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

Primer on Coal Conversion Technology

April 4, 2014

Brent J Sheets

Alaska Center for Energy and Power

UAF UNIVERSITY OF ALASKA FAIRBANKS

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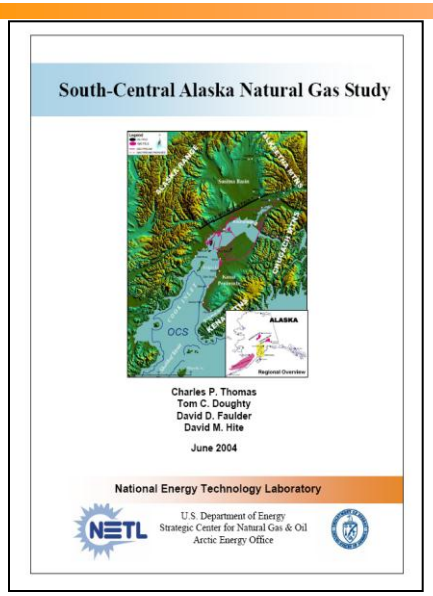
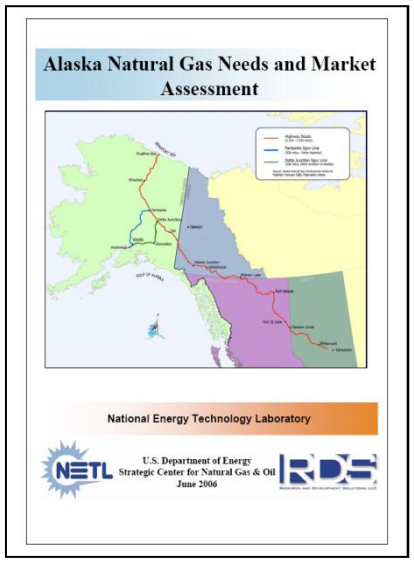
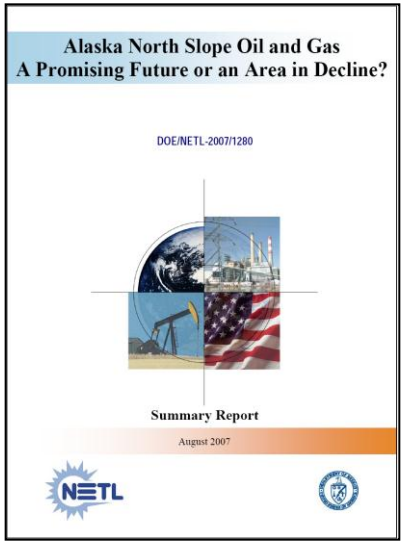
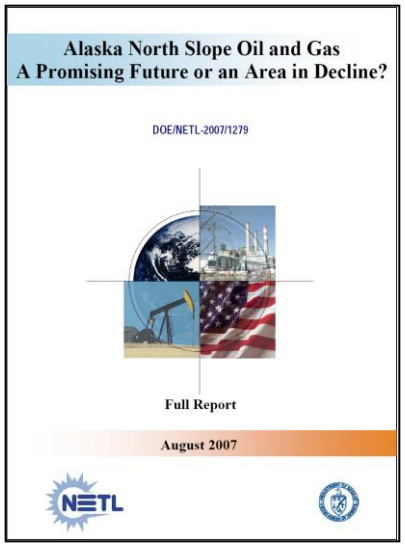
Presentation Agenda

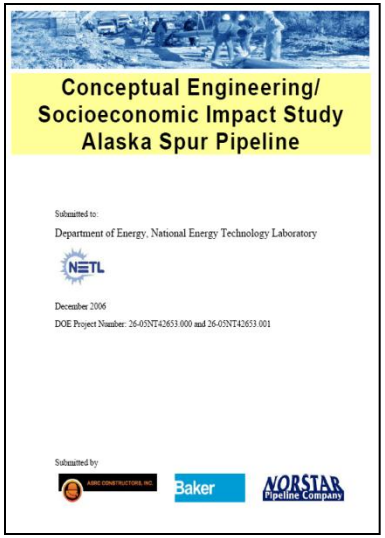
- About ACEP
- Power Generation Technology and Alaska
- Gasification Technology
- Coal Seam Natural Gas

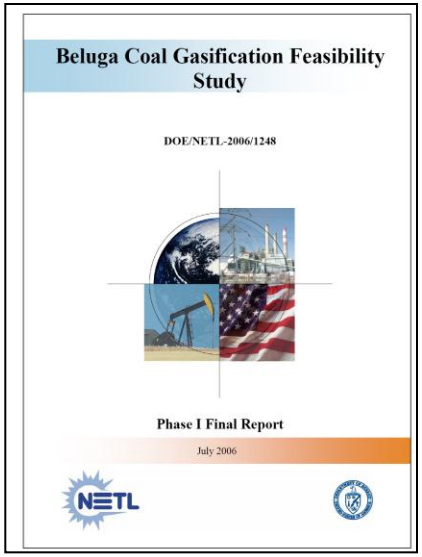


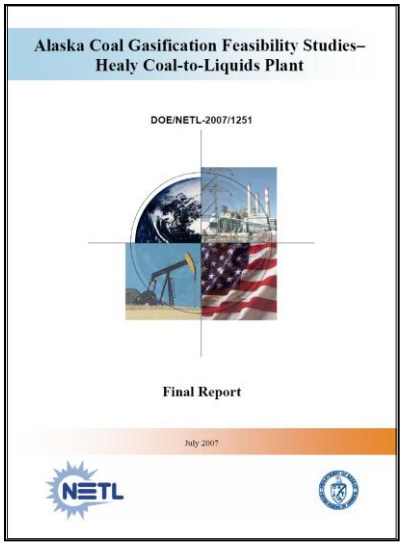


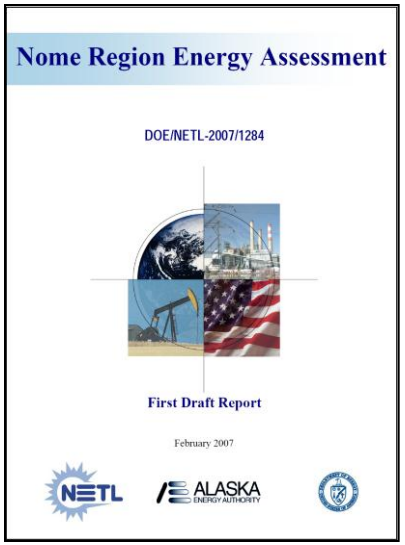












Selected reports during my tenure with the U.S. Department of Energy, National Energy Technology Laboratory's Arctic Energy Office, Fairbanks, AK

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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

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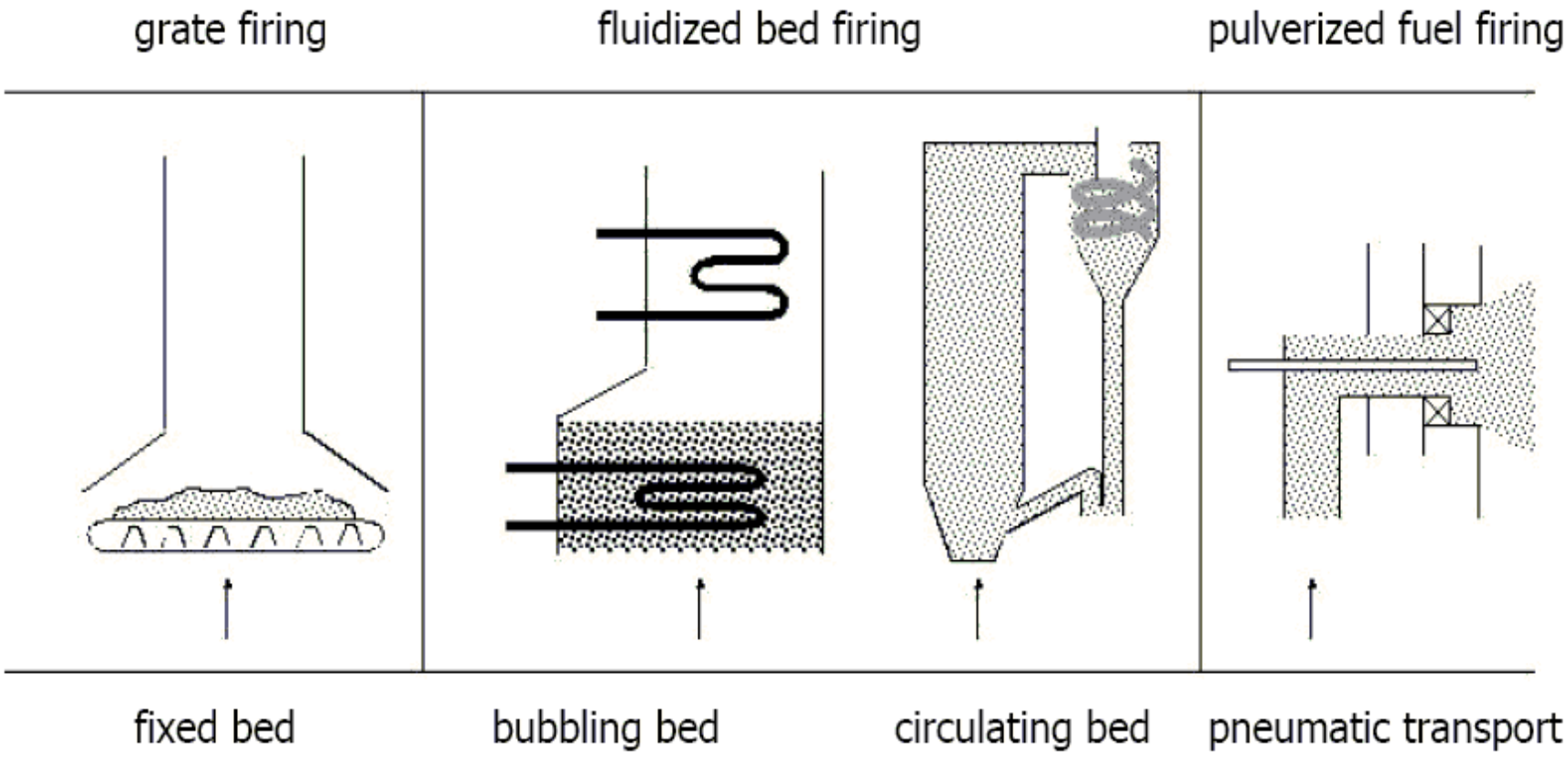
ACEP is a revenue center (not a cost center)

- 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

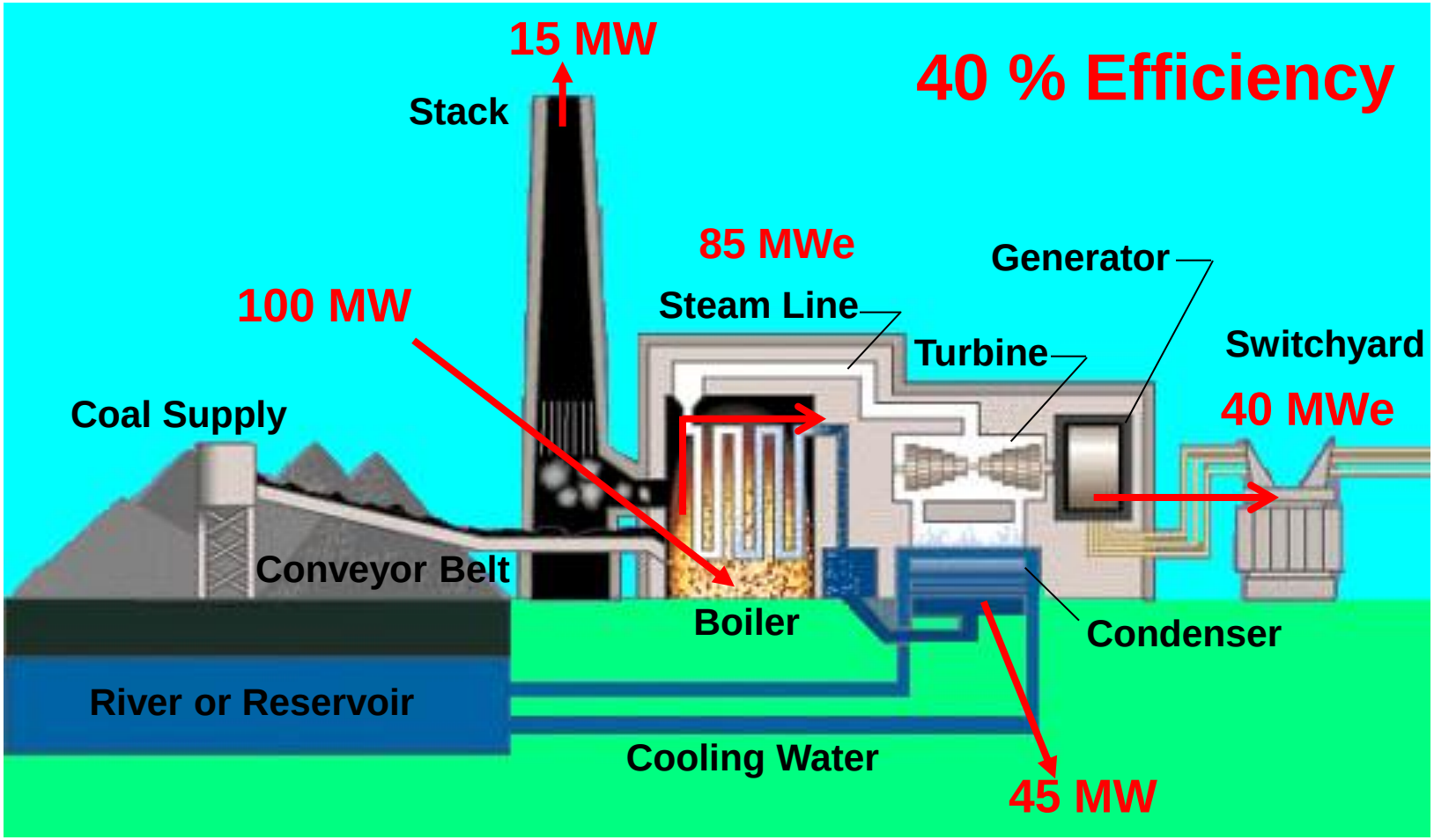
- Pulverized Coal (PC) Boilers
  - Commercialized in 1920s-1930s
  - 5000 units world-wide; >1100 in US
  - Unit sizes up to ~1400 MW
- Fluidized Bed Combustion (FBC) Boilers
  - Commercialized in 1970s-1980s
  - 500 units world-wide; 150 in US
  - Unit sizes up to ~300 MW
  - Costs ~5-10% higher than 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



Conventional Coal Plant

(Illustration only)



Source: EPRI

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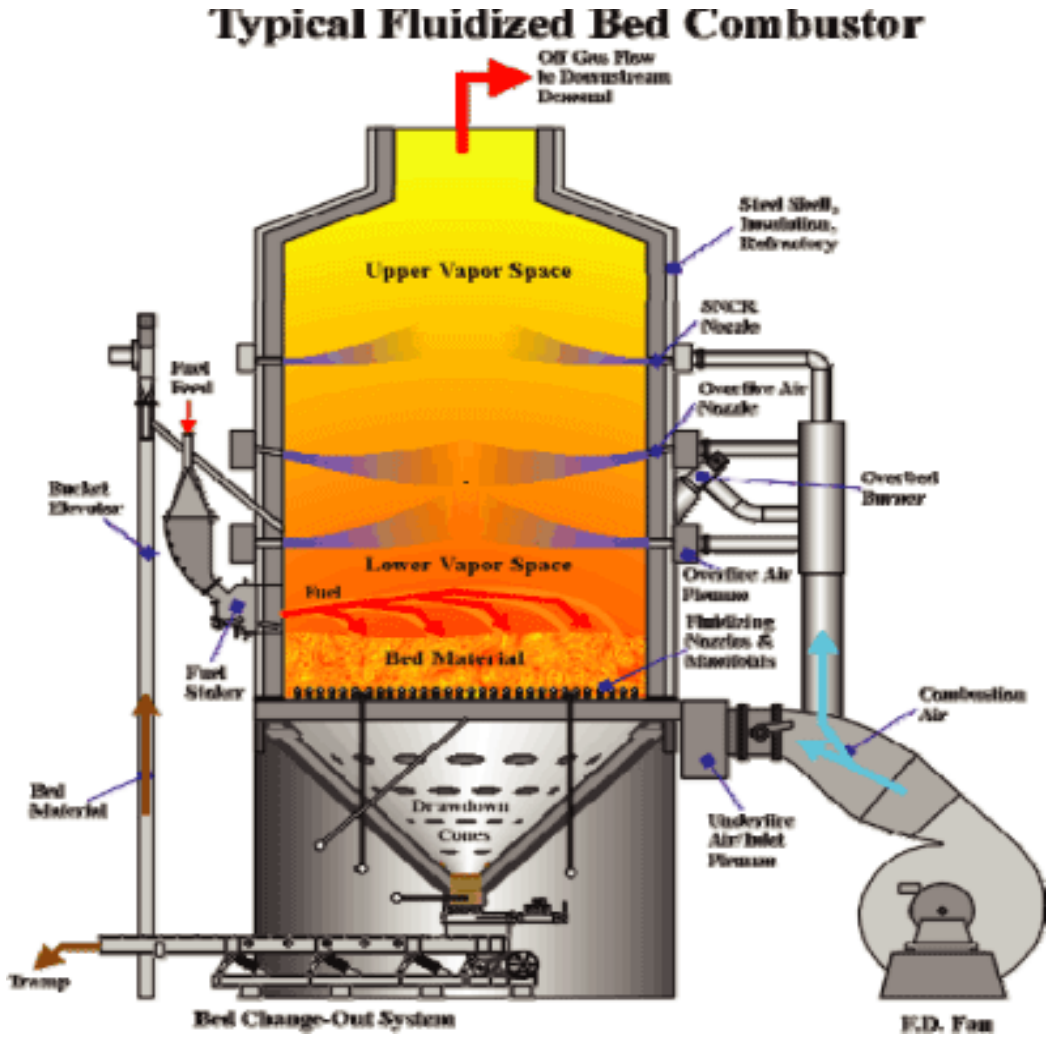
Fluidized Bed Combustion



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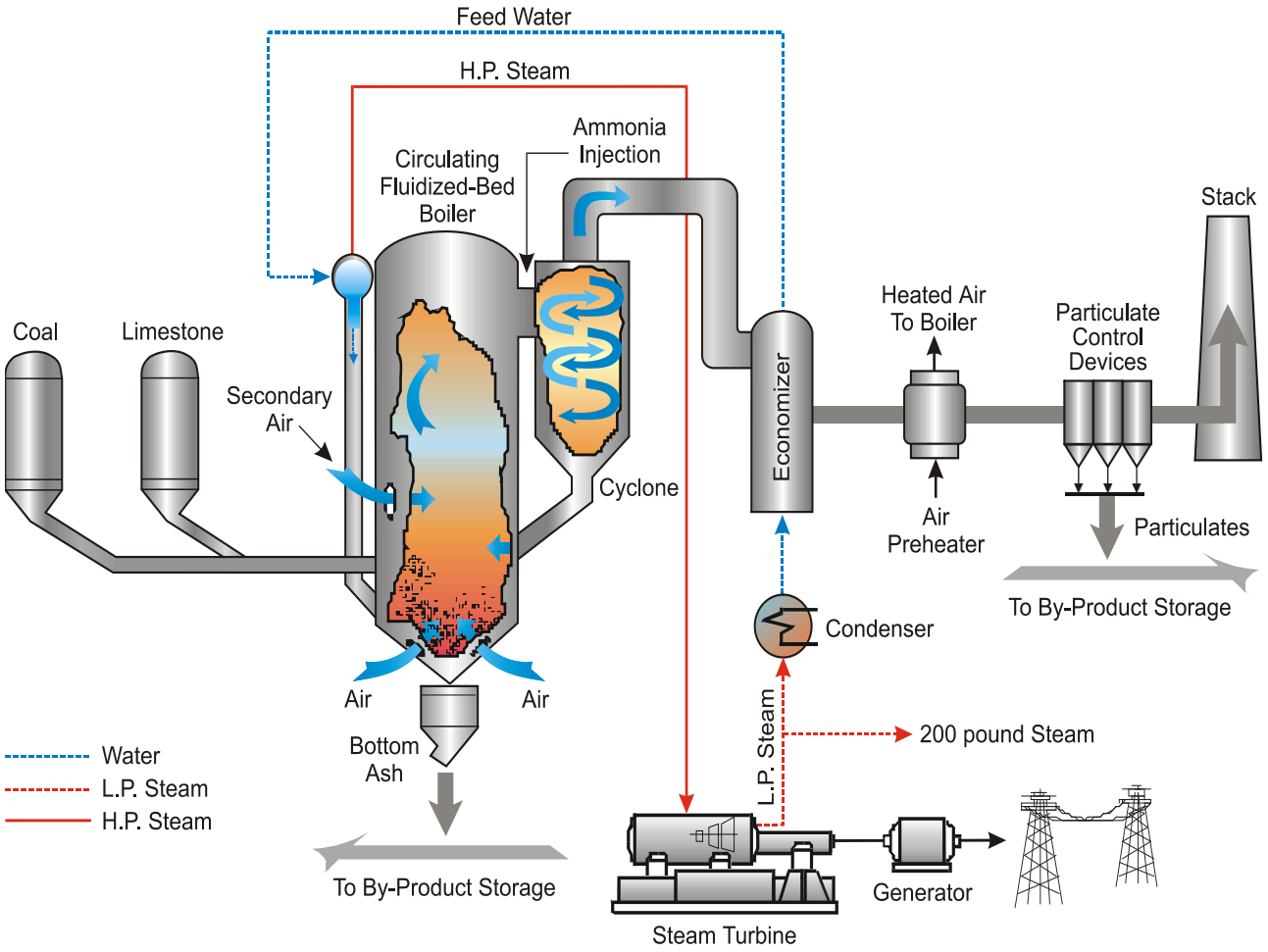
FBC Power Plant-Schematic



SCHEMATIC DIAGRAM OF FBC COGENERATING PLANT

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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

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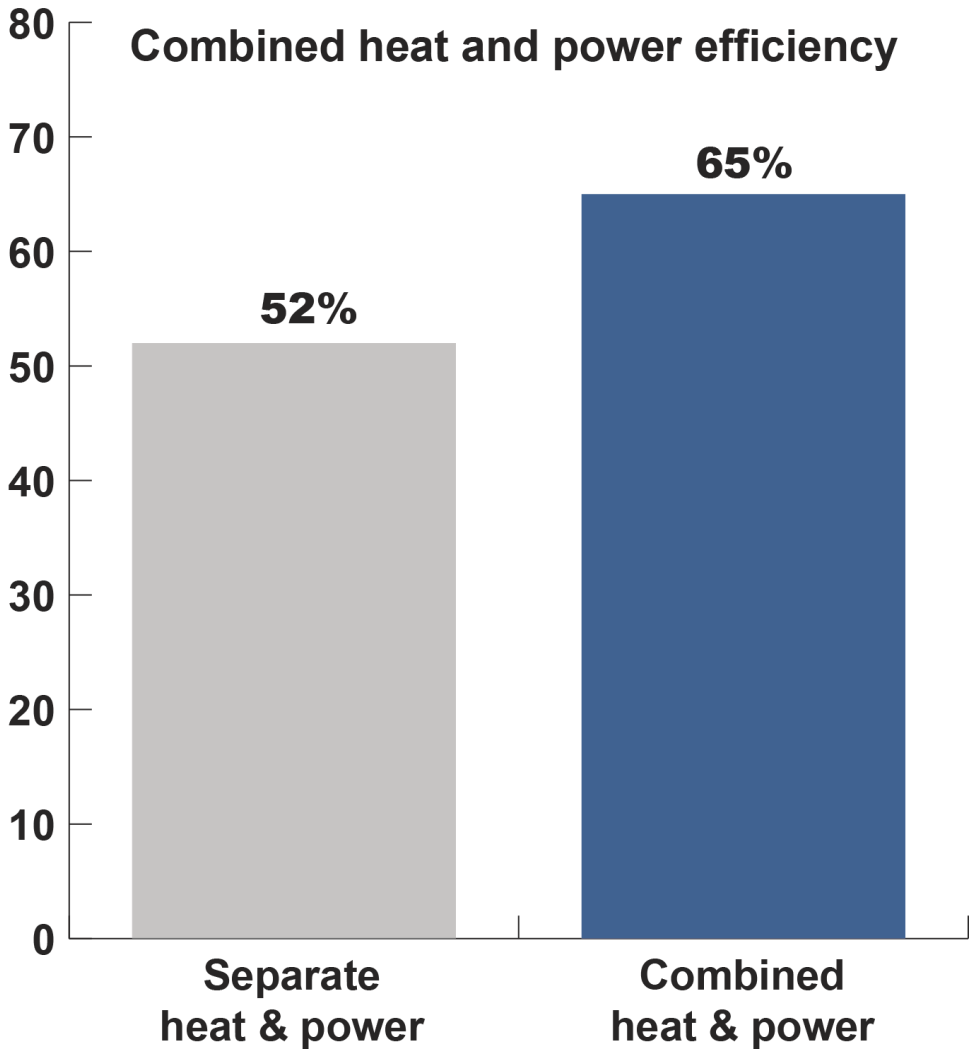
Energy is the Foundation

- 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



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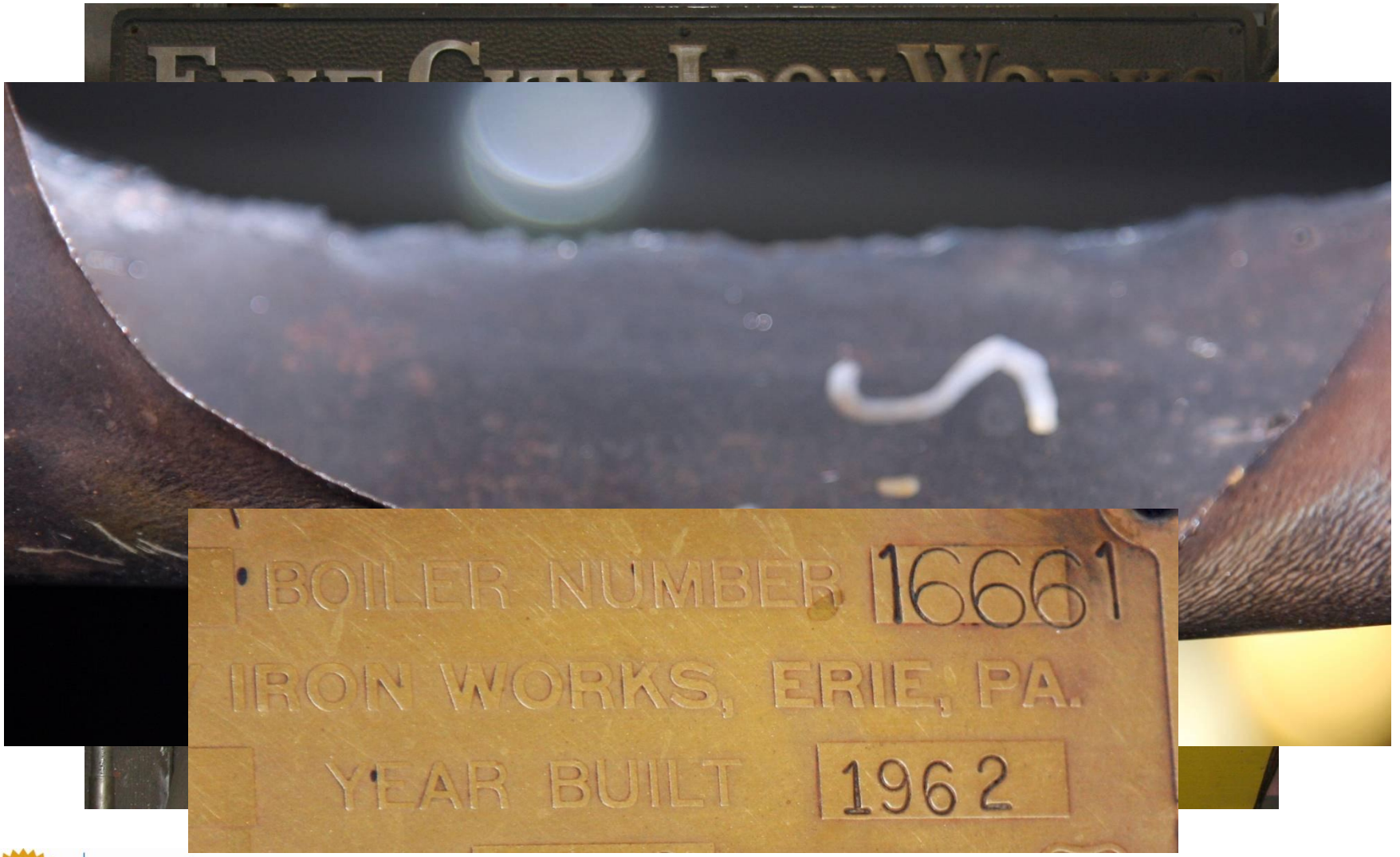
Our foundation looks like this



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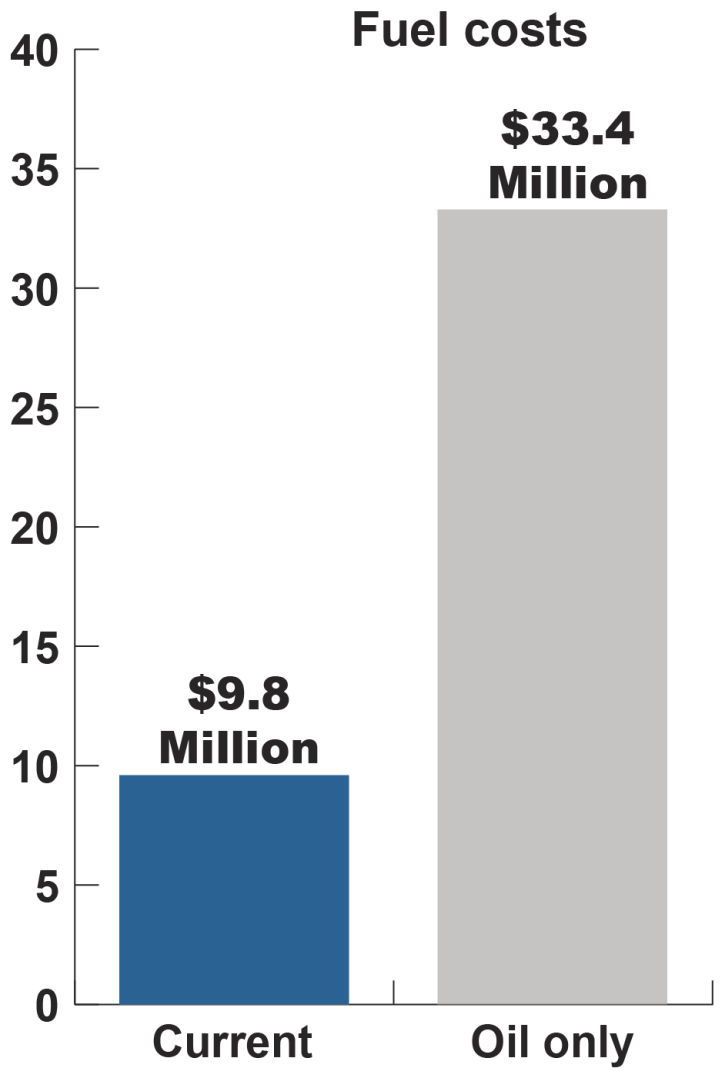
What if the Coal Boilers fail?

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.*



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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.

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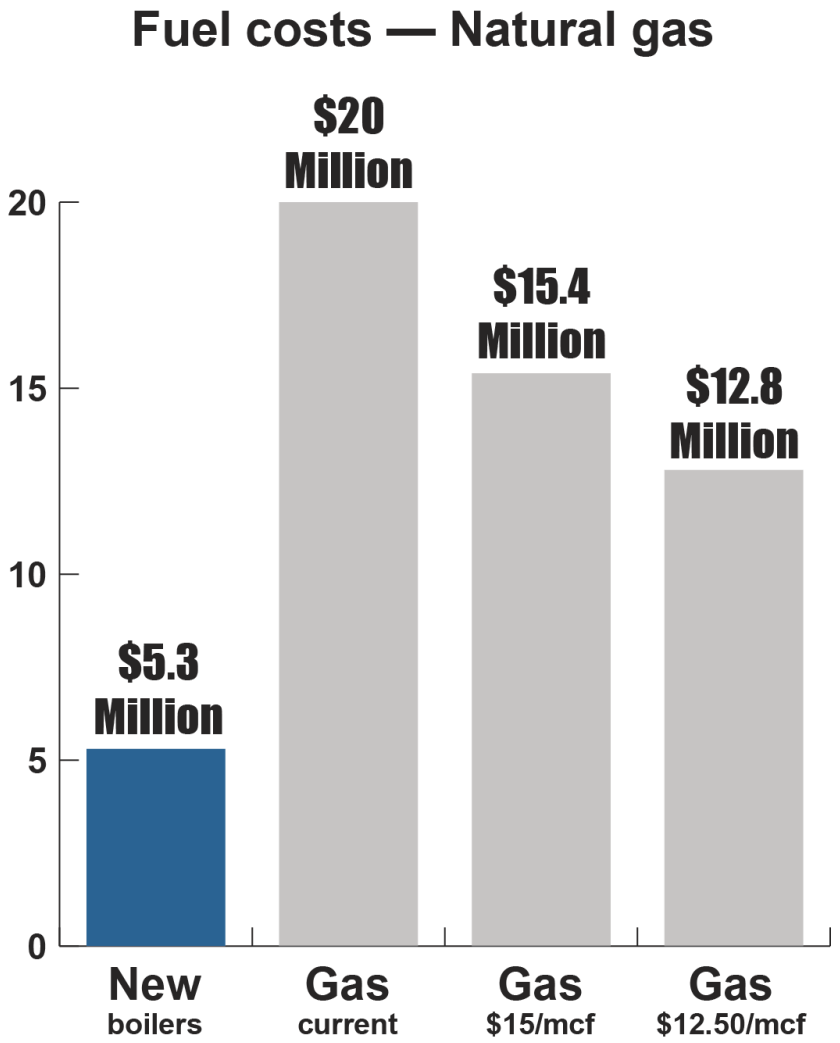
Why don't you _____?

- 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*



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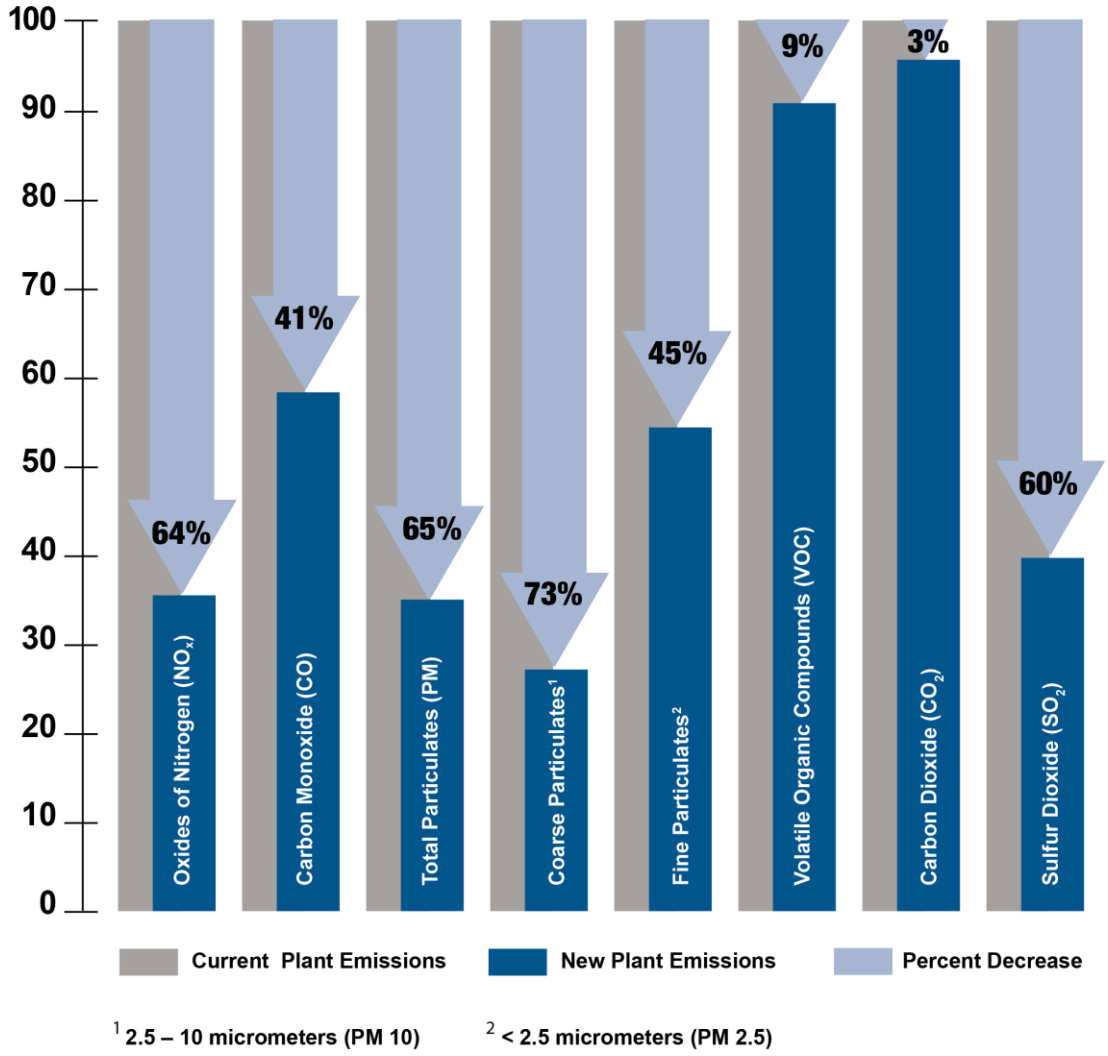
Environmental Benefits

- 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



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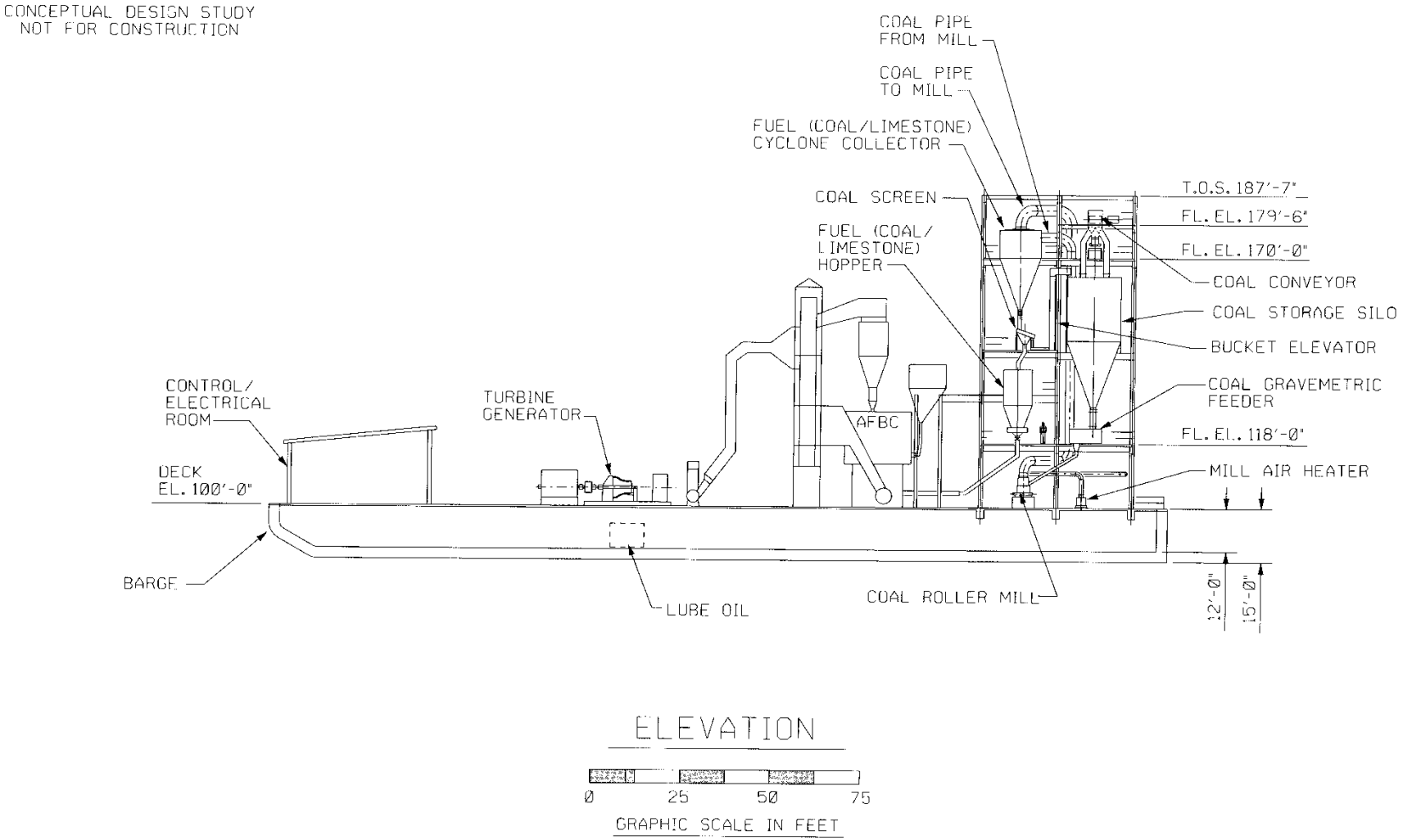
Additional Benefits

- 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
  - $195 million state funding
  - $50 million in bonding authority
    - *UAF can make the bond payment with fuel cost savings*
- Target completion and opening: Winter 2018

Yukon River FBC Unit Elevation View



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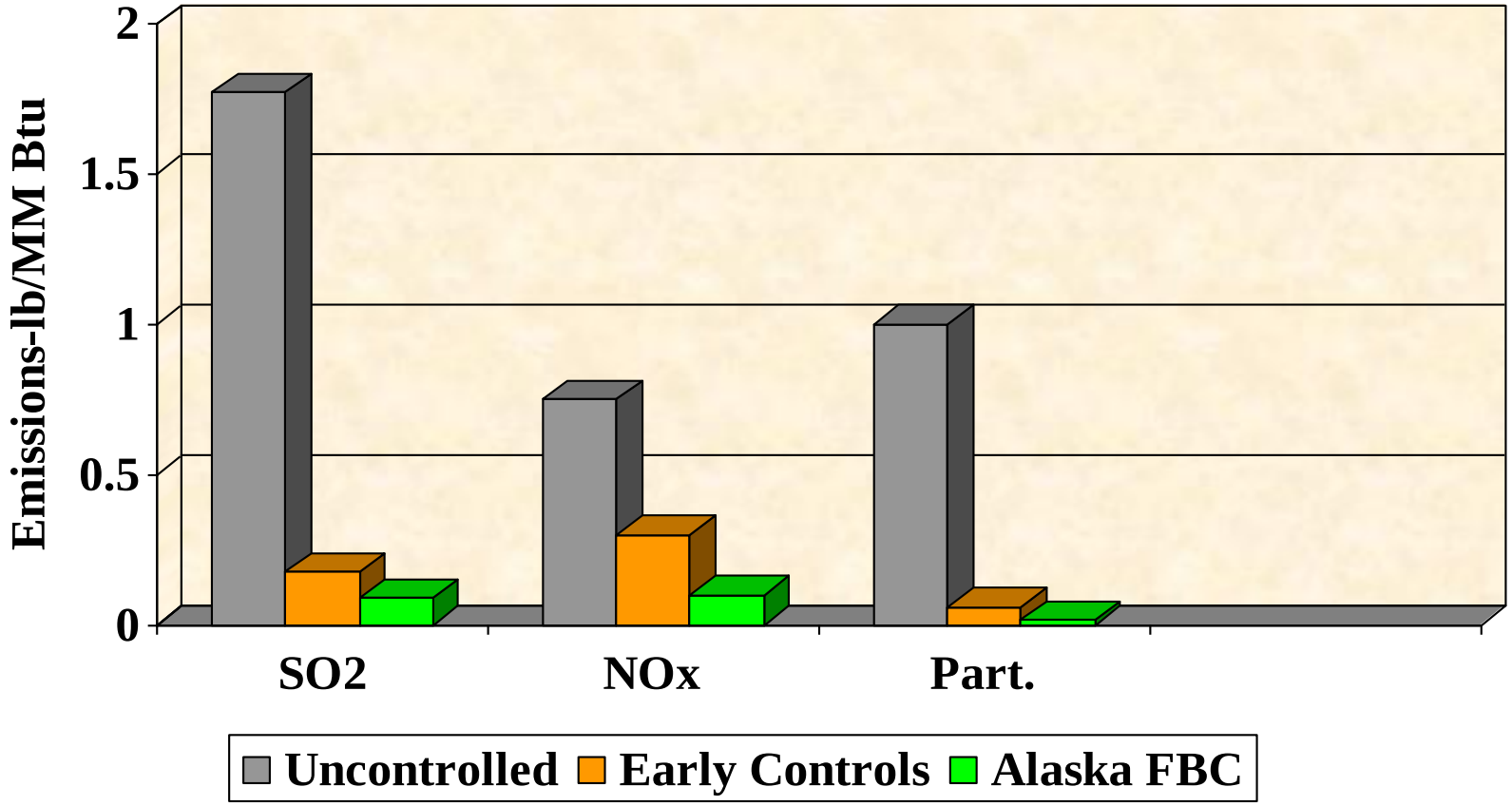
Emissions Comparison Chart

Alaska FBC vs. Technology Maturity



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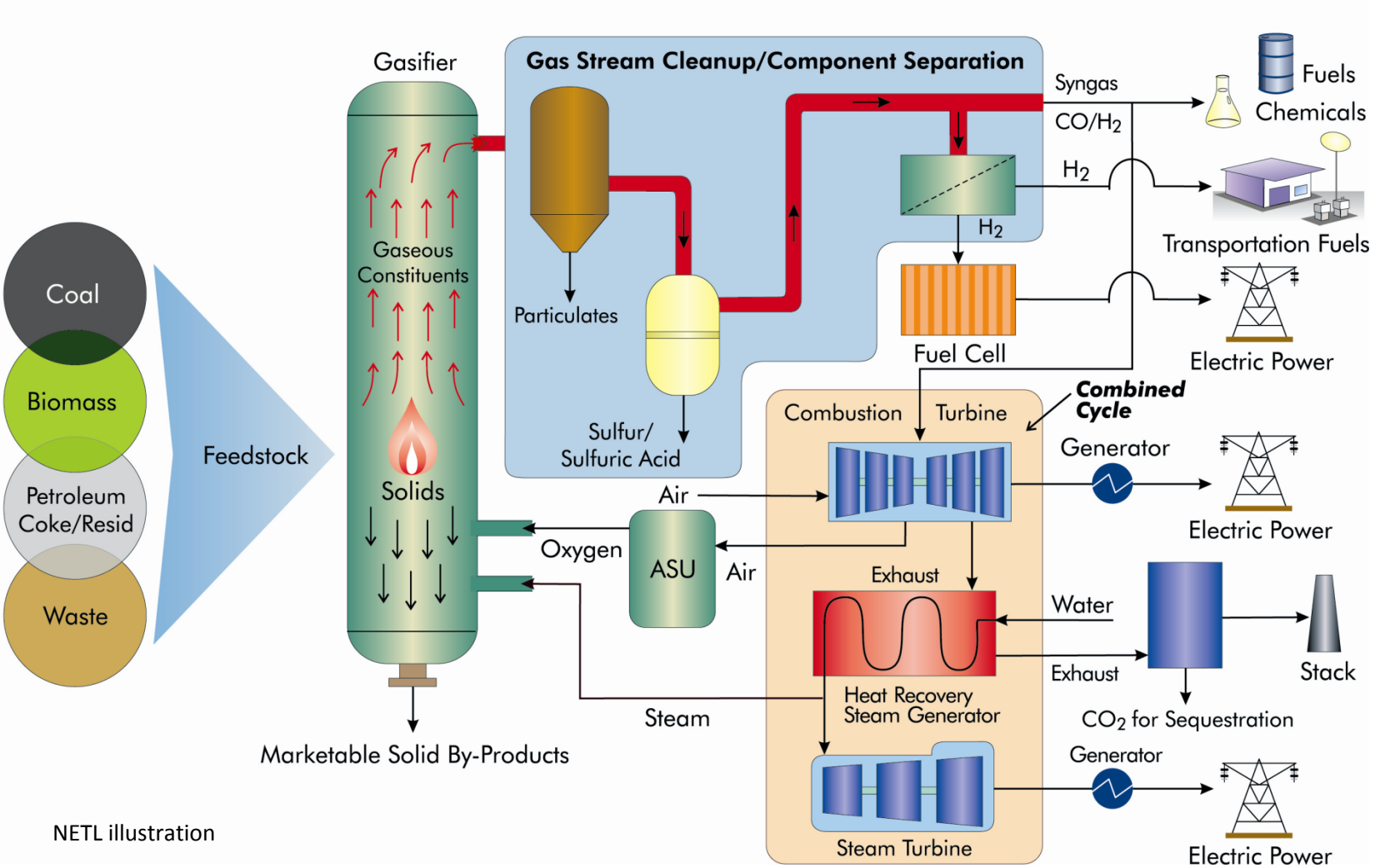
Gasification Plant Options



NETL illustration

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What is Gasification?

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

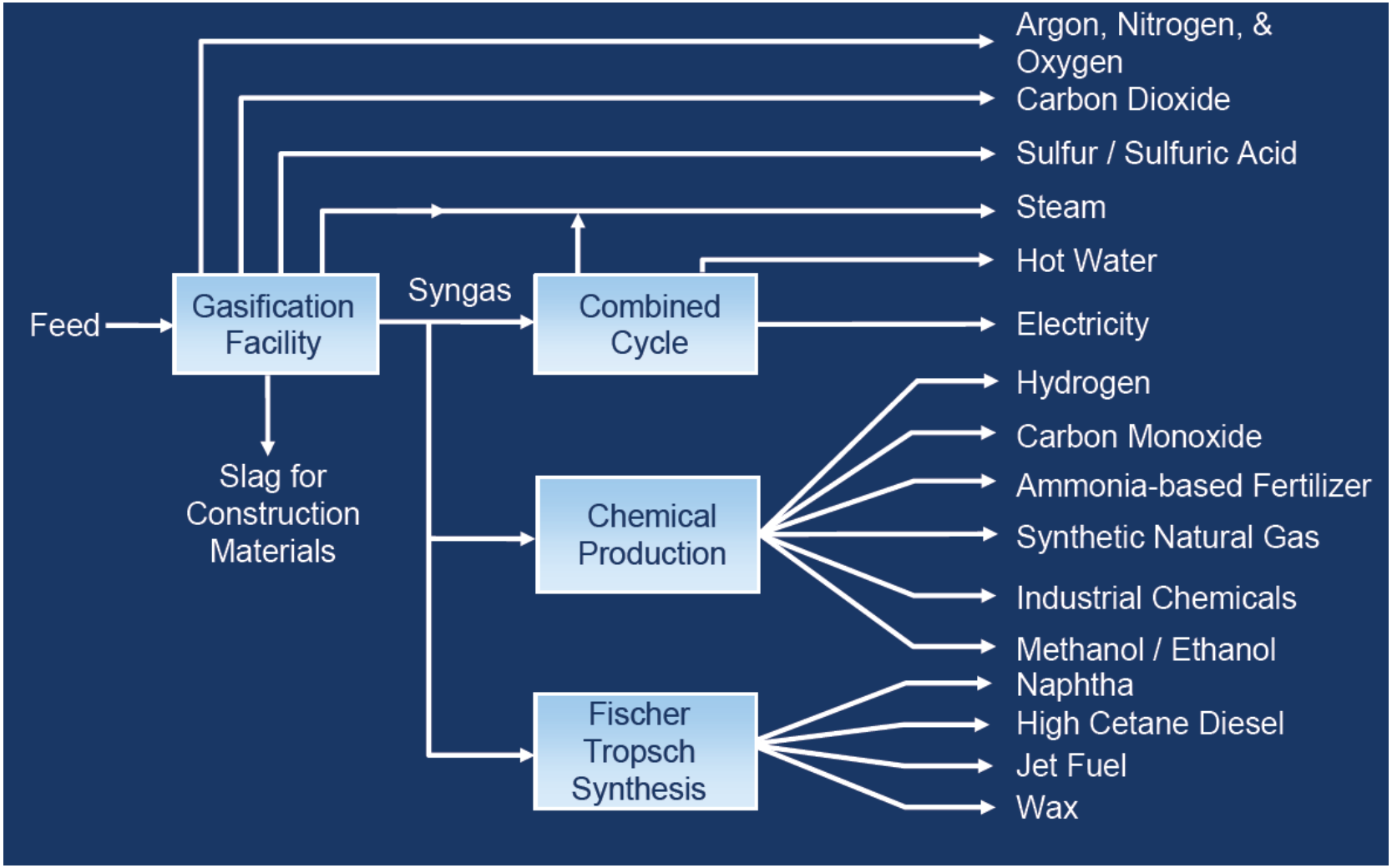
- Syngas can be used as a fuel to generate electricity or steam, as a basic chemical building block for a large number of uses in the petrochemical and refining industries, and for the production of hydrogen.

- 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



Source: FLUOR®

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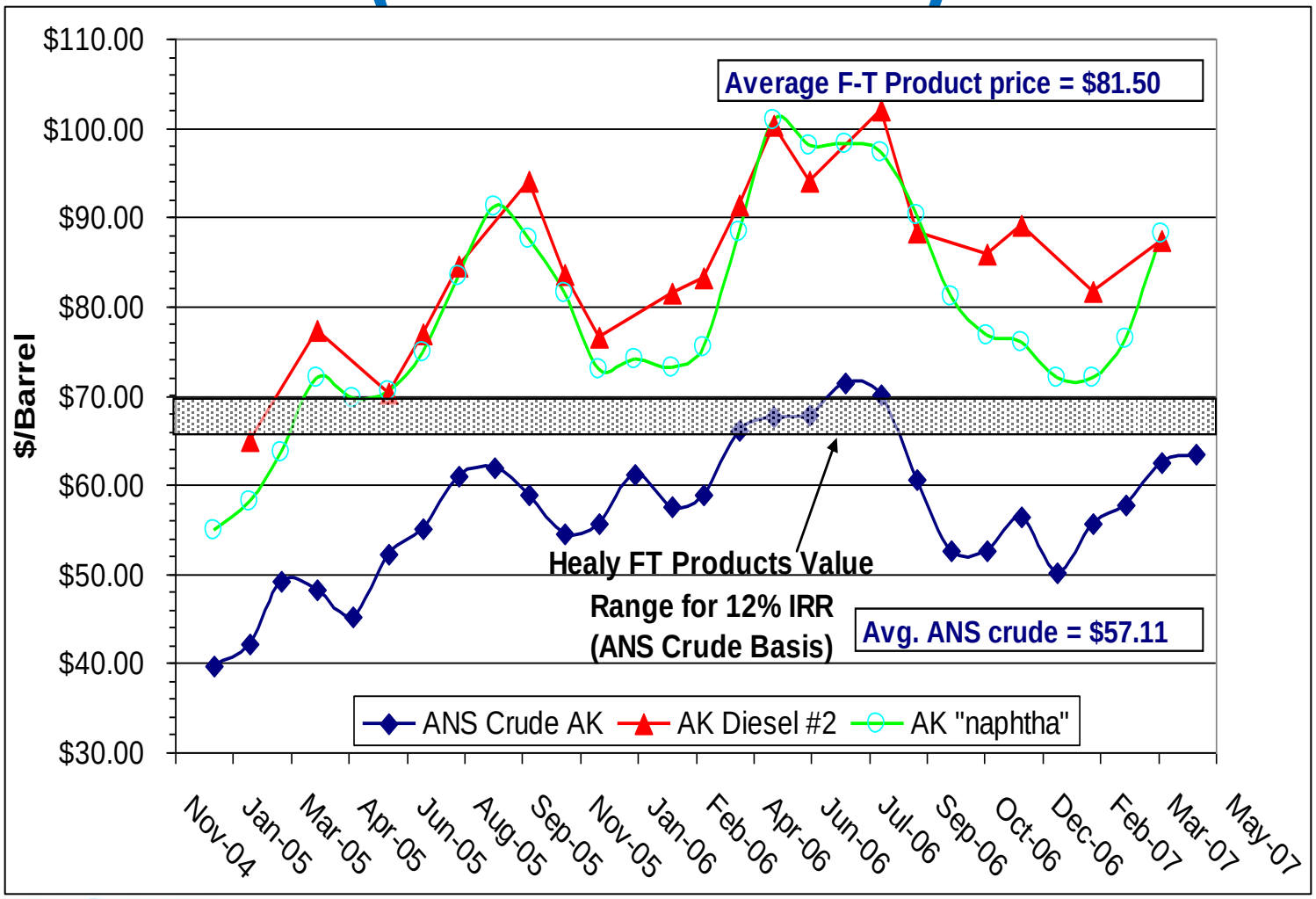
Healy Economics – 2007 (and outdated)



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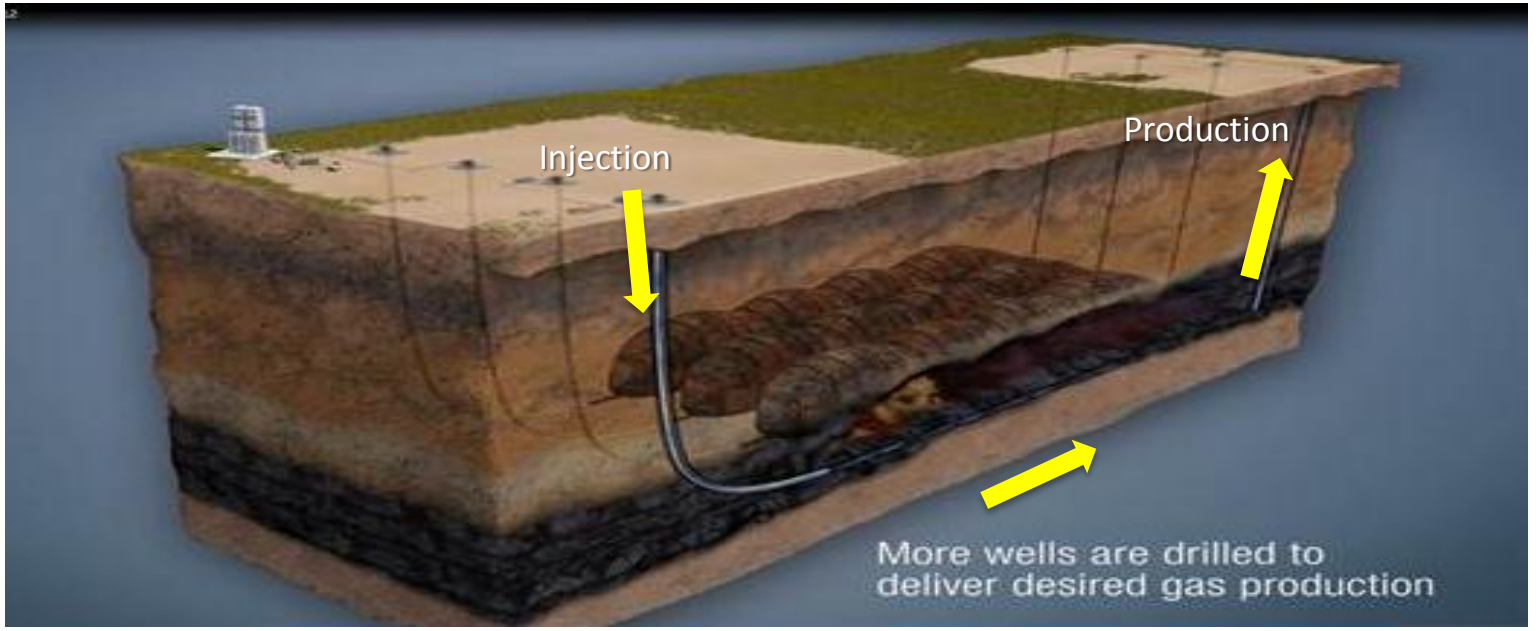
Underground Coal Gasification



1. Combustion of Coal with oxidant
2. Heat is generated
3. Coal + Water + Heat → Syngas (H2+CO) through Gasification
4. Other reaction:
   Water Gas Shift (CO + H2O < -- > H2 + CO2)
   Methanation (CO + 3H2 < -- > CH4 + H2O)
   Pyrolysis (Coal → CH4 + H2O + Hydrocarbons + Tars + Volatile gases)

Illustration courtesy of Linc Energy

Linc UCG License Areas

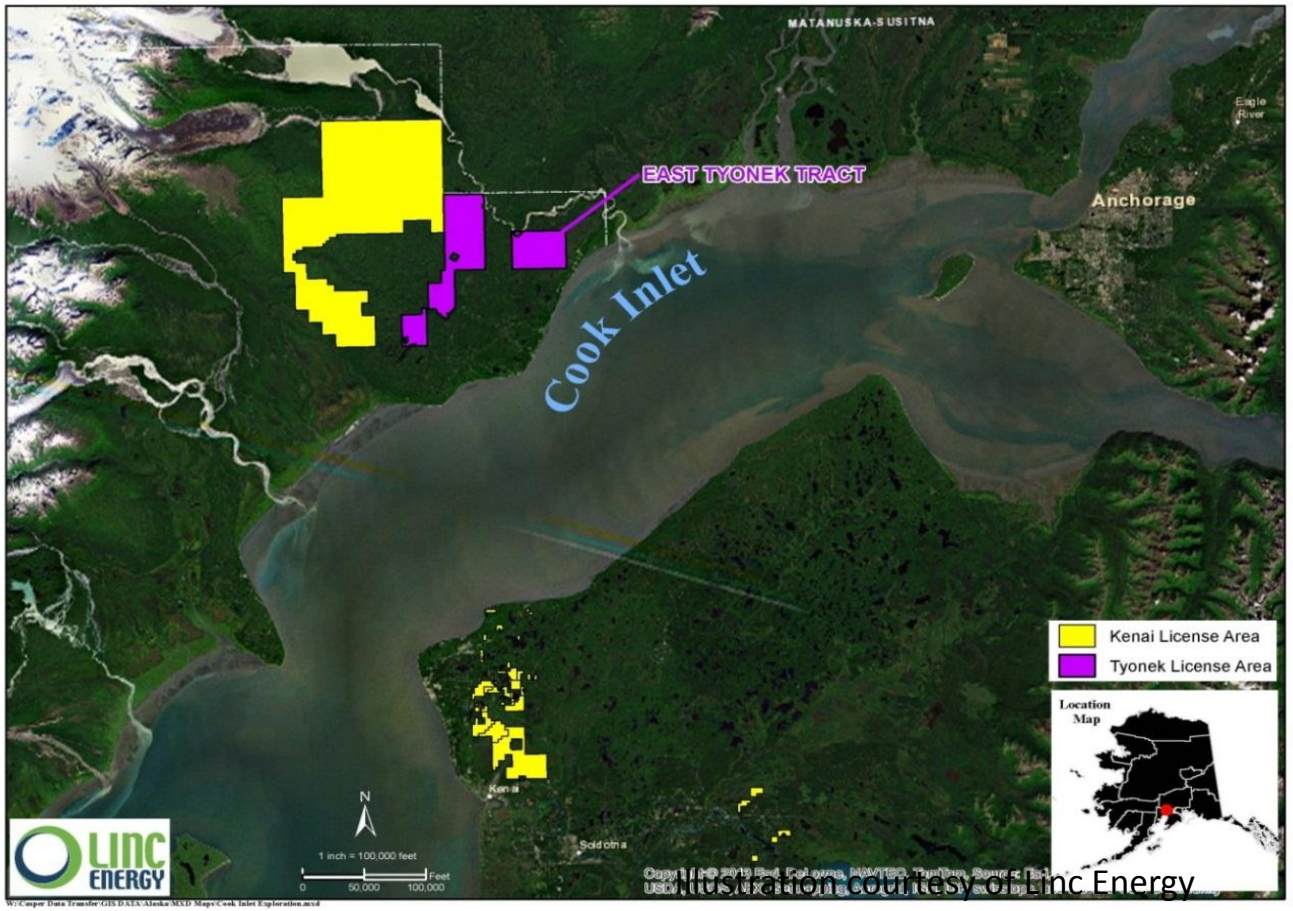
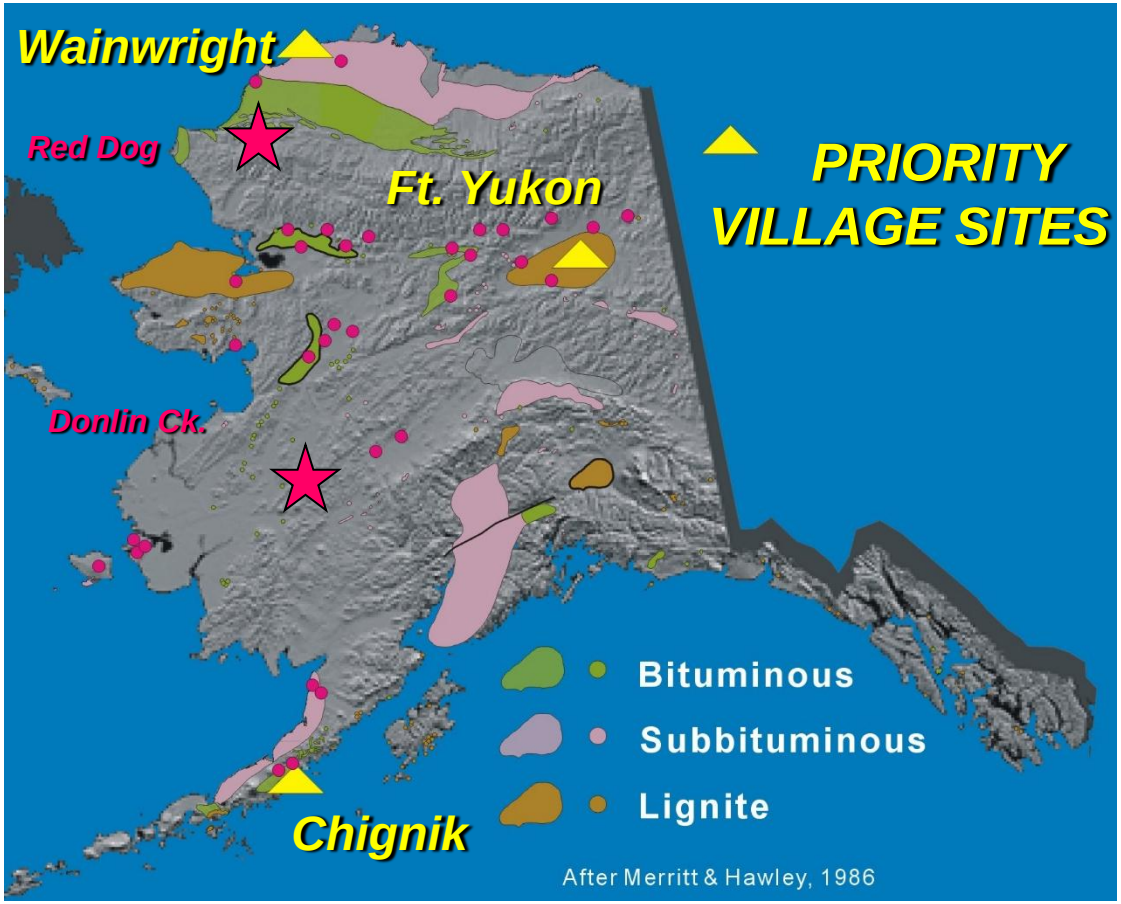


Illustration courtesy of Linc Energy

DGGS: At least 37 Communities Near Potential Coal Seam Methane



Source: DGGS public presentation, 2002

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

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Thank You

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- Linc Energy
- DGGS
- UAF
- State of Alaska

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