Understanding World Natural Gas Markets and Investments

Presented by

ArrowHead Economics

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• Employment History
  – Employee #70 at legendary Xerox PARC (1972-4).
  – Stanford Research Institute, Decision Analysis Group (1974-7).
  – Co-founded and built Decision Focus Inc. (DFI) into $25 million (sales) company (1977-95).
  – Co-founded four new companies (1996-09)
    • Altos Management Partners (management consulting)
    • MarketPoint Inc. (enterprise software)
    • Reticle Inc. (high surface area carbon, water deionization/desalination)
    • Ferritech Inc. (biotechnology/ferric oxidation)
  – Sold Altos and MarketPoint (2011)
  – Founded ArrowHead Economics LLC, software and consulting (2013)

• Stanford (https://msande.stanford.edu/person/dale-nesbitt)
EIA: Thank You for This Topic

- There are so many issues at play today that you need an economic model to keep track of them.
  - There is no hope without it
  - The human brain (and spreadsheets and LPs) are incapable
ArrowHead Offers an Integrated, Interconnected World Hydrocarbon Model

Renewables

\[ \text{CO}_2 \]

Segmented/Regional Demand and Consumption

<table>
<thead>
<tr>
<th>Refined products</th>
<th>Petrochemicals</th>
<th>Gas</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGOM</td>
<td>AGPM</td>
<td></td>
</tr>
<tr>
<td>Crude</td>
<td>Condensate</td>
<td></td>
</tr>
<tr>
<td></td>
<td>NGL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Separation</td>
<td></td>
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<tr>
<td></td>
<td>Pipe</td>
<td></td>
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</tbody>
</table>

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Global, Integrated Model Is Required To Answer Questions

• Oil, condensate, NGL (Y-grade), and gas are produced jointly, meaning interdependent prices, investment, and demand.

• Oil on gas competition has re-emerged, exacerbating this.

• CO2 tax and policy connects them all together

• Renewables and policy connect them all together
The Resource Spans All Fuels Everywhere in the World

The economist Ramsey told us how to model this—we do it!
Each Constituent Model Has Full World Regionality

North America
- Canada
- United States
- Mexico

Europe
- NW Europe
- Scandnia
- SE Europe
- SW Europe
- East Europe

FSU
- Russia
- Western FSU
- Russia
- Caspian

Europe
- NW Europe
- Scandnia
- SE Europe

Asia
- China
- Japan
- S. Korea
- Taiwan
- Philippine
- Other Asia

Latin America
- North Latin America
- Brazil
- South Latin America

Africa

Middle East
- Medit
- Iran
- Saudi Arabia
- Qatar
- Oman
- Yemen

Australia

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Supply-Transport-Demand-Inflow-Outflow Detailed in Every Region/Subregion
You Can’t Understand CO2 Without It

Oil and gas companies need to show that they reduce Scope 3. EIA needs to calculate Scope 1, 2, plus 3 throughout the world. That’s the externality.

- **Scope 1**: Direct emissions from owned or controlled sources. 2%
- **Scope 2**: Indirect emissions from the generation of purchased energy. 0.2%
- **Scope 3**: Indirect emissions that occur in value chain, including emissions upstream and downstream. 97.8%

My owned assets

Stuff I buy

Everybody else
### Pounds of CO2 Emitted per MMBtu of Fuel (EIA Has Done the Hard Work!)

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>CO2 Emitted (lbs/MMBtu)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal (anthracite)</td>
<td>228.6</td>
</tr>
<tr>
<td>Coal (bituminous)</td>
<td>205.7</td>
</tr>
<tr>
<td>Coal (lignite)</td>
<td>215.4</td>
</tr>
<tr>
<td>Coal (subbituminous)</td>
<td>214.3</td>
</tr>
<tr>
<td>Diesel fuel and heating oil</td>
<td>161.3</td>
</tr>
<tr>
<td>Gasoline (without ethanol)</td>
<td>157.2</td>
</tr>
<tr>
<td>Propane</td>
<td>139.0</td>
</tr>
<tr>
<td>Natural gas</td>
<td>117.0</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>0</td>
</tr>
</tbody>
</table>

You have to know how to use this! Here’s how.
How Do You Use EIA Information to Do It?

Example: Every element of the electricity supply chain produces CO2 along the way.
Get the Thermal and Emissions Accounting for Every Node

- MWh output
- Heat Rate
- Pollution Coefficients
- Fuel
- SO₂ Emission
- NOₓ Emission
- Hg Emission
- CO₂ Emission
We Do the Thermo and Stoichiometry on Every Element of Every Supply Chain

Thermal Balance Along the Gas-Power Generation Supply Chain

Point of combustion

Demand

End Use Conversion

Transmission

Generation

Fuel Transmission

Field Processing

Gas Supply in the Field
Operates Worldwide Over the Cloud (AWS)

Your Computer

Browser

Network Data

Cloud Server (Computation Horsepower)

Results Visualizations
Open Access Source Code

• Open access source code for economic logic.
  – Customers can write (and share) economic source code, putting theirs into a library for any or all to see and use or develop.
  – Code must be compilable and should be fast.

• ArrowHead also offers proprietary economic logic.
  – No one is compelled to use non-accessible logic
  – Users can switch
What Are We Learning?

Summary rather than detailed model results

Seventeen points I will choose from
1. Gas and Liquids Have Become Substitutes Again

- Rail (LNG versus diesel)
- Off-road heavy-duty vehicles (dump trucks in mines)
- On-road heavy duty vehicles (e.g., long distance haulage on TransCanada Highway, Interstate-80)
- Intra-continental shipping (LNG versus diesel)
- Inter-continental shipping (LNG versus HS bunker versus LS bunker versus diesel versus refinery hydrogenation)
- CNG in buses and light duty vehicles
- Electric vehicles, which can come from gas
- Hydrogen generation (which used to come from methane or from the “water gas reaction” but now promises to come from electrolytic decomposition of water)
- Industrial substitution in other regions around the world that actually do have an industrial sector
Gas demand is going to continue to rise in the non generation sector.
Relative prices and investments are going to change a lot.
CO2 emissions are going to drop.
17 More Prospective Substantive Points Being Finalized and Prioritized Today

I will select only a subset of the most important points
Thank You

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