Outline Day 1

• Introduction
  – Overview of energy value chains - oil and gas systems in overall context
  – Key issues impacting global energy and trade flows – National Petroleum Council Global Oil and Gas Study
  – National Oil Companies
  – Commodity vs physical markets

• Upstream issues
  – Trends - North America, worldwide
  – Identification of key risks, uncertainties
  – Upstream investment decision considerations
  – Heavy oil resource case study - technology and optimization
Outline Day 2

• Midstream/downstream commercialization
  – Trends - North America, worldwide (oil v gas)
  – Pipeline economics and cost model
  – Refining economics and issues
  – LNG value chain
  – Gas and power business models

• Workshop Problem, Conclusions
  – Business integration models and asset/enterprise valuation

Generic Value Chain Concepts

Overview of Fundamentals
**What is a “Value Chain?”**

- The process of linking specific functions from input through output to delivery, enhancing the economic value of the final product
- Related concepts – “supply chain” “business system,” “industry system”
- The challenge – building value chains around dynamic commodity markets that require fixed infrastructure for physical delivery and “liquidity” for price risk management

**Generic Value Chain**

Source: Porter, 1985
How Thinking Has Changed, I

Traditional Value Chain: Starts with core competencies

Customer Priorities

Modern Value Chain: Starts with the customer

Source: Porter, 1985

How Thinking Has Changed, II

Source: McKinsey & Company

EXHIBIT 5

The value delivery system vs. the traditional model

Traditional product-oriented system

Create the product

Make the product

Sell the product

Value delivery system

Choose the value

Provide the value

Communicate the value to the customer

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Energy Value Chain Issues

Linkages and Key Considerations

---

Human Resource Management with Capital Intensity

Source: McKinsey & Company

<table>
<thead>
<tr>
<th>Country</th>
<th>Productivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>5.9</td>
</tr>
<tr>
<td>Japan</td>
<td>5.6</td>
</tr>
<tr>
<td>Canada</td>
<td>4.6</td>
</tr>
<tr>
<td>Belgium</td>
<td>4.0</td>
</tr>
<tr>
<td>New Zealand</td>
<td>3.2</td>
</tr>
<tr>
<td>France</td>
<td>3.1</td>
</tr>
<tr>
<td>Spain</td>
<td>3.0</td>
</tr>
<tr>
<td>Netherlands</td>
<td>2.6</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>2.3</td>
</tr>
<tr>
<td>Australia</td>
<td>2.2</td>
</tr>
<tr>
<td>Germany</td>
<td>2.1</td>
</tr>
<tr>
<td>Mexico</td>
<td>1.2</td>
</tr>
<tr>
<td>Portugal</td>
<td>1.1</td>
</tr>
<tr>
<td>Greece</td>
<td>1.0</td>
</tr>
<tr>
<td>China</td>
<td>0.6</td>
</tr>
<tr>
<td>India</td>
<td>0.2</td>
</tr>
</tbody>
</table>

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Derivation of Basis Risk

“Basis”
- Differential between cash/spot and nearest futures price as a result of time, product forms, quality, location

“Basis risk”:
- Uncertainty as to whether differential will widen or narrow

Balancing the Market

“Mean reversion” is a reality if market-clearing participants exist
Mean Reversion: Oil Price Example

Price Volatility and Risk Trade Offs with Competition: Open Access Example

Commodity price risk flows

E&P  Pipelines  LDCs  End Users  Power

Capacity price risk flows

Risk accepting entities
Mechanisms to Manage Price Risk

- Trading in futures contracts
- Long-term contracts
- Fixed-price contracts
- Storage for physicals hedging
- Ability to use alternate fuels; efficiency; conservation
- Allow residential customers to choose budget payment plans; energy service contracts for commercial and industrial customers
- Develop mechanisms for capacity risk

Global Oil Market Illustration

Source: Oil in Asia by Paul Horsnell, 1997, Oxford Institute for Energy Studies
Industry Organization: Does Vertical Integration Make Sense?

Source: McKinsey & Company

Vertically integrated pricing behavior

<table>
<thead>
<tr>
<th></th>
<th>Non-integrated</th>
<th>Integrated</th>
</tr>
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<tbody>
<tr>
<td>Upstream costs</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Upstream profit</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Market price for</td>
<td>65</td>
<td>65</td>
</tr>
<tr>
<td>upstream product</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discount to downstream</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>Price paid by downstream</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>Other downstream costs</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>Downstream profit</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Sale price to customer</td>
<td>110</td>
<td>100</td>
</tr>
</tbody>
</table>
| Customer surplus      | 20            | 30         | "Windfall"

"Value in use" to customer

130

130
### Energy Value Add Comparison with Other Industries

#### Channel value-added

<table>
<thead>
<tr>
<th>Industry</th>
<th>Percent of retail price (estimated)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automobiles</td>
<td>15</td>
</tr>
<tr>
<td>Software</td>
<td>25</td>
</tr>
<tr>
<td>Gasoline</td>
<td>28</td>
</tr>
<tr>
<td>Laser printers, fax machines</td>
<td>40</td>
</tr>
<tr>
<td>Packaged food</td>
<td>41</td>
</tr>
<tr>
<td>Channel value-added</td>
<td>40</td>
</tr>
<tr>
<td>Manufacturer value-added</td>
<td>65</td>
</tr>
<tr>
<td>Raw materials/components</td>
<td>53</td>
</tr>
<tr>
<td>Source: Food Cost Review; Lundsberg, Platt; Economist Intelligence Unit; McKinsey analysis</td>
<td></td>
</tr>
</tbody>
</table>

### Derivation of Market Power

- **Production**
  - Monopoly producer
  - Barriers to entry, exit
- **Transportation**
  - Technical economies of scale(?)
  - Natural monopoly systems
  - Barriers to entry, access
- **Distribution**
  - Monopsony buyer
  - Barriers to entry, exit
**Energy Investment Context**

- **DEMOCRACY**
- **INTERNET**
- **ECONOMIC & SOCIAL POLICY**
- **GLOBALIZATION**
- **OIL PRICE**
- **PRIVATISATION**
- **DECENTRALISATION OF POWER**
- **WORLD ECONOMY**
- **INVESTOR**
- **HOST GOVERNMENT**
- **Int'l NGO's**
- **Media**
- **Local NGO's**
- **Competition**
- **MLA's**
- **Local Business**

*From: Fred Gibson, Building Investment Frameworks, 2004 CEE New Era*

---

**What is “Smart Development”?**

- A strategy for improving the risk/reward relationships inherent in doing business
- Consistently optimize benefits of energy project investment for all stakeholders
- Focus on actions that can expand capacity building to strengthen institutional development and public support
Energy Value Chain and Example SD Issues

Production → Transport → Distribution → Conversion → End Use

- Access for private investment
- Rights of way and lands ownership
- Environmental impacts
- Transparency
  - Allocation of economic rents and revenue management
- Local content
- Community relations and community benefits

- Access for private investment
- Environmental impacts
- Transparency
  - Allocation of economic rents and revenue management
- Consumer interface
  - Access to service, reliability, quality of service
- Subsidy and system loss issues and pricing for core customers

Value Chain Examples

Bureau of Economic Geology
Jackson School of Geosciences
The University of Texas at Austin

McCombs School of Business: Energy Finance Program

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The Major Energy Value Chains

Oil and Gas Field Production
- Crude Transport
- Oil Refining (product markets)
  - Natural Gas Liquids Extraction
  - Gas Separation (if needed), Gathering

Midstream
- Pipeline Transportation (imports/exports)
  - Processing (if needed)
  - Gas Separation
  - Regasification
- Liquids (LPG) Transportation
- Gas Separation (if needed)
- Liquefaction (LNG)
- LNG Tanker Shipment (imports/exports)
- Direct Use (e.g., vehicle transport)

Downstream
- Local Distribution
- Industrial (Direct Use)
- Commercial
- Residential
- Electric Power Transmission
- Electric Power Distribution

An Illustration of US Energy Value Chain Pricing, 1999

**Crude Oil Value Chain**
- IN – RAC (18 mmb/d)
  - Domestic: $17.82
  - Import: $17.23
  - Composite: $17.46

**Natural Gas Value Chain**
- Field-to-liquefaction: 10-20%
- LNG: 25-35%
- CNG (methane): 25-35%
- LPG: 15-25%
- End use: Individual, business, government, institutions
- End use: Transportation, industrial processes, power generation

Economics & Technology of the Crude Oil, Natural Gas and LNG Value Chains - 26

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Comparative Refining Margins

<table>
<thead>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Product revenues</td>
<td>94.78</td>
<td>1.52</td>
<td>1.06</td>
<td>2.51</td>
<td>1.66</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feedstock costs</td>
<td>-80.04</td>
<td>-79.01</td>
<td>-71.92</td>
<td>-73.53</td>
<td>-76.71</td>
<td>-79.27</td>
<td></td>
</tr>
<tr>
<td>Gross margin</td>
<td>14.74</td>
<td>9</td>
<td>23.37</td>
<td>18.79</td>
<td>10.87</td>
<td>2.87</td>
<td></td>
</tr>
<tr>
<td>Fixed costs</td>
<td>-2.06</td>
<td>-2.38</td>
<td>-2.32</td>
<td>-2.7</td>
<td>-2.32</td>
<td>-1.8</td>
<td></td>
</tr>
<tr>
<td>Variable costs</td>
<td>-1.93</td>
<td>-1.33</td>
<td>-1.72</td>
<td>-3.05</td>
<td>-2.88</td>
<td>-0.91</td>
<td></td>
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<tr>
<td>Cash operating Margin</td>
<td>10.75</td>
<td>5.29</td>
<td>19.33</td>
<td>13.04</td>
<td>5.67</td>
<td>0.16</td>
<td></td>
</tr>
</tbody>
</table>

Source: Muse, Stancil & Co; OGJ Database

USWC Margins

Source: IEA OMR Oct 07

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$/bbl

NWE Margins

Jan 07  Mar 07  May 07  Jul 07  Sep 07

Brent (Cracking)  Brent (H’skimming)
Urals (Cracking)  Urals (H’skimming)

Source: IEA OMR Oct 07

http://omrpublic.iea.org/indexpublic.asp
Spreadsheet Demo
LNG Value Chain Costs

<table>
<thead>
<tr>
<th>EXPLORATION &amp; PRODUCTION</th>
<th>LIQUEFACTION</th>
<th>SHIPPING</th>
<th>REGASIFICATION &amp; STORAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>$0.5-$1.0/MMBtu</td>
<td>$0.8-$1.20/MMBtu</td>
<td>$0.4-$1.0/MMBtu</td>
<td>$0.3-$0.5/MMBtu</td>
</tr>
</tbody>
</table>

TOTAL = $2.00 - $3.70
TOTAL (with cost escalation) = $2.60 - $4.80

Sources: Industry (estimates exclude some O&M and tax costs)

LNG Value Chain Cost Estimates (Excludes Feedstock)

Sources: El Paso, Pickering Energy Partners, other industry sources, CEE estimates
**LNG Netbacks**

### Liquefaction

<table>
<thead>
<tr>
<th>Location</th>
<th>Algeria</th>
<th>Malaysia</th>
<th>Nigeria</th>
<th>NW Shelf</th>
<th>Qatar</th>
<th>Trinidad</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barcelona</td>
<td>6.7</td>
<td>5.06</td>
<td>5.81</td>
<td>4.95</td>
<td>5.72</td>
<td>5.79</td>
</tr>
<tr>
<td>Everett</td>
<td>6.72</td>
<td>4.41</td>
<td>6.29</td>
<td>4.48</td>
<td>5.06</td>
<td>7.06</td>
</tr>
<tr>
<td>Isle of Grain</td>
<td>8.85</td>
<td>6.44</td>
<td>8.28</td>
<td>6.32</td>
<td>7.11</td>
<td>8.19</td>
</tr>
<tr>
<td>Lake Charles</td>
<td>5.48</td>
<td>3.33</td>
<td>5.19</td>
<td>3.52</td>
<td>3.85</td>
<td>6.18</td>
</tr>
<tr>
<td>Sodegaura</td>
<td>5.14</td>
<td>7.6</td>
<td>5.33</td>
<td>7.14</td>
<td>6.4</td>
<td>4.52</td>
</tr>
<tr>
<td>Zeebrugge</td>
<td>6.46</td>
<td>4.52</td>
<td>6.02</td>
<td>4.41</td>
<td>5.15</td>
<td>6.01</td>
</tr>
</tbody>
</table>

*Source: Purvin & Gertz; OGJ Database, November 2, 2007*

---

**US Natural Gas Value Chain Trends**

Value Chain Segment Prices, $/mcf, real

- **Wellhead**
- **Imports**
- **Citygate**
- **Residential**
- **Commercial**
- **Industrial**
- **Electric**

*Source: U.S. EIA*
Mid-term Generation Fuel Outlook

Planned nameplate additions, 2006-2010, 94 GW (shares do not add to 100% because of omitted categories)

Source: U.S. EIA, Platts and other

Current Dispatched Generation

Dispatched petroleum liquids generation is roughly 8% of US power production

Source: U.S. EIA
Generators Will Take Expensive Gas…

January 2001 - July 2007

Net Generation by Natural Gas Plants ('000 Megawatthours)

Real Wellhead Price ($/Mcf)

Natural Gas Deliveries for Electric Power (MMcf)

http://www.oxfordenergy.org/pdfs/NG18.pdf

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…but Dispatch More at Lower Prices

1994 - 2006

2005

2006

Net Generation by Natural Gas Plants (’000 Megawatthours)

Real Wellhead Price ($/Mcf)

http://www.oxfordenergy.org/pdfs/NG18.pdf

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$16 Trillion Energy Investment Required Across the Energy Value Chains, 2001-2030

### Investment Requirements in the Oil Sector ($ billion)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Exploration &amp; Development</td>
<td>$689</td>
<td>$740</td>
<td>$793</td>
</tr>
<tr>
<td>Unconventional Oil</td>
<td>49</td>
<td>60</td>
<td>96</td>
</tr>
<tr>
<td>Refining</td>
<td>122</td>
<td>143</td>
<td>147</td>
</tr>
<tr>
<td>Tankers</td>
<td>37</td>
<td>79</td>
<td>76</td>
</tr>
<tr>
<td>Pipelines</td>
<td>20</td>
<td>23</td>
<td>23</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>$917</strong></td>
<td><strong>$1,045</strong></td>
<td><strong>$1,135</strong></td>
</tr>
</tbody>
</table>


### Investments Required in Natural Gas Sector

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>E&amp;P</td>
<td>$1.73</td>
</tr>
<tr>
<td>LNG</td>
<td>$0.25</td>
</tr>
<tr>
<td>Power Generation</td>
<td>$4.20</td>
</tr>
<tr>
<td>Pipelines</td>
<td>$0.71</td>
</tr>
<tr>
<td>Transmission</td>
<td>$1.60</td>
</tr>
<tr>
<td>Local Distribution (Gas &amp; Power)</td>
<td>$4.29</td>
</tr>
<tr>
<td><strong>WORLD TOTAL</strong></td>
<td><strong>$12.78</strong></td>
</tr>
</tbody>
</table>

Source: *IEA Global Investment Outlook, 2003*
Comparative Risks and Returns:
Electricity Lags Oil & Gas

Source: IEA Global Investment Survey 2003

Energy Outlooks

2007 National Petroleum Council’s
Global Oil & Gas Study
OECD and Non-OECD Countries

Non-OECD Organization for Economic Cooperation and Development (OECD)
Non-OECD

Source: NPC 2007

Economic Growth Patterns Are Shifting

Global GDP
2006 / 2030 ~ $40 / 80 Trillion

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Range of Projections Point to Growing Demand

... And Energy Demand Growth Follows
Coal, Oil, and Natural Gas Will Remain Indispensable

Source: IEA REFERENCE CASE

1980
288 QUADRILLION BTU

2004
445 QUADRILLION BTU

2030
678 QUADRILLION BTU

OIL

NATURAL GAS

COAL

HYDRO

NUCLEAR

WIND / SOLAR / GEOTHERMAL

BIOMASS

Source: NPC 2007

Global Oil Trade

Source: NPC 2007
Global LNG Trade

Source: NPC 2007

Supply Vulnerability Zones

Source: NPC 2007
Wide Range of Projections

Wide range of projections for conventional ultimate recoverable resource (mean) through 2000, based on data from USGS 2000.

Source: USGS

Large Oil Resource Base

Large oil resource base with unconventional and conventional ultimate recoverable resource (mean) projections.

Source: USGS
Risks Reflected in Range of Production Projections

* Source: NPC Data Warehouse.

**Source:** NPC 2007

Primary Energy

Source: IEA REFERENCE CASE

Source: NPC 2007
Total Energy Resources

- Coal
- Oil
- Gas
- Uranium
- Wind
- Hydro
- Photosynthesis

Source: Craig, Cunningham and Saigo.

Oil Resource Concentration

ILLUSTRATIVE PROJECTION
Source: USGS

Source: NPC 2007
U.S. Hydrocarbon Access Restrictions

Source: NPC 2007

Range of Global Supply Projections – Gas

Source: NPC Survey for the Oil & Gas Study.

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Global Gas Resource Endowment

In-Place: ~50,000 Trillion Standard Cubic Feet (TCFs) (not to scale)

Lower Permeability Reservoirs and/or High Temp & High Pressure

Remaining Resources: ~15,000 (largely conventional)

Remaining Proved Reserves: ~6,400 TCF

Produced: ~3,000 TCF

Increasing Geologic Uncertainty

Source: USGS

Source: NPC 2007

Regional Gas Supply Outlooks


Source: NPC 2007
Global LNG Market Diversification

- LNG demand is diversifying
  - Mexico, India, UK, Portugal and Greece have started LNG imports in past 10 years
  - Canada, China, Germany will begin importing LNG in the next few years

Source: NPC 2007
Uncertainties in Scope / Pace of LNG Development

- Qatar moratorium on new projects
  - Pending detailed field evaluation (2009+ ?)
- Russia refocussing on pipeline gas exports?
  - Shtokman decision, Nordstream and SEGP, Yamal
- Iran – first 9 blocks of South Pars for domestic use
- Venezuela – investment and regulatory regime challenges
- Indonesia – will growth in domestic gas needs offset impact of new LNG projects (Tangguh, …)?
- Australia – many projects, with tough cost and environmental challenges

Source: NPC 2007

LNG Development Slower / More Complex

- Rising costs and EPC bottlenecks leading to project delays
- Technology not key driver in LNG supply potential
  - Industry track record of reducing cost through scale, efficiency and replication

Source: NPC 2007
US LNG Import Outlooks

Global Coal Resource Endowment
Coal Reserve Concentration

75% of current global reserves is located in 5 countries.

Source: NPC 2007

Coal Reserve-to-Production Ratios

**Contribution of Unconventional Liquids**

![Graph showing global production of different unconventional liquids](source: Data From EIA 2007 Reference)

**Annual US Biomass Resource Endowment**

**DOE / USDA “Billion Ton” Study**

- Forest lands have potential to produce ~370 million dry tons of biomass annually.
- Agricultural lands have potential to produce ~1 billion dry tons of collectable biomass and continue to meet food, feed and export demands.
- Biotechnology is expected to double average yield of crops by 2030.

*Source: NPC 2007*
Nuclear Power Outlook

Source: NPC 2007

Hydrogen Fuel Outlook

Massive Infrastructure Investments Required

Refining Capacity Utilization Shifting

Source: NPC 2007

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Infrastructure

• Existing Forecasts
  – Energy supply and demand projections generally assume infrastructure will be built if it is economic to do so
  – Forecasts generally assume no constraints on the ability to finance, permit and build the required infrastructure
  – In practice, social, environmental and land-use constraints do affect infrastructure planning and development
  – Total requirements for new infrastructure to 2030 are difficult to assess with any certainty

Source: NPC 2007

Infrastructure

• Future Requirements
  – Significant investment in all transportation modes required to meet future demand
  – New investments will also be required as alternative energy sources grow
  – The potential scale of CCS activities would also require significant new infrastructure
  – Evolving concentration of energy demand and energy production in different regions around the world will create new trade flows and associated infrastructure requirements

Source: NPC 2007
U.S. Human Resources Challenge

OVER HALF OF THE WORKFORCE ELIGIBLE TO RETIRE IN NEXT 10 YEARS

% OF U.S. WORKFORCE

AGE DISTRIBUTION

Source: U.S. Dept of Labor.

Source: NPC 2007

60% of Emissions Growth in Developing World

GLOBAL CO₂ EMISSIONS

BILLION METRIC TONS

Source: EIA 2006

Source: NPC 2007