Air Cooled Condensing Experience Northeast Wyoming

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ACC Experience NE Wyoming

Powder River Basin Country

- Land of Abundant Energy Resources
- Greatest Concentrated Coal Resource on Earth
- 400 Million Tons/Year Produced
- Low Overburden Ratio, 100' thick coal seams

Power River Basin Country

- River in the name is deceiving.
- Effectively a desert
- No reliable flowing water or reservoir capacity
- Limited well water capability
- Local municipality pipes culinary water 40 miles.


Black Gold

More Coal


Northeast Wyoming-?

Gillette, Wyoming

Largest Lake in Campbell County

Wyodak Mine Operation

ACC Experience NE Wyoming

- Inexpensive Coal and Lack of Water
  - Recipe for economics favoring air cooling
  - Drove ACC technology

Prepare for your quiz

Quiz

- What year did the first direct air cooled coal fired plant become commercial in the US.
- What electric utility was the leader for direct air cooling in the United States?
- How many coal fired units are there in NE Wyoming equipped with air cooling?
- In Wyoming, how is a large city defined?

Quiz-Answers

- The first direct air cooled plant was Neil Simpson-1, 18 mw, commissioned in 1969.
- Black Hills Power is generally recognized as the industry pioneer that helped lay the groundwork for commercial air cooling as we know it today.
- There are 5 coal units in NE Wyoming
- If there is greater population than the feet of town elevation.

NE Wyoming ACC Experience

- Neil Simpson Unit 1 (18 MW)
  - Built in 1969
  - First Air Cooled Condenser in North America
- Wyodak (340 MW)
  - Built in 1978
  - Largest ACC in World for 20 + years
  - BHC is 20% owner, operated by Mid America Energy (Pacific Corp)
- Neil Simpson Unit 2 (88 MW)
  - Built in 1995
  - Totally Air Cooled
    - Steam Cycle & Aux Cooling
- Wygen I (88 MW)
  - Built 2003
  - Totally Air Cooled
    - Steam Cycle & Aux Cooling
- Wygen II (105 MW)
  - Under Construction
  - Totally Air Cooled
    - Steam Cycle & Aux Cooling

Wyodak Plant

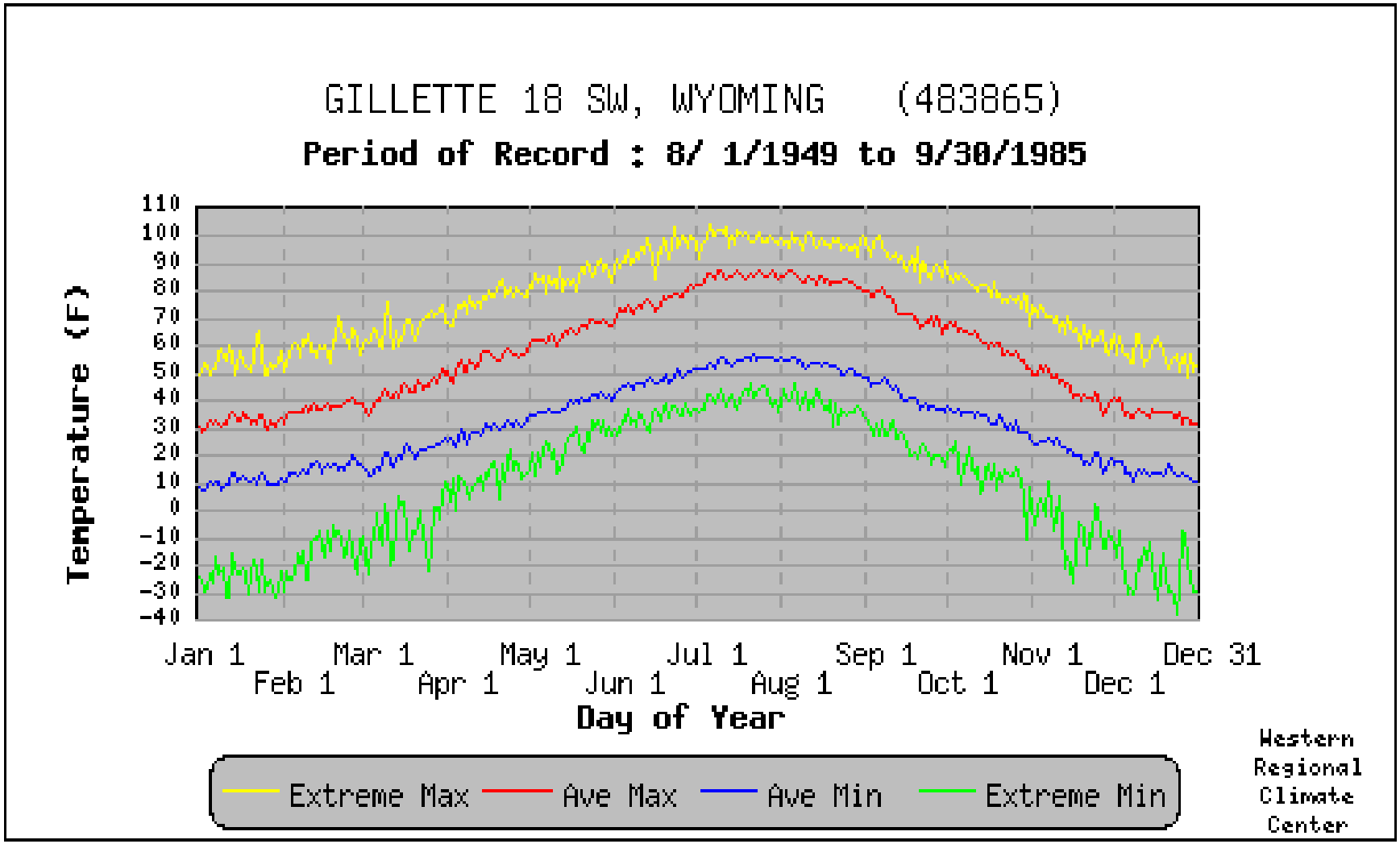
- Commissioned 1978
- 360 Gross MW, 2.8 million pph steam
- At the time largest ACC in the world
- Agreement with DOE Research Testing
  - Backed out when they were required to fund.
- Very cleanly engineered-Only one change order to construction contractor.
- Specially designed D8 GE turbine
  - No L-0 row, L-1 row shortened
  - Designed for 15” Hg backpressure.

Wyodak Plant

- Condenser Design Conditions-6” hg at 60F.
- 11 rows x 6 fans standard surface
  - Elliptical tube, 3 deep
- 1 row x 3 fans prototype surface
  - Elliptical tube, 1 deep
- Vibration indication/trips on fans.
- Tubes/fins, steel, hot-dipped galvanized
- Eickhoff right angle gearboxes
- Two speed, reversible motors
- Parallel flow, with counter-flow D sections
  - ~1/3 surface area counter flow

Wyodak Plant ACC

Gillette, Wy-Weather Extremes



Early Operational Issues

- Cold weather operations
  - Fan speed control
  - Rime ice program
  - D-section freezing
  - No problems on prototype
- Gearbox bearing failures
  - Immersion heaters baked lubricant-blocked oil passages to bearings.
  - Oil leaks, fouled heat transfer surfaces

D-Section Freeze Episodes/Solutions

- Within D-section tube bundle assemble individual tubes ran at different temperatures
- External (away from air removal point) tube assemblies ran consistently colder.
- Performed external thermal camera imaging under varying operating scenarios. Findings:
  - A hot/cold line that would move up and down the tube bundle assembly with varying backpressure, and fan speed.
  - Air removal flow rate affected temperature distribution

- **Solutions**:
  - Programmed to cycle fan speed (after variable frequency)
  - Installed pressure control valve and cycling controls.

Cold Weather Operation–Condensing Tube Bundle Sections

- For the most part, trouble free.
- One instance of drain line blockage and subsequent mass freezing.
- Kept unit on line by pinching tubes closed top/bottom with Jaws of Life, and cutting out tubes.
- Ensure drain thermocouples as well as air removal thermocouples are all working.

Summer Operation-Issues

- As shown in previous slide, temperatures can get to 100F.
- Significant load reductions hot Summer days.
- Cross winds gave problems, loss of cooling.
- Minimize fouling on tube assemblies
  - Implement periodic surface washing to improve performance
  - Avoid running gearboxes with oil leaks.
  - If there are inordinate number of oil seal leaks, find one that works.
- Summer/Winter blade re-pitching not practical

Summer Operation-Enhancements

- Plant designed semi-automated indexing high pressure wash system-

- ~1995, installed variable frequency drives all fan assemblies.
  - Full utilization of motor power ratings.
  - Gained about 3.5 mw net increase through summer months.
  - Set all time plant monthly net generation output record in July the first year in service.
  - In coordination with thermal camera research, improved winter riming controls.
  - Eliminated need for Summer/Winter blade repitch.

Later Life Issues–

- Three deep tube bundle design
  - Experiencing frequent leaks at each tube sheet.
  - Attributed to differential expansion stresses.
  - Some thinning and leaks in vicinity of air removal line at top of D-Section.
  - Appears to be an erosion mechanism from water/steam/non-condensables.

- Prototype single tube bundles have not shown either freezing issues, indications of tube to tube sheet leaks.

Reliability

- Involvement in Wyodak spanned 21 years from 1976 to 1997.
- Gained reputation as most reliable station within the Pacificorp system.
  - One year ran at 102% capacity factor.
- ACC proved very reliable, not forced off line as a result of the condenser.
- Black Hills information indicates that record is still intact.

Wyodak Plant–Other ACC Benefits

- Absence of circulating water system eliminated contamination to condensate.
- Turbine overhauls showed minimal deposits.
  - No performance degradation between overhauls.
- Front end water chemistry was all volatile.
- Avoid chemistry changes that may upset magnetite layer in the condenser.

Wyodak Site

Summary–

- Black Hills Power's foresight and pioneering helped lead the way for large scale air cooling.
- Wyodak Plant was the first large scale air cooled condensing installation in the US.
- Laid the groundwork for much of the air cooling technology today.
- Issues described today are minor in comparison to the high reliability and low O&M cost performance of this equipment.
- Thank you!

Questions?