Northwest Power and Conservation Council

November 6, 2008

MEMORANDUM

TO: Power Committee

FROM: Jeff King, Senior Resource Analyst

SUBJECT: Assessment of nuclear generating resource potential

New nuclear generation is viewed by staff as a potential generating resource option for meeting peak capacity and energy needs in the long-term (2023 or later). Proposed new nuclear plants include both "evolutionary" versions of conventional light water reactor technology and advanced, passive-safe, modular light water reactor designs. While plants incorporating advanced reactor designs have yet to be constructed, the engineering and construction principals are well-established and both the evolutionary and advanced designs can be considered "reliable and available within the time it is needed" for purposes of considering the technology for the power plan. However, staff believes that successful construction and operation of a new nuclear plant elsewhere in the United States will likely be necessary before construction of a new plant in the Northwest would commence, hence the assumption of 2023 as the earliest plausible service date.

Attributes of nuclear power plants include low lifecycle emissions of criteria air pollutants and carbon dioxide (no direct emissions but some emissions elsewhere in the fuel cycle). Other attributes include inherent sustained peaking capability, relatively low fuel price risk, and high availability and reliability (based on existing fleet experience). Issues associated with development of new nuclear plants include long permitting and construction lead time, potential public controversy, large "single shaft" reliability risk, undemonstrated licensing and construction, and high capital cost uncertainty. The estimated levelized lifecycle energy cost for new nuclear plants in the early 2020s is about $90/MWh. This is about the same as for Columbia Basin wind power (with production tax credit) and somewhat greater than a gas-fired combined-cycle plant.

Staff has developed information regarding the performance, cost, and availability of new nuclear power plants. These findings have been discussed with the Council's Generating Resources Advisory Committee. Staff will present the findings and conclusions of this assessment at the November Power Committee meeting. The PowerPoint presentation accompanies this memo.

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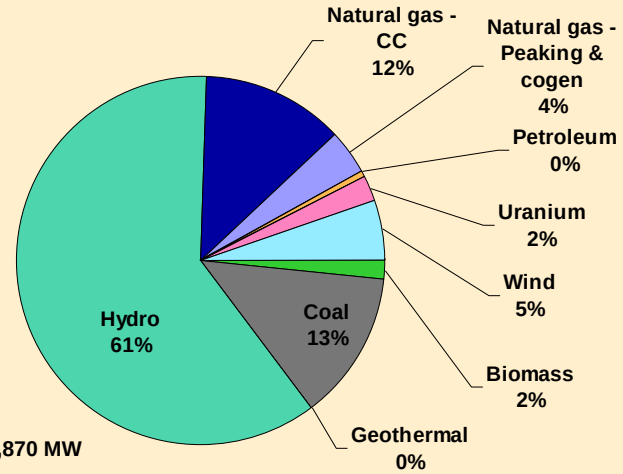
Sixth Northwest Conservation & Electric Power Plan

Proposed Nuclear Power Plant Planning Assumptions

Jeff King
Northwest Power and Conservation Council
Portland, OR
November 18, 2008

Columbia Generating Station provides 2% of Pacific Northwest generating capacity



Total 54,870 MW

Pros affecting future role of nuclear power

- Baseload generating capacity with sustained peaking capability
- No direct production of carbon dioxide
- No direct production of criteria air emissions (SOx, NOx, etc.)*
- Strictly enforced procedures for control, treatment and disposal of low-level radioactive and other waste streams
- Advanced "passive-safe" plant designs now available
- Relatively insensitive to nuclear fuel price
- High reliability; high capacity factor (existing plants)

* Small quantities of gaseous radioisotopes scavenged from the reactor cooling system, including krypton-85, xenon-133, iodine-131 and tritium are periodically discharged via the reactor vent stack following a holding period to allow initial decay.

Cons affecting future role of nuclear power

- Lengthy development and construction lead time (~ 10 years)
- Historically controversial
  - Siting, permitting and construction can be difficult & lengthy
  - In practice, limited siting opportunities, generally remote from major load centers
- High and uncertain capital investment cost; as-built costs sensitive to financing and construction period
- Successful licensing and construction of new nuclear capacity has not been demonstrated in the U.S.
- Successful construction and operation of advanced nuclear technology (AP1000, ESBWR) has not been demonstrated
- Large single shaft (1100 - 1700 MW) system reliability risk
- State & local resistance to proposed spent nuclear fuel repository.

Proposed plant designs for U.S. construction

- **Mitsubishi Heavy Industries US-APWR:** 1560 MW_{net} Evolutionary PWR, application to NRC for U.S. standard design certification docketed Mar 2008 , COLAs for 2 units
- **AREVA U.S. EPR:** 1580 MW_{net} Evolutionary PWR, 4 under construction, application to NRC for U.S. standard design certification docketed Feb 2008, COLAs for 2 units
- **GE ABWR:** 1350 MW_{net} Evolutionary BWR, NRC final design certification Dec 1997, COLAs for 2 units
- **Toshiba Westinghouse AP-1000:** 1100 MW_{net} Advanced (passive) PWR, NRC final design certification Jan 2006, amendments pending, COLAs for 12 units
- **GE Hitachi ESBWR:** 1520 MW_{net} Advanced (passive) BWR, application to NRC for U.S. standard design certification docketed Dec 2005 , COLAs for 7 units

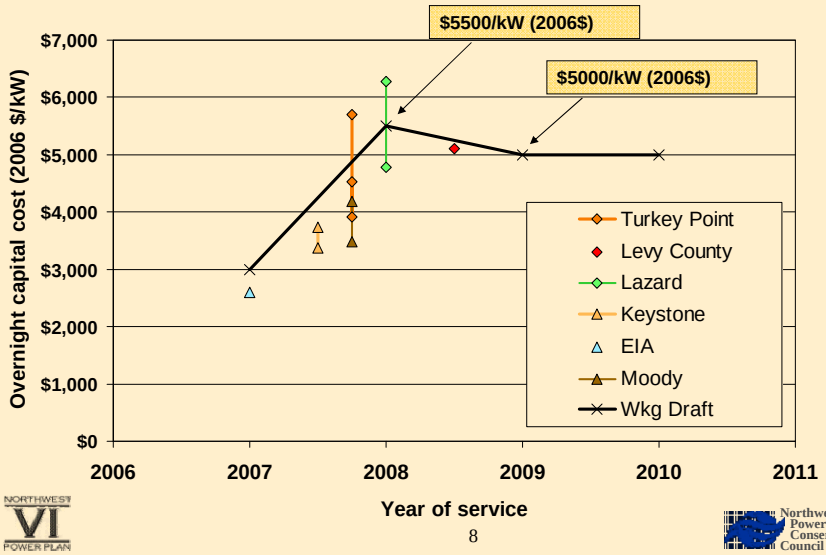
Sources of information

- Announced preconstruction estimates for proposed plants
- Commission filings for proposed plants
- Centre for International Governance Innovation *The Economics of Nuclear Power* (2008)
- CERA *Capital Cost Forum* (proprietary, ongoing)
- EIA *2008 Annual Energy Outlook*
- International Energy Agency *Energy Technology Perspectives* (2008)
- Lazard *Levelized Cost of Energy Analysis* (2008)
- Moody's Investment Service *New Nuclear Generation in the United States* (2007)
- Nuclear Energy Institute *The Cost of New Generating Capacity in Perspective* (2008)
- The Keystone Center *Nuclear Power Joint Fact-finding* (2007)
- World Nuclear Association *The Economics of Nuclear Power* (2008)

Recent cost estimates

Project	Status	Earliest	Location	Type	Project Cost (MM$)	Source
Vogtle 3 & 4	COLA Mar 2008	2016/17	GA	AP1000	$14,000	Press release
Bell Bend	COLA Oct 2008		PA	U.S. EPR	$10,000	Press release
Bellefonte 3 & 4	COLA Oct 2007	2017/19	AL	AP1000	$8,000	Press release
Callaway 2	COLA Jul 2008	2018-20	MO	U.S. EPR	$6,000	Press release
Calvert Cliffs 3	COLA Jun 2008		MD	U.S. EPR	$9,600	Press release
Fermi 3	COLA Jun 2008	2018	MI	ESBWR	$10,000	Press release
Levy County 1 & 2	COLA Jul 2008	2016/17	FL	AP1000	$14,000	PSC Filing (2008)
North Anna 3	COLA Nov 2007	2016	VA	ESBWR	$4,000	Press release
Oikiluoto 3	Construction	2011	Finland	EPR	$5,000	Press release
Peace River	License application	2017	AB	CANDU ACR-1000	$6,200	Press release
South Texas 3 & 4	COLA Sep 2007	2014/15	TX	ABWR	$8,000	Press release
Turkey Point 6 & 7	COLA Mar 2009	2018/20	FL	AP 1000 or ESBWR	$18,500	PSC filing (2007)
Summer 2 & 3	COLA Mar 2008	2016/19	SC	AP1000	$9,800	PSC Filing (2008)
Watts Bar 2 (Completion)	EPC contract Oct 2007	2013	TN	Westinghouse PWR	$2,490	
Lee 1 & 2	COLA Dec 2007	2016	SC	AP1000	$5,000	Press release

Proposed base-year and near-term mid-range capital cost assumptions



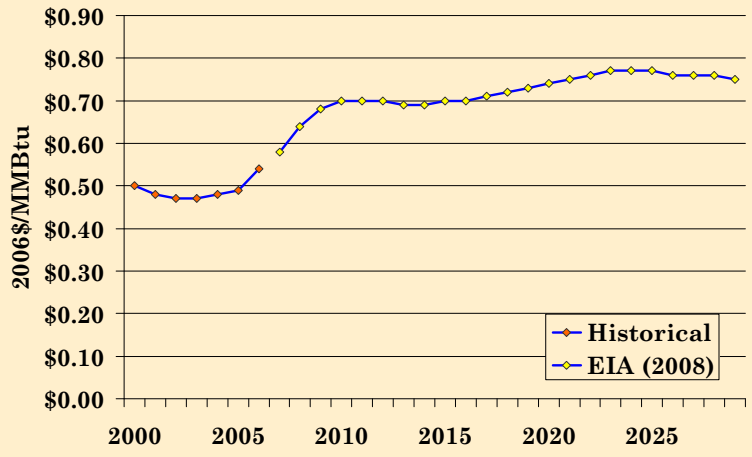
Development phases & cash flow

- Conceptualization - 24 mo, << 1% of Total Plant Cost (TPC)
  - Resource assessment
  - Site selection
  - Design selection
- Licensing - 60 mo, 1% TPC
  - Prepare COLA and secure COL
  - Secure state & local permits
- Preparation - 60 mo, concurrent w/licensing phase, 5% TPC
  - Long lead component procurement
  - Detailed engineering
  - Site clearing & grading
  - Infrastructure, underground utilities, non-NRC jurisdiction structures
- Construction - 60 mo to commercial operation of first unit, 94% TPC
  - Transmission interconnection
  - NRC-jurisdictional foundations
  - Power island and ancillary structures & equipment
  - Fuel load
  - Startup testing and commercial operation

Operation, maintenance and fuel costs

- Elements
  - Fixed operating costs (exclusive of property taxes and insurance, separately modelled)
  - Variable operating costs
  - Capital replacement (as expense)
  - Fabricated fuel cost
  - Decommissioning fund
  - Spent fuel disposal fee
- Proposal
  - Several sources of info, but a riot of metrics, base years, currencies, inclusions and exclusions
  - Use EIA assumptions for provisional values
    - Fixed O&M - $66/kW/yr
    - Variable O&M - $0.48/MWh
    - Fuel - next slide
  - Because of concerns regarding future fuel and O&M costs, we will attempt to normalize available information and further evaluate OM&F costs

EIA 2008 AEO nuclear fuel price forecast

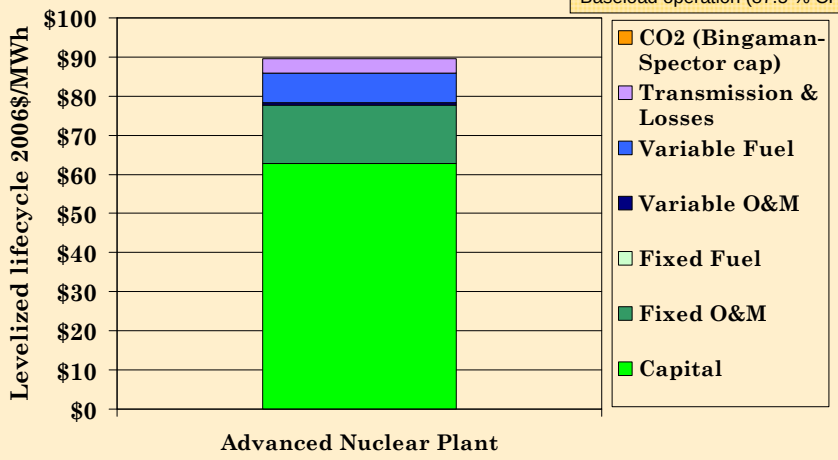


Siting and transmission

- In theory, few siting constraints
  - Transmission
  - Cooling water
  - Transportation facilities for heavy & massive components
- In the Northwest, limited by public acceptance to Columbia Basin or S. ID for the foreseeable future
- These locations imply some local load market but may need some transmission reinforcement to reach major load markets
- Do we or do we not assume transmission reinforcement?
- Need to be consistent w/wind assessment (i.e., we have proposed to include a portion of the cost of McNary - JD + I5 reinforcement for added Columbia Basin wind).

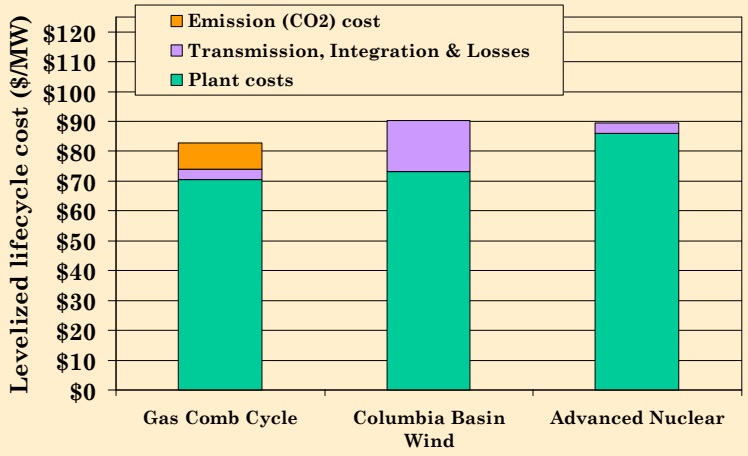
Elements of energy cost

IOU financing
2015 (hypothetical) service
Point-to-point transmission
No EPACT 2005 incentives
Baseload operation (87.5 % CF)



Resource comparison

2020 service
Point-to-point transmission
2008 federal production tax credit for wind
Baseload operation (CC - 85%CF, Nuc 87.5 CF)
Medium NG price forecast (Proposed 6th Plan)
Bingaman/Specter CO2 capping cost



Planning assumptions

- Advanced (AP-1000) technology
- 1100 MW unit size
- Heat rate 10400 Btu/kWh
- $5500/kW overnight development and construction cost, declining to $5000/kW in 2009, constant real thereafter (mid-range case)
- Operating costs (provisional values):
  - Fuel - $0.70 MMBtu (2010)
  - Fixed O&M - $66.00/kW/yr
  - Variable O&M - $0.48/MWh
- 144 months conceptualization to operation
  - 24 mo Conceptualization phase (site & design selection) - << 1% of total plant cost (TPC)
  - 60 mo Licensing phase w/concurrent 60 mo Preparation phase (long-lead equipment, site prep, EPC contract) - 6% of TPC
  - 60 mo Construction phase (completion of Preparation phase to first unit on-line) - 94% of TPC
- Earliest service for new Northwest project ~ 2023
  - Conceptualization phase initiated 2010
  - Construction initiated following successful completion and operation of first U.S. AP-1000 ca: 2017