

# *Economic and Market Impacts of Abundant Shale Gas Resources*

*Prepared By:*
**Vello A. Kuuskraa, President**
**Tyler Van Leeuwen, Consultant**
**ADVANCED RESOURCES INTERNATIONAL, INC.**
**Arlington, VA**

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**A North American Perspective**

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***Unconventional Resources • Enhanced Recovery • Carbon Sequestration***

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# The Paradigm Shift in U.S. Natural Gas Supplies

Driven by a new understanding of the size and availability of gas shales and unconventional gas, a "paradigm shift" is underway on natural gas supplies.

This "paradigm shift" began a decade ago in the U.S., with only modest fanfare.

- Low-cost coalbed methane in the San Juan Basin of Colorado and New Mexico led the way.
- Next came the highly productive tight gas development at the Jonah and Pinedale fields in western Wyoming.
- Third was the emergence of the Barnett and now the other North American shale gas plays.

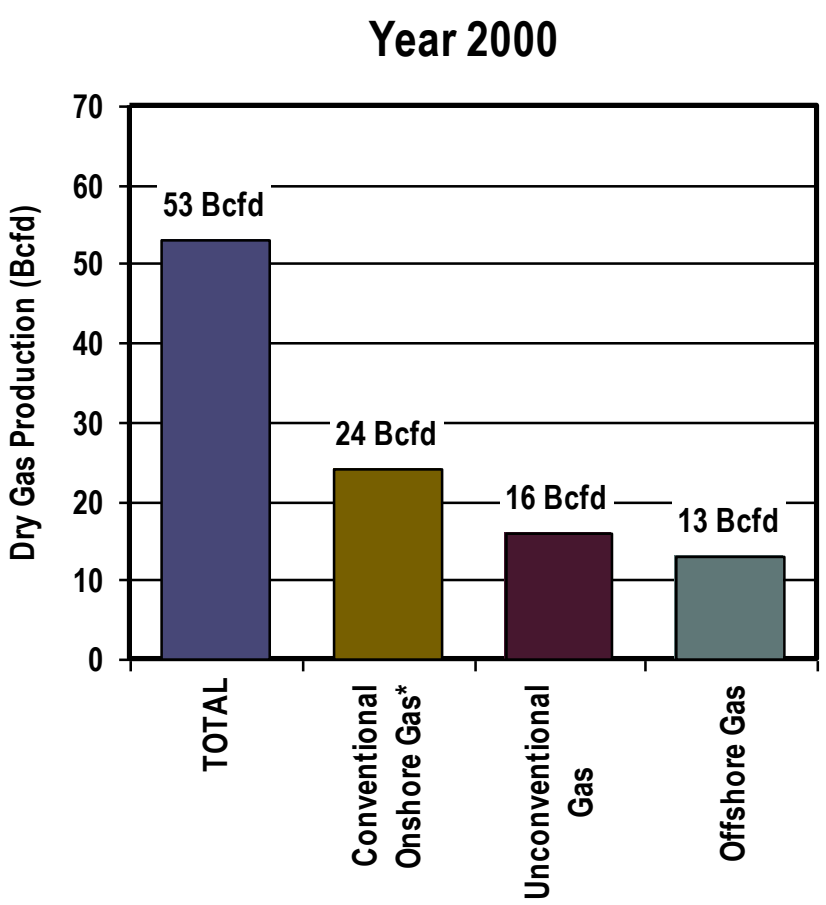
# The Paradigm Shift in U.S. Natural Gas Supplies

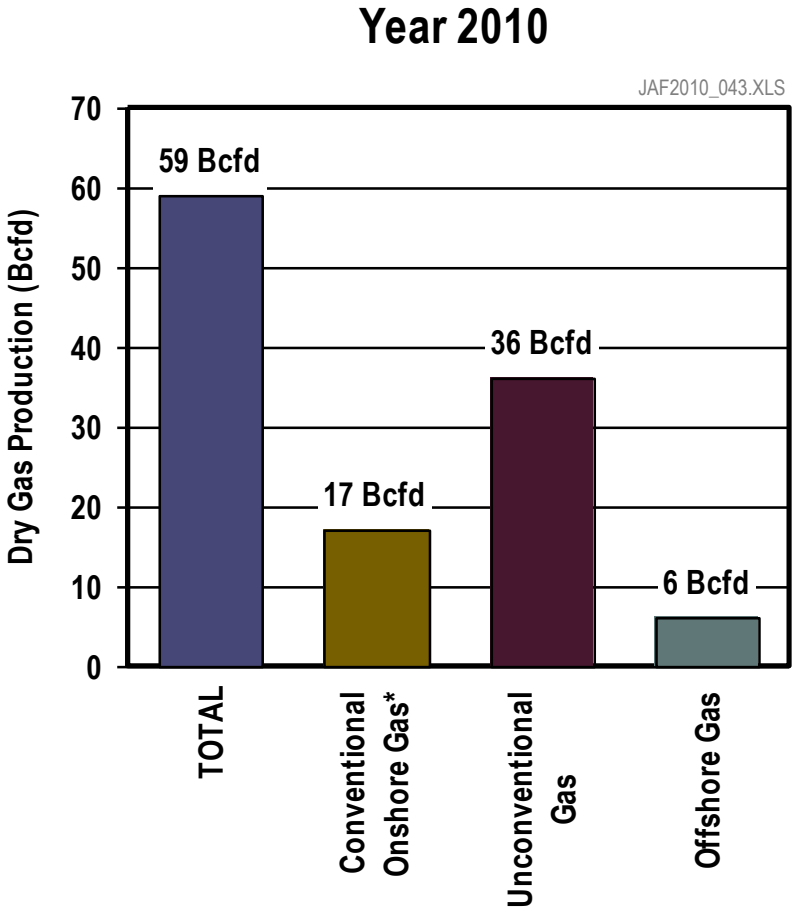
Gas shales have changed the outlook for U.S. natural gas from *"fears of impending scarcity"* to *"expectations of plenty".*

- Instead of declining, U.S. natural gas production increased, from 53 Bcfd in 2000 to 59 Bcfd this year.
- Gains in unconventional gas production of 20 Bcfd more than countered declines in onshore and offshore conventional gas.
- Shale gas provides 12 Bcfd today (20% of domestic natural gas production) and accounts for much of the 20 Bcfd of the growth.
- Today, unconventional gas provides over 60% of U.S. natural gas production.

# Unconventional Gas Is Now the Dominant Source of U.S. Natural Gas Production

The 20 Bcfd growth in unconventional gas production has more than replaced declines in U.S. conventional onshore and offshore production.




*Includes onshore associated, non-associated and Alaska.
Source: U.S. Energy Information Agency (2010); Advanced Resources Int'l (2010).



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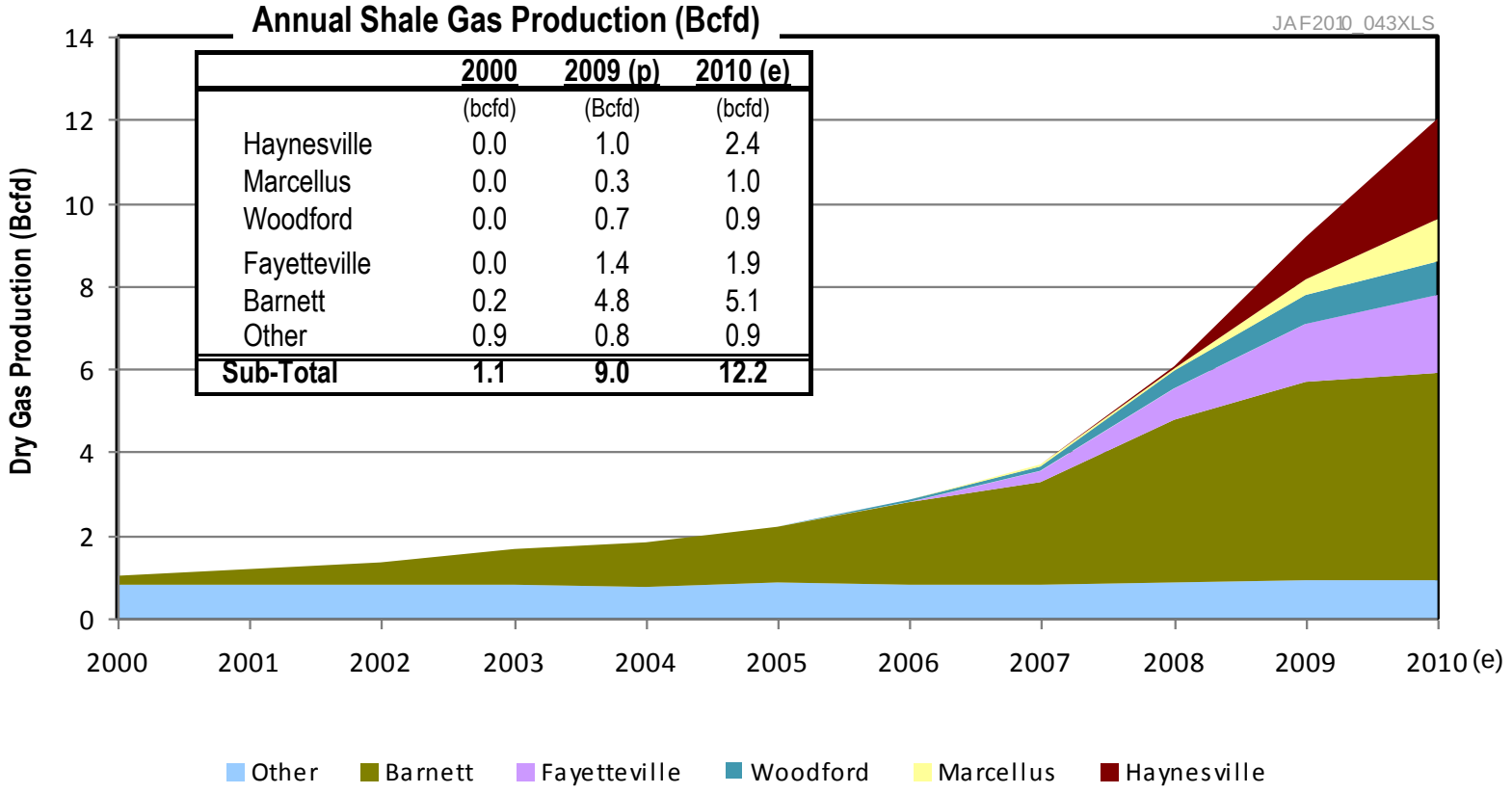
# How Much Does Shale Gas Contribute Today?

Production of shale gas has grown by ten-fold and is expected to exceed 12 Bcfd, equal to 20% of U.S. natural gas production this year.




| | 2000 (bcfd) | 2009 (p) (Bcfd) | 2010 (e) (bcfd) |
|---|---|---|---|
| Haynesville | 0.0 | 1.0 | 2.4 |
| Marcellus | 0.0 | 0.3 | 1.0 |
| Woodford | 0.0 | 0.7 | 0.9 |
| Fayetteville | 0.0 | 1.4 | 1.9 |
| Barnett | 0.2 | 4.8 | 5.1 |
| Other | 0.9 | 0.8 | 0.9 |
| **Sub-Total** | **1.1** | **9.0** | **12.2** |

Source: Advanced Resources International (2010)



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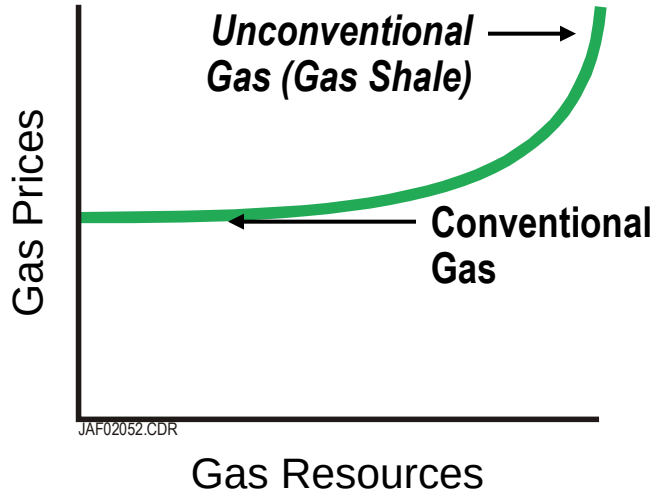
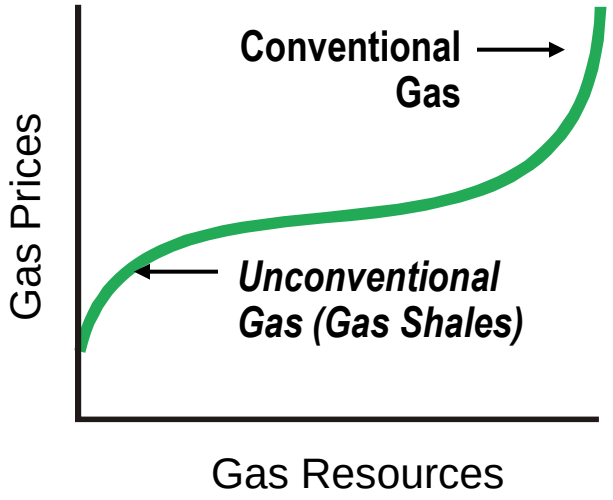
# How Have Shale Gas and Unconventional Gas Impacted Natural Gas Prices?

Unconventional gas (particularly the higher quality gas shales) is today the low cost portion of the natural gas price/supply curve.

## Prior Perception




## New Understanding



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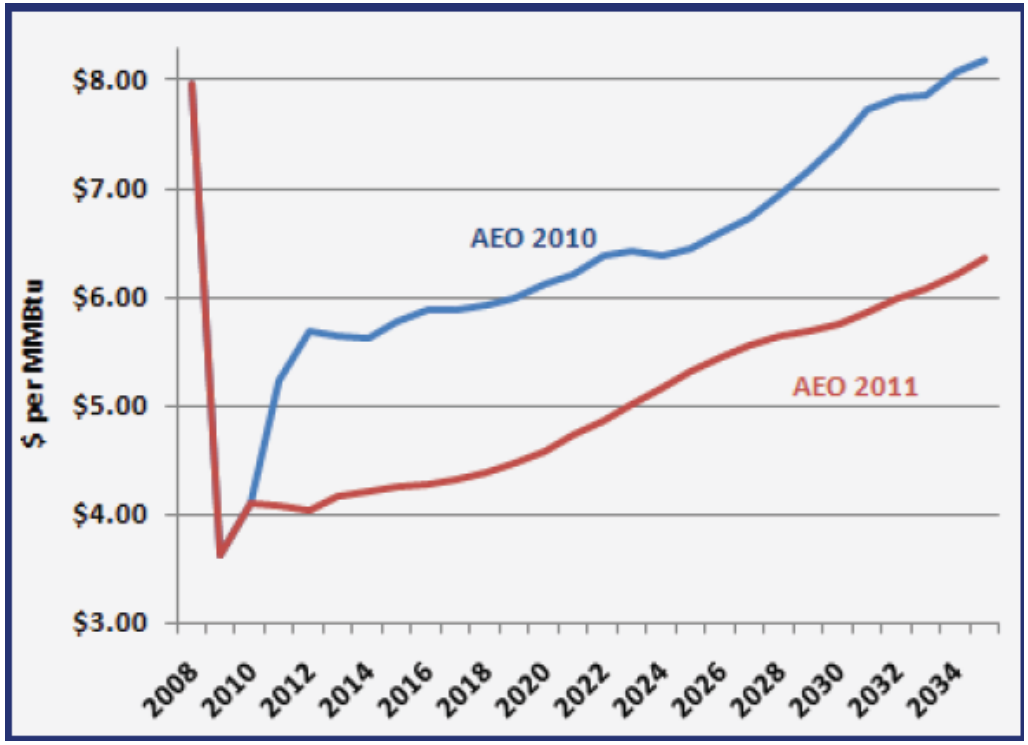
# How Have Shale Gas and Unconventional Gas Impacted Natural Gas Prices?

**Projected Wellhead Natural Gas Prices**
**AEO 2010 versus AEO 2011 (Early Release Overview)**




*In constant 2009 dollars

Source: NG Marketing Notes, January 2011.

The incorporation of a more complete representation of U.S. shale gas resources in the U.S. DOE/EIA Annual Energy Outlook 2011, dramatically lowered projections of future natural gas prices.

The latest projections (AEO 2011) show natural gas prices remaining below $6 per MMBtu (real, 2009 dollars) for the next 20 years.

# Addressing the Fundamental Questions

Projecting the impact and benefits of shale gas and unconventional gas for the U.S. and then for Europe requires that we first address a series of questions:

- *How large is the unconventional gas resource base? Is it large enough to enable unconventional gas to become a major energy, climate change and domestic energy security solution?*
- *How much would progress in technology impact the economically affordable resource base?*
- *Can the resource be developed in an environmentally sound way?*

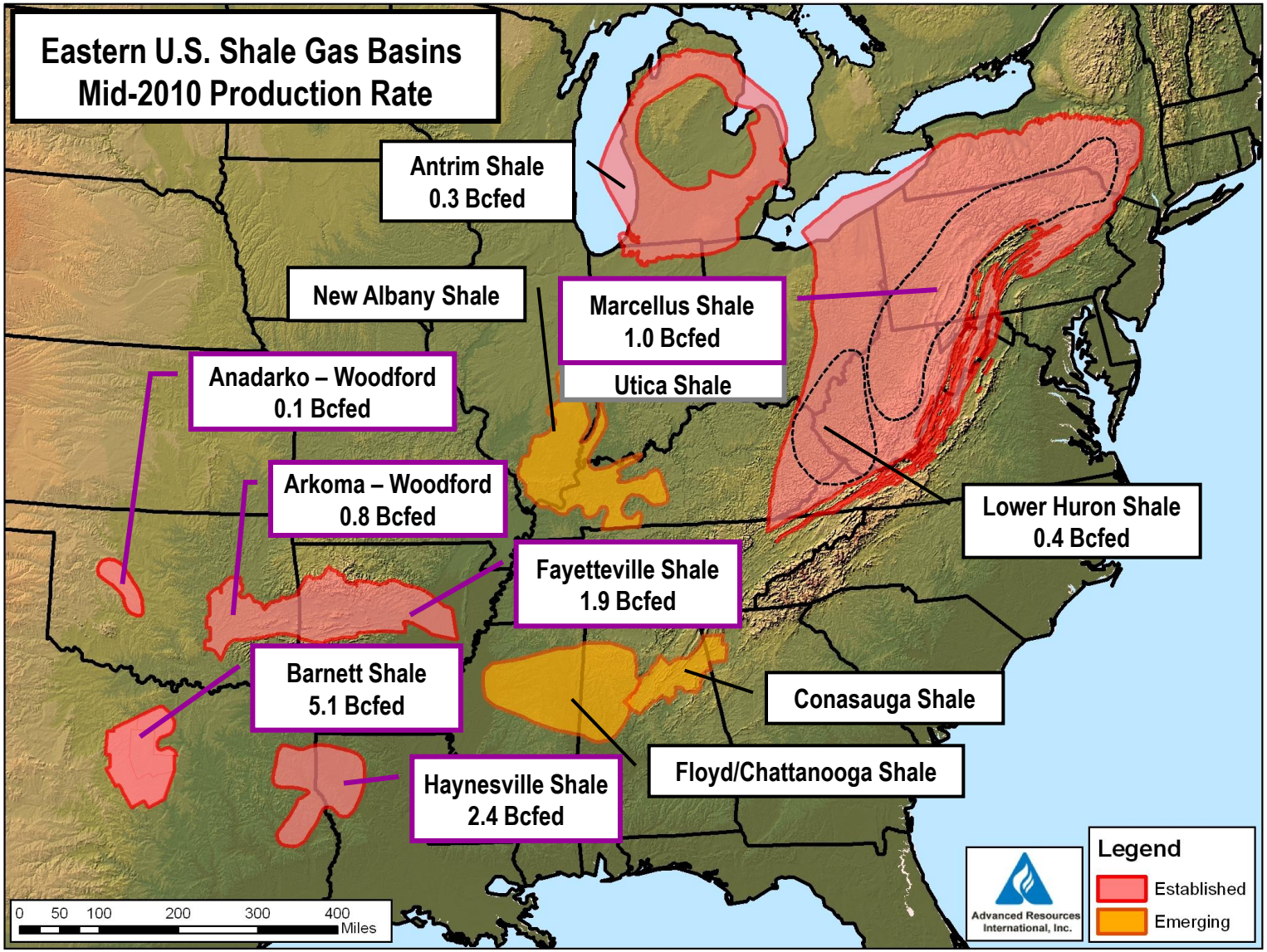
# How Large is the Shale Gas and Unconventional Gas Resource?

Our in-depth assessments of over 100 U.S. shale gas, tight gas sand and coalbed methane basins and plays shows over 1,550 Tcf of technically recoverable resources.

| Sources | Recoverable Resource* |
|---|---|
| | Tcf |
| **Shale Gas** | 820 |
| **Tight Gas Sands** | 610 |
| **CBM** | 126 |

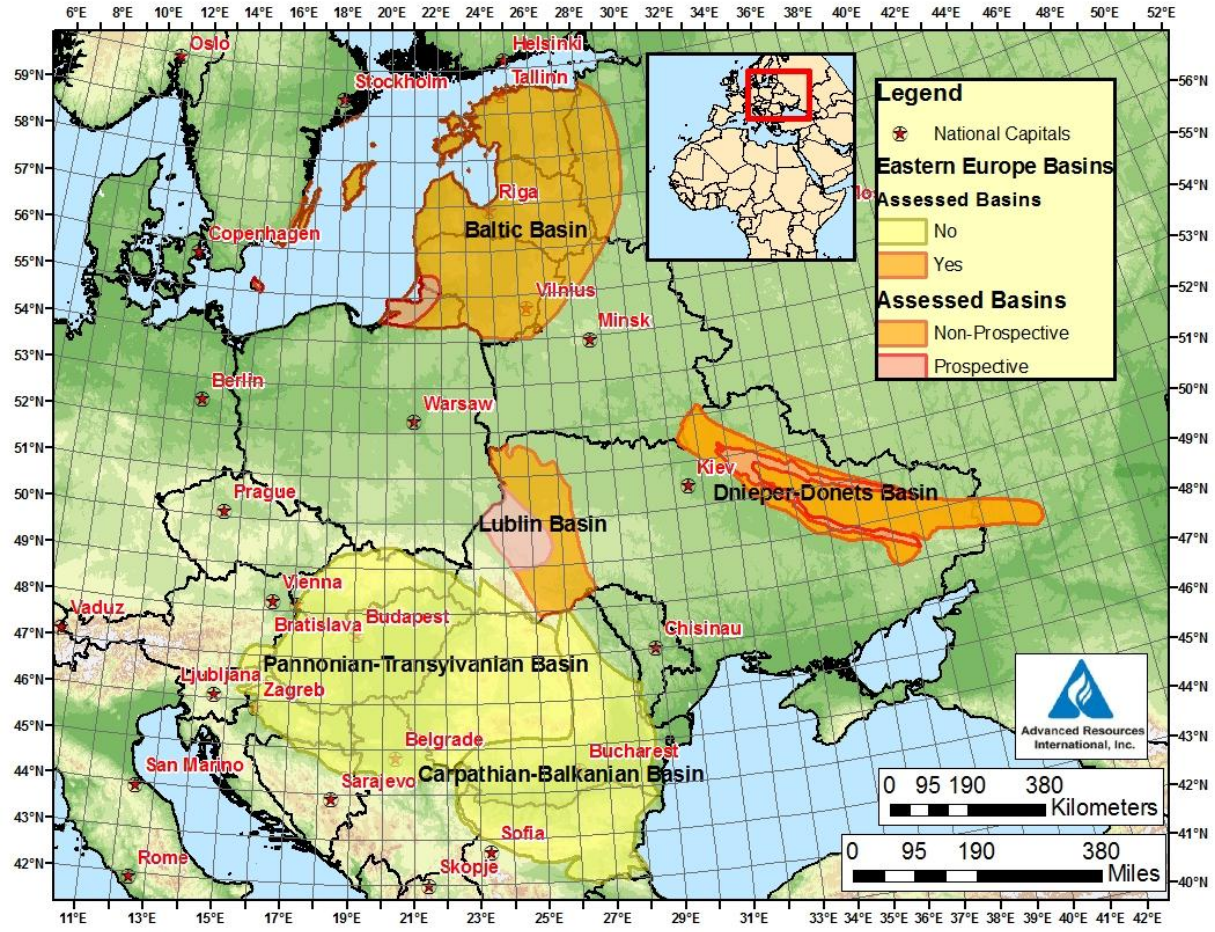
*Includes 39 Tcf of gas shales proved reserves, 96 Tcf of tight gas sands proved reserves and 21 Tcf of coalbed methane proved reserves.

# U.S. Shale Gas Basins




Source: Advanced Resources International

# Eastern Europe's Potential Shale Gas Resources and Basins




Eastern Europe*appears to have a large shale gas resource in Ukraine, Lithuania, and Kaliningrad (Russia) in three basins:

- Baltic
- Dnieper-Donets
- Lublin

Our shale gas resource assessment for Eastern Europe*:

- 290 Tcf (8,560 Bcm) of risked gas in-place.
- 65 Tcf (1,930 Bcm) of risked technically recoverable resource.

Additional shale gas potential, not assessed by this study, exist in the Pannonian-Transylvanian Basin and Carpathian-Balkanian Basin in the southern portion of Eastern Europe.

*Not including Poland.



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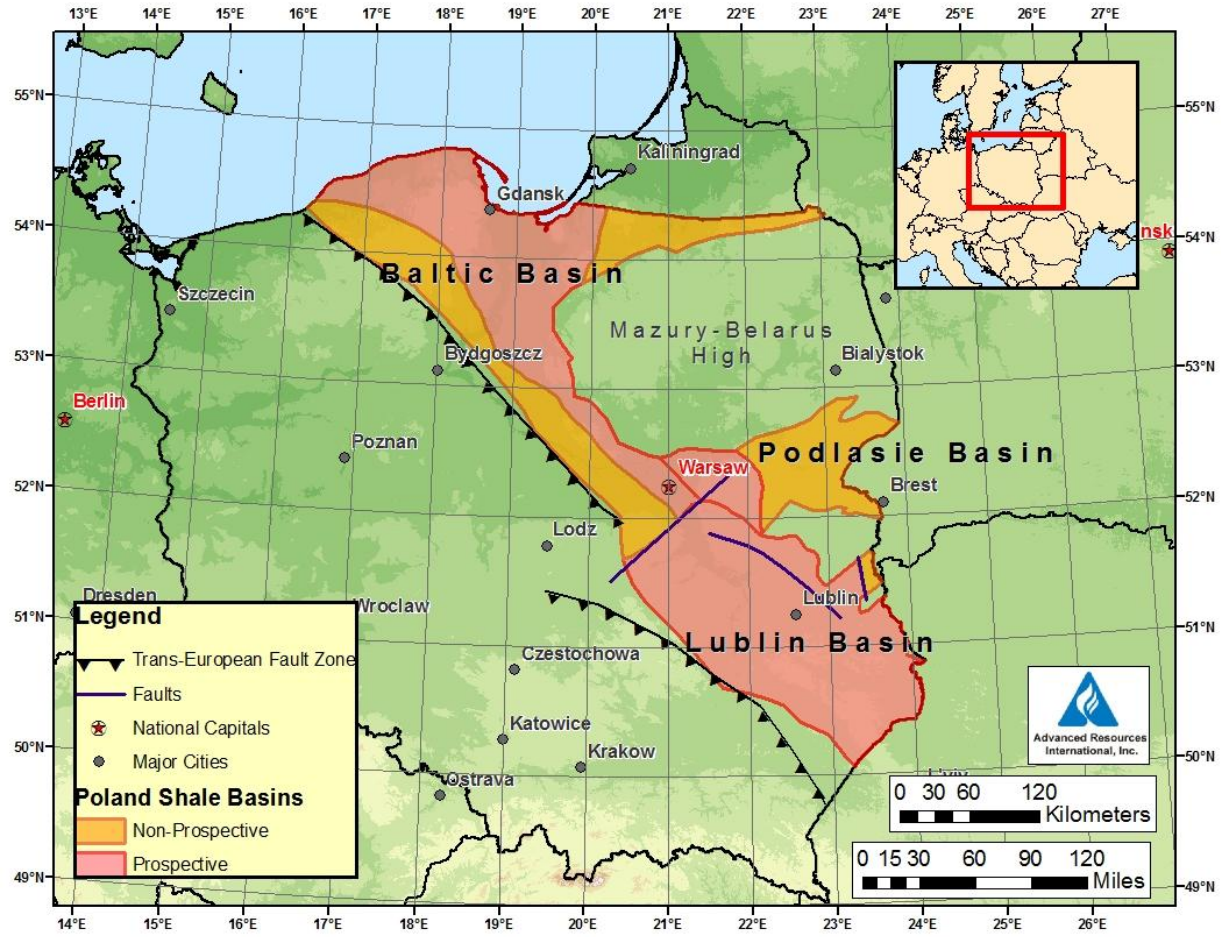
# Poland's Emerging Shale Gas Resources and Basins




Poland appears to hold some of the geologically most favorable shale gas resources in Europe, primarily in three basins:

- Baltic
- Lublin
- Podlasie

Our shale gas resource assessment for Poland:

- 801 Tcf (25,240 Bcm) of risked gas in-place.
- 189 Tcf (6,710 Bcm) of risked technically recoverable resource.



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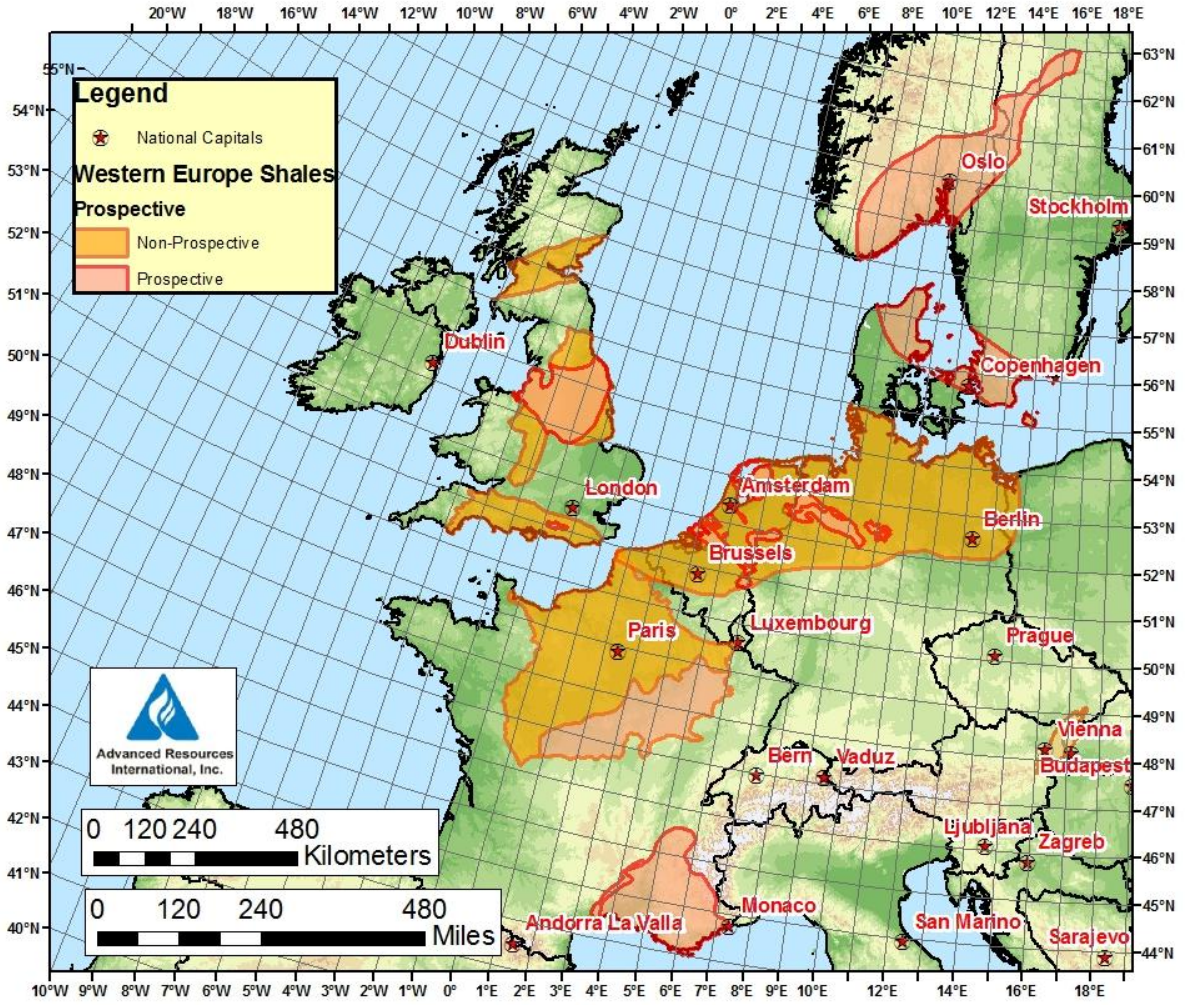
# Western Europe's Potential Shale Gas Resources and Basins




Western Europe's shale gas resources (assessed by our study) exist in the Ordovician Alum Shale of Scandinavia, the Permian/Carboniferous shale of the Paris Basin, and a host of Jurassic-age shale basins.

Our shale gas resource assessment for Western Europe:

- 1,414 Tcf (40,910 Bcm) of risked gas in-place.
- 350 Tcf (11,530 Bcm) of risked technically recoverable resource.



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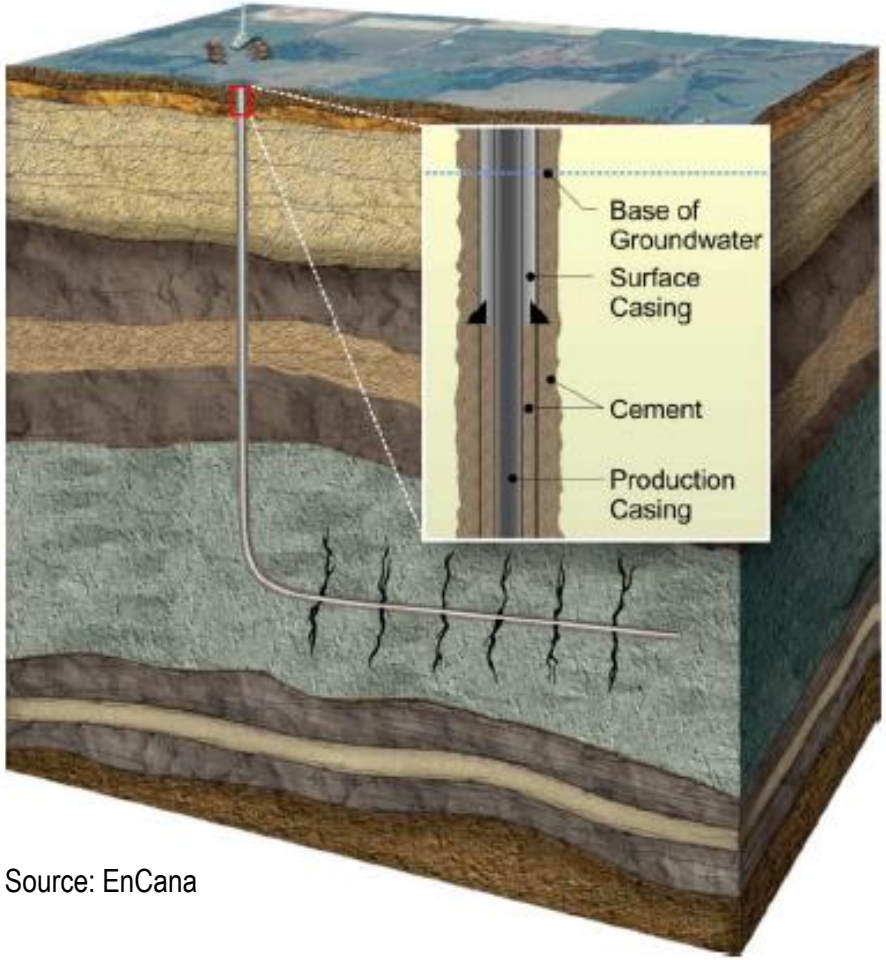
# What Changed the Game?

**Horizontal Well with Multi-Stage Fracturing**




Source: EnCana

Natural gas production from shallow, fractured shale formations in the Appalachian and Michigan basins of the U.S. has been underway for decades.

What "changed the game" was the recognition that one could "create a permeable reservoir" and high rates of gas production by using intensively stimulated horizontal wells.

# *Progress in Technology Converted and Unproducible Resource into a Large, Low Cost Source of Energy*

Shale gas and unconventional gas are a R&D and policy success story:

- The DOE/NETL helped build the essential resource and science knowledge base.
- The Gas Research Institute and industry launched the early technology demos.
- Section 29 tax credits (now expired) helped attract capital and build economies of scale.

However, we are still in the early, emerging stages of having an optimum set of technologies.

# Continued Progress in Technology Will Lower Costs of Producing Gas Shales

An example of the impact of technology progress and continuing cost reductions is provided by improvements in well performance for the Fayetteville Shale.

| Time Frame | New Wells on Production | Average IP Rate (Mcf/d) | Average 30th Day Rate | Average Lateral Length |
|---|---|---|---|---|
| 1st Qtr 2007 | 58 | **1,260** | **1,070** | 2,100 |
| 2nd/3rd/4th Qtr 2007 | 197 | 1,770 | 1,490 | 2,750 |
| 1st Qtr 2008 | 75 | **2,340** | **2,150** | 3,300 |
| 2nd/3rd/4th Qtr 2008 | 244 | 2,920 | 2,480 | 3,720 |
| 1st Qtr 2009 | 120 | **2,990** | **2,540** | 3,870 |
| 2nd/3rd/4th Qtr 2009 | 326 | 3,670 | 2,720 | 4,170 |
| 1st Qtr 2010 | 106 | **3,200** | **2,390** | 4,350 |
| 2nd/3rd Qtr 2010 | 288 | 3,360 | 2,510 | 4,520 |

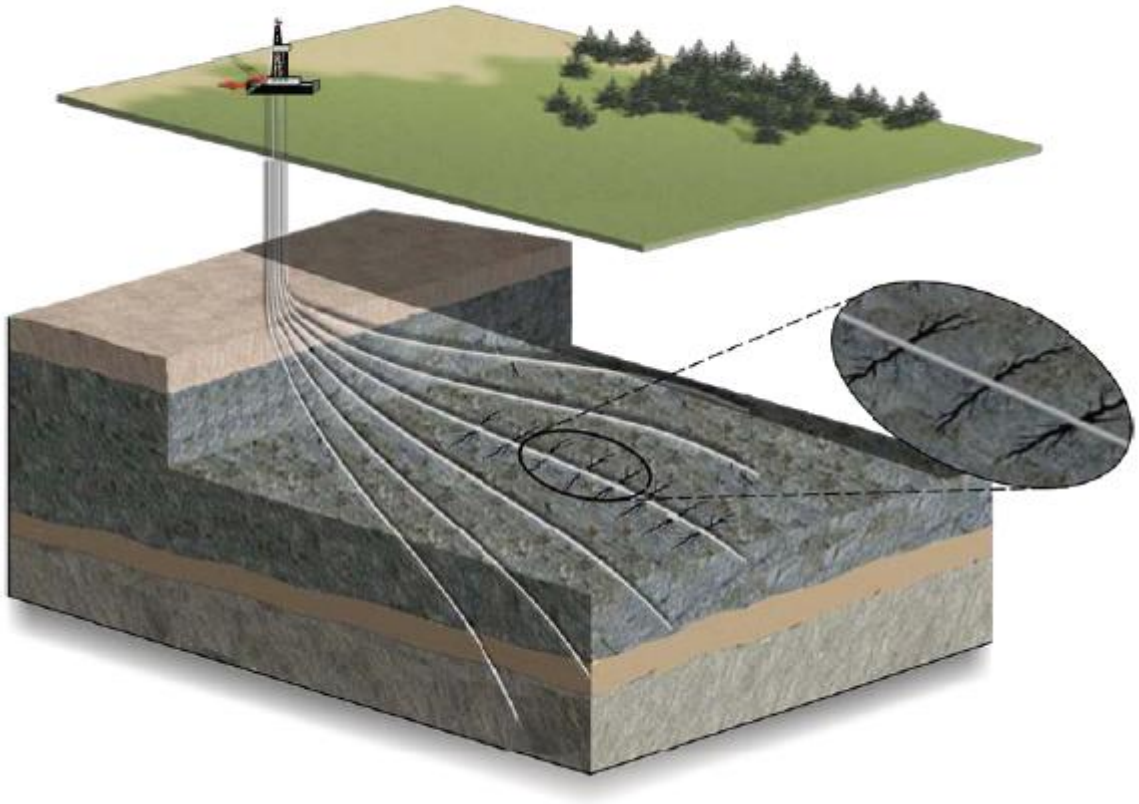
# *Can These New Natural Gas Resources Be Developed In An Environmentally Sound Way?*

As drilling increases and production grows, a harsher spotlight will fall on natural gas. "Green natural gas development" will help put a more environmentally friendly face on this activity.

- Reducing Land Use Impacts
- Reducing Water Use and Disposal
- Capturing Methane Emissions
- Assuring Environmentally Safe Wells and Hydraulic Fractures

# "Green" Unconventional Gas Development

**Reducing Land Use Impacts with Multi-Well Pads and Horizontal Wells**



- Multi-well pad drilling reduces land use impacts and rig mob/demob time.
- Operators can save $100,000 to $200,000 per well by using multi-well pad drilling.

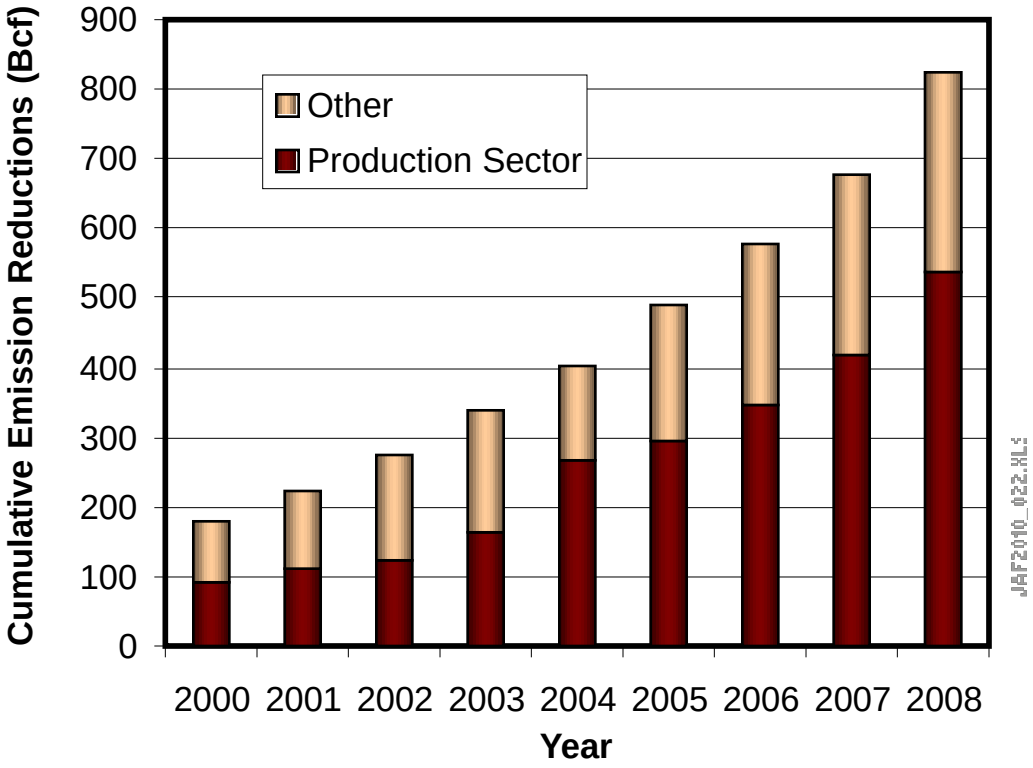
Source: Canadian Association of Petroleum Producers, 2010

# Reducing Water Use and Disposal

- The simplest and most economic option for reducing water use and disposal is recycling the produced frac water.
- Doing so can save up to $200,000 per well and avoid 1,000 water trucks on the road.
- Recycling the produced water may involve modest treatment to remove suspended solids, iron sulfide, and scale forming materials.

# Reducing Methane Emissions

Cumulative Methane Emission Reductions by EPA Natural Gas STAR Partners (2000-2008)




- Since 1990, Natural Gas Star partners have eliminated over 500 Bcf of methane emissions from the oil and gas production sector.
- Williams reports 24 Bcf of methane emissions captured with costs of $17 million and revenues of $159 million.

Source: U.S. Environmental Protection Agency (www.epa.gov.gasstar/accomplish.htm)

Welcome to the Natural Gas STAR Program



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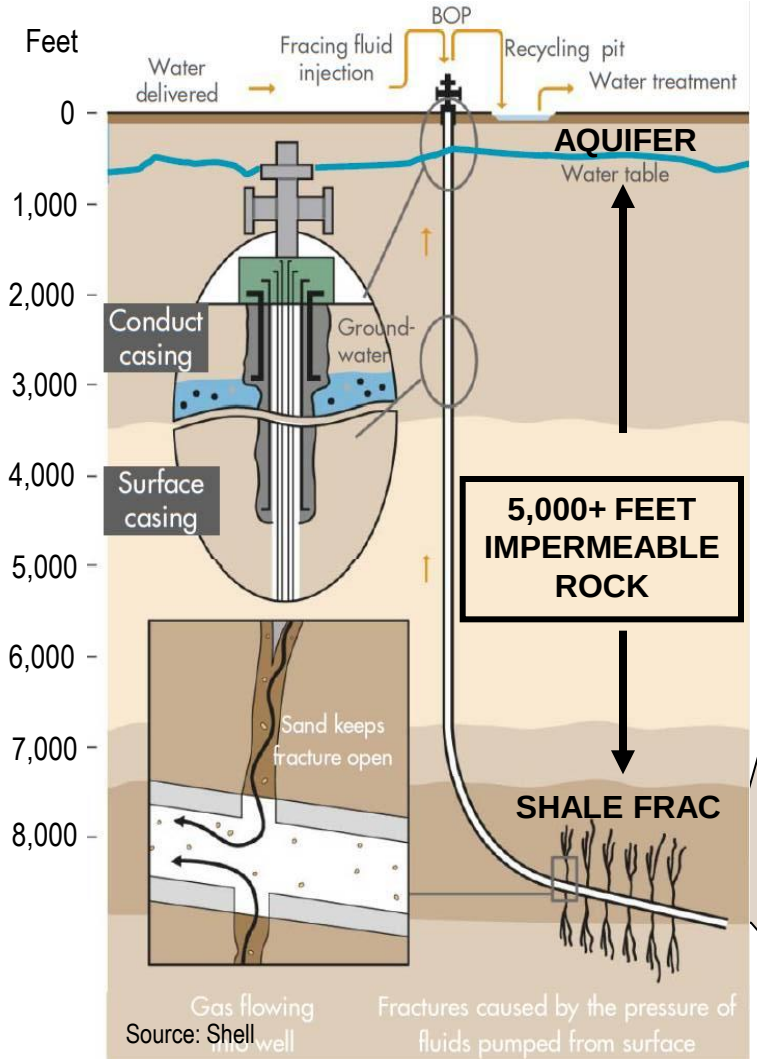
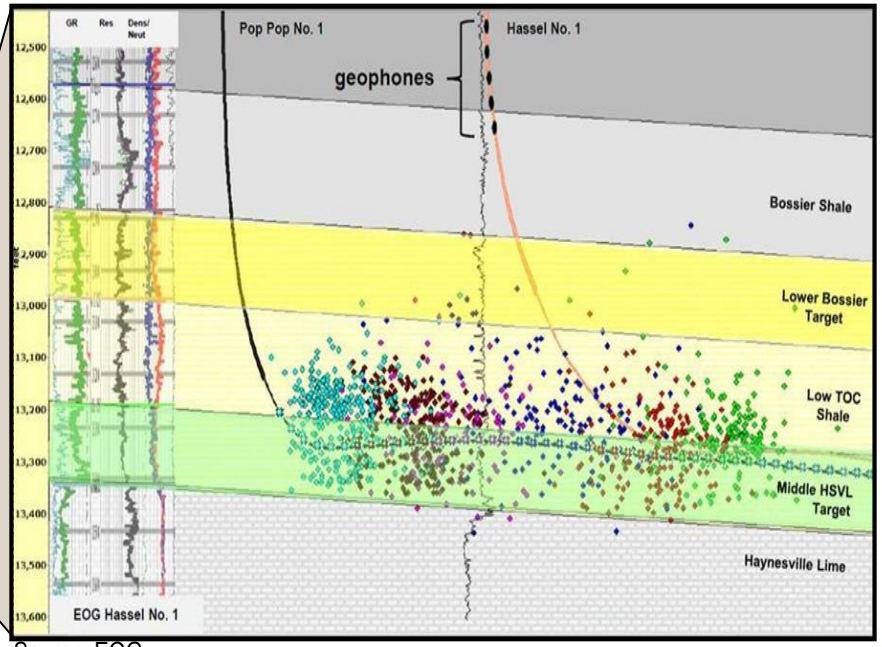
# Properly Designing the Well and Monitoring the Frac




Source: Shell

- The well is designed with steel casing and cement to protect groundwater aquifers.
- The shale interval is 5,000 to 10,000 feet below the water table, protected by unfractured strata.
- Real-time micro-seismic monitoring reveals that the fractures remain in the shales, deep underground.




Source: EOG



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# Concluding Remarks

Our work to date shows that the U.S. and Europe have large resources of shale gas and other unconventional gas. The challenge is to pursue progress in technology so that these resources can be converted into economical reserves.

With “green development practices”, these resources can be developed in an environmentally sound way.

Bountiful supplies from gas shales and unconventional sources can provide many benefits:

- Promote progress on climate change by substituting natural gas for coal in old, inefficient power plants.
- Increase energy security by replacing imported petroleum for transportation with CNG and low $CO_2$ emissions power for electric cars.


***Office Locations***
**Washington, DC**
**4501 Fairfax Drive, Suite 910**
**Arlington, VA 22203**
**Phone: (703) 528-8420**
**Fax: (703) 528-0439**

**Houston, Texas**
**11490 Westheimer, Suite 520**
**Houston, TX 77042**
**Phone: (281) 558-6569**
**Fax: (281) 558-9202**



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