Northwest Power and Conservation Council

December 3, 2008

MEMORANDUM

TO: Power Committee

FROM: Jeff King, Senior Resource Analyst

SUBJECT: Assessment of coal generating resource potential

Power generating resource performance standards in Washington, Oregon, and Montana limit long-term utility acquisitions of base load fossil fuel fired power plants to plants producing carbon dioxide equal to or less than a natural gas combined-cycle plant. Compliance with these limits for a coal-fired plant would require very large CO2 offsets or the provision of CO2 separation equipment and a sequestration facility. Because of these policy constraints, and the generally recognized carbon risk of developing new coal-fired power plants (all but a few of the conventional coal-fired plants proposed in the U.S. recent years have been cancelled), our coal resource assessment will focus on commercial technologies capable of CO2 separation. Currently, commercially-proven CO2 separation technology is limited to coal gasification plants, though pilot-scale technology for the separation of CO2 from post-combustion flue gas is under development for boiler steam-electric power plants.

Advantages of coal-fired per plants include low and stable fuel costs, high reliability and inherent sustained peaking capacity. Uncertain CO2 control requirements, currently high capital costs, and long construction lead times represent the principal risks associated with these plants.

Staff will describe an assessment of the potential cost and performance of integrated coal gasification combined-cycle plants, equipped with, or capable of being equipped with, CO2 separation. The cost and availability of CO2 sequestration will be described later when the results of the Ecosystems Northwest study become available. For completeness, staff will also compile cost and performance information on conventional steam-electric plants, including prospective costs of CO2 separation options under development for new or retrofit applications. A PowerPoint presentation will be provided prior to the meeting.

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Sixth Northwest Conservation & Electric Power Plan

Rankine (steam) Cycle Coal-fired Power Plant Resource Assessment

Jeff King

Northwest Power and Conservation Council

Portland, OR

December 9, 2008

Coal-fired power plant technologies

Rankine-cycle (a.k.a. "conventional", "pulverized coal", "PC" or "steam" technology)

- Subcritical PC - Mature commercial
- ✓ **Supercritical PC - Emerging technology of choice**
- Ultra-supercritical PC - Early commercial
- Any of the above w/fluidized bed combustion - Commercial in smaller sizes
- CO2 separation and sequestration (CSS) for any of the above - Not commercial and likely very expensive

Gasification

- ✓ **Integrated coal gasification combined-cycle (IGCC) - Very early commercial**
- ✓ **IGCC w/CSS - Components are commercial, complete plant not.**

✓Alternatives to be characterized in detail for the portfolio analysis

Rankine-cycle coal-fired power plant considerations I

Investment risk:

- Moderately high capital cost (currently $3000 - 4000/kW)
- Moderately long development and construction lead time
- Proven ability to construct a completed plant on time
- Moderately-high fixed costs

Fuel price risk

- Abundant and low-cost fuel supply
- Exposure to transportation fuel price risk for locations requiring rail haul

Operational characteristics and risks:

- Mature, reliable technology (~90% availability)
- Inherent sustained peaking capability
- Limited regulation and load-following capability

Rankine-cycle coal-fired power plant considerations II

Environmental risks and Catch-22

- Criteria air pollutants (SOx, NOx, particulates, etc.) controlled to "best available control technology" (BACT) levels with established technology.
- Mercury control inherent w/CAP control, further reduction possible at moderate cost using commercial technology (activated C injection).
- Substantial CO_2 production unless equipped with CO_2 separation equipment and an accessible sequestration facility.
- WA, OR & MT state policies effectively prohibits utilities (IOUs in Montana) from executing long-term contracts for coal plants w/o CSS.
- Post-combustion CO_2 separation technology in very early pilot stage.
- Proven sequestration limited to enhanced oil recovery.

Public perception:

- Recent Northwest proposals have been controversial
- Issues, here and elsewhere have been air emissions and CO_2 risk

Why Supercritical Technology?

3500 psig/1050 F vs 2400/1000F psig steam conditions

Results in higher efficiency - 9000 vs 9800 Btu/kWh (38% vs 35%)

Proportionally lower (~ 8%):

- Fuel consumption
- Fuel cost
- Criteria air emissions
- CO2 production

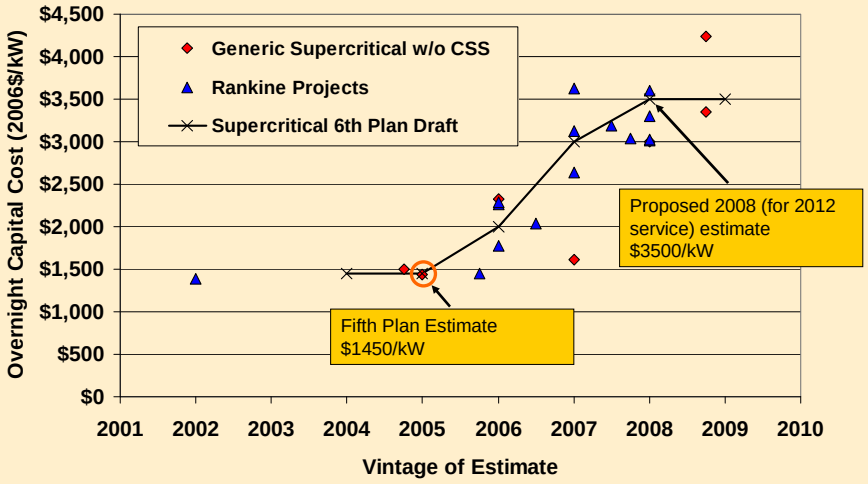
Early reliability problems discouraged use of technology in U.S

Established technology in Europe and Japan (higher fuel costs)

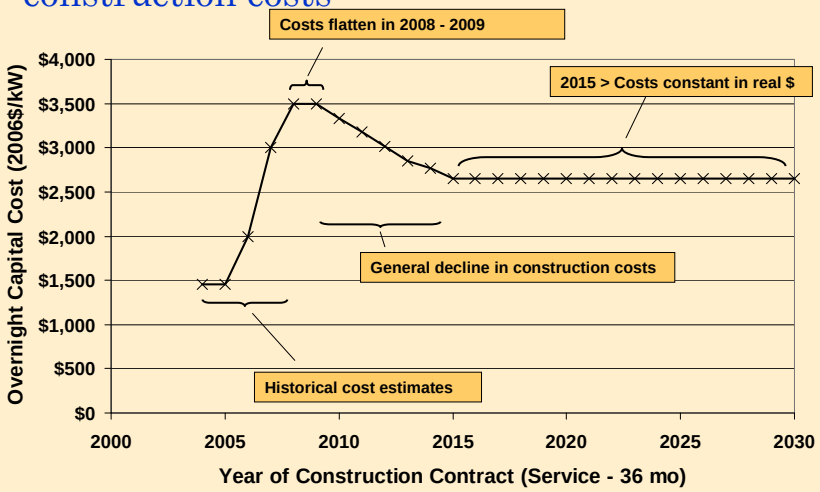
Technology shift appears underway in North America, beginning with Genesee 3 in Alberta (completed in 2005)

Emerging strategy is new supercritical plant + biomass co-firing + BACT retrofit to adjacent existing project(s)

Capital cost estimate: Supercritical PC coal plant (no CSS)



Forecast supercritical PC coal plant construction costs



Supercritical PC coal-fired power plant assumptions

Configuration:

- Single unit; 450 MW supercritical (>3500+ psig) steam cycle
- 90 % availability; 85% capacity factor (for levelized cost of energy estimates)
- Heat rate 8900 - 9000 Btu/kWh (Use 9000; 38%)

Development and construction cost (overnight):

- $3500/kW (2008 cost, 2011 service)

Operating costs:

- Fixed O&M - $60.00/kW/yr
- Variable O&M - $2.75/MWh
- System Integration - None (Fully dispatchable)

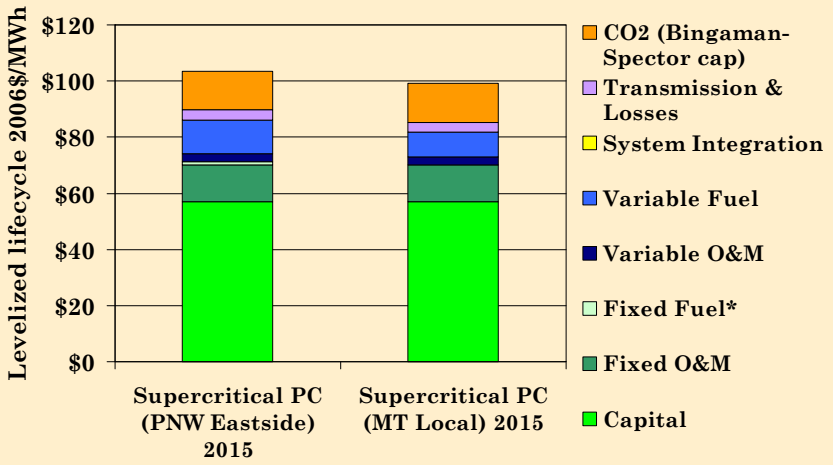
Schedule and cash flow

- Development - 36 mo; 3% of total plant cost
- Optional construction - 8 mo; 27% of total plant cost
- Committed construction - 27 mo; 70% of total plant cost

Earliest service for new project available to the Northwest ~ 2015

Supercritical PC plant cost elements

IOU financing
2015 service
85 % CF



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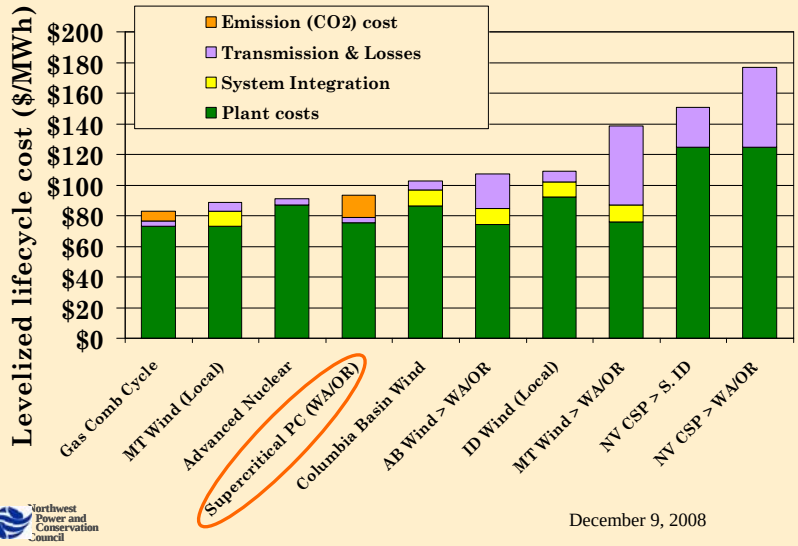
Resource options, early 2020s

Transmission cost & losses to point of LSE wholesale delivery
No federal investment or production tax credits
Baseload operation (CC - 85%CF, Nuc 87.5% CF, SCPC 85%)
Medium NG and coal price forecast (Proposed 6th Plan)
Bingaman/Specter safety valve CO2 cost



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