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

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 2017: 97.7 Quads

Source: LBNL April, 2019. Data is based on DOE/EIA MED (2017). If this information is a reproduction of it in part, 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 by the Energy Information Administration. All of the energy shown in the tool represents the full energy input into electricity generation. Total use efficiency is estimated at 45% for the residential sector, 45% for the commercial sector, 21% 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. LBNL-100-430537

https://flowcharts.llnl.gov/commodities/energy
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
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)
Overview of Natural Gas Gathering & Processing

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

Dec. 5, 2012 update, 
http://www.eia.gov/energy_in_brief/article/about_shale_gas.cfm
North American Conventional Gas Fields

[Map of gas production in conventional fields, Lower 48 States]


Updated: January 4, 2019
Copyright © 2019 John Jechura (jjechura@mines.edu)
North American Shale Gas Plays

North American shale plays
(as of May 2011)

Updated: January 4, 2019
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Marcellus & Utica Shale Formation Map

http://marcelluscoalition.org/pa-map/

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Worldwide Shale Oil & Gas

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

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

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: January 4, 2019
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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/

Updated: January 4, 2019
Copyright © 2019 John Jechura (jjechura@mines.edu)
Basic economics of natural gas & NGL
# Energy & Oil Prices

<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>
</tr>
</thead>
<tbody>
<tr>
<td>CL1:COM</td>
<td>USD/bbl.</td>
<td>46.78</td>
<td>+0.24</td>
<td>+0.52%</td>
<td>Feb 2019</td>
<td>12:16 PM</td>
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<tr>
<td>WTI Crude Oil (Nymex)</td>
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<tr>
<td>CO1:COM</td>
<td>USD/bbl.</td>
<td>55.38</td>
<td>+0.47</td>
<td>+0.86%</td>
<td>Mar 2019</td>
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<td></td>
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<tr>
<td>Brent Crude (ICE)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>CP1:COM</td>
<td>JPY/kl</td>
<td>35,910.00</td>
<td>-90.00</td>
<td>-0.25%</td>
<td>May 2019</td>
<td>12/29/2018</td>
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<tr>
<td>Crude Oil (Tokyo)</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>NG1:COM</td>
<td>USD/MMBtu</td>
<td>2.92</td>
<td>-0.03</td>
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<td>Feb 2019</td>
<td>12:15 PM</td>
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<tr>
<td>Natural Gas (Nymex)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Prices retrieved January 3, 2019

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

Prices retrieved January 3, 2019


---

### CRUDE OIL BRENT LAST DAY (NYMEX:BZ)

<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>
</tr>
</thead>
<tbody>
<tr>
<td>BZ.H19</td>
<td>Mar 2019</td>
<td>54.77</td>
<td>56.20</td>
<td>52.92</td>
<td>55.14</td>
<td>+0.23</td>
<td>+0.46%</td>
<td>11:56</td>
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<tr>
<td>BZ.J19</td>
<td>Apr 2019</td>
<td>54.03</td>
<td>55.46</td>
<td>54.19</td>
<td>55.30</td>
<td>+0.13</td>
<td>+0.30%</td>
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<td>BZ.K19</td>
<td>May 2019</td>
<td>55.15</td>
<td>56.79</td>
<td>54.96</td>
<td>56.20</td>
<td>+0.34</td>
<td>+0.56%</td>
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</tr>
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### CRUDE OIL BRENT LAST DAY (TAS) (NYMEX:RZT)

<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>
</tr>
</thead>
<tbody>
<tr>
<td>BZTH19</td>
<td>Mar 2019</td>
<td>-0.25</td>
<td>-0.25</td>
<td>-0.50</td>
<td>-0.50</td>
<td>+0.00</td>
<td>0.00%</td>
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<tr>
<td>RZT.J19</td>
<td>Apr 2019</td>
<td>-0.25</td>
<td>-0.25</td>
<td>-0.25</td>
<td>-0.25</td>
<td>+0.00</td>
<td>0.00%</td>
<td>08:20</td>
</tr>
</tbody>
</table>

### HENRY HUB FINANCIAL (NYMEX:HP)

<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>HP.G19</td>
<td>Feb 2019</td>
<td>2.970</td>
<td>3.026</td>
<td>2.926</td>
<td>2.980</td>
<td>-0.023</td>
<td>-0.45%</td>
<td>14:20</td>
</tr>
<tr>
<td>HP.H19</td>
<td>Mar 2019</td>
<td>2.982</td>
<td>3.035</td>
<td>2.924</td>
<td>2.924</td>
<td>-0.027</td>
<td>-0.86%</td>
<td>14:20</td>
</tr>
<tr>
<td>HP.J10</td>
<td>Apr 2019</td>
<td>2.706</td>
<td>2.770</td>
<td>2.624</td>
<td>2.637</td>
<td>-0.048</td>
<td>-1.50%</td>
<td>14:20</td>
</tr>
</tbody>
</table>

### HENRY HUB FINANCIAL LAST DAY (NYMEX:HH)

<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>
</tr>
</thead>
<tbody>
<tr>
<td>HH.G19</td>
<td>Feb 2019</td>
<td>2.985</td>
<td>3.056</td>
<td>2.981</td>
<td>2.998</td>
<td>-0.013</td>
<td>-0.20%</td>
<td>10:40</td>
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<tr>
<td>HH.H19</td>
<td>Mar 2019</td>
<td>2.905</td>
<td>2.977</td>
<td>2.870</td>
<td>2.734</td>
<td>+0.045</td>
<td>-1.50%</td>
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<tr>
<td>HH.J10</td>
<td>Apr 2019</td>
<td>2.912</td>
<td>2.912</td>
<td>2.912</td>
<td>2.912</td>
<td>+0.015</td>
<td>-0.57%</td>
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### NATURAL GAS (NYMEX:NG)

<table>
<thead>
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<th>Contract</th>
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<th>High</th>
<th>Low</th>
<th>Last</th>
<th>Change</th>
<th>Pct</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>NG.G19</td>
<td>Feb 2019</td>
<td>2.803</td>
<td>3.011</td>
<td>2.876</td>
<td>2.912</td>
<td>-0.080</td>
<td>-3.00%</td>
<td>10:40</td>
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<tr>
<td>NG.H19</td>
<td>Mar 2019</td>
<td>2.849</td>
<td>2.886</td>
<td>2.771</td>
<td>2.739</td>
<td>+0.033</td>
<td>-1.10%</td>
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</tr>
<tr>
<td>NG.J10</td>
<td>Apr 2019</td>
<td>2.648</td>
<td>2.882</td>
<td>2.601</td>
<td>2.620</td>
<td>-0.067</td>
<td>-2.66%</td>
<td>11:56</td>
</tr>
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</table>

### NATURAL GAS (E-MINI) (NYMEX:QG)

<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>
</tr>
</thead>
<tbody>
<tr>
<td>QG.G10</td>
<td>Feb 2019</td>
<td>2.985</td>
<td>3.010</td>
<td>2.875</td>
<td>2.920</td>
<td>-0.040</td>
<td>-1.35%</td>
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<tr>
<td>QG.H10</td>
<td>Mar 2019</td>
<td>2.845</td>
<td>2.870</td>
<td>2.776</td>
<td>2.710</td>
<td>-0.045</td>
<td>-1.41%</td>
<td>11:56</td>
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<tr>
<td>QG.J10</td>
<td>Apr 2019</td>
<td>2.850</td>
<td>2.885</td>
<td>2.775</td>
<td>2.875</td>
<td>+0.005</td>
<td>+0.10%</td>
<td>00:51</td>
</tr>
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</table>
Energy & Oil Prices

Watchlist

Enter symbols separated by commas or spaces...

Intraday

Symbol | Name | Last | Change | %Chg | Open | High | Low | Volume | Time | Notes | Links
--- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | ---
+ NGG19 | Natural Gas | 2.627 | -0.031 | -1.05% | 2.963 | 3.011 | 2.878 | 66,282 | 11:23 CT | ☐ | 1
+ JCOX19 | Mont Belvieu Ethane 5 Decimal (OPIS) Swap | 0.31313s | +0.00125 | +0.40% | N/A | 0.31313 | 0.31313 | N/A | 01/02/19 | ☐ | 1
+ ICPF19 | Conway Propane (OPIS) BALMO Swap Futures | 0.56625s | -0.01125 | -1.95% | N/A | 0.56625 | 0.56625 | N/A | 01/02/19 | ☐ | 1
+ RBF19 | Gasoline RBOB | 1.32375 | -0.0025 | -0.19% | 1.3285 | 1.3066 | 1.3073 | 2,753 | 12/31/18 | ☐ | 1
+ FLF19 | Ethanol Swaps-Chgo | 1.2450s | +0.0175 | +1.43% | 0.0000 | 1.2450 | 1.2450 | 1,166 | 01/02/19 | ☐ | 1

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https://www.barchart.com/my/watchlist?viewName=main

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Price Changes With Time

Prices updated January 2, 2019
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

Updated: January 4, 2019
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Price Changes With Time

Natural Gas & WTI Daily Spot Prices

Prices updated January 2, 2019
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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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.
NGLs Can Bring Value

Prices updated January 2, 2019
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

Prices updated January 2, 2019
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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NGLs Can Bring Value

Propane & Natural Gas Spot Prices

Prices updated January 2, 2019
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
**Economic “Spreads”**

**NGL Frac spread**

- Difference between the value of components in NGL vs. retaining in the natural gas
  
  Frac Spread = (Value as liquid product) – (Value as component of natural gas)

- Can include value of mixture of C$_2$, C$_3$, iC$_4$, nC$_4$, & C$_5^+$
  - Can be tailored to meet actual NGL compositions
  - Some prices may be difficult to obtain on a daily basis
    - NYMEX C$_2$, C$_3$, nC$_4$, & C$_5^+$ from [www.ino.com](http://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” values:

- Natural gas - $2.931 per MMBtu
- Propane - $0.56625 per gal
  - 91,563 Btu/gal ideal gas gross heating value & standard liquid density

Calculation:

$$\text{Spread} = \left( \frac{0.56625 \text{ \$}}{\text{gal}} \right) \left( \frac{1,000,000 \text{ Btu}}{\text{MMBtu}} \right) \left( \frac{91,563 \text{ Btu}}{\text{gal}} \right) - \left( \frac{2.931 \text{ \$}}{\text{MMBtu}} \right)$$

\[= 3.253 \text{ per MMBtu} \]
\[\Rightarrow 0.298 \text{ per gal} \]

Values retrieved January 3, 2019
https://www.barchart.com/my/watchlist?viewName=main
Example – Ethane Frac Spread

Using “Last” values:

- Natural gas - $2.931 per MMBtu
- Propane - $0.31313 per gal
  - 66,340 Btu/gal ideal gas gross heating value & standard liquid density

Calculation:

\[
\text{Spread} = \left( \frac{0.31313}{\text{gal}} \right) \left( \frac{1,000,000}{\text{MMBtu}} \right) \left( \frac{\text{Btu}}{66,340 \text{ Btu/gal}} \right) - \left( \frac{2.931}{\text{MMBtu}} \right)
\]

\[
= \frac{1.789}{\text{per MMBtu}}
\]

\[
\Rightarrow \frac{0.119}{\text{per gal}}
\]

Values retrieved January 3, 2019

https://www.barchart.com/my/watchlist?viewName=main

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NGLs Can Bring Value

Prices updated January 2, 2019
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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NGLs Can Bring Value

![Propane Spread From Spot Prices](graph.png)

Prices updated January 2, 2019
Sources: [http://tonto.eia.doe.gov/dnav/pet/pet_pri_spt_s1_d.htm](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](http://www.eia.gov/dnav/ng/ng_pri_fut_s1_d.htm)
NGLs Can Bring Value

Using Ethane Mont Belvieu OPIS Swap Values

Prices updated January 2, 2019
Prices collected from ino.com & barchart.com

Updated: January 4, 2019
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Gas processing as part of total production system
Overview of Gas Plant Processing

Adapted from Figure 7.1, *Fundamentals of Natural Gas Processing*, 2nd ed. Kidnay, Parrish, & McCartney
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>
<th>Given Price</th>
<th>Heating Value</th>
<th>Price [$/MWh]</th>
<th>Price [$/MMBtu]</th>
<th>Relative to Natural Gas</th>
</tr>
</thead>
<tbody>
<tr>
<td>RBOB Gasoline - wholesale</td>
<td>1.3387</td>
<td>$/gallon</td>
<td>115,000 Btu/gal</td>
<td>LHV</td>
<td>39.72</td>
</tr>
<tr>
<td>Heating Oil - wholesale</td>
<td>1.7222</td>
<td>$/gallon</td>
<td>130,500 Btu/gal</td>
<td>LHV</td>
<td>45.03</td>
</tr>
<tr>
<td>WTI Crude Oil</td>
<td>46.78</td>
<td>$/bbl</td>
<td>5.8 MMBtu/bbl</td>
<td>HHV</td>
<td>27.52</td>
</tr>
<tr>
<td>Brent Crude Oil</td>
<td>53.38</td>
<td>$/bbl</td>
<td>5.8 MMBtu/bbl</td>
<td>HHV</td>
<td>31.60</td>
</tr>
<tr>
<td>Ethanol - Chicago</td>
<td>1.2450</td>
<td>$/gallon</td>
<td>75,700 Btu/gal</td>
<td>LHV</td>
<td>56.12</td>
</tr>
<tr>
<td>Natural Gas - Henry Hub</td>
<td>2.927</td>
<td>$/MMBtu</td>
<td></td>
<td>HHV</td>
<td>9.99</td>
</tr>
<tr>
<td>Propane - Mt. Belvieu</td>
<td>0.56625</td>
<td>$/gallon</td>
<td>90,905 Btu/gal</td>
<td>HHV</td>
<td>21.25</td>
</tr>
<tr>
<td>Powder River Basin Coal (low sulfur)</td>
<td>11.95</td>
<td>$/ton</td>
<td>8,800 Btu/lb</td>
<td>HHV</td>
<td>2.32</td>
</tr>
<tr>
<td>Illinois Basin (high sulfur)</td>
<td>38.95</td>
<td>$/ton</td>
<td>11,800 Btu/lb</td>
<td>HHV</td>
<td>5.63</td>
</tr>
<tr>
<td>Electricity (Residential, winter season)</td>
<td>5.461</td>
<td>$/kWh</td>
<td></td>
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<td>54.61</td>
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<tr>
<td>Electricity (Residential, summer, over 500 kWh)</td>
<td>9.902</td>
<td>$/kWh</td>
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<td>99.02</td>
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<tr>
<td>Electricity (Small Commercial, winter season)</td>
<td>4.256</td>
<td>$/kWh</td>
<td></td>
<td></td>
<td>42.56</td>
</tr>
<tr>
<td>Electricity (Small Commercial, summer season)</td>
<td>8.512</td>
<td>$/kWh</td>
<td></td>
<td></td>
<td>85.12</td>
</tr>
<tr>
<td>Hydrogen dispensed cost</td>
<td>13.99</td>
<td>$/kg</td>
<td>324.2 MMBtu/kg</td>
<td>HHV</td>
<td>354.77</td>
</tr>
</tbody>
</table>

### References:
- Gasoline, Heating Oil, Crude Oil, Natural Gas from Bloomberg (1/3/2019, Feb contract)
- Natural Gas, Propane, & Ethanol prices from NYMEX via barchart.com (1/3/2019)
  [https://www.barchart.com/nym/](https://www.barchart.com/nym/)
- Coal from US EIA Coal News & Markets (week ending 12/28/18).
- Xcel Energy electric tariff book (retrieved 4/12/2018)
- Ave. hydrogen cost, CA, from "Joint Agency Staff Report on Assembly Bill 8: Assessment of Time and Cost Needed to Attain 100 Hydrogen Refueling Stations in California," Dec. 2015