“Eastman Perspective on Gasification Technology Deployment”

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Director, Energy Policy Development
Eastman Chemical Company
Eastman's Gasification Facility – Kingsport, TN

- Longest continuously producing U.S. coal gasification facility (1983)
- Over 26 years of scientific, engineering, and operational expertise
- Worldwide reputation for outstanding operational performance
Eastman Chemical Company
A Pioneer in Industrial Gasification

- Longest continuously running U.S. gasification facility (Kingsport, TN)
- Best-in-Class Operating Performance

Eastman Gasifier Availability *

Three-Year Cycle (Jan 2007 - Jan 2010) including planned shutdown

[ * Overall Availability of Clean Syngas ]

On-Stream 98.1 %

Estimated single train availability would be 88% - 90%

Best-In-Class Performance

Industry Start-up History

Industry Range of Performance For Others


Eastman Syngas Production Rate

Relative Syngas Annual Output

Eastman – A Leader/Partner with DOE in RDD&D of Advanced Gasification Technologies

- **Air Products/Eastman liquid-phase methanol**
  - Potential for polygeneration of methanol and power
  - Commercial demo (operational since 1997; > 300t/d)

- **RTI/Eastman warm syngas cleanup pilot plant**
  - Comparison of RTI/Eastman warm syngas clean-up technologies with conventional syngas clean-up technologies performed by Nexant:
    - 600 MW case study
    - Increases efficiency by 3.6 points HHV
    - Dispatches 56 MWe more power
    - Reduces CAPEX by $264/KW
    - Reduces COE by 0.69 ¢/kwh

- **Albany Research Center advanced refractory**
- **Syntroleum Co-based F-T process**
- **Volatile mercury removal**
- **Others (pending)**
Eastman Gasification R&D Capabilities

- Feedstock Lab
- Coal
- Coal Analyzer
- Air-water test stand
- Slurry
- H₂O
- ASU
- Low Temp Gas Cooling
- Sour Shift
- Hg Removal
- Low Temp Gas Cooling
- Sulfur Recovery (Claus/Scot)
- Particulate Scrubber
- Raw Syngas Pilot
- Slurry
- Slag/Frit
- Lock Hopper
- Coal Gasifier GE
- Quench Gasifier GE
- Fines/Char
- Dynamic simulation (under development)
- Syngas MeOH
- Acetyl
- CO/H₂ Separation
- H₂
- CO
- CO/H₂
- Dynamic simulation (under development)
Eastman Perspective on Deploying Gasification

- Eastman is **uniquely qualified** to represent the requirements and challenges of the gasification industry.

- Future deployment of gasification in the U.S. will require two drivers:
  
  - Deployment of current gasification technologies in today’s economic environment will require a coordinated and substantial **new national CCS early deployment initiative**.
  
  - To be sustainable in the long-term, the capital and operating costs of gasification must be reduced significantly, requiring an **active RDD&D program to demonstrate an integration of new advanced gasification technologies**.
The current business environment creates a number of very difficult barriers to successfully achieving desired goals ("Valley of Death")

- High capital costs (steep escalation from 2006-2008 and little softening since 2008)
- Uncertain regulatory and liability environment (federal and state)
- Lack of adequate carbon infrastructure and markets at scale
- Strained and volatile commodity markets
- Stressed economy
Little progress can be made for gasification and CCS without a new incentives approach

While a number of incentive programs exist, they are not structured to collectively select and enable projects that advance specific goals and have a high probability of success.

Current incentives are contained in multiple silos with:

- Limited budgets
- Independent selection processes (Treasury, DOE-FE, DOE-FLG, …)
- Different and competing timeframes for decision and implementation
- Allocation across a blending of project development states
- In some cases, lack of certainty for future funding
- Apparent desire by government to spread incentives to a number of projects and locations
Current incentive structures create a scenario where projects all compete for every incentive

- They do not allow a coherent, business-like process for advancing technology deployment.
- In most, if not all, cases the portions of incentives received do not individually enable the project.
- Significant allocations of incentives are locked up for extended periods by projects that are unlikely to move forward.

Together with the private sector, governments should address the financial gaps and risks facing early CCS projects, recognizing that market mechanisms alone will not be sufficient for the early deployment of CCS.”

International Energy Agency
The Administration’s carbon management goals could best be served by a new coordinated national CCS Early Deployment Initiative

Key Features of a National CCS Deployment Initiative:

- Central coordination
- Goals aligned with a roadmap for results
- Selection of a group of projects (perhaps 10 or so) that will advance specific goals and have the highest probability of success
- Bundled incentives with adequate levels of support
- A portfolio/pipeline mechanism for supporting projects through different phases and risk profiles
- Potentially addressable by the President’s Interagency Task Force on CCS and/or by incentives proposed in various energy and climate change bills (if properly structured and implemented)

“The G8 must act now to commit to at least 20 fully integrated industrial-scale demonstration projects by 2010.”

International Energy Agency

“The (Interagency CCS) Task Force shall develop … a proposed plan to overcome the barriers to the widespread, cost-effective deployment of CCS within 10 years, with a goal of bringing 5 to 10 commercial demonstration projects online by 2016.”

President Barack Obama
The benefits of a National CCS Early Deployment Initiative far outweigh the costs

**Benefits:**

- Efficient use of Federal funds
- Enhanced likelihood of successful outcomes – risk reduced for subsequent projects
- Earlier deployment results
- Earlier pathway to policy development
- Foundation for U.S. leadership for international CCS efforts

“There is an urgent need for governments to bring forward a range of regulatory and market-based policies to create a clear, predictable, long-term framework to promote CO₂ reductions across all sectors”

International Energy Agency
Energy Technology Perspectives Scenarios and Strategies to 2050
Building a Sustainable Gasification Model

- Current gasification technologies are **beneficial as low-carbon solutions** and have advantages over other coal-based technologies when CCS is required.

- Current gasification technologies **may not be viable** (without continued incentives) for applications in which added CCS costs cannot be passed through to the consumer.

- Thus, **adequate incentives for first-generation projects are a necessary first step** in gasification technology deployment.

- Longer term, **advanced gasification technologies should be developed, demonstrated, and deployed** to significantly reduce overall costs and enable a **sustainable model** for commercial use of coal and other domestic feedstocks.
How to Reduce Gasification Costs?

To make significant change, all major elements of cost must be addressed.

The process:

Gasification: Partial Combustion, Quench, Ratio Adjustment

Coal/Petcoke

Oxygen Supply

AGR PROCESSES

CO$_2$ Removal

Sulfur Removal

Clean Syngas

CO$_2$ Compression

Sulfur Recovery

ASU

ISBL Equivalent Capital Costs

2:1 Syngas

Each step is a key contributor

Coal/Pet Coke

Gasification

CO$_2$ Compression

SRU/TGTU

Shift Reactor

Cooling Train

AGR

ASU
Eastman Study of Next-Gen Gasification Technologies

18-month Study of Advanced Gasification Technologies Available to Deploy in the Next 5-7 Years

- Collect useful technologies from the literature
  - commercialized as well as academic/developing technologies
  - non-confidential data provided by developers, plus Eastman insight
- Innovate additional options that might meet our objectives
- Screen options for viability (1st pass)
  - Bankability
  - Technical feasibility
  - Business feasibility
  - Potential economic impact
- Heat and material balances (2nd pass)
- Analyze remainder via techno-economic models

**Assumptions**
- 2009 forecasts
- FOB plants
- CO$_2$ captured for no value
- Syngas delivered to gate

**Outputs Analyzed**
- Delivered syngas cost
- Capital cost
- Energy/carbon efficiency
Advanced Technology Options for Eastman Study

- **Feeds**
  - Multiple sources considered
    - (various rank coals, refinery by-products such as petcoke, and biomass)
  - 6 feedstocks modeled

- **Gasifiers**
  - Over 30 reviewed
  - 10 were modeled

- **Acid Gas Removal & Sulfur Recovery Units**
  - Over 90 reviewed
  - 11 were modeled

- **Other Technology Components**
  - Feed Systems
  - Compressors
  - Oxygen Supply
  - Alternatives such as chemical looping, hydrogasification, pyrolysis, underground coal gasification
Eastman Study Results

Syngas Cost vs Gasifier-Fuel Combination and AGR Technology
FOB Plant — 3+1 Scale

TOTAL CASES = 23 (feed/gasifier) x 32 (AGR/SR) = 736
Eastman Study - Key Findings

Studied 4 industrial projects in 3 locations

- **Capital Cost** reduced 20 to 35%
- **Operating Expense** reduced 8 to 30%
- **IRR improved** 600 to 750 basis pts
- More projects now economically viable
- These improvements are greater than benefits from current incentive programs, i.e. *sustainable model*. 
IGCC Case Studies – Technology Impact

- Feed is ILL #6
- Nominal 665 MW gross power
- Includes advanced hydrogen turbine designs (public information) but not the most advanced hydrogen turbine designs now being proposed

<table>
<thead>
<tr>
<th>Metric</th>
<th>IGCC(^1) without CO(_2) Capture</th>
<th>IGCC(^1) with 85% CO(_2) Capture</th>
<th>Advanced Technology Case with 97% CO(_2) Capture</th>
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<tbody>
<tr>
<td>Capital Cost</td>
<td>base</td>
<td>+37%</td>
<td>-6%</td>
</tr>
<tr>
<td>Net Power</td>
<td>base</td>
<td>-12%</td>
<td>+5%</td>
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<tr>
<td>Levelized Power Cost</td>
<td>base</td>
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<td>-16%</td>
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<tr>
<td>Coal Used &amp; CO(_2) Produced</td>
<td>base</td>
<td>0%</td>
<td>-16%</td>
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<tr>
<td>Oxygen Required</td>
<td>base</td>
<td>0%</td>
<td>-31%</td>
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\(^1\) IGCC gasification with conventional slurry-fed gasifier using Amine/Claus/SCOT and no capture as base case
Similar NETL Study (2009 GTC Presentation)

Advanced Technology Progression

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<th>Technology Advancements</th>
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<td><strong>Coal Feed System</strong></td>
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<td>Slurry Feed</td>
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<td>Dry Coal Feed Pump</td>
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<td><strong>Oxygen Production</strong></td>
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<td>Cryogenic Air Separation</td>
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<td>Ion Transport Membrane</td>
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<td><strong>Gas Cleanup</strong></td>
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<td><strong>H₂ Turbine</strong></td>
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<td>90%</td>
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NETL Study (2009 GTC presentation)

**Advanced Technologies Pathway**

- Advanced technologies introduced in approximate order of development
- Evaluate cumulative COE benefits over time

![Graph showing the development of advanced technologies over time](image)
Achieving the NETL Goals…

Advanced Technologies Pathway

- Advanced technologies introduced in approximate order of development
- Evaluate cumulative COE benefits over time

Fewer Steps
Integrated Demo

Approximate development of advanced technologies over time

NATIONAL ENERGY TECHNOLOGY LABORATORY
NETL Study (2009 GTC presentation)

Conclusions

Advanced technologies offer pathway to CCS at significantly lower cost and better performance than conventional IGCC with CCS

♦ 8 percentage points improvement in efficiency
♦ > 30% ($800/kW) reduction in total plant cost
♦ > 30% (3.3 ¢/kWh) reduction in levelized COE

EASTMAN independent analysis estimates:

♦ >40% reduction in total plant cost
♦ >36% reduction in levelized COE
Accelerated Timeline for Advanced Gasification

- Advanced gasification technologies can enable significant (40+%) cost reductions and should be aggressively supported through a well-structured RDD&D program and adequate incentives.

- An integrated demonstration of these advanced gasification technologies could accelerate the overall commercial deployment timeline for these advanced technologies by a decade or more.

- An accelerated timeline for advanced gasification technologies can enable achievement of DOE’s clean coal program objectives much faster and at considerably less cost to the taxpayer.
Conclusions

- Deployment of current gasification technologies in today’s economic environment will require a coordinated and substantial **new national CCS early deployment initiative**.

- Advanced gasification technologies have potential to reduce capital and operating costs of gasification significantly (*game changer*) and should be supported by an aggressive RDD&D program to demonstrate an integration of the most promising technologies.
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Questions and Discussion