Natural Gas

- Welcome to the Golden Age of Gas

- The Shale Revolution

- UOP/Honeywell Offers for Shale Development

- One Honeywell Integration Opportunities
The Golden Age of Gas
Why Natural Gas?

1. Economic Incentive
   - Gas vs oil price
     - Unconventional gas revolution has vastly expanded accessible global reserve base
     - Exploration and production (E&P) costs per shale well in decline with efficiency gains
   - Clean power demand rapid growth in high growth regions.
     - Capital Cost: gas cheaper than nuclear/coal; new power plants quicker to market
     - Operating Cost: global cost advantage of gas vs. crude and liquid products

2. Environmental Benefits
   - Gas produces:
     - 50% fewer greenhouse gas emissions vs. coal for power
     - 20% fewer greenhouse gas emissions vs. diesel for transportation
   - Nuclear share in OECD in decline post Fukushima, Gas-fired turbine most likely replacement

3. Geopolitical Drivers
   - Energy security: gas reserves more distributed than oil (particularly unconventional gas)
   - Local gas price provides partial hedge vs. global oil price dynamics
   - State mandates for increased gas production
Global Primary Energy Demand by Source

**Energy Demand**

- **Total:** 541 TCF 728 TCF
- **2010:**
  - Renewables: 11% (116 TCF)
  - Hydro: 2% (6 TCF)
  - Nuclear: 22% (173 TCF)
  - Gas: 32% (390 TCF)
  - Oil: 27% (148 TCF)
- **2035:**
  - Renewables: 15% (180 TCF)
  - Hydro: 3% (6 TCF)
  - Nuclear: 25% (180 TCF)
  - Gas: 27% (195 TCF)
  - Oil: 24% (187 TCF)


**Comments**

- **Renewables:** ~2.5% global growth CAGR
- **Hydro:** Nuclear continues to grow in Asia & Mid East

**Gas**

- ~2.2% global growth CAGR
- Supply more regionally distributed than oil

**Oil**

- ~1.2% global growth CAGR
- Limited growth due to fuel switching and vehicle efficiency gains

**Coal**

- ~1% global growth CAGR
- Limited growth due to greenhouse emissions & high power plant capital cost

**Natural Gas Fastest Growing Hydrocarbon Fuel**
Global Gas Supply and Demand

- Abundant Shale Supply
- North America remains separate from global markets but export projects gaining in credibility

- South America: Imports ramping up again; potential new regional supply

- Strong demand growth across Asia
- Liquefaction Supply Surge
- Significant Resources
- Japanese crisis – strong incremental LNG demand
- China-world’s largest shale gas potential
- Large Gas Reserves Ready for Harvest

Emerging Gas Sources, Clean Energy and Changing Regional Flows Require Technology and Innovation to Maximize Gas Monetization
Customers: Energy Price Dynamics

Sources: IEA 2012 World Energy Outlook, CME Futures, & IHS 2011 World LPG Market Outlook

- Oil: 1 barrel = 5.8MMBTU; Coal: 1 metric ton coal = 27.8MMBTU; Propane: 1 metric ton = 43.5MMBTU

Price Spread Encourages:

1. Gas Trade Arbitrage (LNG)
2. Coal vs. Gas Power & China SNG
3. Diesel Switching to Gas
4. NGL Recovery

Global Propane (LPG)
OECD Crude Oil
Japan LNG
UK NBP Gas
China Gas Proxy
US HH Gas
OECD Coal

Sources: IEA 2012 World Energy Outlook, CME Futures, & IHS 2011 World LPG Market Outlook

- Global Propane (LPG)
- OECD Crude Oil
- Japan LNG
- UK NBP Gas
- China Gas Proxy
- US HH Gas
- OECD Coal

Energy Equivalent Basis, $/mmBTU (Constant 2011 Dollars)
The Shale Revolution
Conventional Gas: Harder to Find, Easier to Produce
Unconventional Gas: Easier to Find, Harder to Produce
US Shale Plays

Shale Gas and Shale Oil Plays, Lower 48 States
High Rates of Return in Liquids-Rich Plays Driving Activity

All Wet Gas Plays Drive >20% Return at Current Prices

Liquid rich field plays are forecasted to generate over 75% of incremental gas in USA (+4 TCF) over next 6 years

HH Dry Gas Price = $3.00/MMBTU
NGL Price = 40% WTI
Reason for value-added optimization

- Typical example of revenue associated with NGL recovery
- 180 MMSCFD of 3 GPM gas (~1,100 BTU/SCF)
- Monthly revenue: 14 MM$
- 200 MMSCFD cryogenic NGL recovery plant cost: 20 MM$
- Potential benefit of full optimization is offset by loss in revenue due to schedule increase

**Example**

<table>
<thead>
<tr>
<th>Shale Gas</th>
<th>178 million cubic feet per day (MMcf/d)</th>
<th>@ 3GPM NGL's</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methane</td>
<td>Ethane</td>
<td>Propane</td>
</tr>
<tr>
<td></td>
<td>45%</td>
<td>29%</td>
</tr>
<tr>
<td>n-Butane</td>
<td>i-Butane</td>
<td>Natural Gasoline</td>
</tr>
<tr>
<td>10%</td>
<td>5%</td>
<td>11%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Comp</th>
<th>Price Basis</th>
<th>Value over fuel $M/month</th>
</tr>
</thead>
<tbody>
<tr>
<td>Henry Hub</td>
<td>41% WTI</td>
<td>$4.3</td>
</tr>
<tr>
<td>64% WTI</td>
<td>$4.4</td>
<td></td>
</tr>
<tr>
<td>77% WTI</td>
<td>$1.9</td>
<td></td>
</tr>
<tr>
<td>81% WTI</td>
<td>$1.0</td>
<td></td>
</tr>
<tr>
<td>92% WTI</td>
<td>$2.5</td>
<td></td>
</tr>
</tbody>
</table>

1. Henry Hub = $3.00/mmBTU; WTI = $80/bbl

**Need for value-added optimization without schedule impact**
Overall NGL Barrel & Cryo Plants Projected

Continued Growth in US NGL Production Forecasted

Source(s): Bentek Energy & Ponderosa Advisors
U.S. C2/C3 Supply

US Ethane Industry Dynamics

- Low cost ethane replacing heavier feedstocks (Naphtha, Gas Oil)
- Adding 9,700 kMTA ethylene by 2017 (adds 28% to US Capacity)
- One additional cracker/year expected thereafter
- C2 pricing to vary between ~$6-$10 / mmbtu through 2018

US Propane Industry Dynamics

- Widening of the Panama Canal will allow US LPG to enter the growing Pacific Basin market
- LPG exports adding more than ~400 kb/d by 2015
- PDH will grow to fill propylene gap (4 units sold and total 9 units announced)
- C3 pricing to vary between $500-$700 / MT through 2017

US NGL supply surge to drive olefin expansions

Source: Bentek; *Does not include US imports; domestic supply only
US Shale Development: Natural Gas

- Shale gas to reach ~40% share of US supply by 2015
- Natural gas liquids (NGLs) economics driving continued shale drilling despite reduced US gas price
- Increased E&P efficiencies resulting in continued robust production with fewer active rigs
- Significant incremental US gas supply available for new demand (petrochemicals, power, industry)
Increasing Natural Gas Value Chain Complexity

GP&H Building Capability to Capture & Manage all Major Gas Processing Needs

- Conventional Gas, Shale Gas, CBM, Offshore (FPSO)
- Gas Processing Plant*
- LNG Loading
- LNG Shipping
- LNG Terminal: downloading, storage, re-gasification*
- CNG/LNG Station*
- NGL Extraction Opportunities

*GP&H Growth Areas
# Lessons from U.S. Shale Gas Variability

## Barnett Shale Gas Composition

<table>
<thead>
<tr>
<th>Well</th>
<th>C₁</th>
<th>C₂</th>
<th>C₃</th>
<th>CO₂</th>
<th>N₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>80.3</td>
<td>8.1</td>
<td>2.3</td>
<td>1.4</td>
<td>7.9</td>
</tr>
<tr>
<td>2</td>
<td>81.2</td>
<td>11.8</td>
<td>5.2</td>
<td>0.3</td>
<td>1.5</td>
</tr>
<tr>
<td>3</td>
<td>91.8</td>
<td>4.4</td>
<td>0.4</td>
<td>2.3</td>
<td>1.1</td>
</tr>
<tr>
<td>4</td>
<td>93.7</td>
<td>2.6</td>
<td>0.0</td>
<td>2.7</td>
<td>1.0</td>
</tr>
</tbody>
</table>

“Oil and gas geochemistry and petroleum systems of the Fort Worth basin”, AAPG Bulletin, Vol. 91, No. 4 (April 2007)

## Marcellus Shale Gas Composition

<table>
<thead>
<tr>
<th>Well</th>
<th>C₁</th>
<th>C₂</th>
<th>C₃</th>
<th>CO₂</th>
<th>N₂</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>79.4</td>
<td>16.1</td>
<td>4.0</td>
<td>0.1</td>
<td>0.4</td>
</tr>
<tr>
<td>2</td>
<td>82.1</td>
<td>14.0</td>
<td>3.5</td>
<td>0.1</td>
<td>0.3</td>
</tr>
<tr>
<td>3</td>
<td>83.8</td>
<td>12.0</td>
<td>3.0</td>
<td>0.9</td>
<td>0.3</td>
</tr>
<tr>
<td>4</td>
<td>95.5</td>
<td>3.0</td>
<td>1.0</td>
<td>0.3</td>
<td>0.2</td>
</tr>
</tbody>
</table>

“Compositional variety complicates processing plans for US shale gas”, Oil & Gas Journal, March 9, 2009

## New Albany Shale Gas Composition

<table>
<thead>
<tr>
<th>Well</th>
<th>C₁</th>
<th>C₂</th>
<th>C₃</th>
<th>CO₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>87.7</td>
<td>1.7</td>
<td>2.5</td>
<td>8.1</td>
</tr>
<tr>
<td>2</td>
<td>88.0</td>
<td>0.8</td>
<td>0.8</td>
<td>10.4</td>
</tr>
<tr>
<td>3</td>
<td>91.0</td>
<td>1.0</td>
<td>0.6</td>
<td>7.4</td>
</tr>
<tr>
<td>4</td>
<td>92.8</td>
<td>1.0</td>
<td>0.6</td>
<td>5.6</td>
</tr>
</tbody>
</table>


## Antrim Shale Gas Composition

<table>
<thead>
<tr>
<th>Well</th>
<th>C₁</th>
<th>C₂</th>
<th>C₃</th>
<th>CO₂</th>
<th>N₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>27.5</td>
<td>3.5</td>
<td>1.0</td>
<td>3.0</td>
<td>65.0</td>
</tr>
<tr>
<td>2</td>
<td>57.3</td>
<td>4.9</td>
<td>1.9</td>
<td>0.0</td>
<td>35.9</td>
</tr>
<tr>
<td>3</td>
<td>77.5</td>
<td>4.0</td>
<td>0.9</td>
<td>3.3</td>
<td>14.3</td>
</tr>
<tr>
<td>4</td>
<td>85.6</td>
<td>4.3</td>
<td>0.4</td>
<td>9.0</td>
<td>0.7</td>
</tr>
</tbody>
</table>

Distributed Global Gas Reserves

Remaining Recoverable Natural Gas Resources
HON regions, 2012, tm cubic metres (tcm)

<table>
<thead>
<tr>
<th>Region</th>
<th>Acid Gas</th>
<th>NGL Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>North America (ex. Mexico)</td>
<td>67 High</td>
<td>47 Med</td>
</tr>
<tr>
<td>Latin America</td>
<td>48 High</td>
<td>32 Med</td>
</tr>
<tr>
<td>Africa</td>
<td>40 High</td>
<td>49 Med</td>
</tr>
<tr>
<td>Middle East</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CIS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Western Europe</td>
<td>22 High</td>
<td>24 Med</td>
</tr>
<tr>
<td>India</td>
<td>4 High</td>
<td></td>
</tr>
<tr>
<td>China</td>
<td>48 High</td>
<td>36 Med</td>
</tr>
<tr>
<td>OAP</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

No circle within a region indicates minimal known Acid Gas or NGL Content

Opportunities for GP&H in Med-to High Acid Gas or NGL Areas

Sources: IEA, BP, PFC Energy, EIA

World total = 790

Unconventional 328
Conventional 462
Honeywell Offers for Shale Resource Monetization
UOP Offers to the Oil and Gas Industry

**Upstream**
Exploring for, drilling for and producing crude oil and natural gas

**Midstream**
Processing, storage and transportation

**Downstream**
Refining and converting oil / gas into end products such as fuels and chemicals
Maximize Value of Gas Projects with Speed of Implementation

Monetize Methane and Natural Gas Liquids
UOP Natural Gas Solutions

Natural Gas Extraction
- Dehydration
- Mercury Removal
- Acid Gas Removal (CO2, H2S)

Acid Gas

Sulfur Recovery

Liquids Recovery

Fractionation

Liquefaction

- Sulfur
- Dry Sweet Gas
- LNG
- Raw Natural Gas Liquids
- Ethane
- Propane
- Mixed Butanes
- Natural Gasoline

UOP Petrochemical technology to further convert / upgrade NGLs

HUR and UOP: Many solutions to maximize gas monetization
HUR: The Gas Processing Experts *TM*

- **Company Overview**

- **History:**
  - Private company founded in 2002. Headquarters and operations in Tulsa, OK
  - Second Company Founded by Thomas Russell in Gas Plant Design
    - First Company sold to Hanover and later merged into Exterran
  - 70% ownership acquired by Honeywell UOP in October 2012

- **Business Description:**
  - Design, engineer, manufacture & install skid mounted natural gas conditioning plants
  - Emphasis on NGL extraction and processing
  - Pre-engineered designs & significant know-how in plant designs

- **Corporate Office:**
  - Tulsa, OK. HUR base for Engineering, Project Management, Sales and Admin, within 15 miles of our Manufacturing Shop

- **Manufacturing Shop:**
  - Port Of Catoosa location
  - Enclosed 32,000 sq ft Fabrication site
  - Fully Equipped for lifting and welding
  - 120,000 sq ft parts storage facility
  - 12 acres of secure lay-down area

- **Employees:** ~115
  - ~10 in New Products Development / Sales Support
  - ~40 Engineering Group
  - ~15 Projects Group
  - ~50 Manufacturing
UOP Russell Products

Nat Gas Conditioning

- Dehydration
  - Mol Sieve Adsorption
  - Glycol (TEG, DEG) Absorption

- Acid Gas Treatment
  - Amine Units (200, 400, 700, & 1000 gpm sizes)

Acid Gas Treatment

- Amine Units (200, 400, 700, & 1000 gpm sizes)

NGL Recovery

- Rich Gas Conditioner
  - Mechanical Refrigeration
  - Cryogenic Turboexpander

- GAS NGL CONTENT (GPM)²
  - 9
  - 6
  - 4
  - 3
  - 2

- ²GPM = gallons of NGL per thousand scf of natural gas

- ¹gpm = gallons of amine per minute

Segment

Offering

NGL Upgrading

- Fractionation
  - Deethanizer, Depropanizer, Debutanizer

Complete Modular Equipment Solution
UOP Russell Cryogenic plant Skids

UOP Russell’s Skids are Factory Tuned and Ready for Installation
UOP Russell Packaged NGL Plant

19 weeks later ...

Modular Design
UOP Russell Packaged Plant Capabilities

Package process technology as skid-mounted, shop-fabricated packages for:

- Lower cost fabrication versus on-site construction
- Faster installation
- Trusted process and mechanical performance
- High on-stream efficiency

Ideal candidates for packaged units:

- Units sized for 200 MMSCFD or less
- Remote locations
- Plants with multiple trains

UOP Russell technology solutions (CO2 removal, dew pointing and NGL recovery) delivered as pre-fabricated modules
UOP Russell: Packaged Plants Benefits

Fast Gas

- Quick Startup
- Skid Mount Mobility
- In-Parallel Field / Skid Construction
- Procurement Begins at Order Date
- Flexibility in Feed
- Reduction in Engineering
- Subvendor Delivery Optimization
- Reduced Field Construction
- Quick Startup

UOP Russell Packaged Plants deliver faster on-stream time, lower installed cost and highest feed gas flexibility.
HUR NGL Recovery Packaged Plants

Headquarters
U.S. Plant Locations

- 4-9 GPM Cryo, Refrigeration: Atlas, Crosstex, ETP, Kinder-Morgan
- 4.7 GPM Cryo, Refrigeration: DCP
- 4.9 GPM Cryo, Refrigeration: Enogex, ETP
- 3.7 GPM Cryo, Refrigeration: Scissortail, Wilson
- 5.5 GPM Cryo: Pecan
- 1-9 GPM Cryo, Refrigeration: MarkWest, Wilson

HUR is the #1 supplier of pre-fabricated, modular NGL recovery plants

250 Executed Projects
>100 Operating Plants
>10BSCFD Gas Treated
Methane and NGL Monetization Options

Upgrade to higher value products

Gas Field
Shale Gas

Demethanizer
Deethanizer
Depropanizer
Debutanizer

Ethane
Methane
Propane
Butane
Natural Gasoline
Monetize Methane to Olefins

- Methanol-to-Olefins (MTO) is now a reality in China
- >20 MTO projects in various stages of D&C
- UOP’s work in MTO dates back to 1980’s
- UOP has 4 UOP licensed plants in China
- First UOP Advanced MTO Process Unit to s/u in 2013
Monetize Propane to Propylene

Propylene Supply / Demand (MMTPA)

- Supply from Refinery FCCs
- Supply from Steam Crackers
- Demand (Polymer/Chemical Gr.)

Data Source: IHS Chemical

- "Propylene Gap" is growing
  - Propylene demand growing at ~4% CAGR
  - Crackers shifting to lighter feedstocks, with less propylene
  - "On-Purpose Propylene" to fill the gap; MTO and PDH

PDH - Propane Dehydro

- "Propylene Gap"
- $500/MT – $800/MT
- $1300/MT

UOP Oleflex™ Process

- "Single Feed – Single Product" enables simple project execution
- Excellent forward or back integration
- 14 operating PDH plants world-wide (9 utilize UOP’s Oleflex Process)
- New unit activity focused in China and North America
- UOP has 16 PDH awards since 2011

Oleflex™ - A Key Technology for Filling Propylene Gap
Monetize Butanes to Fuels & Petrochemicals

- **Alternate Products**
  - ETBE
  - HPIB
  - MMA
  - Isoprene

- 6 Commissioned MTBE Complexes with UOP Oleflex Process
- 7 New C4 Oleflex Awards since 2011
- 4 mixed C3/C4 Oleflex Units – “Best of Both Worlds”

- **Fresh Methanol**
  - $375/MT

- **MTBE**
  - $1150/MT

- **ButamerTM Unit**
  - $800-900/MT
  - C5+
  - nC4 → iC4

- **Oleflex Unit**
  - iC4 → iC4=

- **EthermaxTM Unit**

- **DeC3 Column**

- **CSP ORU**
One Honeywell Integration Opportunities
One Honeywell Approach: Integrated Value

Honeywell Business Units

- UOP GP&H
- UOP PT&E
- Honeywell Process
  - HFS
  - HA
  - HSP
- Honeywell Security
  - Integrated Security/CIP
- Sensors & Controls

Honeywell Technology Offerings

- Gas To Liquids NGL Separation
- Acid Gas Removal
- Gasification
- Dehydrogenation
- Gas Purification
- High Purity Hydrogen H2
- Flare Stack
- Burners
- Oxidizers
- DCS Control Systems
- Gas Measurement & Metering
- Sensors & Wireless Transmitters
- Fire & Smoke Detection Systems
- Gas & Flame Detectors
- Personal Protective Equipment
- PPE
- Access & Monitoring
- Control Systems
- Sensors, Actuators

Oil & Gas Value Chain Areas

- Offshore
  - FPSO / FLNG
  - Oil & Gas Platform
- Onshore
  - Oil & Gas Reserves
  - Shale Oil & Gas
- Offloading & Storage
- Chemical Plant
- Refinery
- Gas Treatment
- Storage
- Pipeline
- Transfer
- Liquefaction
- LNG CNG
GP&H / HPS Integration Opportunities

- Honeywell UOP Russell
- Aligning HPS with UOP PSA Projects
- Integrated FPSO Solutions
- Small scale LNG
- Natural Gas Vehicles Value Chain
- Account Management / Sales Alignment
UOP is the Market Leader in Acid Gas Removal Membranes: 6,000 MMSCFD Installed Capacity

North America 549 MMSCFD

Latin America 472 MMSCFD

Africa 791 MMSCFD

Europe 981 MMSCFD

Pakistan 897 MMSCFD

S.E. Asia 2,277 MMSCFD

China and FSU 43 MMSCFD

Australia 34 MMSCFD
Honeywell is uniquely situated to provide a full suite of technology solutions for the FPSO vessel. Our Technology employed can provide significant increase in yield and operational efficiency to the owners/operators.

“Input from Honeywell during the design phase of our FPSO resulted in a significant reduction of labor costs.”

–Mike Baker
Project C&I Lead Texaco Captain FPSO

**Successful Projects**
- Captain FPSO Laminaria
- Esso Norge Jotun FPSO
- FPSO Cidade de Angra dos Reis (MODEC)
- FPSO Cidade de Sao Paulo (MODEC)
- FPSO Replicants (Petrobras)
- FPSO Cessao Onerosa (Petrobras)

UOP has been selected for 100% of Petrobras pre salt FPSOs tendered (Cidade de Angra dos Reis, Sao Paulo, Replicants and Cessao Onerosa)

**Honeywell FPSO Solutions**

- **Well/Reservoir Monitoring & Control**
  - Production Well Monitoring & Choke Control
  - Gas Lift Control
  - Gas/Water Injection Well Monitor & Choke Control
  - Down-hole Monitoring

- **Advanced Applications**
  - Production Optimization
  - Power Management
  - Gas Lift Optimization

- **Acid Gas Treating and Dehydration**
  - Membrane CO2 Removal Systems
  - Bulk, selective or trace acid gas removal
  - Gas Dehydration Systems
  - Mercury Removal

- **Power Applications**
  - Power management
  - Load Shedding
  - Turbo Generator Control

- **Business and Other Applications**
  - Well Test Accounting
  - Production Accounting
  - Data Warehousing
  - Equipment Health Management
  - Operator Training

- **Other Systems**
  - Personnel Address
  - Drilling
  - Communications

- **Helipad Applications & Others**
  - Guidance and obstruction lighting
  - (Condition-based Maintenance)

- **Safety Systems**
  - Process Shutdown
  - Security
  - Emergency Shutdown
  - Fire and Gas detection
  - Heating, Ventilation and Air Conditioning

- **Topside Process Control**
  - Gas Processing Control
  - Flow Control & Metering
  - Compressor Control
  - Gas/Oil Pipeline Monitor & Control
  - Turbo Generator Control
  - Gas/Oil/Water Separation Control
  - Well Test Control
  - Water Treatment Control

- **Marine Systems**
  - Propulsion & Dynamic Positioning
  - Loading Computer
  - Cargo & Ballast Control

- **Aero**

- **UOP**

- **Automation & Control Solutions**