Northwest Power and Conservation Council

January 7, 2008

MEMORANDUM

TO: Power Committee

FROM: Jeff King, Senior Resource Analyst

SUBJECT: Assessment of utility-scale solar-photovoltaic generating resource potential

Aggressive renewable portfolio standards and greenhouse gas control policies may lead to the need for large-scale sources of renewable or low-carbon energy in addition to wind power. Utility-scale, central-station (tens to hundreds of megawatts) solar plants using commercially available photovoltaic (PV) technology could be one such source. Numerous small-scale distributed PV installations of tens to hundreds of kilowatts in capacity are in operation throughout the West and two central-station prototype plants, White Bluffs (30 kW) and Wild Horse (500 kW), operate in the Northwest. Two commercial plants are in operation in North America: El Dorado (10 MW) near Boulder City, Nevada, and Nellis AFB (14 MW) in Nevada, the largest in North America. Power sales agreements have been signed by California utilities for 250 MW power and 550 MW plants to be constructed in California between 2010 and 2013.

Photovoltaic plant attributes include no direct emissions of criteria air pollutants and carbon dioxide, short construction lead time, high modularity, no fuel price risk, and extremely positive public perception. Unlike solar thermal (CSP) plants, PV modules use indirect as well as direct solar radiation, and can function (though at less than full output) in areas subject to haze and cloud cover. Plant output, however, is diurnally intermittent and seasonally variable, and not coincident with the peak loads of most Northwest utilities. Unlike CSP plants, PV plants require system integration services and provide only limited capacity value. Very high capital cost, currently \$5,000 - 8,000/kW, has been the principal barrier to development of photovoltaics. In contrast to other forms of generation, PV costs have remained stable over the past several years and are expected to decline, possibly significantly, with the scheduled near-term expansion of module production capacity.

Staff will describe an assessment of the potential cost and performance of hypothetical utility-scale photovoltaic plants at several Northwest locations. The estimated cost of energy from these will be compared to the estimated cost of energy from a hypothetical plant located in central Nevada and serving Northwest loads via new transmission. A PowerPoint presentation will be provided prior to the meeting.

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

Sixth Northwest Conservation & Electric Power Plan

Central-station Solar Photovoltaic Resource Assessment

Jeff King

Northwest Power and Conservation Council

Missoula, MT

January 13, 2008

Utility-scale solar photovoltaic plants

Resource widely distributed

Financial issues:

- Very high capital cost (currently $7000 - 10,000/kW)
- Good prospects for significant cost reduction
- Short development and construction lead time
- Highly modular - readily scaleable
- No fuel price risk

Siting requirements

- Land with low financial and ecological value (~ 10Acres/MWdc)
- Low slope
- Lower transmission voltages
- Little interference w/adjacent land-uses

Environmental and siting issues

- No production of carbon dioxide or criteria air pollutants (SOx, NOx, etc.) during operation
- Moderate level of embodied CO2
- Potential ecological impacts from habitat preemption
- Large land area required (500 acres/50 MW plant)
- Feasible in more northerly latitudes than CSP (Uses global solar radiation in addition to direct normal solar radiation)
- Public perception is very positive with respect to existing small-scale installations. Some concerns regarding large-scale proposals in CA.
- New transmission from remote resource areas could engender concerns

Technical issues

Maturity:

- Modules - Reliable, commercially established technology; significant potential for cost and efficiency improvement.
- Inverters - Durability issues, require replacement or rebuild at ~10 yr intervals

Flat plate technology operates on global (indirect & direct) radiation

Diurnally intermittent and seasonally variable output

- No storage
- Extreme ramps (clouds) may preclude large arrays at single locations

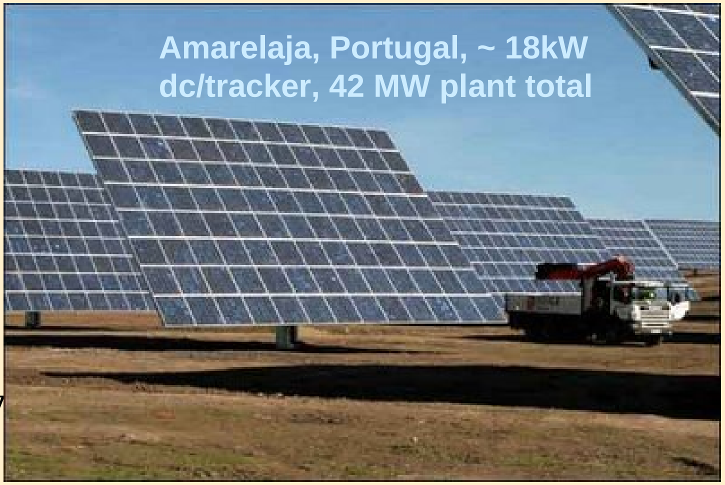
Regulation and load-following reserves required for system integration

- Demand for and cost of reserves not known at this time

Limited peaking capacity value

Poor seasonal & diurnal load-resource coincidence for winter-peaking utilities; good load-resource coincidence for summer-peaking utilities.

Flat Plate Photovoltaics



Single- or poly-crystalline silicon modules - higher cost, higher efficiency; or

thin-film modules - lower cost, lower efficiency

Single-axis or dual axis tracking - higher cost, more productive; or

fixed mount - lower cost, less productive

DC module output converted to AC w/inverters (AC rating ~ 75-80% of DC rating)

North American Development

- Nellis AFB, Las Vegas, Nevada - 14 MW crystalline Si, single axis tracking (Dec 2007)
- El Dorado, Boulder City, NV - 10 MW thin film, fixed mounting (Dec 2008)
- Alamosa, CO - 8.2 MW (part) fixed and single axis trackers (Dec 2007).
- Springerville, AZ - 4.6 MWdc - crystalline Si, fixed mounting (2001-04)
- Wild Horse (Vantage, WA) - 500 kW
- Power sales agreements for 2 projects totalling 800 MW in CA

Concentrating PV (CPV)

Concentrating mirrors and lenses focus solar radiation on high-efficiency PV cells

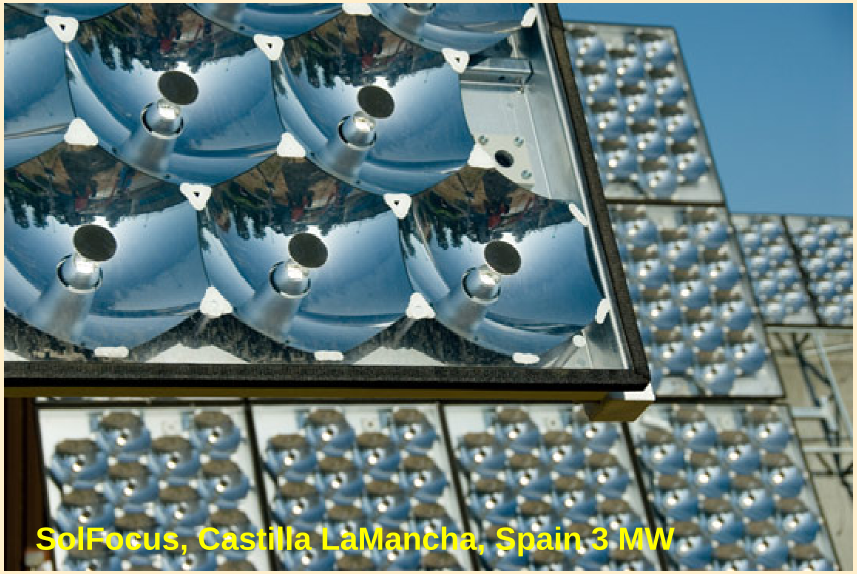
Smaller cell area, can justify expensive high-efficiency cells

High-efficiency mono-crystalline Si, gallium arsenide & multi-junction cell designs

Dual-axis tracker-mounted to maximize available energy

Uses direct-normal radiation

Demonstration stage



North American Development:

Alamosa, CO - 8.2 MW (part) (Dec 2007).

GreenVolts GV-1, Tracy CA - 2.0 MW power purchase agreement (2009).

Flat plate crystalline silicon w/single-axis trackers selected as representative technology

Concentrating technology limited to direct normal radiation - more suitable for desert southwest

Crystalline silicon cells, though more expensive than thin-film are more efficient, commercially mature with an extensive operating record

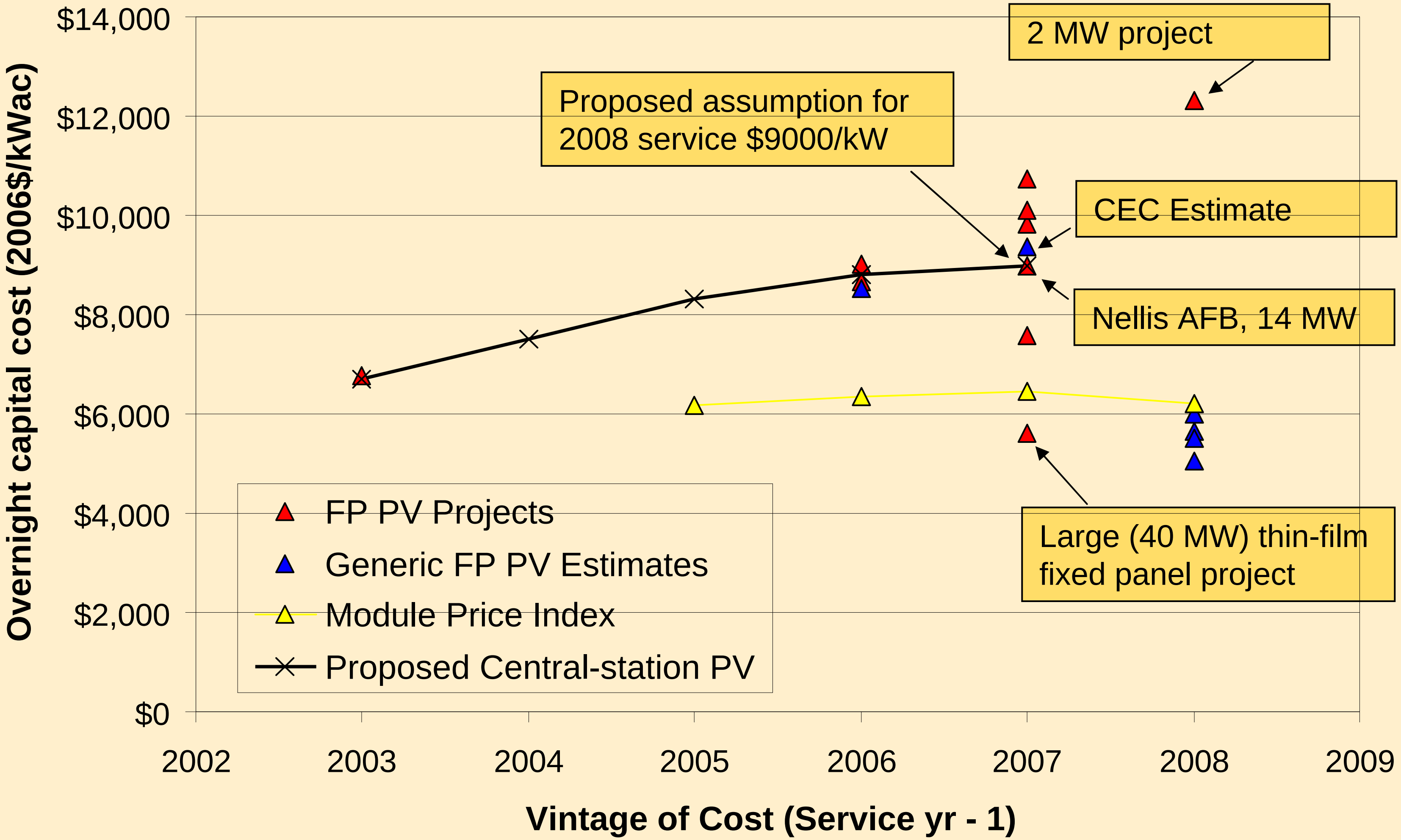
Trackers significantly increase captured energy (~130%), though at greater cost.

Preponderance of current central-station installations are flat plate crystalline silicon w/single axis trackers

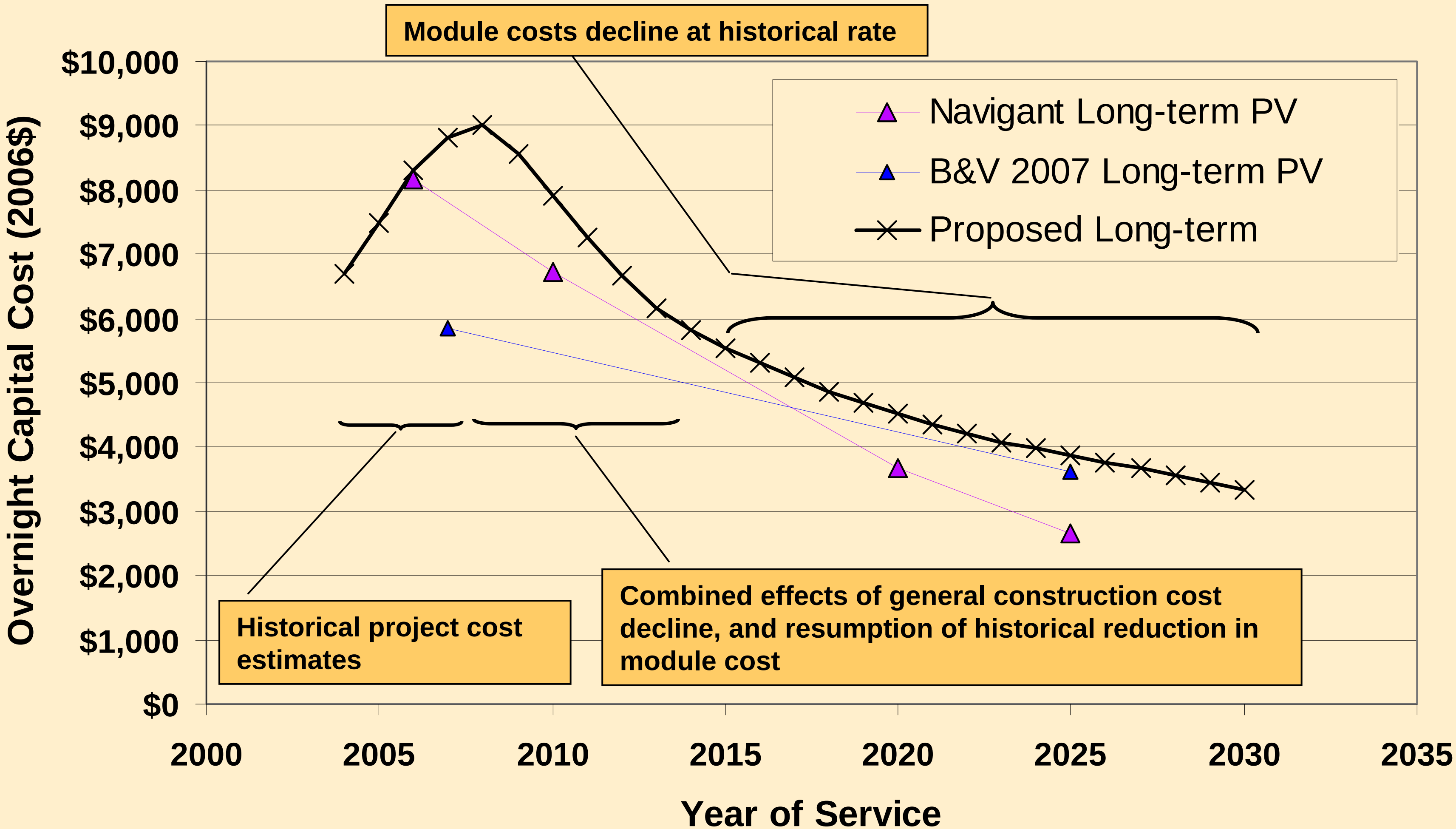
Ultimate preferred technology??

- Efficient but expensive - Si w/trackers
- Less efficient, but less expensive - Thin film fixed

Derivation of central-station PV capital cost assumption



Construction costs over the long-term



Northwest Power and Conservation Council

January 13, 2008

Summary of central-station photovoltaic plant assumptions

Configuration:

- 65MWdc/50 MWac flat plate, crystalline Si single-axis tracker plant

Development and construction cost (overnight):

- $9000/kWac (2008 service)

Operating costs:

- Fixed O&M - $36.00/kWac/yr
- Variable O&M - Included in fixed O&M
- System Integration - $8.85/MWh in 2010 > $10.90/MWh in 2024 (Same as wind)

Schedule and cash flow

- Development - 24 mo; 2% of overnight cost
- Preparation - 12 mo; 14% of overnight cost
- Construction - 24 mo; 85% of overnight cost

Earliest service for new projects in the Northwest ~ 2012

Operating life: 25 years

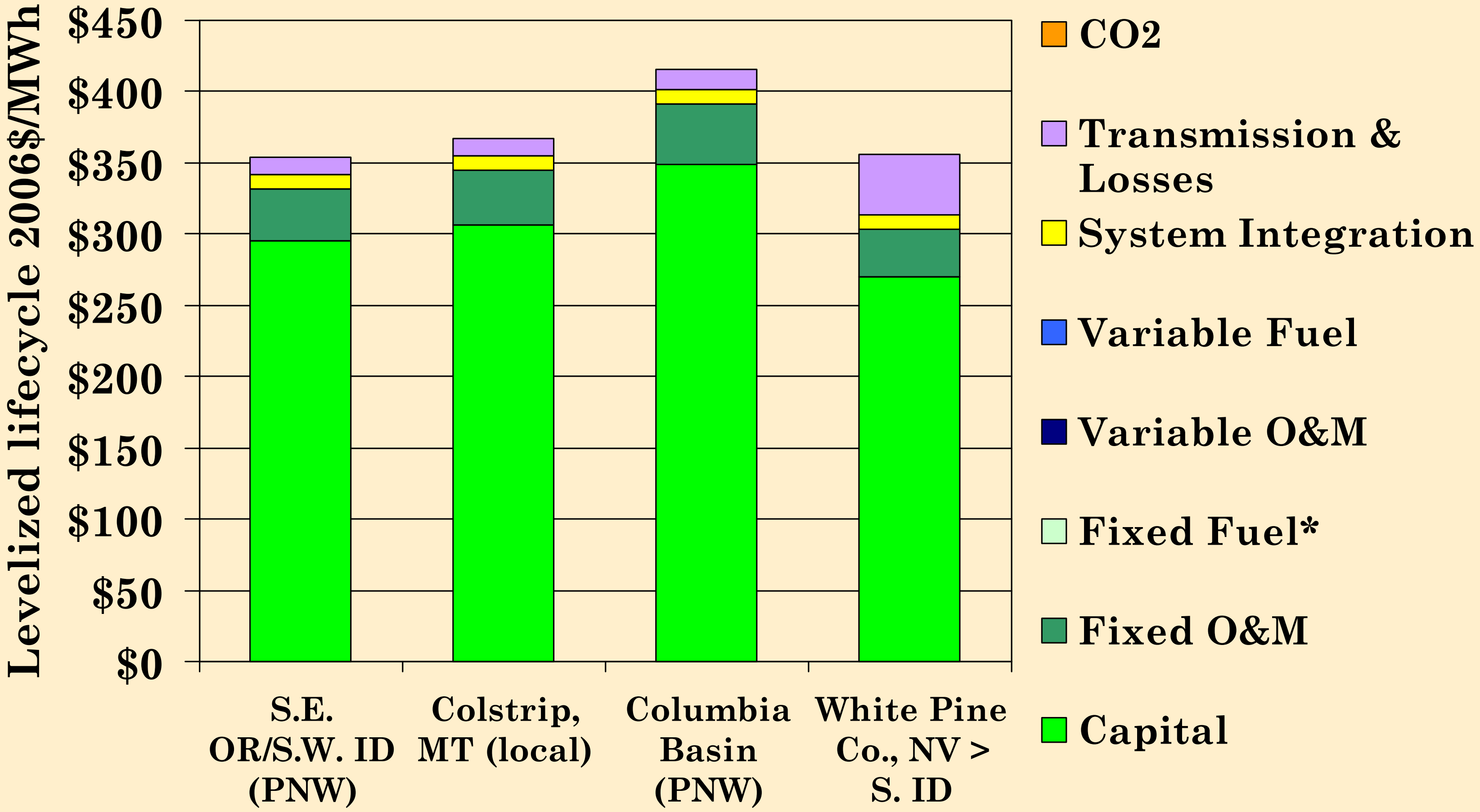
Incentives: 5-yr MACRS depreciation; 30% ITC through 2016

Central-station PV plant
Cost elements & locations

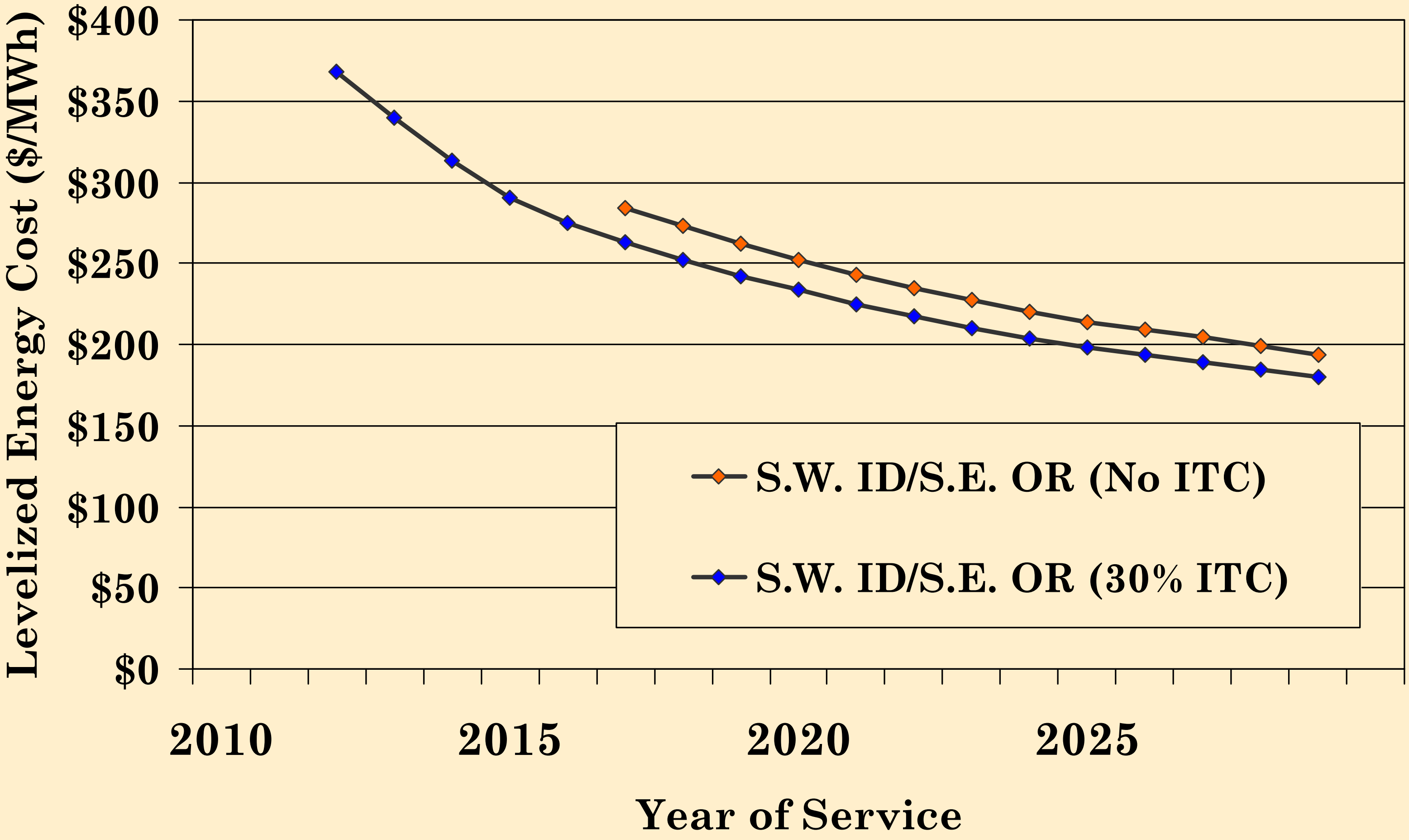
2015 service

IOU financing; no incentives

CO_2 - Bingaman-Spector cap

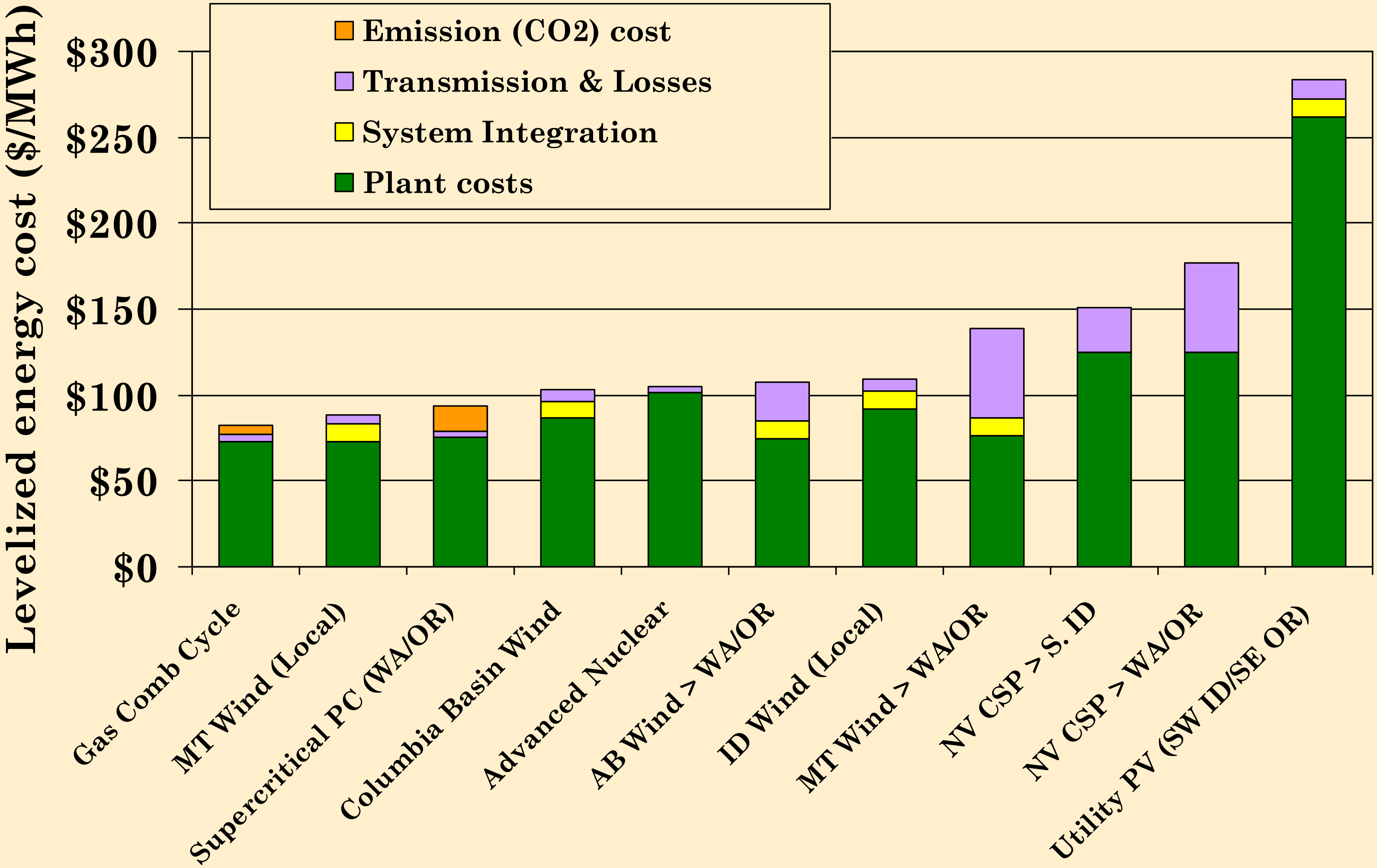


Forecast cost trends



Resource options Early 2020s

Transmission cost & losses to point of LSE wholesale delivery
No federal investment or production tax credits
Baseload operation (CC - 85%CF, Nuc 85% CF, SCPC 85%)
Medium NG and coal price forecast (Proposed 6th Plan)
Bingaman/Specter safety valve CO2 cost



Northwest Power and Conservation Council

January 13, 2008