Overview
Gas & NGL Processing
Topics

Energy consumption & natural gas’s place
- Natural gas sources
- Relationship with petroleum

Basic economics of natural gas & NGL
- Trends for prices
- What are appropriate margins for the industry?

Gas processing as part of total production system
Energy consumption &
natural gas’s place
Growth of U.S. Energy Consumption


Updated: June 3, 2017
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World Energy Consumption by Source

Growth will not be uniform among all energy sources

- Renewable & nuclear power projected to be fastest-growing energy sources, increasing by 2.5% per year
- Natural gas fastest growing fossil fuel, increasing by 1.7% per year
- Coal grows faster than petroleum because of China’s increasing consumption

Source:
http://www.eia.gov/forecasts/ieo/
Energy Markets Are Interconnected

Estimated U.S. Energy Consumption in 2016: 97.3 Quads

Source: LLNL March, 2017. Data is based on DOE/EIA 920 (2014). If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. This chart was revised in 2017 to reflect changes made in mid-2016 to the Energy Information Administration’s analysis methodology and reporting. The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy inputs into electricity generation. End-use efficiency is estimated as 6% for the residential sector, 48% for the commercial sector, 26% for the transportation sector, and 44% for the industrial sector which was updated in 2017 to reflect DOE’s analysis of manufacturing. Totals may not equal sum of components due to independent rounding. LLNL-TR-616527

https://flowcharts.llnl.gov/commodities/energy

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Origins of Oil & Gas

- Organic life buried in sedimentary rock
- Transformation to hydrocarbons
- Migration from source rocks
- Accumulation of oil & gas
- Flow of oil & gas through porous media

Oil forms throughout a temperature range from about 150 to 300 degrees F (the oil window.) Thermogenic natural gas is formed at temperatures above 300 degrees F.
Petroleum & Natural Gas

Consumption influenced by production & cost of fuels

Figure 33. World oil prices in three cases, 1990-2040 (2011 dollars per barrel, Brent crude oil)

Figure 34. World liquids consumption in three oil price cases, 2010 and 2040 (million barrels per day)

Figure 40. World natural gas consumption, 2010-2040 (trillion cubic feet)
Flow of Natural Gas in U.S.

Natural Gas Annual, 2014
https://www.eia.gov/naturalgas/annual/

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Overview of Natural Gas Gathering & Processing

Fundamentals of Natural Gas Processing, 2nd ed.
Kidnay, Parrish, & McCartney

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Natural Gas Resources

Petroleum & natural gas formed from decomposing organic matter in “source rock”

Conventional – gas & liquids migrate through permeable rock toward the surface until it is stopped by some trapping mechanism

Unconventional – gas & liquids are trapped at the source rock because of extremely low permeabilities

North American Conventional Gas Fields

Source: Energy Information Administration based on data from HPDI, IN Geological Survey, USGS
Updated: April 8, 2009

North American Offshore Gas Fields

Source: Energy Information Administration based on data from MMS, HPDI, CA Dept of Oil, Gas & Geothermal
Updated: April 8, 2009

North American Shale Gas Plays

Marcellus & Utica Shale Formation Map

http://marcelluscoalition.org/pa-map/
Shale Oil & Gas

Shale oil & gas have the potential to dramatically alter world energy markets

Source: Supplemental presentation is support of International Energy Outlook 2013, U.S. Energy Information Agency
http://www.eia.gov/forecasts/ieo/
Expected Natural Gas Production by Source

Figure MT-46. U.S. dry natural gas production by source in the Reference case, 1990–2040

Retrieved November 26, 2016
http://www.eia.gov/energy_in_brief/article/shale_in_the_united_states.cfm
U.S. Gas Processing & Transportation

http://www.eia.gov/state/maps.cfm?v=Natural%20Gas

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Gas Plants Capacities in U.S. Lower 48

Natural gas processing plant capacity in the United States, 2014

plant capacity
million cubic feet per day

2,100
1,050
210
<100

= Shale plays

Source: Energy Information Administration (EIA), Form EIA-757, "Natural Gas Processing Plant Survey."

http://www.eia.gov/todayinenergy/detail.cfm?id=8530
U.S. Gas Transportation, Storage, & Terminals

http://www.eia.gov/state/maps.cfm?v=Natural%20Gas

Updated: June 3, 2017
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Interstate Natural Gas Flow

Figure 13. Principal Interstate Natural Gas Flow Capacity Summary, 2014

Natural Gas Annual, 2014
https://www.eia.gov/naturalgas/annual/

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Basic economics of natural gas & NGL
# Energy & Oil Prices

## Crude Oil & Natural Gas

<table>
<thead>
<tr>
<th>INDEX</th>
<th>UNITS</th>
<th>PRICE</th>
<th>CHANGE</th>
<th>%CHANGE</th>
<th>CONTRACT</th>
<th>TIME (EST)</th>
<th>2 DAY</th>
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<tr>
<td>CL1:COM</td>
<td>USD/bbl</td>
<td>53.72</td>
<td>+0.46</td>
<td>+0.86%</td>
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<td>3:26 PM</td>
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<td>WTI Crude Oil (Nymex)</td>
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<tr>
<td>CO1:COM</td>
<td>USD/bbl</td>
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<tr>
<td>Brent Crude (ICE)</td>
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<tr>
<td>GP1:COM</td>
<td>JPY/kl</td>
<td>40,280.00</td>
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<td>Crude Oil (Tokyo)</td>
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<tr>
<td>NG1:COM</td>
<td>USD/MMBtu</td>
<td>3.32</td>
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<tr>
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<td></td>
<td></td>
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</tr>
</tbody>
</table>

http://www.bloomberg.com/energy/
### Energy & Oil Prices

#### MONT BELVIEU LDH PROPANE (NYMEX:B0)

<table>
<thead>
<tr>
<th>Market</th>
<th>Contract</th>
<th>Open</th>
<th>High</th>
<th>Low</th>
<th>Last</th>
<th>Change</th>
<th>Pct</th>
<th>Time</th>
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</thead>
<tbody>
<tr>
<td>B0.F17.E</td>
<td>Jan 2017 (E)</td>
<td>0.66750</td>
<td>0.66750</td>
<td>0.65750</td>
<td>0.70391</td>
<td>-0.00234</td>
<td>-0.33%</td>
<td>05/17 33</td>
</tr>
<tr>
<td>B0.G17.E</td>
<td>Feb 2017 (E)</td>
<td>0.53167</td>
<td>0.53167</td>
<td>0.53167</td>
<td>0.70250</td>
<td>-0.00125</td>
<td>-0.18%</td>
<td>05/17 33</td>
</tr>
<tr>
<td>B0.H17.E</td>
<td>Mar 2017 (E)</td>
<td>0.69250</td>
<td>0.69250</td>
<td>0.67063</td>
<td>0.70039</td>
<td>+0.00093</td>
<td>+0.09%</td>
<td>05/17 33</td>
</tr>
</tbody>
</table>

#### NAPHTHA CARGOES CIF NWE (PLATTS) (NYMEX:UN)

<table>
<thead>
<tr>
<th>Market</th>
<th>Contract</th>
<th>Open</th>
<th>High</th>
<th>Low</th>
<th>Last</th>
<th>Change</th>
<th>Pct</th>
<th>Time</th>
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<tbody>
<tr>
<td>UN.G17.E</td>
<td>Feb 2017 (E)</td>
<td>493.434</td>
<td>493.434</td>
<td>493.434</td>
<td>493.434</td>
<td>+14.004</td>
<td>+2.84%</td>
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<tr>
<td>UN.H17.E</td>
<td>Mar 2017 (E)</td>
<td>492.673</td>
<td>492.673</td>
<td>492.673</td>
<td>492.673</td>
<td>+12.310</td>
<td>+2.50%</td>
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#### NATURAL GAS (NYMEX:NG)

<table>
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<th>Open</th>
<th>High</th>
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<th>Change</th>
<th>Pct</th>
<th>Time</th>
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</thead>
<tbody>
<tr>
<td>NG.G17.E</td>
<td>Feb 2017 (E)</td>
<td>3.260</td>
<td>3.346</td>
<td>3.172</td>
<td>3.300</td>
<td>+0.033</td>
<td>+1.01%</td>
<td>05/15 24</td>
</tr>
<tr>
<td>NG.H17.E</td>
<td>Mar 2017 (E)</td>
<td>3.236</td>
<td>3.332</td>
<td>3.165</td>
<td>3.288</td>
<td>+0.039</td>
<td>+1.20%</td>
<td>05/15 23</td>
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<tr>
<td>NG.J17.E</td>
<td>Apr 2017 (E)</td>
<td>3.195</td>
<td>3.283</td>
<td>3.135</td>
<td>3.246</td>
<td>+0.035</td>
<td>+1.09%</td>
<td>05/15 23</td>
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#### NATURAL GAS (E-MINI) (NYMEX:QG)

<table>
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<th>Market</th>
<th>Contract</th>
<th>Open</th>
<th>High</th>
<th>Low</th>
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<th>Change</th>
<th>Pct</th>
<th>Time</th>
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<td>QG.G17.E</td>
<td>Feb 2017 (E)</td>
<td>3.255</td>
<td>3.340</td>
<td>3.175</td>
<td>3.300</td>
<td>+0.035</td>
<td>+1.07%</td>
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<td>QG.H17.E</td>
<td>Mar 2017 (E)</td>
<td>3.235</td>
<td>3.330</td>
<td>3.170</td>
<td>3.310</td>
<td>+0.060</td>
<td>+1.85%</td>
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<tr>
<td>QG.J17.E</td>
<td>Apr 2017 (E)</td>
<td>3.20</td>
<td>3.26</td>
<td>3.15</td>
<td>3.26</td>
<td>+0.05</td>
<td>+1.56%</td>
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#### NATURAL GAS (TAS) (NYMEX:NGT)

<table>
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<th>Contract</th>
<th>Open</th>
<th>High</th>
<th>Low</th>
<th>Last</th>
<th>Change</th>
<th>Pct</th>
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<tr>
<td>NG.T17.E</td>
<td>Feb 2017 (E)</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>+1</td>
<td>0.00%</td>
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<tr>
<td>NG.H17.E</td>
<td>Mar 2017 (E)</td>
<td>-1</td>
<td>1</td>
<td>-1</td>
<td>0</td>
<td>+1</td>
<td>0.00%</td>
<td>05/14 28</td>
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<tr>
<td>NG.J17.E</td>
<td>Apr 2017 (E)</td>
<td>-1</td>
<td>1</td>
<td>-1</td>
<td>0</td>
<td>+1</td>
<td>0.00%</td>
<td>05/14 31</td>
</tr>
</tbody>
</table>

Price Changes With Time

Natural Gas Spot Price (Henry Hub)

Sources: http://tonto.eia.doe.gov/dnav/pet/pet_pri_spt_s1_d.htm & http://www.eia.gov/dnav/ng/ng_pri_fut_s1_d.htm
Price Changes With Time

Sources: [http://tonto.eia.doe.gov/dnav/pet/pet_pri_spt_s1_d.htm](http://tonto.eia.doe.gov/dnav/pet/petPri_spt_s1_d.htm) & [http://www.eia.gov/dnav/ng/ng_pri_fut_s1_d.htm](http://www.eia.gov/dnav/ng/ngPri_fut_s1_d.htm)
No Such Thing as a “Global” Gas Price

There has always been a major disparity between regional prices.

In 2012, Henry Hub in the United States averaged $2.76/MMBtu; the price in Japan was $16.75/MMBtu.

European pricing was somewhere in the middle: $9.46/MMBtu in the UK to $11.03/MMBtu in Germany.

[Graph showing gas prices in select markets from 2000 to 2012 for Japan, Germany, UK, and the United States.]

SOURCE: BP STATISTICAL REVIEW OF WORLD ENERGY (JUNE 2013)

http://www.slideshare.net/enalytica/gas-market-outlook-lng-business-fundamentals

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NGLs Can Bring Value

Sources: http://tonto.eia.doe.gov/dnav/pet/pet_pri_spt_s1_d.htm & http://www.eia.gov/dnav/ng/ng_pri_fut_s1_d.htm
NGLs Can Bring Value

Propane & WTI Spot Prices

Sources: http://tonto.eia.doe.gov/dnav/pet/pet_pri_spt_s1_d.htm & http://www.eia.gov/dnav/ng/ng_pri_fut_s1_d.htm
NGLs Can Bring Value

Propane & Natural Gas Spot Prices

Sources: http://tonto.eia.doe.gov/dnav/pet/pet_pri_spt_s1_d.htm & http://www.eia.gov/dnav/ng/ng_pri_fut_s1_d.htm

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Economic “Spreads”

NGL Frac spread

- Difference between the value of components in NGL vs. retaining in the natural gas
  \[ \text{Frac Spread} = (\text{Value as liquid product}) - (\text{Value as component of natural gas}) \]

- Can include value of mixture of C₂, C₃, iC₄, nC₄, & C₅⁺
  - Can be tailored to meet actual NGL compositions
  - Some prices may be difficult to obtain on a daily basis
    - NYMEX C₂, C₃, nC₄, & C₅⁺ from www.ino.com

- Can be expressed as $/MMBtu (ideal gas heating value) or $/bbl (NGL volume)
  - Make use of values for standard liquid density & heating value

- NGL frac spread requires a definition for NGL composition

Spark spread

- More important to electricity producer rather than gas processor
- Gross margin of a gas-fired power plant selling a unit of electricity having bought the fuel to produce it
Example – Propane Frac Spread

Using (Last) February values:
- Propane - $0.70250 per gal
- Natural gas - $3.300 per MMBtu

Propane conversion factors:
- 91,563 Btu/gal ideal gas
  gross heating value & standard liquid density

Calculation:

\[
\text{Spread} = \left( \frac{0.70250 \text{ $/gal}}{1,000,000 \text{ Btu/MMBtu}} \right) \left( \frac{91,563 \text{ Btu/gal}}{1,000,000 \text{ Btu/MMBtu}} \right) - \left( \frac{3.300 \text{ $/MMBtu}}{1,000,000 \text{ Btu/MMBtu}} \right)
\]

= $4.372 per MMBtu

Values retrieved January 10, 2016
NGLs Can Bring Value

Source: http://tonto.eia.doe.gov/dnav/pet/pet_pri_spt_s1_d.htm & http://www.eia.gov/dnav/ng/ng_pri_fut_s1_d.htm
NGLs Can Bring Value

Sources: http://tonto.eia.doe.gov/dnav/pet/pet_pri_spt_s1_d.htm & http://www.eia.gov/dnav/ng/ng_pri_fut_s1_d.htm
Gas processing as part of total production system
Total Production System

J.M. Campbell & Company
Adapted from Gas Processors Association (GPA), Tulsa, Oklahoma
Overview of Gas Plant Processing

Fundamentals of Natural Gas Processing
Summary
Summary

Natural gas supplies nearly 30% of the US’s energy
  ▪ Contribution expected to continue to grow

Production
  ▪ May be associated with petroleum production
  ▪ Unconventional sources – shale & coal

Primary distribution via pipelines
  ▪ Gas processing near the mouth of the pipeline system

NGLs bring value
  ▪ Comparison is the value as a liquid vs the heating value as part of the natural gas
Supplemental Slides
## How do energy prices compare?

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>RBOB Gasoline - wholesale</td>
<td>1.6373</td>
<td>115,000 Btu/gal</td>
<td>48.58</td>
<td>14.24</td>
<td>4.3</td>
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<tr>
<td>Heating Oil - wholesale</td>
<td>1.6933</td>
<td>130,500 Btu/gal</td>
<td>44.27</td>
<td>12.98</td>
<td>3.9</td>
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<tr>
<td>WTI Crude Oil</td>
<td>53.63</td>
<td>5.8 MMBtu/bbl</td>
<td>31.55</td>
<td>9.25</td>
<td>2.8</td>
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<tr>
<td>Brent Crude Oil</td>
<td>56.76</td>
<td>5.8 MMBtu/bbl</td>
<td>33.39</td>
<td>9.79</td>
<td>3.0</td>
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<td>Ethanol - rack</td>
<td>1.545</td>
<td>75,700 Btu/gal</td>
<td>69.64</td>
<td>20.41</td>
<td>6.2</td>
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<tr>
<td>Natural Gas - Henry Hub</td>
<td>3.300</td>
<td></td>
<td>11.26</td>
<td>3.30</td>
<td>1.0</td>
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<td>Propane</td>
<td>0.7025</td>
<td>90,905 Btu/gal</td>
<td>26.37</td>
<td>7.73</td>
<td>2.3</td>
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<td>Powder River Basin Coal (low sulfur)</td>
<td>11.00</td>
<td>8,800 Btu/lb</td>
<td>2.13</td>
<td>0.63</td>
<td>0.2</td>
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<tr>
<td>Illinois No. 6 Coal (high sulfur)</td>
<td>34.50</td>
<td>11,800 Btu/lb</td>
<td>4.99</td>
<td>1.46</td>
<td>0.4</td>
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<td>Electricity (Residential, winter season)</td>
<td>4.604</td>
<td>c per kWh</td>
<td>46.04</td>
<td>13.49</td>
<td>4.1</td>
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<td>Electricity (Residential, summer, over 500 kWh)</td>
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<td>Electricity (Commercial, winter season)</td>
<td>3.920</td>
<td>c per kWh</td>
<td>39.20</td>
<td>11.49</td>
<td>3.5</td>
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<td>Electricity (Commercial, summer season)</td>
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<td>c per kWh</td>
<td>64.50</td>
<td>18.90</td>
<td>5.7</td>
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<td>Hydrogen dispensed cost</td>
<td>4.03</td>
<td>324.2 Btu/scf</td>
<td>102.20</td>
<td>29.95</td>
<td>9.1</td>
</tr>
</tbody>
</table>

**References:**
- Gasoline, Heating Oil, & Crude Oil from Bloomberg (1/5/2017, Feb delivery)
- Propane & Ethanol prices from NYMEX (1/5/2017, Feb delivery)
- Coal from US EIA Coal News & Markets (week ending 12/30/16).
- Xcel Energy electric tariff book (as of 8/5/2016)