



# Strategic Advantage

## A Primer on Advanced Resources' North American Natural Gas Supply and Price Service



# Highlights of Advanced Resources' Accomplishments

**Advanced Resources (ARI) initiated their natural gas supply analysis in the late 1970s with the three volume report, “Enhanced Recovery of Unconventional Gas”.**

- In the 1980s and 1990s, ARI helped evaluate and unlock coalbed methane and the Antrim and Barnett shale resources, as lead geological/reservoir engineering support contractor to DOE, the Gas Research Institute and Mitchell Energy.
- In 1996, ARI built EIA’s initial unconventional gas supply and economics model (in NEMS) for shale gas, tight gas and coalbed methane.
- From 2002-2016, as both a technical consultant and Member of the Board, Mr. Kuuskraa assisted Southwestern Energy take the Fayetteville Shale from a concept to a major source of natural gas supply.
- Starting in 2006, ARI advised Cheniere Energy to revise their business plan from being a LNG importer to becoming a LNG exporter, enabling Cheniere to become the “first mover” and gain a multi-year competitive advantage on the industry.
- Currently, ARI provides customized natural gas supply and price outlooks to a select group of major energy and electric power companies.

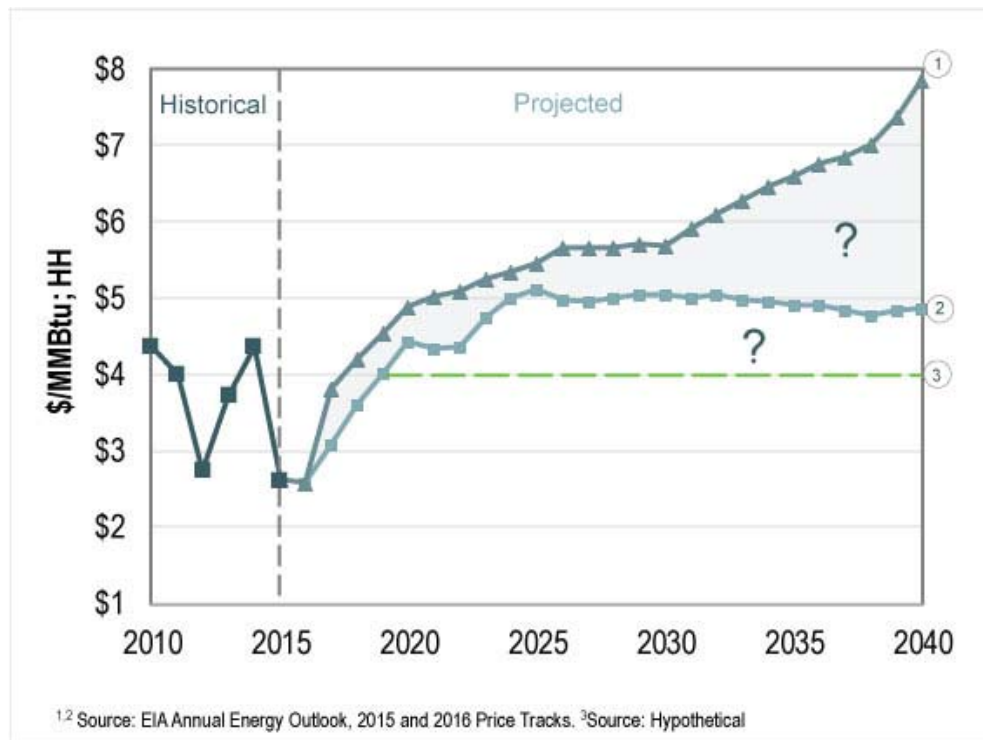
# How Can One Obtain a More Rigorous, Confident Outlook for North American Natural Gas?

***The outlook for natural gas supplies and prices is the single most important factor shaping future fuel purchase and power generation strategies.***

**Gaining insight, instead of opinion, on the outlook for Northern America natural gas supply and prices requires:**

- ***Detailed cost-supply curves*** for each source of U.S. natural gas. For example, our unconventional resource cost curves are constructed from 1,000+ distinct natural gas “break-evens”.
- ***Rigorous understanding of the “dynamic” nature of these cost-supply curves.*** Our models include depletion of highly productive “core areas,” addition of new resource plays, and improved well performance from progress in technology.
- ***Incorporation of other factors.*** Our projections account for infrastructure availability, industry’s financial status and expected growth in natural gas exports and consumption.

# Alternative Outlooks for North American Natural Gas Prices



Considerable uncertainty surrounds the outlook for natural gas supplies and particularly natural gas prices.

For example, over the past year, the U.S. Energy Information Administration (EIA) has lowered its long-term outlook for natural gas prices dramatically while other analytical services tout flat natural gas prices “forever.”

Advanced Resources detailed cost-supply data and market dynamics for 1,000+ North American natural gas “break-evens” enables us to provide more rigorous outlooks for natural gas supplies and prices than others.

# Constructing “Dynamic” Oil and Natural Gas Supply Models

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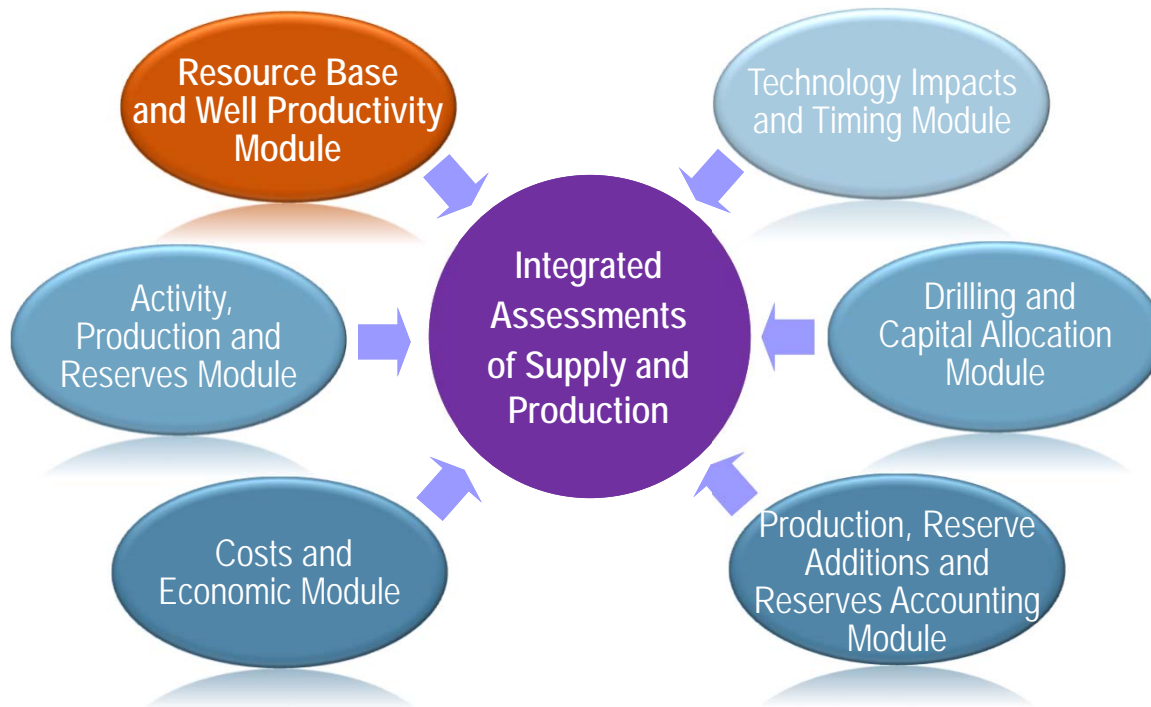
**Our oil and natural gas supply models contain a series of key features that capture the “dynamic” nature of the North American oil and gas supply sector:**

- A. Industry’s DUC inventory, capital availability and financial health
- B. Technology progress, geologic learning and resource depletion
- C. Well D&C cost-price relationship
- D. NGL pricing and costs
- E. Infrastructure constraints and regulatory environment

**Each of these factors affects the “break-even” costs of natural gas supply and, when integrated with demand, the “market-clearing” price for natural gas.**

# Integrated Modeling of North American Oil and Natural Gas Production

## North American Natural Gas Supply and Price Model



Our North American Natural Gas Supply and Price Model incorporates an extensive conventional and unconventional resource data base, “type curve” based assessments of well performance, and specialized cost and economic modules.

The modeling system accounts for both technology progress and resource depletion for all unconventional oil and gas resources.

# ARI's North American Resource Base and Well Productivity Module

***Our North American Resource Base and Productivity Module Provides Comprehensive Coverage of U.S. and Canadian Oil and Natural Gas Resources.***

**For U.S. crude oil and natural gas, the ARI supply module includes:**

- Onshore L-48 conventional oil and natural gas
- Shale / “tight” oil and gas
- Tight gas sands
- Coalbed methane
- CO<sub>2</sub> enhanced oil recovery
- Offshore Gulf of Mexico (shallow and deep water)
- Alaska
- Natural gas liquids (PADD level projections for ethane, propane, butane and pentane).

**For Canada's crude oil and natural gas, the ARI supply module includes:**

- Conventional oil and natural gas (inc. CO<sub>2</sub>-EOR)
- Shale / “tight” oil and gas
- Tight gas sands
- Coalbed methane
- Oil sands
- Natural gas liquids (individual projections for ethane, propane, butane and pentane).

# ARI's Shale and Other Unconventional Cost-Supply Curves

**The detail and quality of ARI's resource databases are what separates our capability from others.**

Unconventional Gas Source	Recoverable Undeveloped Resources	No. of Basins	No. of Unique "Break-Evens"	Economically Viable			
				<\$4	\$4-5	\$5-6	>\$6
	(Dry; Tcf)			(Tcf)	(Tcf)	(Tcf)	(Tcf)
Shale	2,241	21	489	<i>(Our Proprietary Advantage)</i>			
Tight Sand	899	14	339				
CBM	92	11	93				
<b>Total</b>	<b>3,232</b>	<b>46</b>	<b>921</b>				

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- Cost/supply curves for unconventional gas includes 261 distinct U.S. plays and 46 distinct Canadian plays representing "sweet spots" to "goat pasture". These plays hold 921 "break-evens".
- Cost/supply curves updated regularly with new plays added (e.g., "Stack and Scoop") as they emerge and changes in technology incorporated into future well performance.
- Data base includes associated gas production from "tight" oil, plus NGLs and condensate from wet gas.
- Similar supply data bases for U.S. conventional onshore and offshore natural gas and for Canadian oil and natural gas, containing an additional 114 "break-evens".



# ARI's Unconventional Gas Resource Base

Our resource data base includes the following major U.S. and Canadian shale gas, tight gas and coalbed methane basins and plays.

**U.S. Shale Gas.** The U.S. shale gas assessment includes 143 plays in 23 basins with 429 "break-evens":

- Antrim Shale (3 break-evens)
- Big Sandy Shale (9 break-evens)
- Bakken/Three Forks (54 break-evens)
- Barnett Shale (15 break-evens)
- Bossier Shale (6 break-evens)
- Eagle Ford Shale (48 break-evens)
- Fayetteville Shale (12 break-evens)
- Haynesville Shale (24 break-evens)
- New Albany Shale (3 break-evens)
- Lewis Shale (3 break-evens)
- Mancos Shale (9 break-evens)
- Marcellus Shale (33 sub plays)
- Monterey Shale (15 break-evens)
- Niobrara Shale: Denver (15 break-evens)
- Niobrara Shale: Piceance (6 break-evens)
- Niobrara Shale: Powder River (6 break-evens)
- Pearsall Shale (6 break-evens)
- Upper Devonian (12 break-evens)
- Utica Shale (45 break-evens)
- Eaglebine Shale (9 subplays)
- Tuscaloosa Marine Shale (9 break-evens)
- Wolfcamp Shale (33 break-evens)
- Cline Shale (6 break-evens)
- Avalon Shale (3 break-evens)
- Meramec (9 break-evens)
- Springer Shale: (6 break-evens)
- Woodford Shale: Ardmore (3 break-evens)
- Woodford Shale: Anadarko (21 break-evens)
- Woodford Shale: Arkoma (6 break-evens)

**U.S. Tight Gas Sands.** The U.S. tight gas sands assessment includes 88 plays in 18 basins with 264 "break-evens":

- Anadarko Tight Gas (36 break-evens)
- Appalachia Tight Gas (18 break-evens)
- Arkoma Tight Gas (3 break-evens)
- Bossier Tight Gas (9 break-evens)
- Cotton Valley Tight Gas (15 break-evens)
- DJ Basin Tight Gas (9 break-evens)
- Granite Wash Tight Gas (15 break-evens)
- Green River Tight Gas (30 break-evens)
- Gulf Coast Tight Gas (15 break-evens)
- James Lime Tight Gas (3 break-evens)
- Permian Tight Gas (30 break-evens)
- Piceance Tight Gas (12 break-evens)
- Powder River Tight Gas (18 break-evens)
- San Juan Tight Gas (9 break-evens)
- Travis Peak Tight Gas (3 break-evens)
- Uinta Tight Gas (12 break-evens)
- Wind River Tight Gas (12 break-evens)
- Austin Chalk (15 break-evens)

**U.S. Coalbed Methane.** The U.S. coalbed methane assessment includes 30 break-evens in 11 basins with 90 "break-evens":

- Appalachia CBM (9 break-evens)
- Cahaba CBM (3 break-evens)
- Green River CBM (6 break-evens)
- Illinois CBM (3 break-evens)
- Mid-Continent CBM (6 break-evens)
- Piceance CBM (12 break-evens)
- Powder River CBM (12 break-evens)
- Raton CBM (9 break-evens)
- San Juan CBM (15 break-evens)
- Uinta CBM (9 break-evens)
- Warrior CBM (6 break-evens)

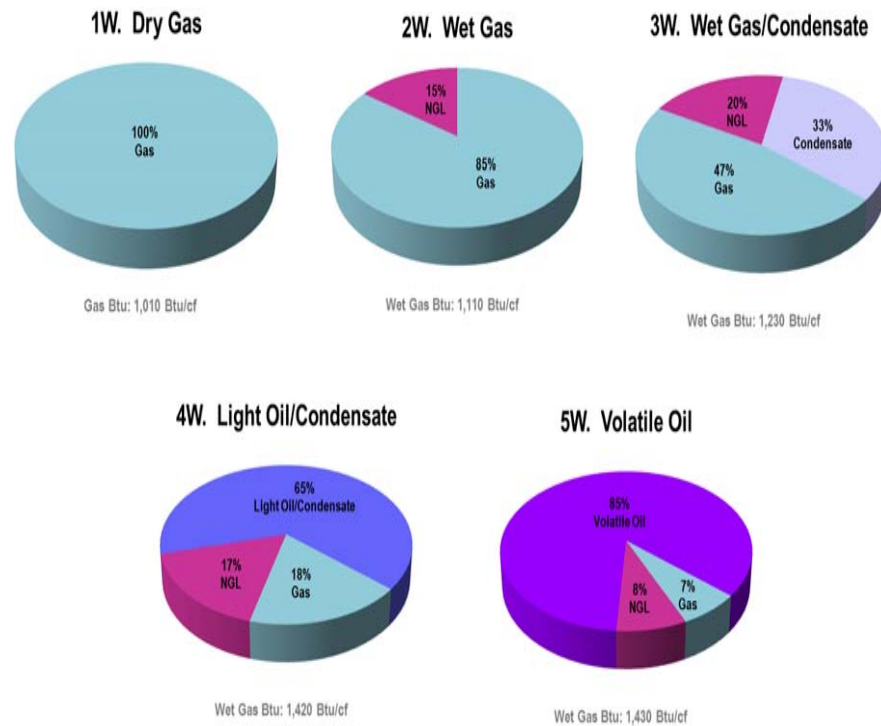
**Canada.** The Canadian unconventional gas resource assessment includes 46 plays in 11 basins with 138 "break-evens":

- Cordova Shale (6 break-evens)
- Duvernay Shale (12 break-evens)
- Utica Shale (15 break-evens)
- Cardium (15 break-evens)
- Horn River Shale (12 break-evens)
- Liard/Besa River Shale (6 break-evens)
- Wilrich (9 break-evens)
- Viking (9 break-evens)
- Bakken (15 break-evens)
- Montney (36 break-evens)
- Alberta Basin CBM (3 break-evens)

# ARI's Oil and Natural Gas Resource Database

**Our resource base contains detailed partitions to capture the geologic diversity and wide range in well performance unique to each basin.**

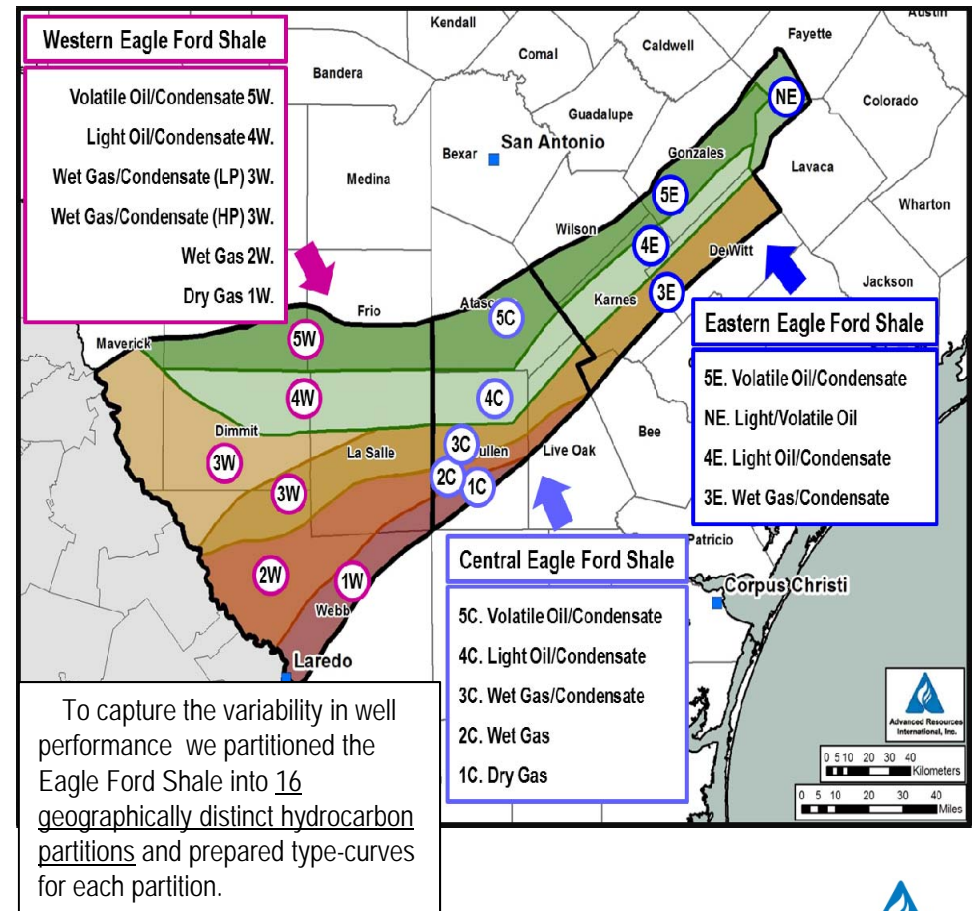
*Five Hydrocarbon Types: Sixteen Partitions and Forty-Eight Break-Evens.* The hydrocarbon content of the Eagle Ford Shale ranges from 100% dry gas in the south to 85% volatile oil in the north. The geologic setting range from ultra-deep in the south to moderately shallow in the north.



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Source: Advanced Resources International, 2014

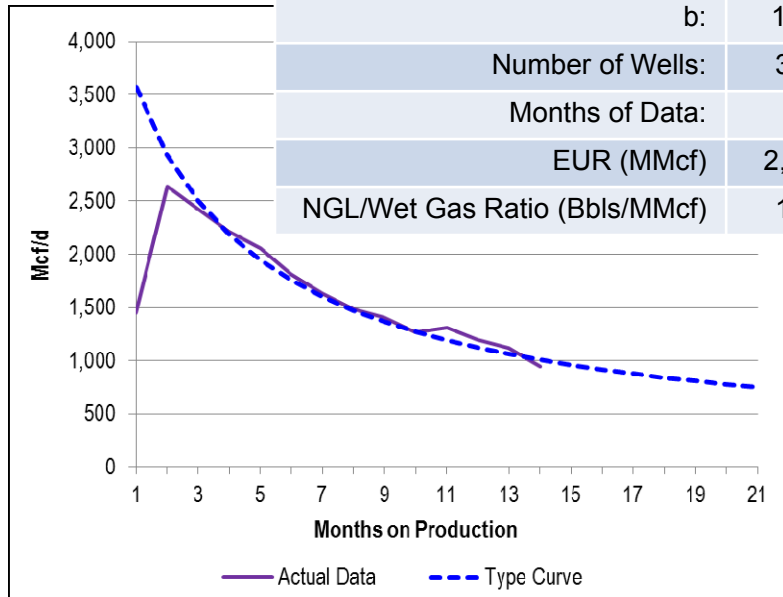
## Eagle Ford Shale Partitions



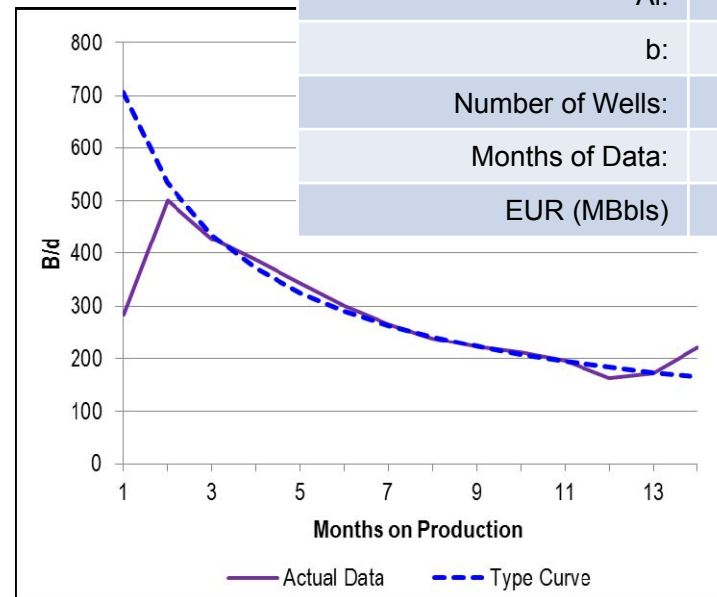
# ARI's Oil and Natural Gas Well Productivity Module

At the heart of our well performance and economic assessments are well productivity “type curves”, as depicted for one of the 16 geographic partitions of the Eagle Ford Shale (Partition #3E, Wet Gas and Condensate, southern Karnes and Northern DeWitt counties).

Wet Gas Type Well	
Initial Rate (Mcf/d):	4,000
Avg. Rate 1st Month (Mcf/d)	3,574
Ai:	3.0
b:	1.15
Number of Wells:	318
Months of Data:	14
EUR (MMcf)	2,481
NGL/Wet Gas Ratio (Bbls/MMcf)	101



Oil/Condensate Type Well	
Initial Rate (B/d):	840
Avg. Rate 1st Month (B/d)	706
Ai:	5.0
b:	1.3
Number of Wells:	318
Months of Data:	14
EUR (MBbls)	435



# ARI's Economics and Cost Module

Resource:		Shale	
Basin:		Eagle Ford	
Play:		3E Wet Gas/Cond -- Depth 13,000'	
<b>1. Well Performance (Bcf/Well)</b>		<b>1. Realized Price (\$/Mcf)</b>	
EUR/Well (Gross)	2.48	Henry Hub (\$/MMBTU)	\$ 3.00
NRI	80%	Less: Basis Differential	\$ (0.15)
EUR/Well Net	1.98	Plus: Condensate Adjustment*	\$ 7.96
EUR/Well Net (Discounted)	1.03	Plus: NGL Adjustment**	\$ 1.75
<b>2. OPEX (\$/Mcf)</b>		Less: Gas Loss	\$ (0.32)
LOE & Liquids Lifting	\$ 2.39	Less: NGL Separation Fee	\$ (0.36)
G&A	\$ 0.40	Net Price	\$ 11.88
Gathering/Other	\$ 0.25	<b>2. OPEX (\$/Mcf)</b> \$ (4.05)	
Compression Fuel	\$ 0.13	<b>3. F&amp;D @ 15% ROR (BT)</b> \$ (8.99)	
Water Disposal	\$ -	<b>4. Net Profit (\$/Mcf)</b> \$ (1.17)	
Severance Tax	\$ 0.89	<b>5. Break-Even Price (\$/Mcf)</b>	
Total	\$ 4.05	<i>Full Cycle</i>	
<b>3. F&amp;D Costs (\$/Mcf)</b> \$ 4.67		Henry Hub	\$ 4.17
<b>4. CAPEX (\$MM)</b>		Well Head	\$ 4.02
Drilling	\$ 3.12		
Completion	\$ 4.68		
Dry Hole/Mech Failures	\$ 0.28		
Land (@ \$1K/A)	\$ 0.04		
Other (Seismic, ect.)	\$ 1.15		
Total	\$ 9.26		
* Assumes Condensate Production of 174 Bbls/MMcf (NPV Basis), Oil EUR of 435 MBbls and Oil Price of \$50/B (WTI)			
** Assumes 1218 BTUs/cf, Excess BTUs are sold as NGLs (yield of 90 Bbls NGLs/MMcf)			
<b>Other Inputs</b>			
Discount Factor		<b>0.52</b>	

**For Eagle Ford Partition #3E, we have calculated a full-cycle break-even cost of \$4.17/Mcf (HH) based on well performance and costs.**

The wells in this break-evens receive much of their value from production of oil and NGLs. (See Condensate and NGL Adjustment values.)

# Near-Term Outlook for Natural Gas Supplies and Prices

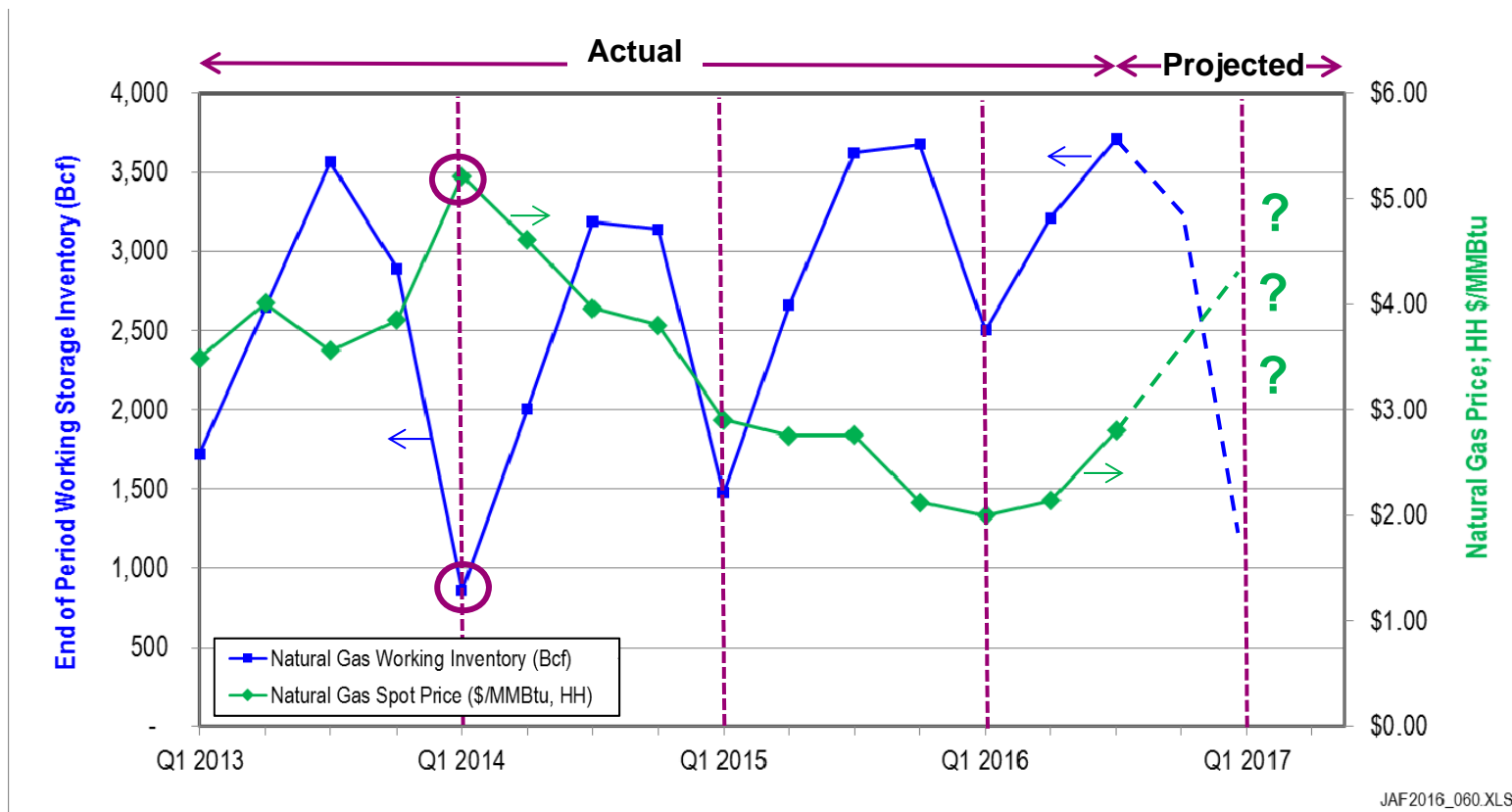
**We look for significant near-term volatility and increased prices for natural gas for the rest of 2016 and the first half of 2017.**

- Domestic consumption and net exports will be 2 to 3 Bcfd higher than in the comparable time periods last year (late 2015/early 2016).
- Meanwhile, domestic natural gas production will be 2 to 3 Bcfd lower than in late 2015 and early 2016:
  - The massive backlog of DUC's (drilled but uncompleted wells) has been mostly consumed.
  - Lower oil prices have led to declining associated gas production from "tight oil" (e.g., Bakken and Eagle Ford).

As a result, we look for a sharp drawdown of natural gas inventories from currently record high levels (assuming normal weather) and the need for higher prices to stimulate additional production.

# Natural Gas Storage and Prices

The sharp decline in natural gas inventories during the winter of 2013/2014 raised prices in 1Q 2014 to over \$5/MMBtu. With sharply lower natural gas inventories expected at the end of 1Q 2017, we project natural gas prices to rise and become highly volatile.



# Longer-Term Outlook for Natural Gas Supplies and Prices

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After the anticipated near-term price volatility, the question becomes: *What will natural gas prices be in the longer-term (2018 – 2040)?*

ARI has a proprietary natural gas supply and price forecasting service that helps answer this question.

- Our natural gas service can be custom tailored to client needs, including numerous demand and oil price scenarios. Clients are provided with detailed information on individual plays as well as on special topics impacting price and supply forecasts.
- We believe that our detailed natural gas resource data base and our ability to capture the “dynamic” nature of the industry, gained from 40 years of experience, separate us from our competitors.

Please email us at [tmalone@adv-res.com](mailto:tmalone@adv-res.com) or call us at 703-528-8420 if you would like to learn more about our services.



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