MODELING THE IMPACT ON ASIA OF THE DEVELOPING GLOBAL NATURAL GAS MARKET

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with the support of the Global Oil and Gas practice of Navigant Consulting, Inc.

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PRESENTATION OVERVIEW

• **Global Market Overview**
  - What is changing in the global market for natural gas?
  - Who are the key players?
  - Who are the challengers?
  - What are the target markets?

• **G2M2: The Global Gas Market Model**
  - What was the development strategy?
  - What economic principles are used?
  - What is its scope?
  - What data sources does it use?
  - How was it designed?

• **Study Purpose and Results**
WHAT IS CHANGING IN GLOBAL GAS?

• The dynamics of natural gas and LNG are going through a major shift
  
  • Prices have declined - dramatically
  
  • The market position of incumbents is impacted – perhaps eroding
  
  • New challenges and challengers have arisen
  
  • Uncertainty has increased for prized markets and for supply
THE INCUMBENTS

- **Pipeline Gas**
  - Russia
  - Norway
  - Turkmenistan
  - Algeria

- **LNG**
  - The Middle East
  - North and West Africa
  - Malaysia, Indonesia, and Australia
THE CHALLENGERS

• **Pipeline Gas**
  - Russia – to Asia?
  - Azerbaijan – to Europe?
  - Turkmenistan – to Europe?
  - Iraq – to Europe?
  - Iran – to South Asia? to Europe?
  - Eastern Med (Israel, Egypt, Cyprus) – to Turkey? to Europe?

• **LNG**
  - Australia (major new projects)
  - North America (USA and Canada)
  - East Africa (Mozambique, Tanzania)
  - Middle East – North Africa (Iran, Egypt)
WHAT’S THE PRIZE?

• **Market growth** in Asia
  • China
  • India
  • Pakistan
  • Southeast Asia

• **Market share** in Europe

• **New growth markets**
  • Africa
  • The Middle East
  • South America
HOW WILL THIS GAME TURN OUT?

• **Vast sums are being spent** to create the energy world of the upcoming decades

• **Incumbent positions** are not guaranteed

• **Challengers** are poised to fight for existing and newly forming markets

• **Robust evaluation** of investment proposals and opportunities is a must!
  • That is what G2M2 is designed to help you do
G2M2 DEVELOPMENT STRATEGY

- Experienced and knowledgeable team
  - RBAC, Inc.
    - Model design, development, and testing
    - Database design
    - System integration
  - Navigant Consulting, Inc.
    - Model requirements specification
    - Identification of key market factors
    - Data compilation, evaluation, and integration
    - Reality check: do model results make real market sense?

- Use workable principles from prior successes
  - GPCM North American Natural Gas Modeling System
G2M2 ECONOMIC MODEL

- **Version 1.0: Competitive market approximation**
  - Enhanced Spatial Equilibrium Model (Samuelson)
  - Non-linear supply, demand, and transport curves
  - LNG contracts modeled as take-or-pay with limited-flexibility delivery schedules
  - Approximations permit LP or QP solution

- **Version 2.0: Mixed market model using MCP**
  - First, reformulate model using KKT conditions
  - Then, replace complementarity conditions for entities with ability to exert market power
  - Use PATH solver in place of Gurobi (LP/QP/MIP)
G2M2 SCOPE

- **Monthly time frame:** permits modeling of seasonality
- **Scenario forecast horizon:** from now to 2050
  - Can “back-cast” from 2006 to now
- **Coverage:** more than 100 countries represented
  - All natural gas producing and / or consuming countries
  - All LNG exporting and / or importing countries
  - Large markets divided into sub-country areas
    - USA -> Census Regions
    - Canada, Mexico, Russia -> East and West
- **Nearly 400 gas pipelines:** existing and proposed
- **Multiple LNG tankers classes**
  - Q-Max, Q-Flex, conventional grouped by size
G2M2 DATA SOURCES

- International Group of Liquefied Natural Gas Imports (GIIGNL)
- International Gas Union (IGU)
- Gas Infrastructure Europe (GIE)
- U.S. Energy Information Agency (EIA)
- U.S. Federal Energy Regulatory Commission (FERC)
- U.S. Department of Energy (DOE)
- Canada National Energy Board (NEB)
- LNG Journal
- LNG Company websites
- Panama Canal Authority (ACP)
- Suez Canal Authority (SCA)
- Timera Energy
- BP Statistical Review 2007-2014
- International Energy Agency (IEA)
- Joint Organizations Data Initiative (JODI)
- European Network of Transmission System Operators for Gas (ENTSOG)
- East European Gas Analysis (EEGA)
- Gazprom and other company websites
DESIGN METHODOLOGY

• **Construct the conceptual design**
  • Simple node, arc network models

• **Write the model using AMPL modeling language**
  • Supply and demand equations
  • Gas flow: node balance equations (spatial / temporal), pipeline inputs, flows, outputs
  • LNG flow: production, shipping (spot/contract), transportation cost functions, regasification

• **Programmatically create the application**
  • Create the required I/O tables in a relational database
  • Create the user interface for the application
  • Create test problems to debug the model

• **Test, iterate and refine the model**
  • Run test problems and examine the results
  • Modify AMPL code, re-create application, run tests, and analyze results until the model is working exactly as desired
G2M2 INTER-GPU PIPELINE MODEL

Pipe A deliveries to GPU 2
Segment 1 (Pipe A)
Pipe A deliveries to GPU 3
Segment 2 (Pipe A)
Pipe A deliveries to GPU 4
Segment 3 (Pipe A)
Pipe A deliveries to GPU N
Segment N (Pipe B)

Pipe Link 1-2
Pipe Link 2-3
Pipe Link 2-4
Pipe Intx

Pipe A receipts from GPU 1
G2M2 LNG FLOW MODEL

Liquefaction / Export Region (GPU 1)

1

LNG Tanker Shipment from 1 to 2

LNG Tanker Shipment from 1 to 3

LNG Tanker diversion from 3 to 2

2 Import Region (GPU 2)

3 Import Region (GPU 3)
Day Rate ($/day) is function of tanker utilization:

\[ A + B \times U / (1 - U) \]

Example shows Day Rate Multiplier for \( A = 1, B = 0.5 \).
PURPOSE OF THIS STUDY

• Forecast the effect of additional pipeline gas supply on the NE Asian market using the G2M2 modeling system

• Scenario Assumptions
  • **Base Supply Case** includes pipelines in-service as of 2015 plus Power of Siberia and Central Asia Pipeline Line D (to China); Turkish Stream and Southern Gas Corridor (Caspian to Europe)
  • **Low Supply Case** excludes Power of Siberia from the Base Supply Case
  • **High Supply Case** adds Power of Siberia 2 and Nord Stream 2
  • **Russian production capacity:**
    • +60 BCM in High Supply Case, -40 in Low Supply Case
  • **LNG Supply**
    • All cases include known contracts as of 2015
    • Uncontracted capacity available to short-term or spot market
## Scenario Definitions

<table>
<thead>
<tr>
<th>Pipelines / Supply</th>
<th>Base</th>
<th>High</th>
<th>Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power of Siberia (38 BCM)</td>
<td>&gt;2019</td>
<td>&gt;2019</td>
<td>X</td>
</tr>
<tr>
<td>Power of Siberia 2 (30 BCM)</td>
<td>X</td>
<td>&gt;2021</td>
<td>X</td>
</tr>
<tr>
<td>Nord Stream 2 (55 BCM)</td>
<td>X</td>
<td>&gt;2019</td>
<td>X</td>
</tr>
<tr>
<td>Russian prod cap (BCM)</td>
<td>~700</td>
<td>+60</td>
<td>-40</td>
</tr>
</tbody>
</table>
POWER OF SIBERIA PIPELINE

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POWER OF SIBERIA 2 PIPELINE
NORD STREAM 2 PIPELINE
STUDY QUESTIONS

• How well can gas from Russia and Central Asia compete with LNG for a share in the NE Asia imports market?

• When will new pipelines such as Power of Siberia be needed by this market?

• Which LNG producing regions will be most competitive in this market?

• What will be the effect on prices of new Russian supply into NE Asia?

• What is the sensitivity of imports to cost of new pipeline gas?
NE ASIA PIPELINE IMPORTS (BCM)
NE ASIA LNG IMPORTS (BCM)
TOTAL NE ASIA IMPORTS (BCM)
NE ASIA PIPE IMPORTS HIGH CASE (BCM)
NE ASIA LNG SOURCES – HIGH CASE (BCM)
NE ASIA LNG SOURCES – BASE TO HIGH (BCM)
MARGINAL PRICE INTO CHINA ($/1000 M³)
NE ASIA PIPE IMPORTS (BCM)
NE ASIA LNG IMPORTS (BCM)
**TAKEAWAYS FROM THE STUDY**

- Imports into Northeast Asia will grow by as much as 60% over the next 25 years
  - LNG will provide the majority of the growth in the first 15 years
  - The fastest growing suppliers of LNG will be North America and FSU

- Power of Siberia, Power of Siberia 2, and Central Asia Line D will have a hard time competing against LNG between now and 2030

- However, pipeline gas from Russia and Turkmenistan will be required to satisfy additional growth between 2030 and 2040

- Prices in NE Asia will begin to rise in 2020 and continue to rise throughout the forecast horizon to 2040
  - But Russian and Turkmen pipeline gas will help to stabilize prices 2030-2040

- Lower cost pipeline gas could compete against LNG 2-3 years earlier
THANK YOU!

QUESTIONS?
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ABOUT RBAC INC.

RBAC Inc. develops and licenses economic forecasting tools for management decision support systems for the energy industry, as well as State and Federal government agencies involved with Energy, Transportation and the Environment. RBAC’s principal products include the industry standard GPCM Natural Gas Market Forecasting System®, including the GPCM® Base Case Database for North America and GPCM Viewpoints on Natural Gas®.

We continuously work to improve our modeling tools through the development and regularly released updates, based on client requests and energy industry needs. Those client and industry needs led to the development of RBAC’s North American Natural Gas Liquids Model (NGL-NA™) and GPCM Daily™.

Additional forecasting tools scheduled for release include:

- NGL-NA for MS-SQL®
- G2M2™ Global Gas Market Modeling System™
- GPCM for MS-SQL®
- GLNG™ Global LNG Modeling System™

Future projects also include detailed modeling tools similar to GPCM for major regional markets such as Europe and Asia.

Licensees of RBAC’s systems include medium to large size corporations in natural gas exploration and production, LNG infrastructure development and marketing, natural gas marketing and transportation, electric power generation, natural gas distribution, and commodities trading, as well as most of the major consulting firms that service business and planning needs of the energy industry and its bankers.

RBAC Inc. was founded in 1987 by Dr. Robert Brooks, who developed the foundation of RBAC’s core business through his doctoral research in natural gas transportation economics at MIT. Building these types of tools for forecasting prices, basis, and flows in the global energy market is the core of RBAC’s business. The company employs experts in energy supply and demand for natural gas, NGL’s as well as LNG and their transportation and storage. RBAC staff and associates have extensive expertise in software engineering, mathematical algorithm development, database design and implementation, mathematical modeling and statistical analysis.