REINHOLD ENVIRONMENTAL ®

2025 Reinhold/PCUG Round Table Presentation

Hosted by AEP and Buckeye Power

in The Hilton Columbus Polaris Hotel, Columbus, OH

on June 23-24, 2025

Coal to Gas Economics

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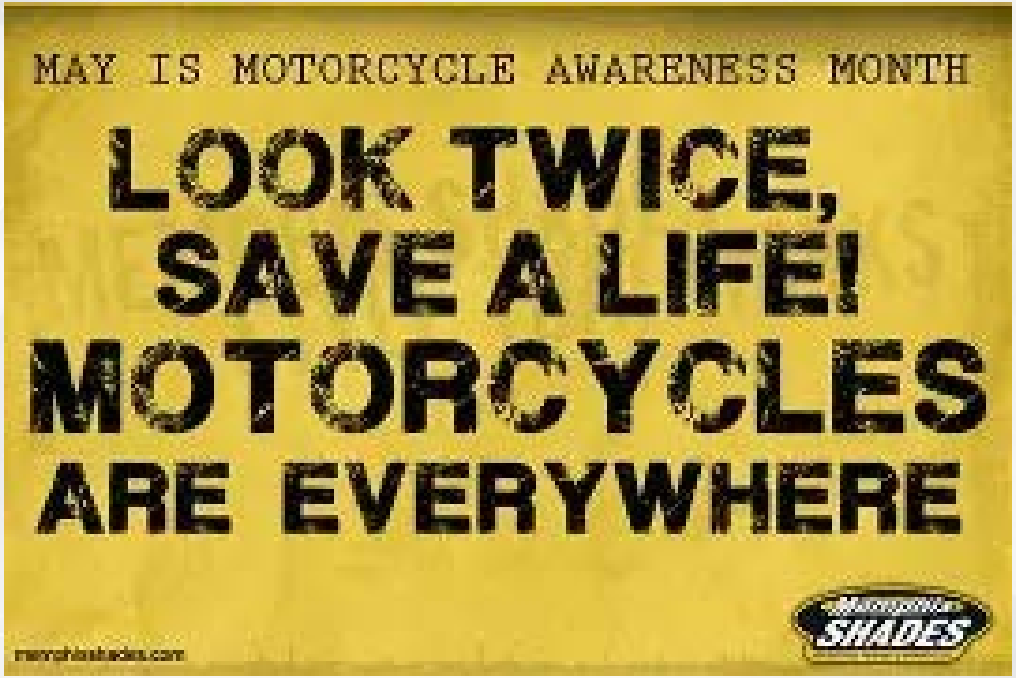
Senior Director, Sales & Business Development

June 24, 20205

Safety Minute

DON'T BE A DISTRACTED DRIVER



What's old is new, Fortune Magazine Advertisement from 1950's

....

"...taking full advantage of fuel availability"

"Fuel bargains are always being sought by plant operators..."

Time-line of Gas Firing for Utility Power Applications

- 1950's: Initial use of natural gas in OEM design and supplied steam cycle power plants
- 1970s-1980's: Volatile and cyclical natural gas commodity prices
  - Base load – coal and nuclear assets
  - Natural Gas simple-cycle peakers
  - Investment in GT Combined Cycle plants begins
- 1990's early 2000's: Stabilization of NG pricing
  - Smaller Utility Steam Cycle Plants convert to NG (in lieu of AQCS or shutdown)
  - GT Power Investment and Growth
- Current
  - Wind and Solar have disrupted base load operating approaches
  - Ash and CO2 pressures impact coal use horizons
  - GT and simple cycle investment to meet growth curve expectations (bridge fuel)
  - Larger Utility Coal fired plants seeking natural gas additions, conversions and re-starts
  - Growth expectations in power demand ahead (datacenters most notably)

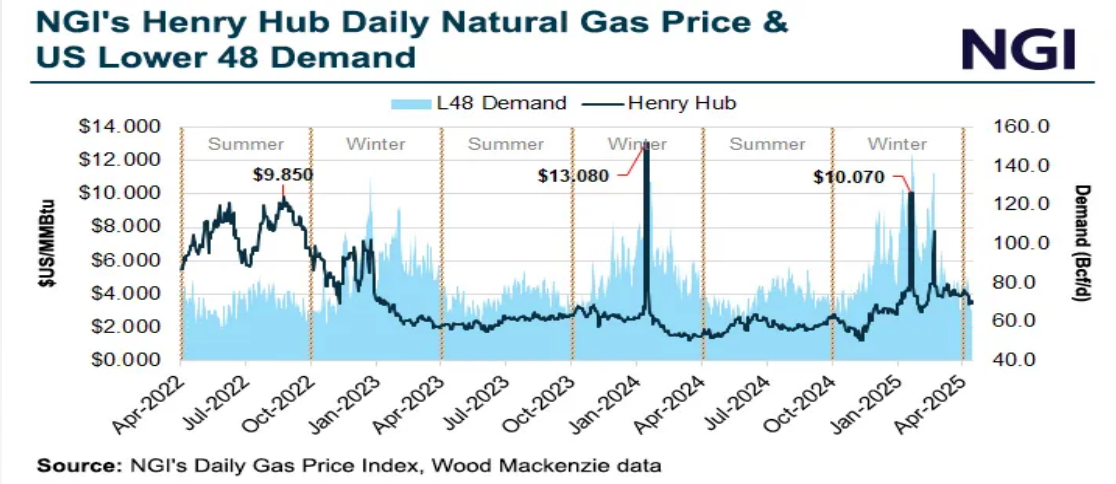
Economic Considerations in a Coal to Natural Gas Addition or Conversion

- Fuel costs
- Expense to get natural gas to the site
- Operation & Maintenance (O&M) expenses
- Capital costs
- Heat rate and efficiency
- Other considerations:
  - Start-up time
  - Fuel flexibility/natural gas curtailment
  - Emissions and AQCS

Bituminous Coal and Natural Gas Pricing History

The current price of US Bituminous Coal = $106.6/Ton
This equates to $4.28/MMBTU

The current price of NG at the Henry Hub is $3.90/MMBtu



*Cost data as of 6/20/2025

Industry Commentary on Coal versus Gas Costs

- Coal prices are expected to remain flat in the $2.4/mmbtu range nominally
  - Sub-bituminous at the low end ($1.03/mmbtu)
  - Bituminous at the higher end ($4.28/mmbtu)
    - The above prices are exclusive of delivery costs

- Natural Gas prices are projected above $4/mmbtu for the next three years on average due to increased power demand being met by NGCC plants (existing and new) and increased LNG export terminals being built

- Lazard puts the marginal cost of power generation (no debt service) for an existing plant at $31/mwh for coal ($1.47/mmbtu coal) and $24/mwh for gas ($3.45/mmbtu NG).
  - This conclusion presumes costs over and above fuel of less than $1/mwh for gas and nearly $15/mwh for coal.

Range of Fuel Cost Calculations Coal versus Gas

Gas price = $3.90/MMBtu

Combined Cycle

- Heat Rate = 7,200 BTU/KWhr
- Fuel Cost: $3.90x 7.2 = $28.08/MWhr

Steam Cycle/Simple Cycle

- Heat Rate = 10,750 BTU/KWhr
- Fuel Cost: $3.90x 10.75 = $41.925/MWhr

Bituminous Coal price = $4.28/MMBtu

- Heat Rate = 10,500 BTU/KWhr
- Fuel Cost: $4.28x10.5= $44.94/MWhr

Sub Bituminous Coal price = $1.03/MMBtu

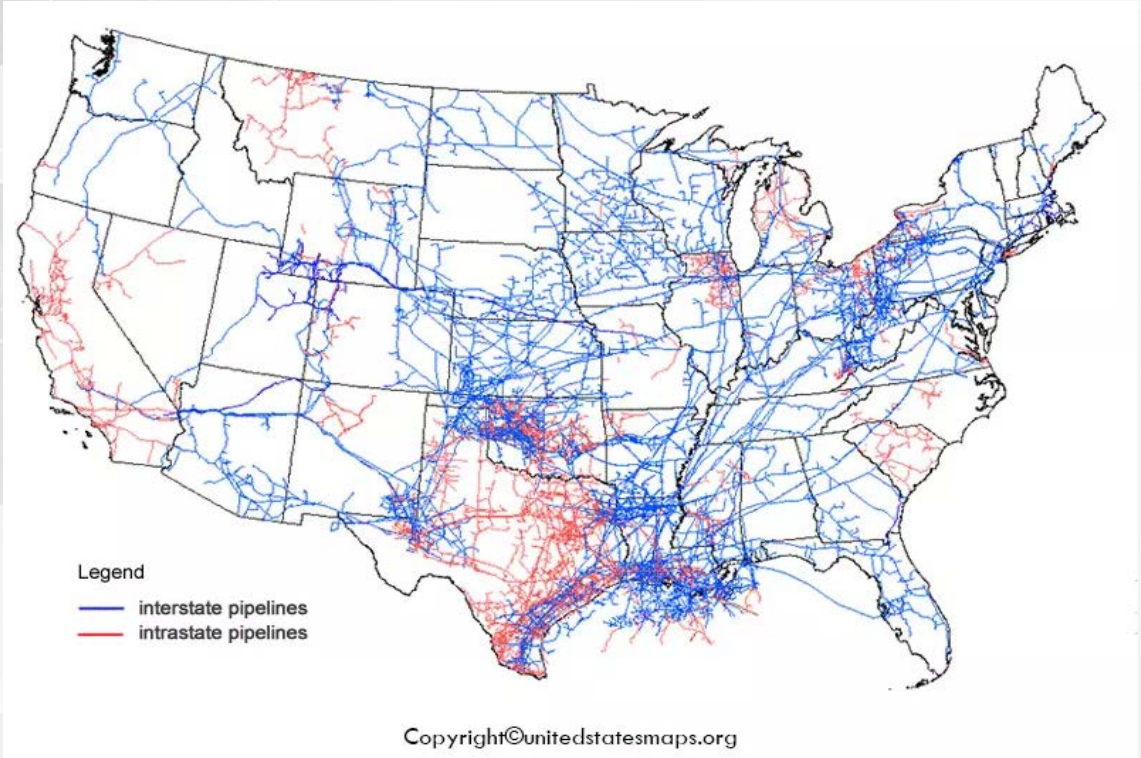
- Heat Rate = 10,500 BTU/KWhr
- Fuel Cost: $1.03x10.5= $10.8/MWhr

Against the Capital Needs of the Project

- Do we need to get gas to the site?
- How much will the project cost to implement?
- Operations and Maintenance Differences?

Getting Natural Gas to My Site

Map of Gas Supply Pipelines in the United States



Cost of a Pipeline

- Historically, $1 million per mile rule of thumb
- Anecdotally, instances of current pricing at $10 million per mile
- Noted current experience at $3 million to $4 million per mile

Capital Costs

Steam Cycle – Existing Unit Retrofit

- $50 to $200 per KW
  - 3-year concept to completion
  - $75 to $100 per KW range suitable for most projects
- Variability in costs, driven by the complexity of the retro-fit
  - Unit performance needs/fixes
  - Control Approach
  - Automation and Redundancy
  - Unit condition
  - Demolition

Gas Turbine – New Build

- Simple Cycle - $1000-$1100 per KW
  - 5-year concept to completion
- Combined cycle – $1500-1700 per KW
  - 5-year concept to completion

EXPANDING PROCURMENT TIMELINES AND COSTS

Operations and Maintenance

Gas Conversion vs. Gas Addition

Gas Conversion

- Elimination of coal handling; coal yard, pulverizer maintenance and AQCS scrubbers (and possibly SCR)
- Theoretical 90% staff reduction, with actual results dependent on other factors such as taking on other functions and demographic/turnover planning.

Gas Addition

- Keep and maintain coal and AQCS capabilities
  - Full-time,
  - Or via supplemental workforce when needed

Other Considerations

Start up time – Idle to Full Load

- Coal Steam Cycle – 2 days, nominally
- Gas Steam Cycle – 1 day, nominally
- Simple Cycle – less than an hour, nominally

Fuel Flexibility/Natural Gas Curtailment

- Should coal-firing capability be maintained versus a gas conversion?
- Staffing – how are coal yard; mill maintenance and AQSC (scrubber/precipitator/baghouse) operational capabilities maintained?

Emissions and AQCS

- SCR operation
- FGR for NO_X control and/or unit performance
- Permitting
  - Very “local”
  - Repowering typically to new unit levels

Gas Turbine Build Considerations

Tony Gerstenberger, P.E.

- New Gen. and Oversight Eng. Mgr

AMERICAN ELECTRIC POWER

WHAT ABOUT NEW GAS TURBINE BUILDS?

Plan, Plan, Plan!

Aligned to Integrated Resource Plans → Does this still work? Interconnection, Regulatory, OEM Lead Times drive planning 4-6 years ahead of COD

Where?

Site feasibility

What?

Technology and configuration?

How?

Interconnection

With whom?

Construction strategy

Green Country Natural Gas Plant
795MW CCGT, Jenks, OK
– Photo Credit, www.psoklahoma.com

WHAT ABOUT NEW GAS TURBINE BUILDS?

Where?

- Site selection considerations
  - Greenfield vs brownfield
  - Environmental Site Assessment / Critical Issues Analysis
  - Gas and water availability

What?

- Equipment lead times
  - Gas Turbines and GSU – 36-48 months and getting longer
- Technical Options
  - Configuration – SCGT, CCGT 1x1 single/multi-shaft, 2x1, 3x1, F, H, J class
  - Fuel alternatives and environmental contemplation- Fuel Oil, Carbon Capture, Hydrogen
  - Plan for expansion or conversion → SCGT to CCGT
  - Power Augmentation – Evap Cooler, Wet Compression, Duct Firing

Dresden Power Plant
580MW CCGT, Dresden, OH
- Photo Credit, AEP internal photo archive

WHAT ABOUT NEW GAS TURBINE BUILDS?

How?

Interconnection

- Application timeline – Reuse, Expedited, Normal Path
- Station expansion or new build and network upgrades
- Large Load Customer
  - Power Quality
  - Behind Meter?

With Whom?

Labor Strategy

- Multi-prime
- EPC

Solve with creative strategic partnerships?

Build Costs (Installed Cost $/kw)

SCGT - $1000-1100/kw

CCGT - $1500-1700/kw

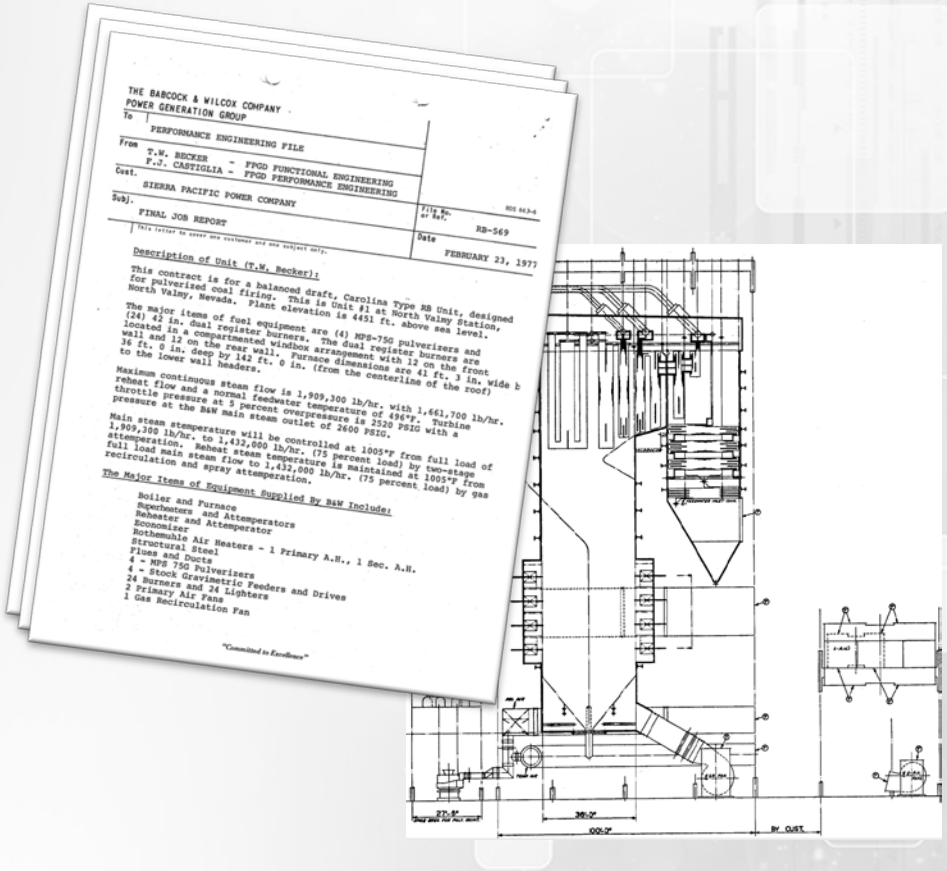
Source - Appalachian Power 2025 Renewable Portfolio Standard Plan

Key Take-Away

- Long lead equipment and activities drive need for planning
  - Strategic Partnerships
  - Creative Contracting
  - Regulatory Pre-approval
- All natural gas options are part of the solution

Technical Considerations in Coal to Natural Gas Conversions

- Coal-fired units were historically designed around a “spec fuel,” but with notable robustness, conservatism and flexibility. In addition, over the years, many have been modified to consider changes in coal and optimize operations.
- The switch from coal to natural gas has these inherent changes in steam generator performance:
  - Lower efficiency/higher firing rates (BTU/hr)
  - Lower flue gas mass flow (no ash or moisture in the fuel)
  - Elimination of fuel-conveying primary air
  - No need for mill-out maintenance considerations (fewer burners)



THE BABCOCK & WILCOX COMPANY
POWER GENERATION GROUP

To PERFORMANCE ENGINEERING FILE

From T.W. BECKER - FPGD FUNCTIONAL ENGINEERING
F.J. CASTIGLIA - FPGD PERFORMANCE ENGINEERING

Cust. SIERRA PACIFIC POWER COMPANY

Subj. FINAL JOB REPORT

File No. or Ref. RB-569

Date FEBRUARY 23, 1977

This letter to cover one customer and one subject only.

Description of Unit (T.W. Becker):

This contract is for a balanced draft, Carolina Type RB Unit, designed for pulverized coal firing. This is Unit #1 at North Valmy Station, North Valmy, Nevada. Plant elevation is 4451 ft. above sea level.

The major items of fuel equipment are (4) MPS-75G pulverizers and (24) 42 in. dual register burners. The dual register burners are located in a compartmented windbox arrangement with 12 on the front wall and 12 on the rear wall. Furnace dimensions are 41 ft. 3 in. Wide b 36 ft. 0 in. deep by 142 ft. 0 in. (from the centerline of the roof) to the lower wall headers.

Maximum continuous steam flow is 1,909,300 lb/hr, with 1,661,700 lb/hr. reheat flow and a normal feedwater temperature of 496°F. Turbine throttle pressure at 5 percent overpressure is 2520 PSIG with a pressure at the B&W main steam outlet of 2600 PSIG.

Main steam stemperature will be controlled at 1005°F from full load of 1,909,300 lb/hr. to 1,432,000 lb/hr. (75 percent load) by two-stage attemperation. Reheat steam temperature is maintained at 1005°F from full load main steam flow to 1,432,000 lb/hr. (75 percent load) by gas recirculation and spray attemperation.

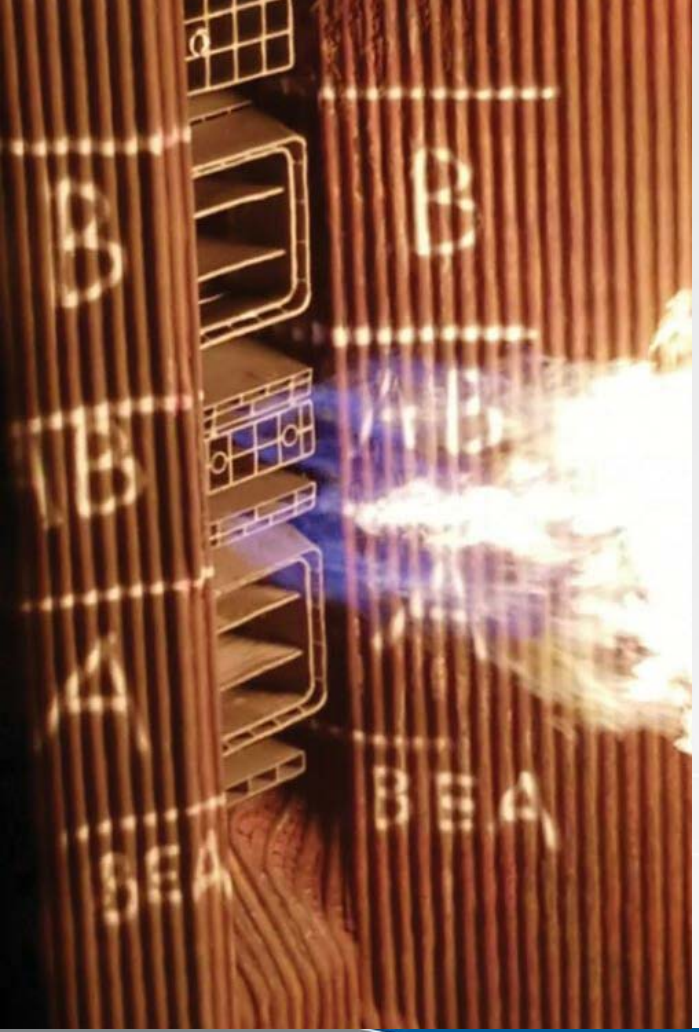
The Major Items of Equipment Supplied By B&W Include:

Boiler and Furnace
Superheaters and Attemperators
Reheater and Attemperator
Economizer
Rothemuhle Air Heaters - 1 Primary A.H., 1 Sec. A.H.
Structural Steel
Flues and Ducts
4 - MPS 75G Pulverizers
4 - Stock Gravimetric Feeders and Drives
24 Burners and 24 Lighters
2 Primary Air Fans
1 Gas Recirculation Fan

"Committed to Excellence"

Technical Considerations in Coal to Natural Gas Conversions

- In many, circumstances, the robustness and conservatism in the coal-fired steam generating unit's design allows for the fuel switch without concerns beyond the addition of combustion equipment, fuel delivery (valve trains) and DCS modifications.
- However, the unit should be evaluated for the following items to provide and effective design arrangement and avoid potential limitations:
  - Cleanliness based on operating data
  - FEGT
  - Burner elevation and number of burners to be converted
  - Convection pass metals
  - FD/ID fan capacity and re-use of primary air
  - Stack Temperature – WFGD quench
  - Hopper-bottom (decommissioned ash handling)
  - Emissions - NOx
    - Existing OFA/convert the upper burner elevation
    - FGR
    - Re-use of existing SCR



Steam Cycle Coal-to-Gas Heat Rate Impacts

- Although natural gas is a lower-CO_2 generating fuel in comparison to coal, it is a less-efficient burning fuel.
  - CH4 – Heat of Vaporization
  - 4% Efficiency Loss, Nominally
- Some of the fuel firing inefficiency can be regained through de-commissioning of parasitic power demands: such as pulverizers, PA fans, and scrubbers.

Summary

	Cost of gas to site	Operations and Maintenance	Capital Cost ($/kW)	Heat Rate (BTU/kWhr)	Idle to Full-Load
GAS ADDITON TO COAL	$3 million to	$$$$	$50 to $200	8000 to 10000	2-days
GAS CONVERSION FROM COAL	$4 million	$$	$50 to $200	9000 to 11000	1-day
SIMPLE CYCLE	per	$	$1,000-$1,100	9500-11000	<1 hour
COMBINED CYCLE	Mile (+)	$$	$1,500-$1,700	6000-7500	< 1 day