Can UCG Give Coal a New Lease on Life in 21st Century?

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The 8th Annual Summit & Expo GASIFICATION INDIA 2017, New Delhi, 6-7 December 2017
Outline

• “Dirty word, four letters across?” (Coal)
• From riches to rags: decline of King Coal
• Is “clean coal” real?
• Can UCG make coal acceptable again?
• Where to start?
That Dirty C#@&

Allegedly:

- Coal is the absolute dirtiest of all energy sources and the greatest contributor to global warming [US DOE]
- Coal-fired power plants are responsible for over 83% of the CO₂ pollution since 1990, and have the highest ratio of CO₂ output per unit of electricity out of all the fossil fuels [US DOE]
- In the U.S., 59% all SOₓ and 18% of all NOₓ emissions causing acid rains come from coal-fired power plants. [US EPA]
- In summer 2010, the EPA proposed regulating coal slurry (also known as coal ash, containing carcinogenic compounds and toxic heavy metals) as hazardous waste. [CATF]
Allegedly:

- Pollution from coal power plants causes ... **30,000 deaths a year** in the US – that’s more than drunken driving, AIDS, or homicides. [CATF]
- “Coal-fired power plants are the largest single man-made source of mercury pollution in the U.S.” [US EPA]

Charges:

- Air pollution (mercury, particulates, acid rains,...)
- Largest carbon emissions
- Ash dams leaching
- Miners’ safety
In North America today:

- Impossible to permit a new coal-fired power plant
- Province of Ontario retired all coal-fired plants, Province of Alberta to follow
- New environmental regulations make it increasingly more difficult and expensive to operate existing coal-fired power plants
- Debilitating competition from cheap oil and natural gas
- Social, regulatory, NGO, community pressure

- Owners retire coal power plants, build natural gas GTCC instead…
- Coal demand is decreasing
- Coal prices are dropping
- Mines are shutting down
From R to R: Coal Price

Plunging Metallurgical Coal
With world awash in the steelmaking ingredient, the benchmark price has tumbled.

$340 metric ton

Sources: Bloomberg Intelligence

Central Appalachia
From R to R: Production & Employment

COAL PRODUCTION PLUMMETS

23% DECREASE

EMPLOYMENT - COAL MINERS

Source: Federal Reserve Bank of St. Louis
From R to R: Blood Bath

Largest U.S. coal producers go bankrupt:
• Peabody Energy (2016)
• Arch Coal (2016)
• Patriot Coal (2015)
• Walter Energy (2015)

Over the past 5 years, the industry has lost 94% of its market value, from $68.6 billion to $4.02 billion.
Is “clean coal” a savior?

- Problems of coal mining remain
- Problems of coal use remain
  - transportation,
  - preparation,
  - processing,
  - ash storage
- Plants are too difficult to run
- Products are not competitive
- Air pollution
- High cost leaves no room for CCS
Can Coal Find a Way to Survival?

“Can’t we just dye the smoke green?”
(The New Yorker, April 2007)
Wouldn’t you want to

- Build on existing coal assets
- Produce clean energy and hydrocarbons
- Keep workers safe
- Prevent air pollution
- Eliminate ash storage
- Compete with natural gas on price
- Implement CCS
- Become the lowest CO₂ producer per unit of energy
UCG & CO₂ Sequestration

Diagram showing the process of UCG (Underground Coal Gasification) and CO₂ sequestration. The diagram includes:
- Air/Oxygen Plant
- Power/Chem. Plant
- CO₂ Capture
- CO₂ Compression
- CO₂ to sequestration
- Injection Well
- Production Well
- Coal
- Underground
- Active Panel
- Depleted Panel
- Gas: N₂, CO, H₂, CH₄, H₂S, CO₂, C₅H₁₀
εUCG vs. Conventional Coal

Underground Coal Gasification
- Overall efficiency: 43%
- CO₂: 330 kg/MWh (67% less)
- Cost: <$30/MWh

Surface Gasification
- Overall efficiency: 21.5%
- CO₂: 766 kg/MWh (24 % less)
- Cost: >$80/MWh

Pulverized Coal
- Overall efficiency: 15%
- CO₂: 1,000 kg/MWh (100%)
- Cost: >$60/MWh
Compare Air Emissions

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Synthesis Products

Raw H₂ → Pressure Swing Adsorption → Ammonia Synthesis → Urea Synthesis → Urea

Clean Syngas → Tailgas → Fischer-Tropsch → LPG, Naphtha, Diesel

1-2 : 1 H₂ to CO → Tailgas

2 : 1 DME & Gasoline Synthesis → DME, Gasoline

2 : 1 Alcohol Synthesis → Methanol, CH₃OH, Ethanol, C₂H₅OH

3 : 1 Methanation → SNG, CH₄

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UCG vs. CG - Electricity

Cost of Electricity, $/MWh Sent-Out

Gulf Area, USA

Source:
EIA report 2016-08-04
Wt. Average 12 months
Wholesale Texas
http://www.eia.gov/energy wholesales

http://www.eia.gov/energywholesale/
Cost of Urea, $/metric tonne

**For Gulf Area, USA**

- **UCG**: $132
- **CG**: $237
- **CG(M)**: $220

*Source: [http://www.indexmundi.com/commodities/?commodity=urea](http://www.indexmundi.com/commodities/?commodity=urea)*)
• Large-scale coal mining technology (over 0.3 MT/a)
• Incorporates rock deformation and ground water influx
• Injects oxygen, air, H$_2$O, CO$_2$ etc.
• Drilling of directional, inclined, vertical and other wells
• Modern technology based on 70+ years of Soviet work
• Optimized for great depth coal/lignite deposits
• Applied in the USA, Canada, New Zealand, South Africa, Australia, China, India etc.