Welcome

Energy & Telecommunications Interim Committee
to
Colstrip SES
VPP is a Journey, not a Destination
Electricity producers in Montana...

- PPL Montana Billings, MT 26%
- Puget Sound Energy Bellevue, WA 14%
- Portland General Electric Portland, OR 6%
- Northwest Energy Butte, MT 5%
- PacificCorp Portland, OR 3%
- Avista Corporation Spokane, WA 16%
- U.S. Government Washington, D.C. 27%
- Other 3%

All generation capacity numbers based on summer capacity data for 2002 as published by the WECC.
PPL Montana Generation Resources

Hydro
11 Units; 577 MW

Fossil (Coal)
2 Stations; 728 MW
## Colstrip Ownership

<table>
<thead>
<tr>
<th></th>
<th>Unit 1&amp;2</th>
<th>Unit 3&amp;4</th>
<th>Total</th>
<th>Total MW</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Puget</strong></td>
<td>50%</td>
<td>25%</td>
<td>32%</td>
<td>736 MW</td>
</tr>
<tr>
<td><strong>PPL</strong></td>
<td>50%</td>
<td>15%</td>
<td>25%</td>
<td>575 MW</td>
</tr>
<tr>
<td><strong>PGE</strong></td>
<td>20%</td>
<td>14%</td>
<td>32%</td>
<td>322 MW</td>
</tr>
<tr>
<td><strong>NorthWestern Energy</strong></td>
<td>15%</td>
<td>11%</td>
<td>32%</td>
<td>242 MW</td>
</tr>
<tr>
<td><strong>Avista</strong></td>
<td>15%</td>
<td>11%</td>
<td>32%</td>
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</tr>
<tr>
<td><strong>PacifiCorp</strong></td>
<td>10%</td>
<td>7%</td>
<td>32%</td>
<td>161 MW</td>
</tr>
</tbody>
</table>
Colstrip Plant . . .

- Total 2276 Megawatts
- 350 Employees
  - Annual payroll (Including T&B)-$38 million
- Consume 10 Million tons of coal per year
  - 274 cars to run one day
  - 1 carload fuels Colstrip for 5 minutes
- 2007 Budgets
  - O&M Budget-$97.6M
  - Capital-$52.6M
How Fossil Electricity is Generated
How Colstrip Generates Electricity

The process begins with Coal Storage and moves through the conveyor to the Moving Coal area. The coal is then fed into the furnace and burned to create hot gases. These gases pass through the Boiler, where they heat water to create steam. The steam is then directed to the Main Steam Line, where it is used to run the Turbine. The Turbine generates electricity, which is then sent to the Exciter and Generator to be converted into usable power.

The steam from the turbine is condensed back into water in the Condenser. This water is then purified in the Water Demineralizer Unit and returned to the Boiler to be reheated and reused. The steam is also returned to the boiler reheater for additional heating. The Air Preheater and Desulfurization Scrubber further clean the air before it is released into the atmosphere.

The electricity generated by the Turbine is then sent through the Step Up Transformer to increase its voltage. This high-voltage electricity is then distributed through the grid for use in homes and businesses.

The process of generating electricity at Colstrip is a complex but efficient system, designed to produce clean, reliable energy.
Tangential Fired Boiler
Steam Turbine
Generator
Transmission Interconnection

MT - NW

2,200 MW

600 MW
In 3-phase process
to uprate to 1,350 MW

MT - Idaho

337 MW

Yellowtail

Miles City
DC Tie

200 MW

400 MW

150 MW

450 MW
Simplified Flow Diagram

Scrubbers

Flue Gas
Out of Boiler Air Preheater
Plenum

Emergency Water
Plumb Bob

Spray
Mist Eliminator
Wash Tray

Clean Flue Gas
Cooling Tower Waste Stream

Reheat
I.D. Fan

Bleed
(Waste Stream)

Recycle Pumps

Recycle Slurry

Tray Recycle

Fly Ash (Ash Disposal) Pond

Wash Tray (Ash Disposal) Pond

Pond Return
Groundwater Protection

- Colstrip is a zero-discharge facility
- Wet scrubbers use surface impoundments for final disposal
- Ponds lined with clay, synthetic liners, or concrete wall
- Over 800 monitoring wells to help ensure protection of groundwater
- Current strategy to protect groundwater (~$34 million)
  - Paste disposal process (90% reduction in seepage potential)
  - Double-lined clearwater ponds with leachate collection
  - Forced evaporation/wastewater treatment
SO2 Control

- Units 1&2 – limit of 1.2 lb/mmbtu
  - Normal control efficiency of 65-75%
  - Normal emission rate of 0.35 lb/mmbtu
  - 38th cleanest coal-fired power plant in country (~350 plants)

- Units 3&4 – limit of 0.10 lb/mmbtu
  - Normal control efficiency of 95%
  - Normal emission rate of 0.08 lb/mmbtu
  - In 2006, 9th lowest SO2 emissions from US coal-fired plants
Particulate Control

- Units 1&2 particulate emission limit of 0.10 lb/mmbtu
  - Normal removal efficiency of 99.5%
  - Normal emission rate of 0.04 lb/mmbtu

- Units 3&4 particulate emission limit of 0.05 lb/mmbtu
  - Normal removal efficiency of 99.5%
  - Normal emission rate of 0.03 lb/mmbtu

- Continuous monitoring of Opacity to help ensure compliance with particulate emissions at all times
75% NOx reduction

Low-NOx burners with a SOFA, $20 million

Unit 3 in 2007, Unit 4 in 2009

3&4 will rank ~60th out of 350 coal-fired power plants for NOx
Mercury Control

- EPA federal rule required 20% reduction by 2010 and 80% reduction by 2018

- 17 states have promulgated/proposed stricter limits than EPA Federal Rule
  - MT has second strictest rule (0.9 lb/Tbtu, 85-90% reduction by 2010)

- ~1% of mercury deposited in Montana is from Montana power plants, based on EPA models

- Colstrip currently emits 6-8 lb/Tbtu (use Astrodome analogy)

- Mercury control technology installed by 2010, ~$16 million capital, ~$4.5 million/yr O&M
Recent Mercury Control Testing on Unit 3

- In September, conducted tests involving addition of calcium bromide and treated activated carbon to remove mercury

- Preliminary results are encouraging
  - Achieved about 90% reduction and an emission rate of about 1 lb/Tbtu

- Additional testing in 2008 to fine tune process and evaluate balance of plant impacts
PPL Climate Change Strategy

- PPL generated 39 percent of its electricity from non-fossil fuel power plants in 2006.

- PPL participates in the beneficial reuse of ash which offsets greenhouse gas emissions from the cement industry.

- PPL is decommissioning two coal-fired power plants in 2007, which will reduce annual carbon dioxide emissions by about 1.3 million tons.

- PPL has developed 12 megawatts of renewable energy projects; plans to invest at least $100 million in renewable energy projects over the next five years.

- PPL plans to expand generating capacity at existing nuclear and hydro plants.
PPL Climate Change Strategy

❖ PPL is a member of the FutureGen Industrial Alliance, which is developing a near-zero emission power plant that can capture carbon dioxide for sequestration.

❖ PPL is a member of Big Sky Carbon Sequestration Partnership

❖ PPL participates in the Montana Governor’s Climate Change Advisory Committee.

❖ PPL plans to participate in EPRI (Electric Power Research Institute) to evaluate technology options as they are developed, then support demonstration projects as appropriate at Colstrip
Colstrip CO2 Control – Opportunities?

- Colstrip SES emits ~18 million tons CO2/yr
  - 18th largest power plant, rank ~50th for CO2 emissions

- Current technologies are in developmental stage

- Possible control technologies
  - Amine scrubber w/sequestration
  - Chilled ammonia w/sequestration
  - GreenFuel’s Algae-to-Biofuel
Amine Scrubber Process

Basis:
- Carbon capture from flue gas and geologic sequestration
- Current status 1200 tpd, Colstrip 40,000 tpd
- Study conducted on Wyodak power plant by Idaho National Laboratory, scaled up for Colstrip 1-4
- Current technology, no improvements
- Target 90% capture of CO2

Following cost estimates are ballpark
- Capital Cost: $430 Million
- O&M Annual Cost: $900 Million
  - Includes “Energy Penalty” of 30% (625 MW)
  - CO2 removal and sequestration cost per ton: $53

Source: Robertson, INL, 2006 (Wyodak study)
Amine Scrubber Process

Amine-Based Absorption - CO2 Capture

SHADY POINT, OKLAHOMA, USA
An AES CFB power plant with MEA CO2 separation

- MEA has demonstrated performance on coal based flue gas
- Work required to address:
  - Regeneration power
  - Compression ratio
  - Cost of solvent
Chilled Ammonia Process

**Basis:**
- Carbon capture from flue gas and geologic sequestration
- ALSTOM’s 5mw pilot test at Pleasant Prairie
- Scaled up for Colstrip 1-4 (2276 mw)
- Target 90% capture of CO2

**Following cost estimates are ballpark**
- Capital Cost: $430 Million
- O&M Cost: $650 Million
  - Includes “Energy Penalty” of 9% (189 MW)
  - CO2 removal and sequestration cost per ton: $39

Source: Alstom Power, November, 2007
Chilled Ammonia Process

Schematic of commercial Ammonia-based CO2 capture system retrofitted downstream of the FGD

Existing FGD

Flue Gas

120F

Chiller

Purge

35F

2 stage Cooling

Wash

CO2 Absorber

Lean AC

Rich ABC

CO2

Existing Stack

Reboiler

HX

Pump

CO2 Regeneration

Cooling & Cleaning of FG

CO2 Absorption
Green Fuels Algae-to-Biofuel

■ Basis:
  — Flue gas to ‘feed’ algae, then convert to bio-fuel
  — Use of Existing Technology without improvements
  — 40% capture of CO2
  — Scaled up for Colstrip 1-4, 26 sq. miles of algae fields

■ Following cost estimates are ballpark
  — Capital Cost: $1.7 Billion
  — O&M Cost: $417 Million
    • Revenue Potential is $750 million

■ Recent setback w/bioreactor system results in layoff of half the 50 person staff

Source: Greenfuels Technology, Inc., 2006
Green Fuels Algae to Biofuel

Process Flow

Generation → Algae Bioreactor → Water Recycling → Algae Biomass → Dewatering → Biogas → O₂ + N

Ethanol/Methanol → Biodiesel → Protein Residue → Other Valuable Products

Transportation Fuels
QUESTIONS?