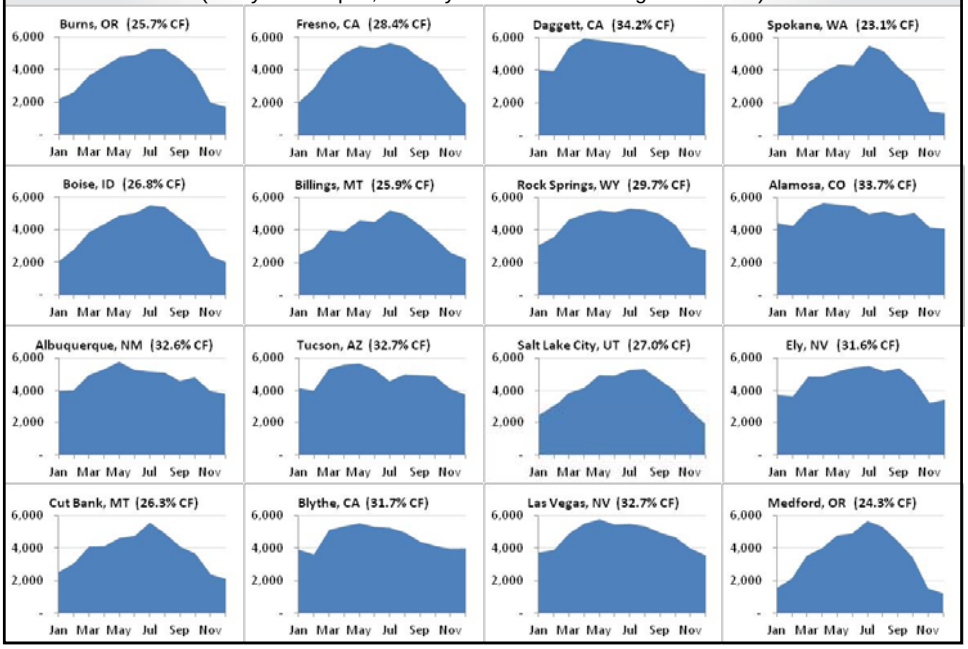
Capacity Factor = Annual generation (kWh AC) ÷ System Rating (kw AC) ÷ 8,760 (hrs/yr)

Location	Load Resource Area	Capacity Factor (AC-AC rating basis)
Burns, OR	**E. WA/OR (1)**	**25.7%**
Fresno, CA	N. CA (2)	28.4%
Daggett, CA	S. CA (3)	34.2%
Spokane, WA	**BC (4)**	**23.1%**
Boise, ID	**S. ID (5)**	**26.8%**
Billings, MT	**MT (6)**	**25.9%**
Rock Springs, WY	WY (7)	29.7%
Alamosa, CO	CO (8)	33.7%
Albuquerque, NM	NM (9)	32.6%
Tucson, AZ	AZ (10)	32.7%
Salt Lake City, UT	UT (11)	27.0%
Ely, NV	N. NV (12)	31.6%
Cut Bank, MT	AB (13)	26.3%
Blythe, CA	Baja (14)	31.7%
Las Vegas, NV	S. NV (15)	32.7%
Medford, OR	**W. WA/OR**	**24.3%**



Monthly Annual Energy (MWh)

(First year output, each year thereafter degrades 0.5%)



Questions?

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