Blundell Geothermal Power Plant

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PacifiCorp Energy Representatives

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Introduction - Agenda

- Blundell Geothermal Power Plant
  - PacifiCorp Corporate Structure
  - Roosevelt Hot Springs (KGRA)
  - History
  - Blundell Unit 1
  - Blundell Unit 2
  - Blundell Unit 3
  - Other Geothermal Resources
PacifiCorp Corporate Structure

- MidAmerican Energy Holdings Company
  - PacifiCorp
    - Rocky Mountain Power
    - PacifiCorp Energy
    - Pacific Power
      - New Resource & Construction
        - Blundell Geothermal Power Plant
Roosevelt Hot Spring Known Geothermal Area

- Located approximately 15 miles north-east of Milford Utah
- Roosevelt Hot Spring Unit Area
  - Established in 1976
    - First geothermal Unit Agreement approved by the U.S. Dept. of the Interior
  - Area is eight (8) miles long by six (6) miles wide
    - Encompasses 30,720 Acres
- Production depths between 1,253 feet to 7,321 feet
- Reservoir temperatures between 464°F to 514°F
Roosevelt Hot Springs Known Geothermal Area
Roosevelt Hot Spring – Geology

- Located in the Basin and Range geological province
- Many systems in the Basin Range province are heated by regional circulation of groundwater.
- Ground water circulation reservoirs temperatures range between 300°F and 400°F
- Roosevelt Hot springs is heated by a young volcanic heat source. Temperatures between 600°F to 400°F.
- Volcanic depression can be seen. (Located south-east of the plant)
- Depression typically forms over rising magma.
Roosevelt Hot Spring – Geology

- Roosevelt has high vertical permeability upward flow zones due to highly fracture rock formations
- Sub-surface fractures allow for circulation of fluid around heat source
- Production zones bordered by the Opal Mound Fault and the Negro Mag Fault
- Geothermal fluid mainly water with a partial steam cap
- Water source is from snow and spring runoff.
- Water is circulated within the reservoir. Higher temperature (lower density) water located near top of the reservoir.
Roosevelt Hot Spring – Geology
Roosevelt Geothermal Hot Spring – Temperature Model

Figure 4.3: Initial State temperature matching, layer 2, at 5000 ft, msl

2007, GeothermEx, Inc.
Figure 4.6: Initial State temperature matching, layer 5, at 2000 ft, msl
Figure 4.8: Initial State temperature matching, layer 7, at 0 ft, msl

2007, GeothermEx, Inc.
Blundell Geothermal Power Plant – History

- 1880s: Hot Springs first discovered
- 1900s: Resort established
- 1972: University of Utah initiated scientific studies
- 1974: Phillips Petroleum Company obtains 18,871 acres through a competitive lease
- 1975-1979: Productive wells drilled near the old resort. Reservoir determined to be productive
- 1980: Phillips Petroleum and Utah Power & Light (now PacifiCorp) signed an agreement to develop the resource for electrical production
- 1981: A1.6 MW bi-phase turbine was installed as a research project. Turbine used energy from one geothermal well
- 1982: Construction begin on Blundell Unit 1. A single flash geothermal power plant
- 1984: Blundell Unit 1 goes on-line
- 2007: Blundell Unit 2 goes on-line
- 2007: Blundell Unit 3 development begins
- Utah’s only operating flash geothermal plant
Blundell Unit 1
Blundell Unit 1

- Single flash facility producing 23 net Megawatts
- Four (4) production wells producing 2.25 million pounds per hour of geothermal brine
  - Brine temperature at wellhead ~ 450°F
- Four (4) well head separators flash 400,000 pound per hour steam and deliver it via pipeline to turbine
Blundell Unit 1

- General Electric turbine generator set
  - 26 Gross Megawatts
  - 23 Net Megawatts
- Three (3) injection wells used to return spent geothermal brine back into reservoir.
  - Brine temperature ~ 350°F
- Continuous operation since 1984
Blundell Unit 2
Blundell Unit 2

- Became operational December 2007
- Ormat bottoming cycle
- Average net output: 10 Megawatts
- Working fluid: iso-pentane
- Heat source: Blundell Unit 1 spent geothermal brine
  - Inlet temperature: 350°F
  - Outlet Temperature: 190°F
- Acid injection to control silica scaling
- Air condenser used for cooling n-pentane
Blundell Unit 3

- In May 2007 PacifiCorp begun investigating development of Unit 3
- Reason for Development:
  - PacifiCorp renewable energy commitment.
    - 2000 Megawatts by 2013
  - Bring Roosevelt Geothermal Hot Spring extraction up to its maximum sustainable capacity
  - Part of PacifiCorp’s environmental stewardship commitment
  - Rising cost of natural gas & coal makes geothermal development more attractive
- Potential Unit 3 Location: Directly south of Blundell Units 1 & 2
Blundell Unit 3

- Proposed plant would be 33 net Megawatts
  - Depending on outcome of production well test
- Dual flash technology selected at this time
  - Lower capital cost
  - Higher efficiency
- Unit 3 design
  - Four (4) production wells of 5,000 feet deep
  - Four (4) injection wells 6,500 feet deep
- Expected temperatures between 500°F to 650°F
- Chemical injection system to control silica scaling
- Five steam separators
  - Four high pressure
  - One low pressure
Blundell Unit 3 – Proposed Site Map
Blundell Unit 3 – Proposed Site Map
Blundell Unit 3 – Development Activities

- Drill two (2) “proofing wells
  - One production (completed)
  - One injection (in set up)
- Permitting
  - Cultural Artifacts
  - Biological surveys
  - Drill Permits
  - Air Permits
  - Environmental Assessments
  - Storm water permits
- Pilot Plant test
  - Silica scaling control
Blundell Unit 3 – Development Activities

- Production well testing
  - Rig test
  - Full production test
- Injection well testing
  - Rate of injection of fluid
- Turbine-generator sizing
  - Size
  - Flow rates
- Transmission upgrades
  - 16 miles of transmission line would need to be upgraded
On April 17, 2008 a rig test was conducted and the results were encouraging.
Blundell Unit 3 – Proposed Plant Parameters

- 33.7 net Megawatts
  - Axial exhaust turbine
  - 138 kilovolts output voltage
  - 3600 RPM

- Production parameters:
  - Geothermal Fluid – 2.40 million pounds per hour
  - Steam Flash Rate – ~25% (625,000 lbs/hr)
  - Temperature at wellhead – 450°F
  - Pressure at wellhead – 400 psig.
  - Turbine Inlet pressure – 125 psig.
  - Four high pressure wellhead separators
  - One low pressure plant separator
Blundell Unit 3 - Challenges

- Production Tax Credit Expiration
  - Current PTC expires December 31, 2008
- Utilizing new portion of steam field
  - Concerns over dry or non-productive wells
- Scheduling / Construction
  - One year worth of well drilling
  - Turbine-generator lead-times, 18 to 24 months
  - Labor shortages
  - Technical expertise
- Drilling
  - Water Supply
  - Large Equipment
  - Time
Other Geothermal Resources

- PacifiCorp would like to develop more geothermal resources in Utah
- Challenges in locating good resources
  - Limited in development and accessible locations
  - Regulatory
- Development cost
  - Until Senate Bill 202 a utility could not recoup any development costs
  - Well field development expensive. Approximately $1,700 per kilowatt.
- Purchase existing operating resource
Blundell Geothermal Power Plant

April 22, 2008

End