ACEP Mission: Develop and disseminate practical, cost-effective, and innovative solutions for Alaska and beyond

Primer on Coal Conversion Technology

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Alaska Center for Energy and Power
Presentation Agenda

🌞 About ACEP

🌞 Power Generation Technology and Alaska

🌞 Gasification Technology

🌞 Coal Seam Natural Gas
Selected reports during my tenure with the U.S. Department of Energy, National Energy Technology Laboratory’s Arctic Energy Office, Fairbanks, AK
Alaska Center for Energy and Power

ACEP Mission: Develop and disseminate practical, cost-effective, and innovative solutions for Alaska and beyond

Who we are:

- Organized 6 years ago under the Institute of Northern Engineering as ‘Gateway’ to Energy Research for UA
- Based at UAF with a satellite office in Anchorage
- 20 dedicated staff (mostly engineers)
- 35 affiliated faculty and 50 students
Role of ACEP and the University of Alaska

- Developing information for decision makers
  - Technology testing and optimization (industry)
  - Energy analysis (policy makers, communities)
  - Data management

- Preparing students to work in energy-related disciplines

- Commercializing energy innovation
ACEP is a revenue center (not a cost center)

- ACEP has received a total of $3.1M through UA operating budget (over 6 years)
- ACEP has received a total of $26M in grants and contracts during this period
- Where has this funding gone?
  - ~40% to fund 100+ small Alaska-based businesses to support research enterprise
  - ~40% to fund researchers throughout UA system (not just within ACEP)
  - ~20% to fund base University operating costs ($6M)
Technology Perspectives

- **Pulverized Coal (PC) Boilers**
  - Commercialized in 1920s-1930s
  - 5000 units world-wide; >1100 in US
  - Unit sizes up to ~1400 MW

- **Fluidized Bed Combustion (FBC) Boilers**
  - Commercialized in 1970s-1980s
  - 500 units world-wide; 150 in US
  - Unit sizes up to ~300 MW
  - Costs ~5-10% higher than PC units

- **Integrated Gasification Combined-Cycle (IGCC) Power Plants**
  - Commercialized in 1980s-1990s
  - 7 coal-based units world-wide; 2 in US
  - Unit sizes several hundred MW up to Gigawatts
  - Costs ~ 10-20% higher than PC units
Comparison of Coal-Based Power Generation Platform Technologies

<table>
<thead>
<tr>
<th>grate firing</th>
<th>fluidized bed firing</th>
<th>pulverized fuel firing</th>
</tr>
</thead>
<tbody>
<tr>
<td>fixed bed</td>
<td>bubbling bed</td>
<td>circulating bed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>pneumatic transport</td>
</tr>
</tbody>
</table>

ACEP
Alaska Center for Energy and Power
Conventional Coal Plant

(Illustration only)

- Cooling Water
- Conveyor Belt
- Boiler
- Generator
- Switchyard
- River or Reservoir
- Condenser
- 15 MW
- 85 MWe
- 100 MW
- 40 % Efficiency
- 45 MW
- 40 MWe
- Stack
- Coal Supply
- Steam Line
- Turbine
- Condenser

Source: EPRI
Fluidized Bed Combustion
FBC Power Plant-Schematic

SCHEMATIC DIAGRAM OF FBC COGENERATING PLANT
Major plant upgrade for UAF

A diversified energy portfolio

• New circulating fluidized bed (CFB) boilers
  • Flexible solid fuel, proven technology
  • Coal with up to 15 percent biomass
  • Capable of generating 17 MW of power

• Oil/natural gas backup boilers

• Purchase renewable energy, when available

• Energy conservation on campus

• Small renewable projects on campus

Flexible, sustainable, fiscally responsible
Energy is the Foundation

- UAF has 3.1 million square feet of public facilities
- Average age of building: 34 years
- All these things need heat and power
- More than 500 schools and universities have their own heat and power plants
Our foundation looks like this
What if the Coal Boilers fail?

That could mean firing up the backup oil/gas boilers.

• An adequate supply of gas is not available.

• Using only diesel would more than triple fuel costs.

• The university’s existing operating budget cannot absorb that.
What if the entire plant fails?

• Billions of dollars in public infrastructure at risk of freezing. More than $1 billion to repair.

• Students need alternate housing.

• Research stops. Education stops. Service stops.

• Enrollment and funding impacted for years in the future.
Why don’t you _________?

- Buy power from GVEA
  - We need **heat** and **electricity**.
  - Not cost effective to **heat** with electricity

- Build a natural gas plant
  - A **reliable supply of gas is not available**
  - Lower capital cost
  - Double to more than triple the fuel cost

![Fuel costs — Natural gas](chart)

- New boilers: $5.3 Million
- Gas current: $5.4 Million
- Gas $15/mcf: $15.4 Million
- Gas $12.50/mcf: $12.8 Million
Environmental Benefits

- Current main boilers are 1890’s technology
- Plant burns coal, diesel and gas
- Newer technology is more efficient
- Current load and upgraded plant reduces emissions

<table>
<thead>
<tr>
<th>Emission Type</th>
<th>Current Plant Emissions</th>
<th>New Plant Emissions</th>
<th>Percent Decrease</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxides of Nitrogen (NOx)</td>
<td></td>
<td>41%</td>
<td></td>
</tr>
<tr>
<td>Carbon Monoxide (CO)</td>
<td></td>
<td>65%</td>
<td></td>
</tr>
<tr>
<td>Total Particulates (PM)</td>
<td></td>
<td>73%</td>
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</tr>
<tr>
<td>Coarse Particulates1</td>
<td></td>
<td>45%</td>
<td></td>
</tr>
<tr>
<td>Fine Particulates2</td>
<td></td>
<td>9%</td>
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</tr>
<tr>
<td>Volatile Organic Compounds (VOC)</td>
<td></td>
<td>3%</td>
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</tr>
<tr>
<td>Carbon Dioxide (CO2)</td>
<td></td>
<td>60%</td>
<td></td>
</tr>
<tr>
<td>Sulfur Dioxide (SO2)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. 2.5 – 10 micrometers (PM 10)
2. < 2.5 micrometers (PM 2.5)
Additional Benefits

• Increase in available construction jobs for Alaskans
• Increase in economic activity during 2015-2018 time period
• Public safety
  • *UAF historically serves as a place of shelter during emergencies.*
  • *Upgraded plant could heat and power campus independent of the grid.*
Timeline

• Current: $3 million for preliminary design and permitting

• FY15: Requesting $245 million for full design, boiler and equipment purchase, and construction
  o $195 million state funding
  o $50 million in bonding authority
    • UAF can make the bond payment with fuel cost savings

• Target completion and opening: Winter 2018
Emissions Comparison Chart
Alaska FBC vs. Technology Maturity

- Emissions-lb/MM Btu
- SO2
- NOx
- Part.
- Uncontrolled
- Early Controls
- Alaska FBC

Uncontrolled | Early Controls | Alaska FBC
Gasification Plant Options

NETL illustration
What is Gasification?

• Gasification converts any carbon-containing material into synthesis gas, composed primarily of carbon monoxide and hydrogen (referred to as syngas)

• Syngas can be used as a fuel to generate electricity or steam, as a basic chemical building block for a large number of uses in the petrochemical and refining industries, and for the production of hydrogen.

• Gasification adds value to low- or negative-value feedstocks by converting them to marketable fuels and products.
History of Gasification

• Used during World War II to convert coal into transportation fuels (Fischer – Tropsch)

• Used extensively in the last 50+ years to convert coal and heavy oil into hydrogen – for the production of ammonia/urea fertilizer

• Chemical industry (1960’s)

• Refinery industry (1980’s)

• Global power & CTL industries (Today)
Gasification Products

- Argon, Nitrogen, & Oxygen
- Carbon Dioxide
- Sulfur / Sulfuric Acid
- Steam
- Hot Water
- Electricity
- Hydrogen
- Carbon Monoxide
- Ammonia-based Fertilizer
- Synthetic Natural Gas
- Industrial Chemicals
- Methanol / Ethanol
- Naphtha
- High Cetane Diesel
- Jet Fuel
- Wax

Source: FLUOR®
Healy Economics – 2007 (and outdated)

Average F-T Product price = $81.50
Healy FT Products Value
Range for 12% IRR (ANS Crude Basis)
Avg. ANS crude = $57.11

- ANS Crude AK
- AK Diesel #2
- AK "naphtha"
1. Combustion of Coal with oxidant
2. Heat is generated
3. Coal + Water + Heat $\rightarrow$ Syngas (H2+CO) through Gasification
4. Other reaction:
   - Water Gas Shift (CO + H2O $\leftrightarrow$ H2 + CO2)
   - Methanation (CO + 3H2 $\leftrightarrow$ CH4 + H2O)
   - Pyrolysis (Coal $\rightarrow$ CH4 + H2O + Hydrocarbons + Tars + Volatile gases)

Illustration courtesy of Linc Energy
Linc UCG License Areas
DGGS: At least 37 Communities Near Potential Coal Seam Methane

Source: DGGS public presentation, 2002

Alatna  Koyuk
Allakaket  Koyukuk
Ambler  McGrath
Atqasuk  Mekoryuk
Beaver  Naknek
Bettles  Nightmute
Birch Ck  Nikolai
Chalkyitsik  Noatak
Chignik  Nulato
Chignik Lg  Perryville
Chignik Lk  Point Lay
Deering  Rampart
Evansville  Selawik
Fort Yukon  Shungnak
Galena  Toksook Bay
Kaltag  Unalakleet
Kiana  Venetie
King Salmon  Wainwright
Kobuk

DGGS: At least 37 Communities Near Potential Coal Seam Methane

Source: DGGS public presentation, 2002
Thank You

- NETL – U.S. Dept of Energy
- Linc Energy
- DGGS
- UAF
- State of Alaska
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