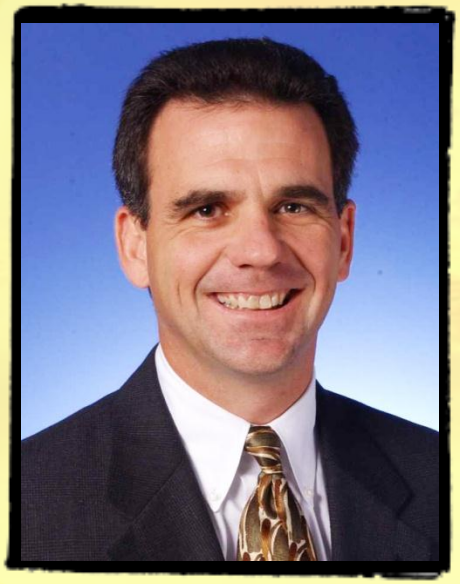
Shale Gas: Where, Why and How?

JEFF REILLY

ConocoPhillips



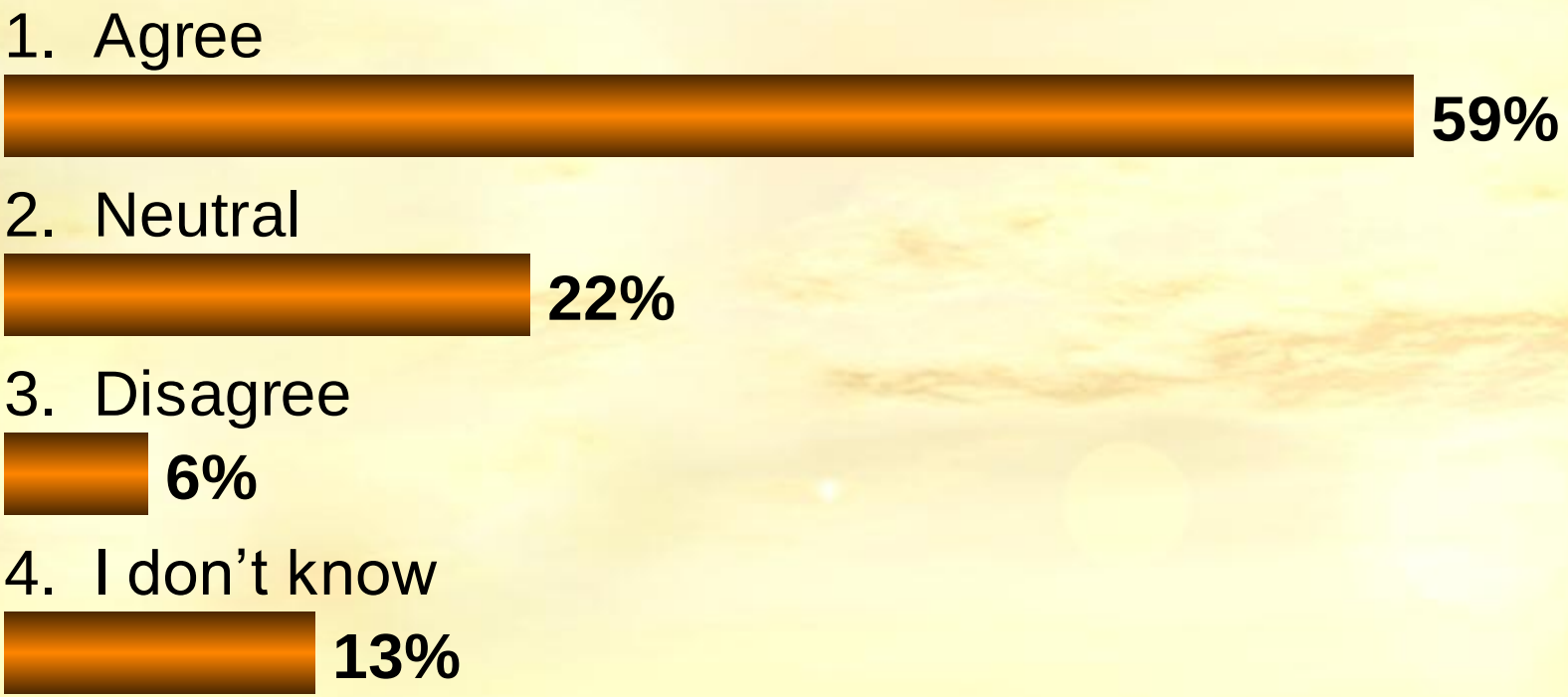
Program Co-Chair

JOURNEY INTO UNCHARTED TERRITORIES

PLENARY SESSION 3

ARS

Shale Gas is a game changer for the capital projects business.



Shale Gas: Where, Why and How?

LAURA ATKINS

Director of Petroleum Research, Hart Energy

JOURNEY INTO UNCHARTED TERRITORIES

PLENARY SESSION 3

Shale Gas: Unfamiliar to Unknown Territory

- Shale Gas Production is a Recent Phenomenon in North America –
  - Barnett Shale reached 1 bcf/d in 2005, 5 bcf/d in 2010
  - Learning curve is steep
  - Intensive capital$ and manpower
- Outside of North America we are heading into uncharted territory

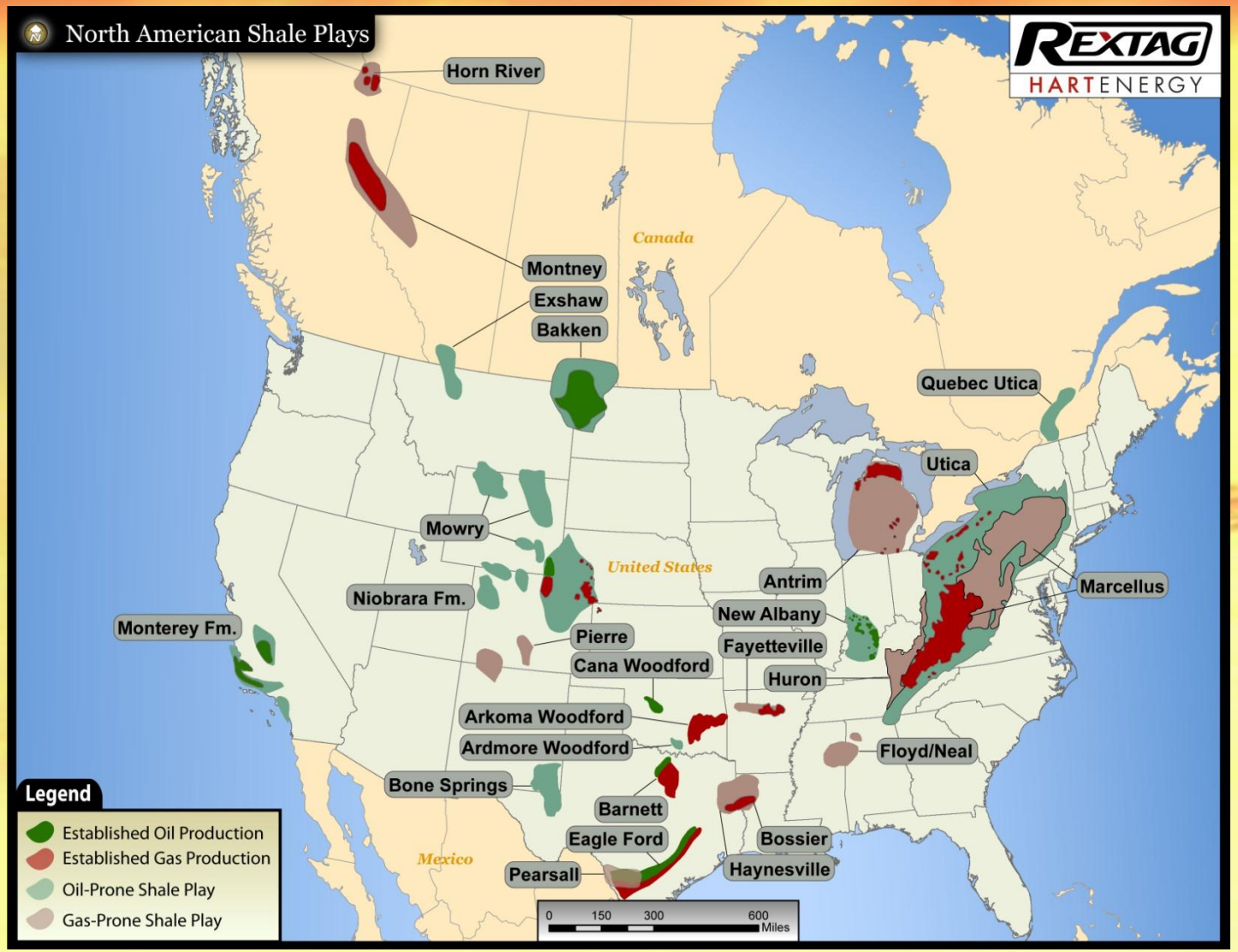
Gas has been produced from shales for a long time
(but quantities were small until recently)

Fractured Dunkirk Shale NY gas production	Shale gas wells drilled Appalachia	Antrim Shale Michigan	Speckled Shale Alberta	US Gov initiates shale gas research	9000 Wells in the Antrim
1850	1920	1948	1950	1960	1980

George Mitchell drills 1st Barnett Shale well	1st Barnett hydraulic frac	Barnett massive fracs in vertical wells	Multistage Fracs in Horizontal wells	Haynesville /other shale gas plays begin	Barnett Shale production 5 BCF/D
1981	1986	1990	2003	2007	2010

Shale Gas Production Begins to Take Off

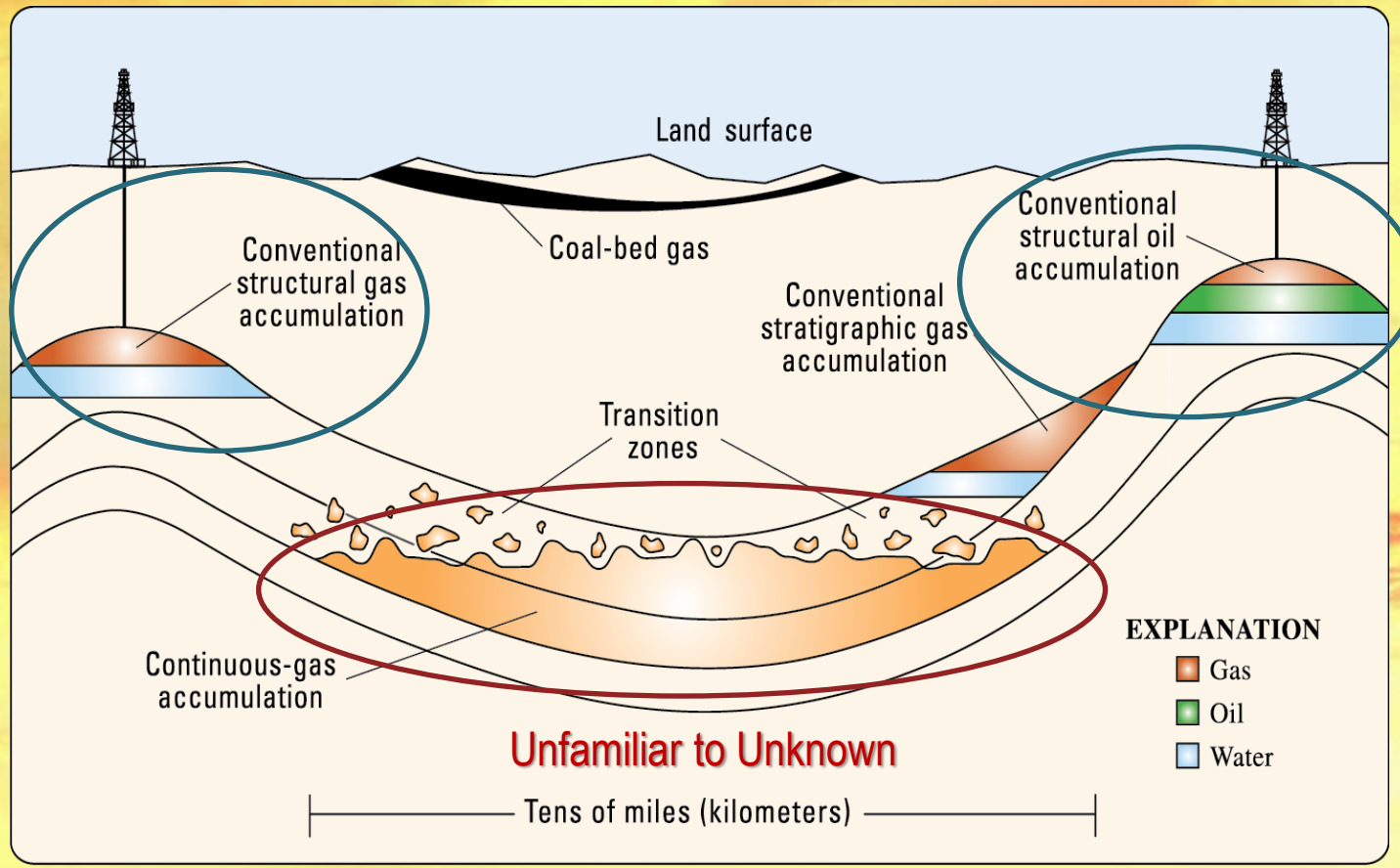
North American Shale Plays



Source: Hart Energy Data and Mapping Service

Unconventional Gas vs. Conventional Gas

Known



Known

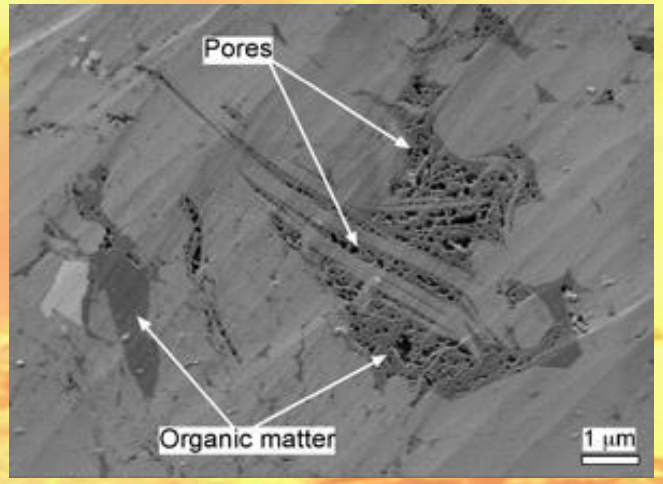
Source: USGS

What is Shale?

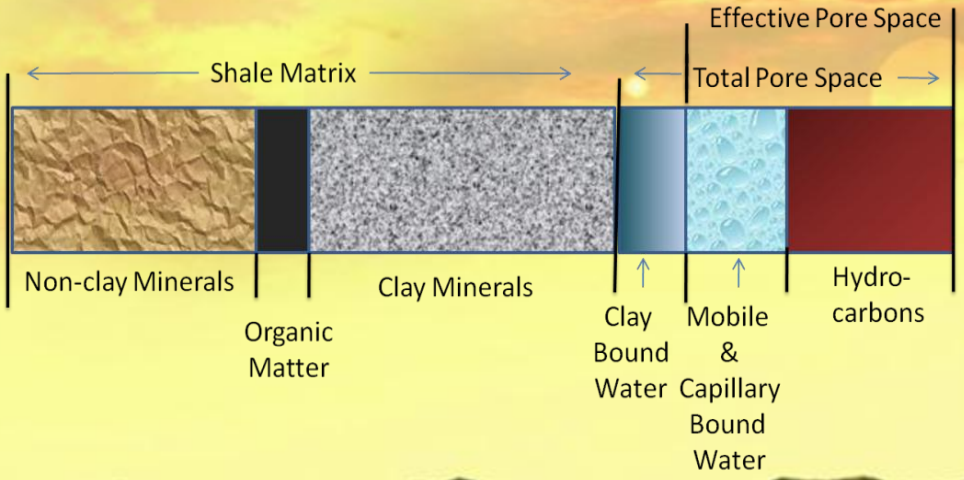
Marcellus Shale Outcrop

Source: Geoexpro.com

Shale under an Electron Microscope



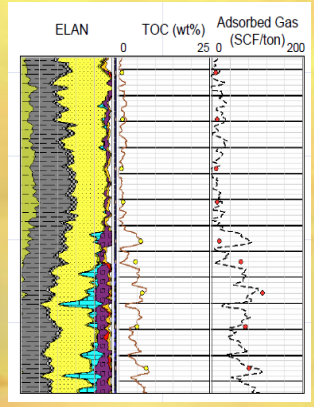
Source: Bureau of Economic Geology



Evaluating & Developing a Shale Gas Play

1 Meter =
1 Million Yrs.

Vertical Variations

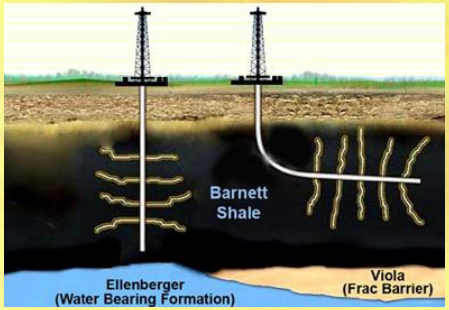


Data

Lateral Variations

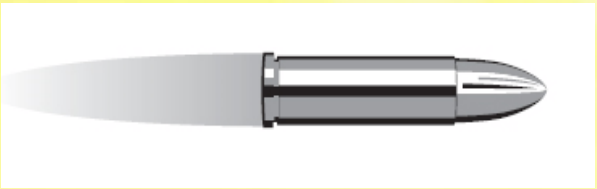
Rocks !

Drilling and Fracturing



Continuous Learning

High Rate
Low Cost Wells

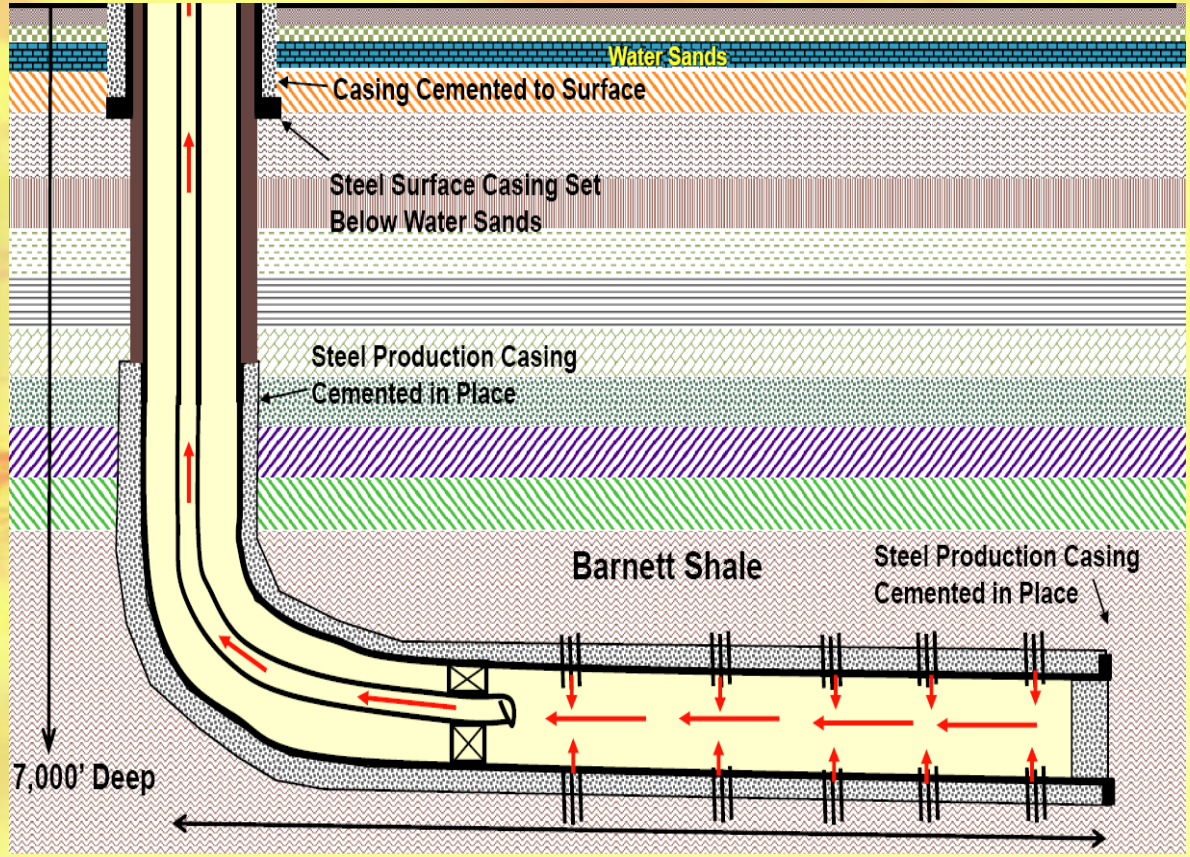


JOURNEY INTO UNCHARTED TERRITORIES

A Horizontal Well

Typical Hydraulic Fracture:

- 4 - 11 million gallons water
- 100 to 5,500 tons sand
- ~2% chemical additives
- 10 to 30 stages



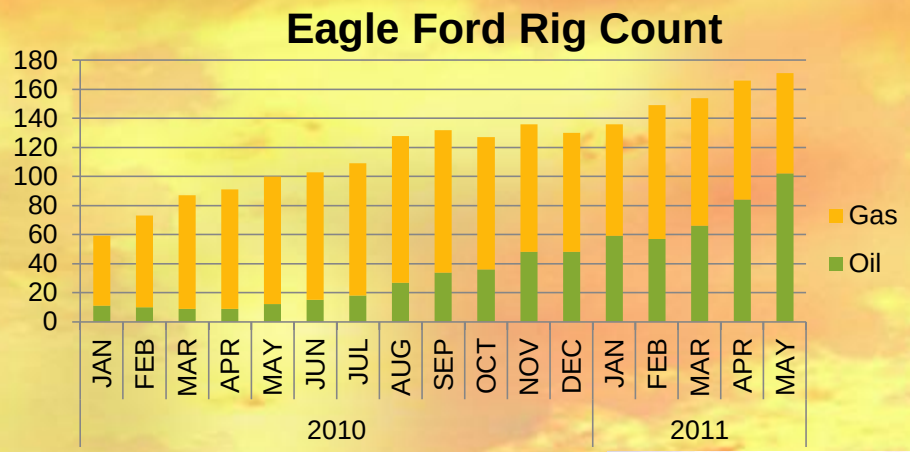
Source: Fort Worth League of Neighborhoods Gas Drilling 101, Oct 23, 2007

Hydraulic Fracturing- Shale Natural Gas Extraction

Shale Video YouTube Link

http://www.youtube.com/watch?v=lB3FOJjpy7s

The Logistics Are Complex and the Scale Enormous

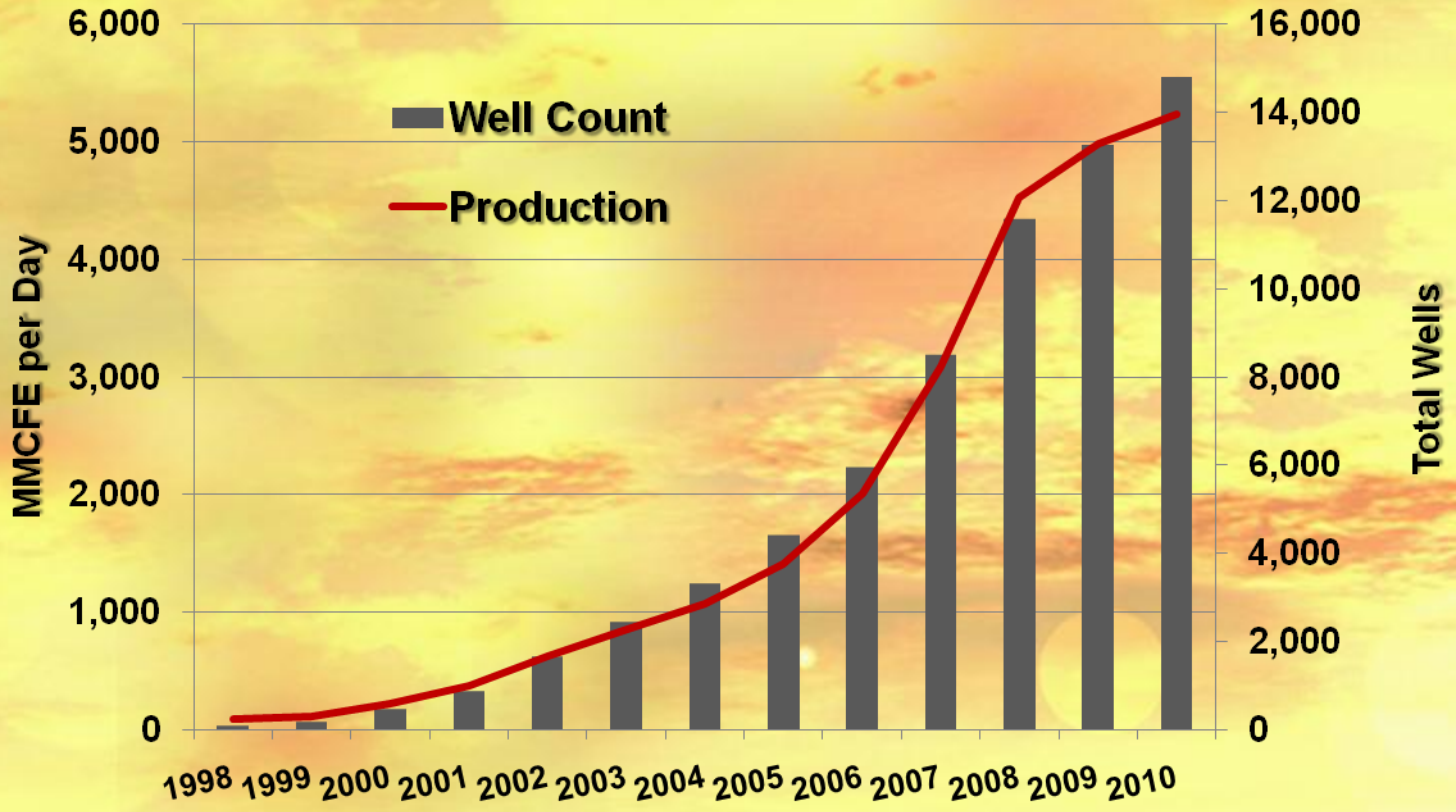


Source: Hart Energy/Rystad Energy North American Shale Quarterly

Halliburton assembled 34 pump trucks for the Barnett shale frac job in 2004 (Source: Halliburton)

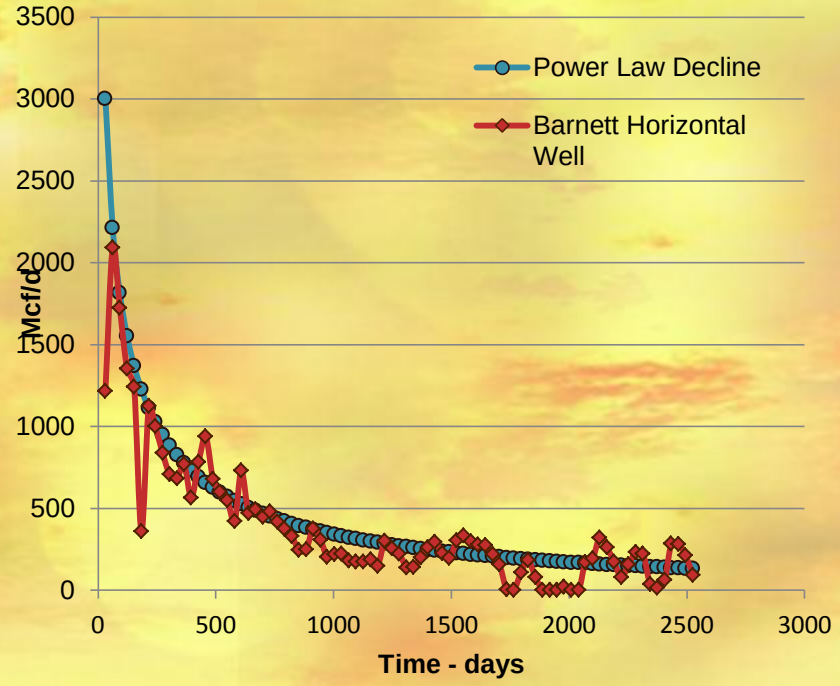
Frac trucks laden with compressors, water lines, and other equipment are essential for completing a well in the Barnett (photo from Devon Energy, source: OGJ)

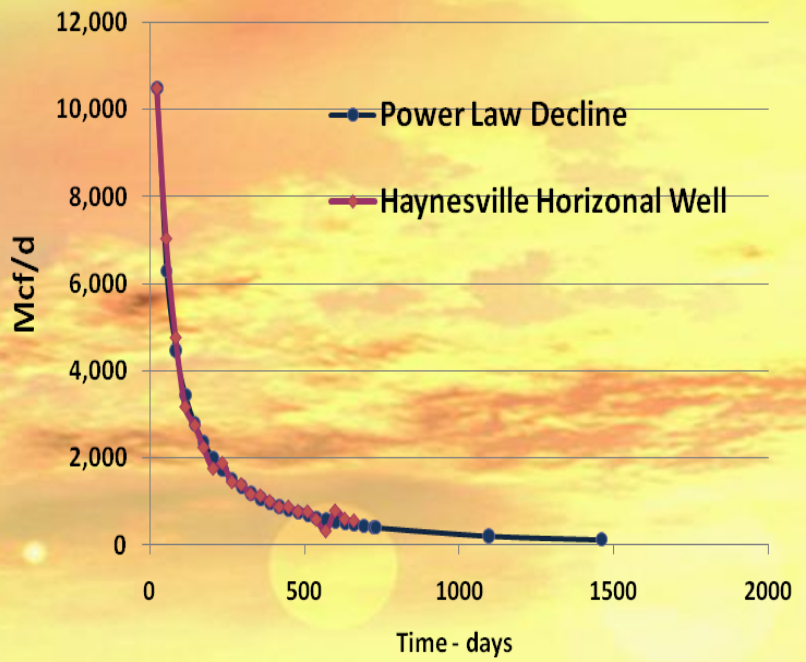
The Barnett Shale has over 14,000 Wells



Source: Texas Railroad Commission

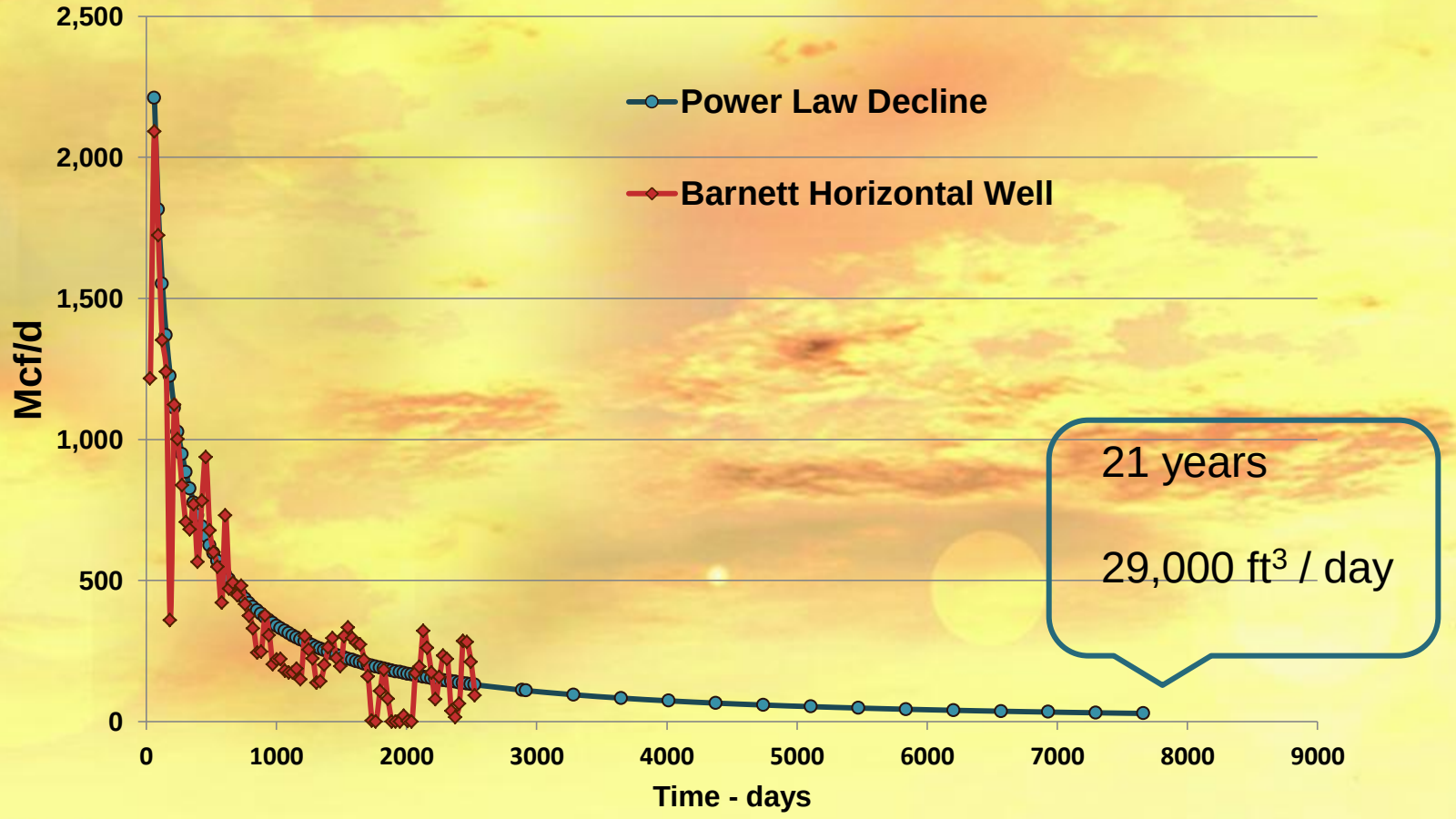
Why So Many Wells are Necessary





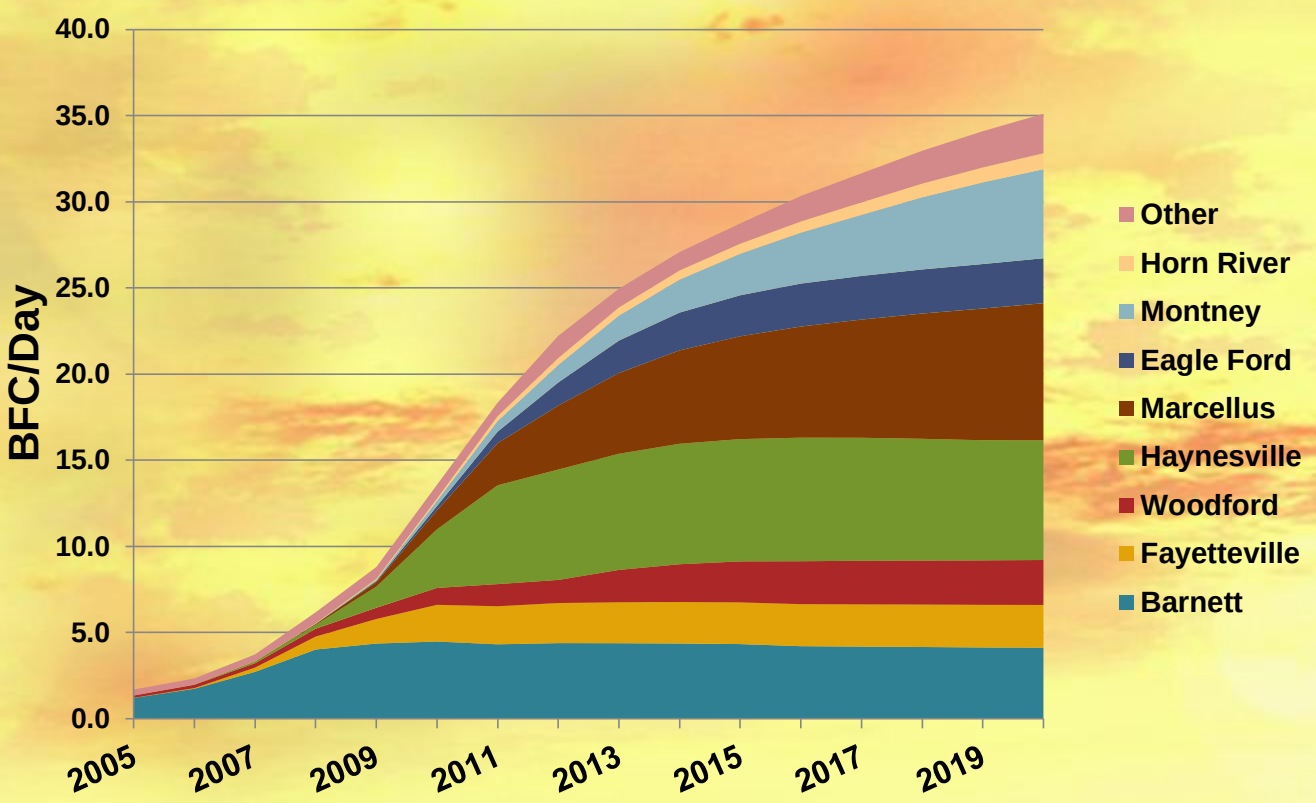
Source: Hart Energy

Shale Gas Wells Can Produce for a Long Time



Source: Hart Energy

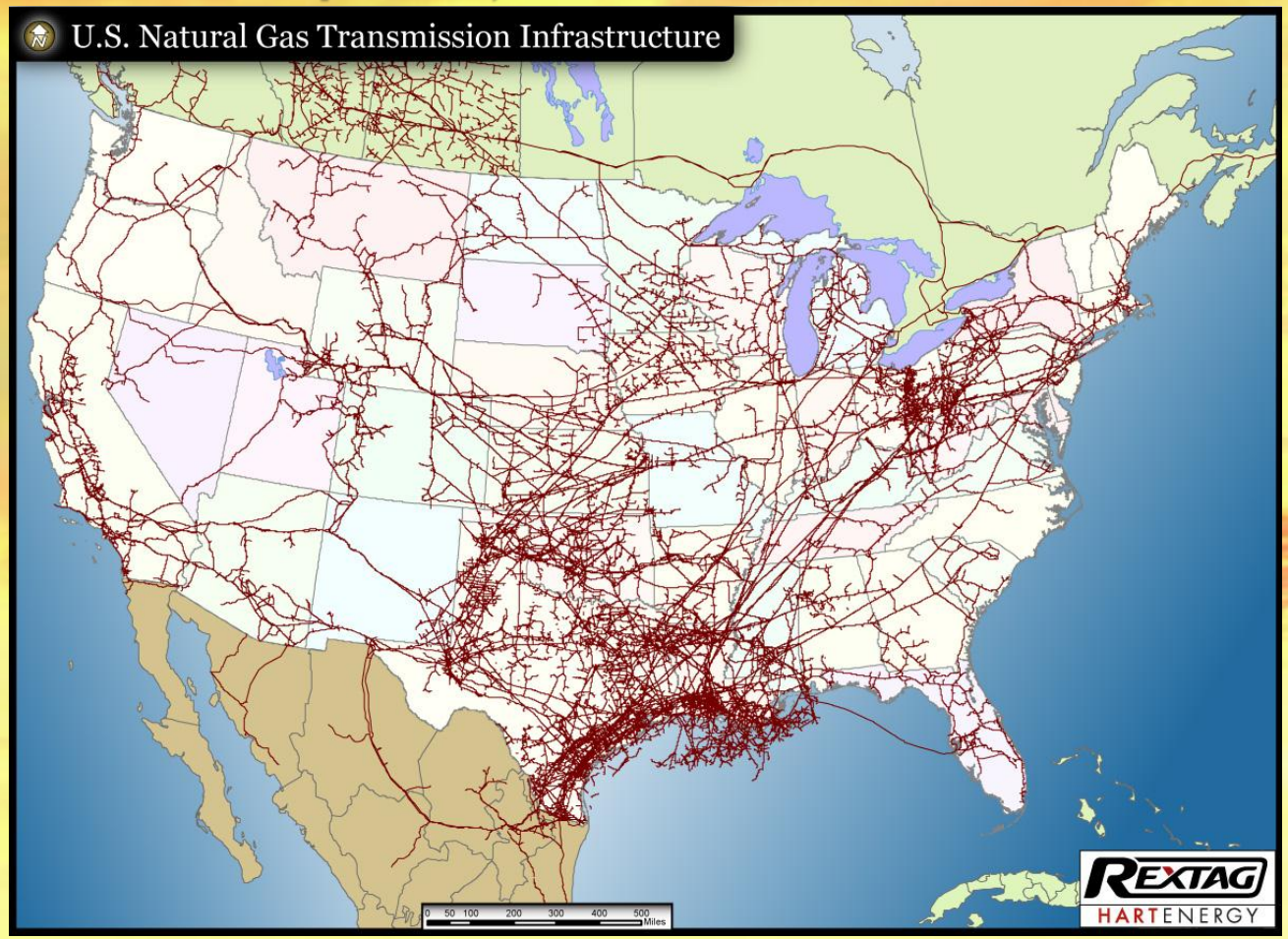
North American Shale Gas 35 BCF/D by 2020



28.5 BCF/D ⟹ 40% of US supply in 2020

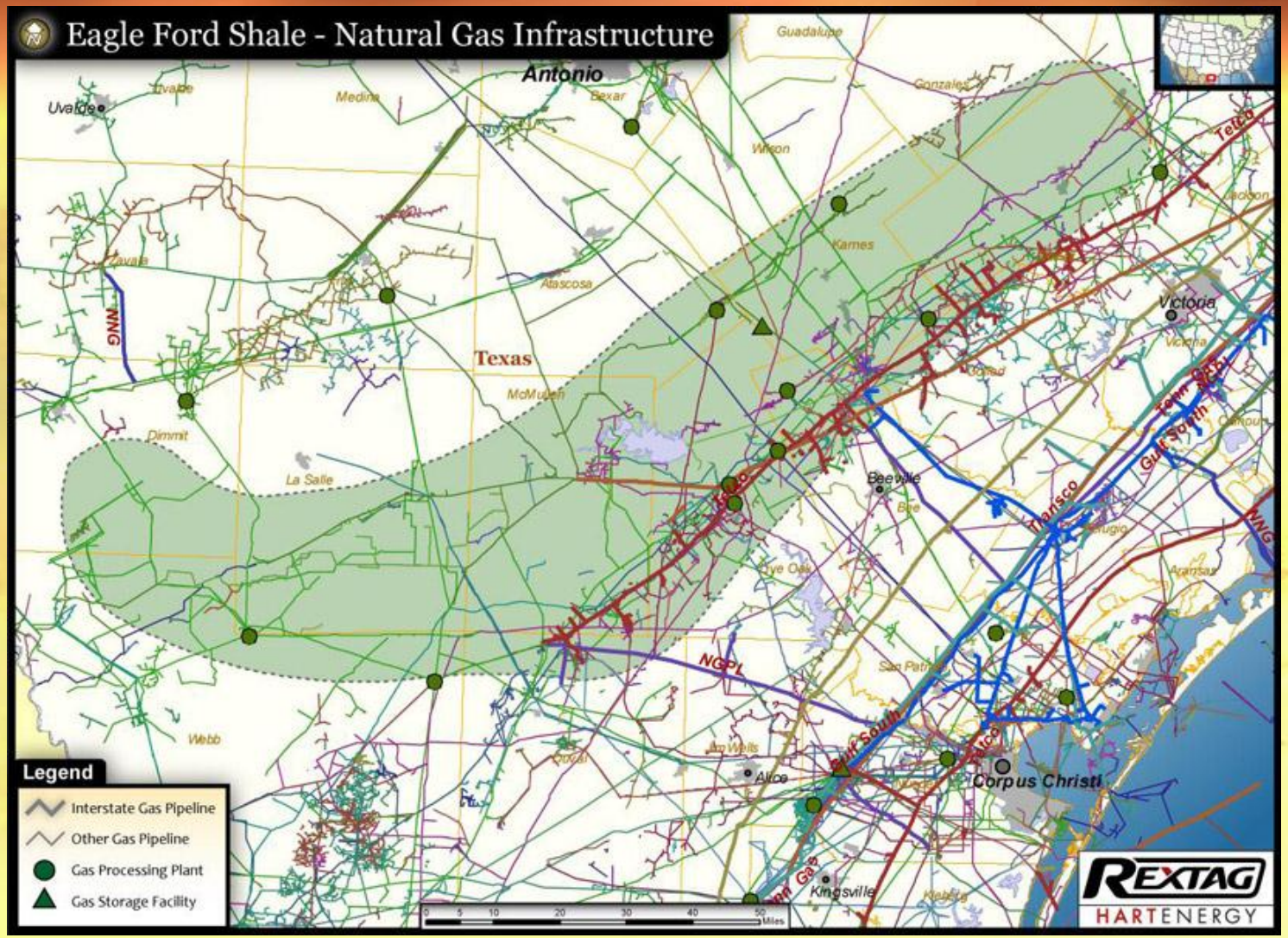
Source: Hart Energy/Rystad North American Shale Quarterly

North American Gas Infrastructure is Extensive
(But More is Required)



Source: Hart Energy Data and Mapping Service

Eagle Ford Shale Infrastructure



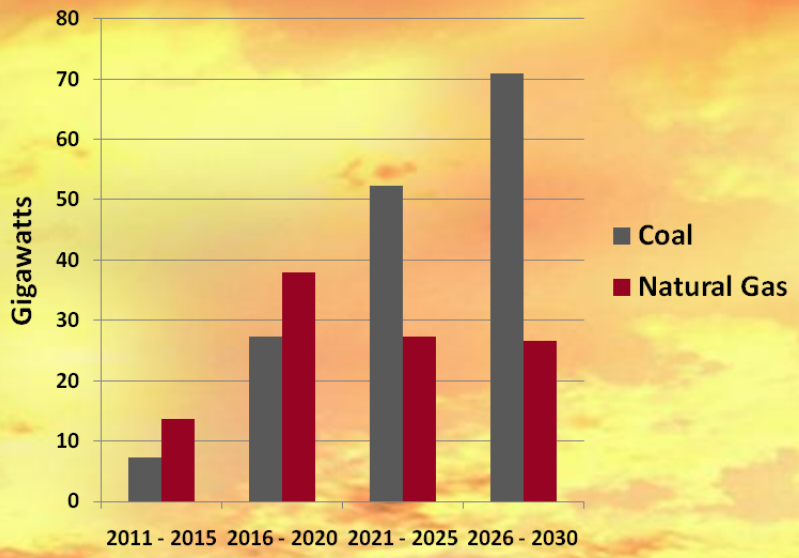
Source: Hart Energy Data and Mapping Service

North American Infrastructure
(Recent Headlines)

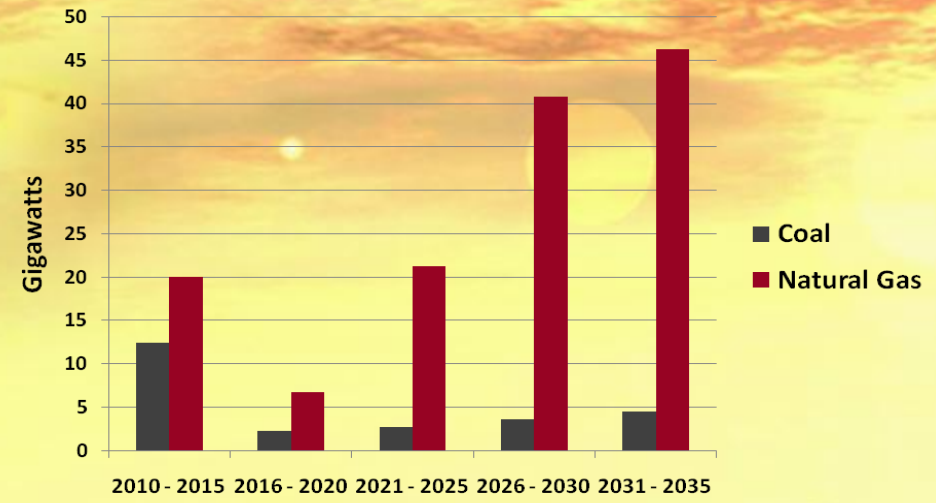
- Southern Union To Build Processing Plant For Avalon, Bone Spring Plays - Aug. 23 2011
- DCP Midstream To Build Eagle Ford, Permian Pipeline - Aug. 19 2011
- Key Energy Services Finalizes Acquisition Of Midstream Cos. - Aug. 8 2011
- NuStar, EOG Team Up For Shale-Focused Terminal Project - Aug. 5 2011
- Dominion Details Major Marcellus/Utica Midstream Project - Aug. 4 2011
- Peregrine Given Green-Light For Uinta Storage Facility - Aug. 3 2011
- Pembina To Expand Cutbank Processing Complex - Aug. 3 2011
- Monroe Gas Initiates Open Season For Storage Facility- Aug. 1 2011
- El Paso Places Rockies-Focused Ruby Pipeline In Service- Jul. 28 2011
- Crosstex To Grow Texas, Louisiana Midstream Infrastructure- Jul. 26 2011
- Enterprise To Build Sixth Mont Belvieu NGL Fractionator - Jun. 27 2011
- El Paso, Spectra Hold Open Season For Marcellus Ethane Pipeline - Jun. 27 2011

Shale Gas is a Game Changer in the US Power Sector

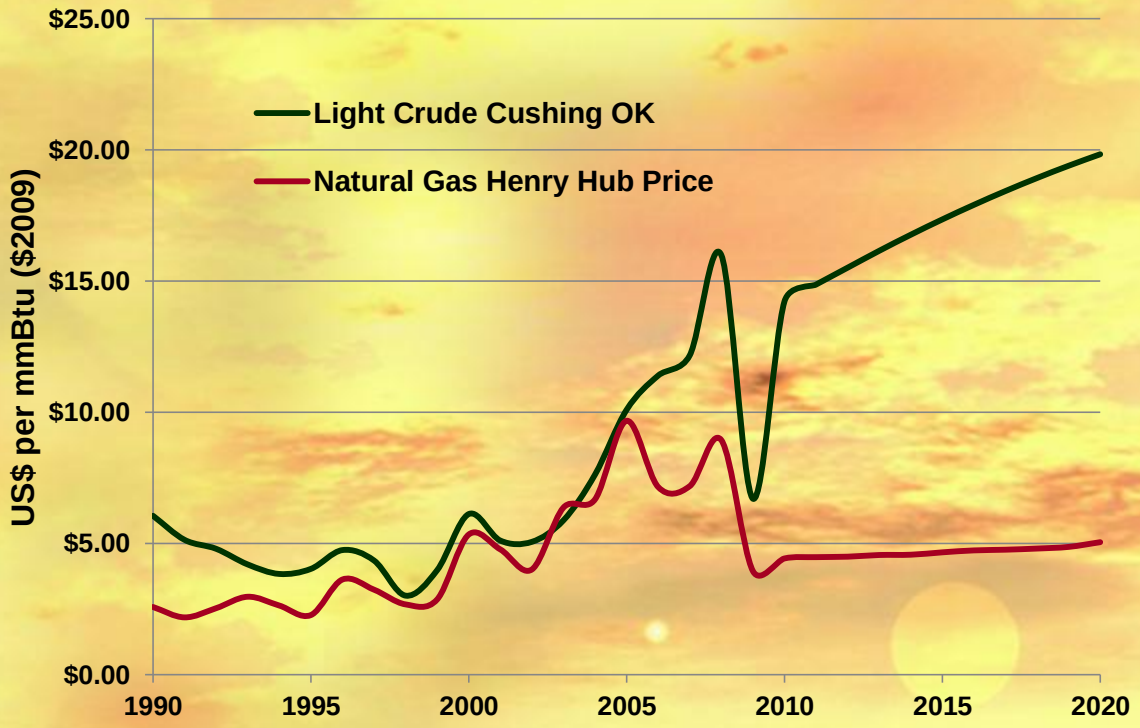
EIA 2006 Outlook for
New Power Generation



EIA 2011 Outlook for
New Power Generation

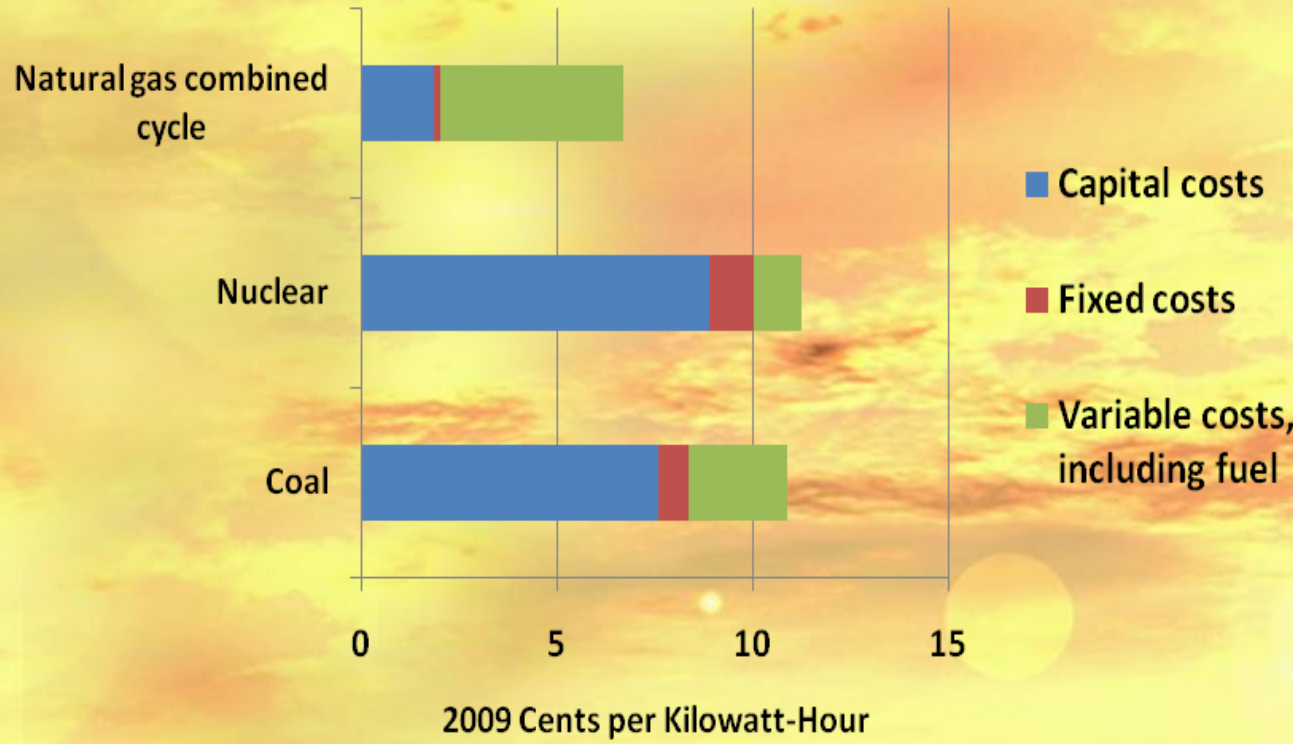


Price Disparity between Oil and Natural Gas Continues



Source: EIA AEO 2011 Reference Case

Levelized Costs for Power Generation in 2020

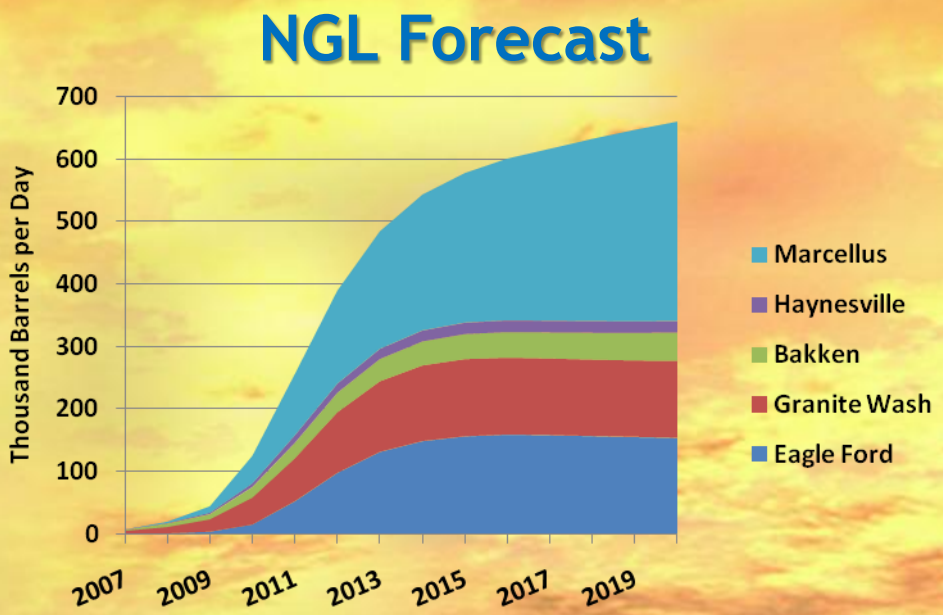


Source: EAI AEO 2011

Long Term Low Cost Gas Supply: Opportunities in Petrochemicals

- Ethane production up by 25%
- Ethane cost lower
- Margins stronger for ethylene and derivatives
- Incremental near-term capacity growth
  - Debottlenecking of existing light-feed capacity
  - Conversion of heavy-feed crackers
- Examples
  - Dow Chemical re-starting ethane cracker in Louisiana and adding ethane feedstock flexibility in Louisiana and Texas
  - Westlake Chemical expanding ethane cracking capacity in Louisiana

Greenfield Projects Supported by Feedstock Supply Growth



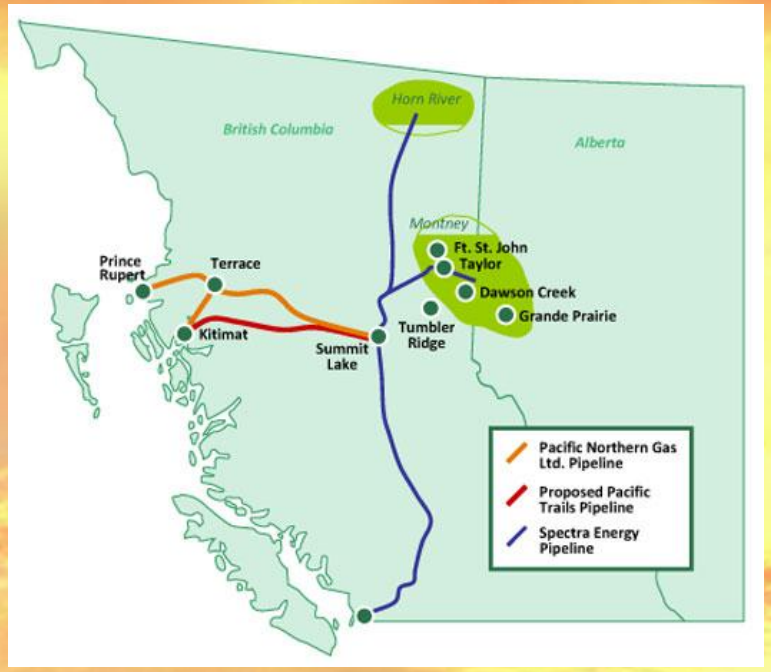
- Shell new ethane cracker for Marcellus Shale
  - 60,000 to 80,000 barrels per day capacity
  - Cost ~ US$ 1 billion
- Dow Chemical new ethylene plant US Gulf Coast by 2017
- Dow Chemical new propylene production facility, Texas, 2015

Source: Hart Energy/Rystad North American Shale Quarterly updated Aug 2011

Other Opportunities

LNG Exports

- Kitimat, BC
  - ❑ 700 mmcf/d 5 million tons/year
  - ❑ Construction start 2010
- Sabine Pass Liquefaction LLC
  - ❑ Up to 2.2 bcf/d
  - ❑ Approval received from DOE



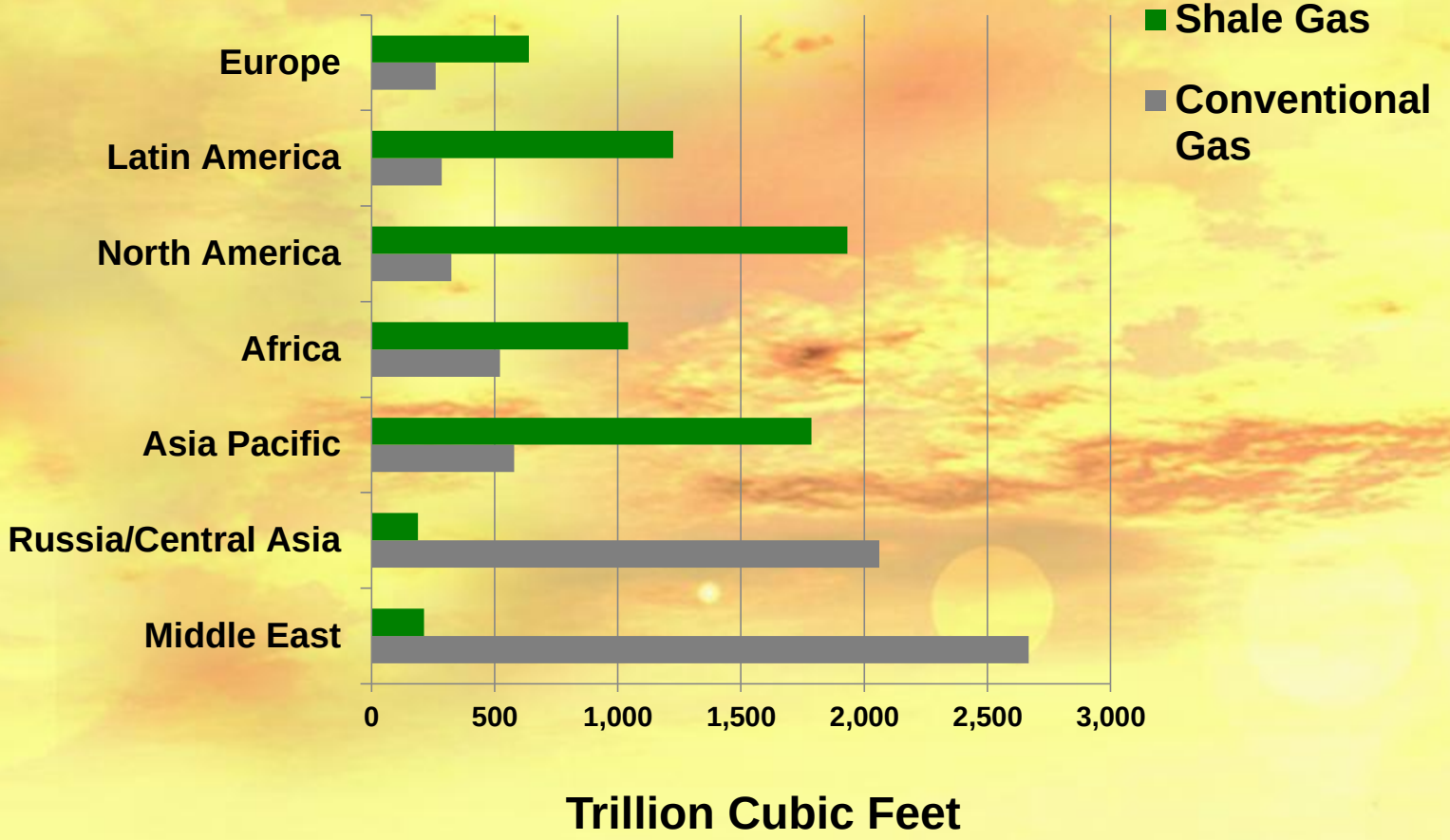
Natural Gas vehicles

- Fueling infrastructure would have to be built
- May be more appropriate for fleets

Will Shale Gas be Developed Outside N. America?

- Huge potential in high quality formations
- Compelling reasons to increase domestic supplies
  - Growing gas demand
  - Imports from high cost and/or unstable countries
  - Conventional gas declining or inaccessible
- Huge Challenges
  - Land access
  - Required scale of operations unavailable
  - Lack of infrastructure
  - Unfavorable fiscal terms
  - Public opposition

Shale Gas is Evenly Distributed Compared to Conventional Gas



Sources: EIA, IEA, OPEC

Uncharted Territories for Shale Gas

Poland

- Highly dependent on Russian gas
- Huge shale gas resource – 700 TFC
- Most Activity in Europe today
- Most of the acreage has been leased but farm ins are being done
- Challenges
  - Control over drilling rigs by NOC
  - Land Use and Environmental Concerns

Source of Data: http://maps.nationmaster.com/country/pl/1

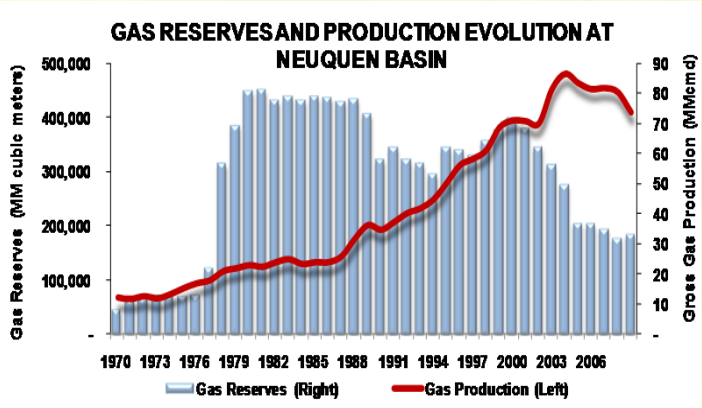
Vibrator trucks (for seismic) owned by Geofizyka Krakow in a farmer's field west of Gdansk

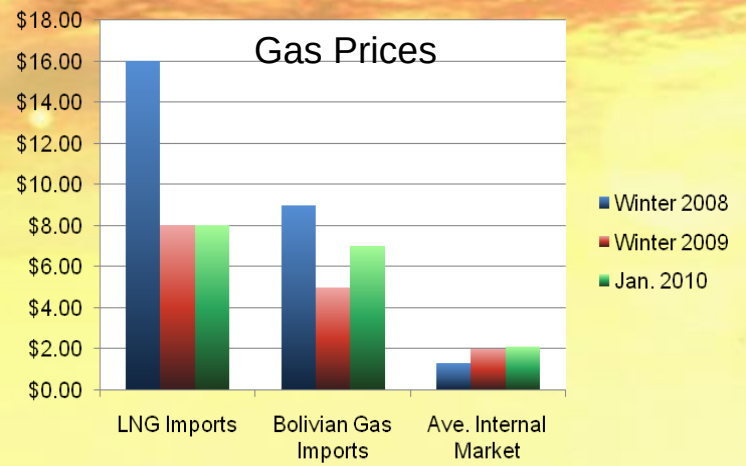
Source: Hart Oil and Gas Investor

Argentina

- Great rocks- Early exploration results are encouraging
- Gas infrastructure in place
- Major challenges with political and economic instability, uncertain fiscal terms, high inflation and powerful labor unions
- But, they really need the gas:

	Imports
2010	300 mmcf/d
2011	780 mmcf/d

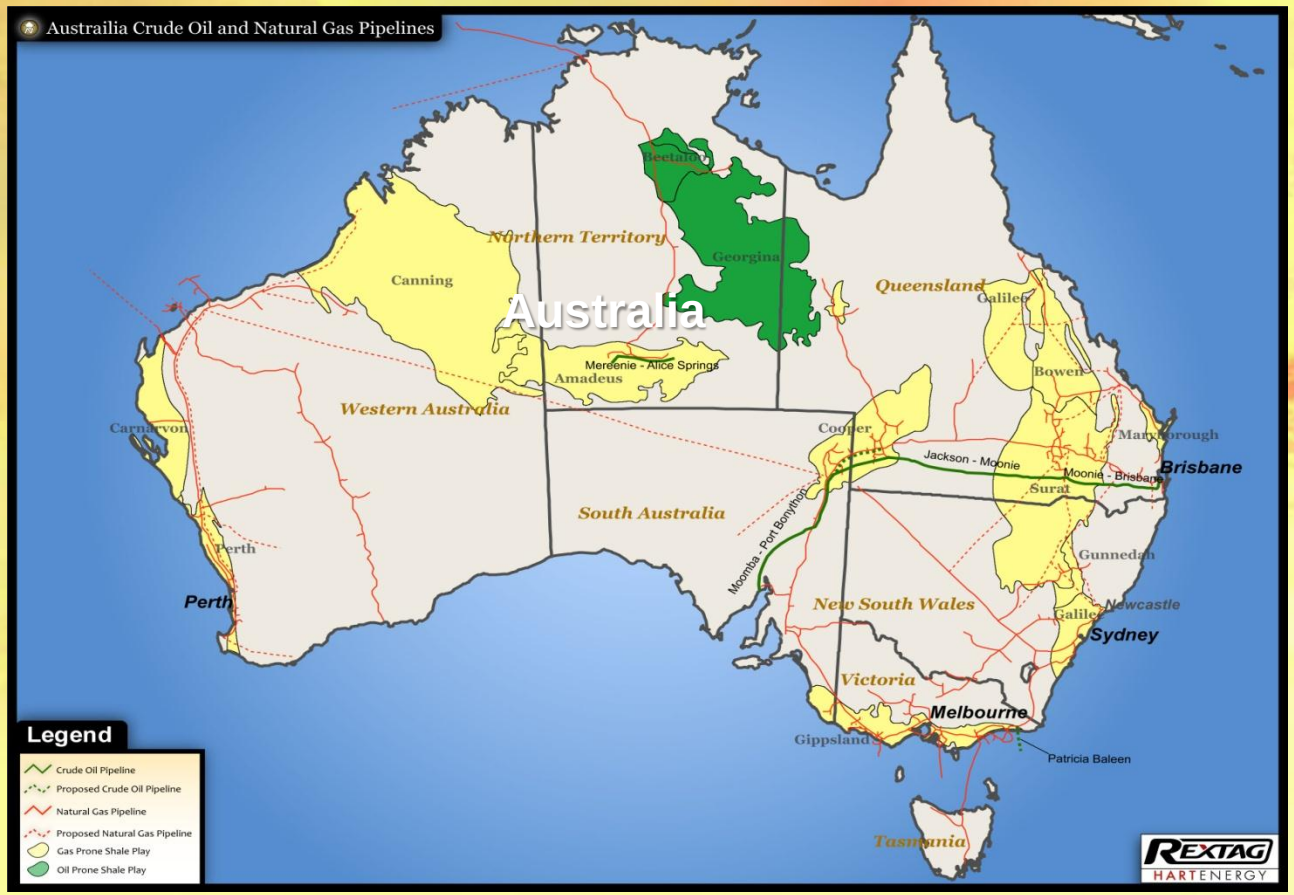




Source: Ruben Etcheverry presentation to Congreso de Producción del Bicentenario 21 Mayo 2010

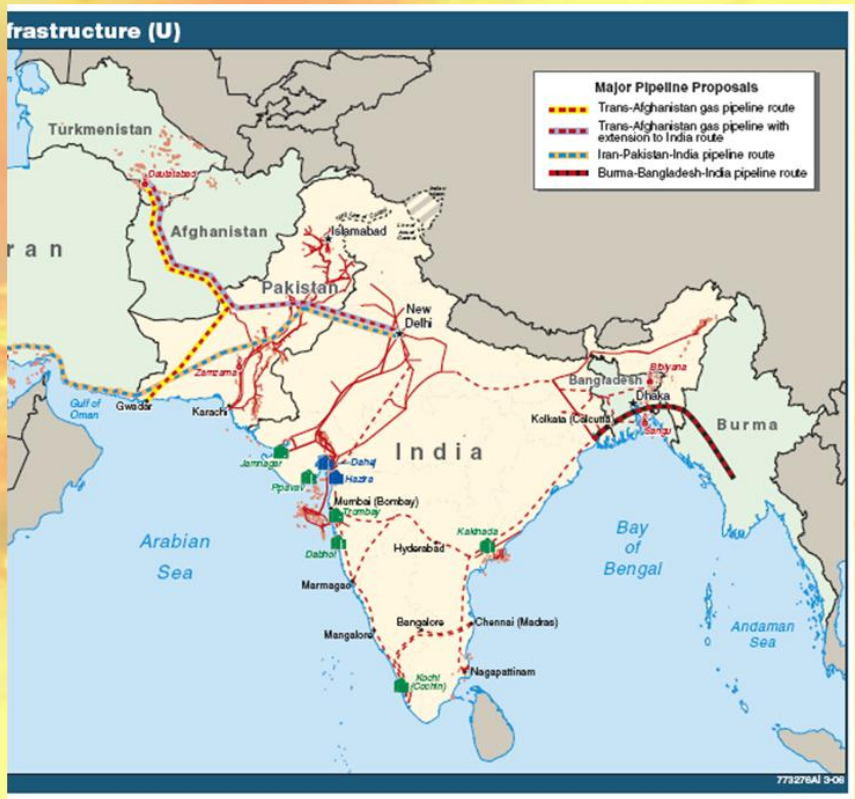
Australia

- Large conventional gas reserves, but most are offshore Northwest Shelf
- No infrastructure to serve internal markets
- Three separate markets favor shale gas and coal bed methane



Uncharted - India

- LNG imports increasing every year
- Government wants to reduce coal usage
- Schlumberger hired for feasibility study
- Challenges:
  - Little gas infrastructure
  - Poor fiscal terms for IOCs
  - Low gas price except for LNG



Coming Attractions

- China
  - Shale gas blocks were awarded to Chinese companies
  - IOCs can come in later under a PSA but economics of shale gas are difficult with this fiscal structure
- Saudi Arabia
  - Huge conventional gas reserves but it is associated gas and not available
- Turkey
  - Most energy is imported
  - Potential 15 TCF but mostly untested

Western Europe - Public Resistance to Shale Gas

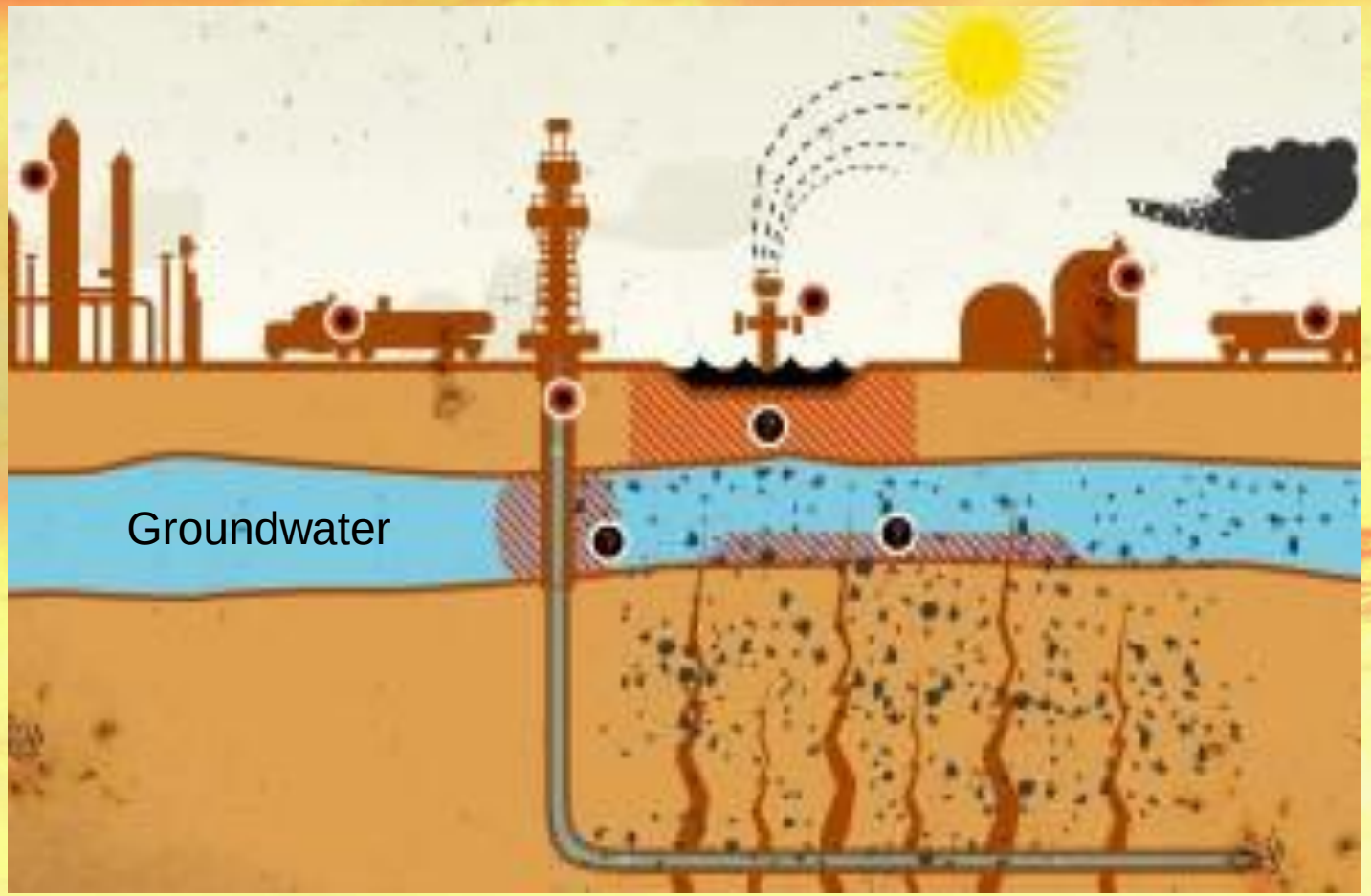
JOURNEY INTO UNCHARTED TERRITORIES

43RD ANNUAL ECC CONFERENCE

Will it be This?

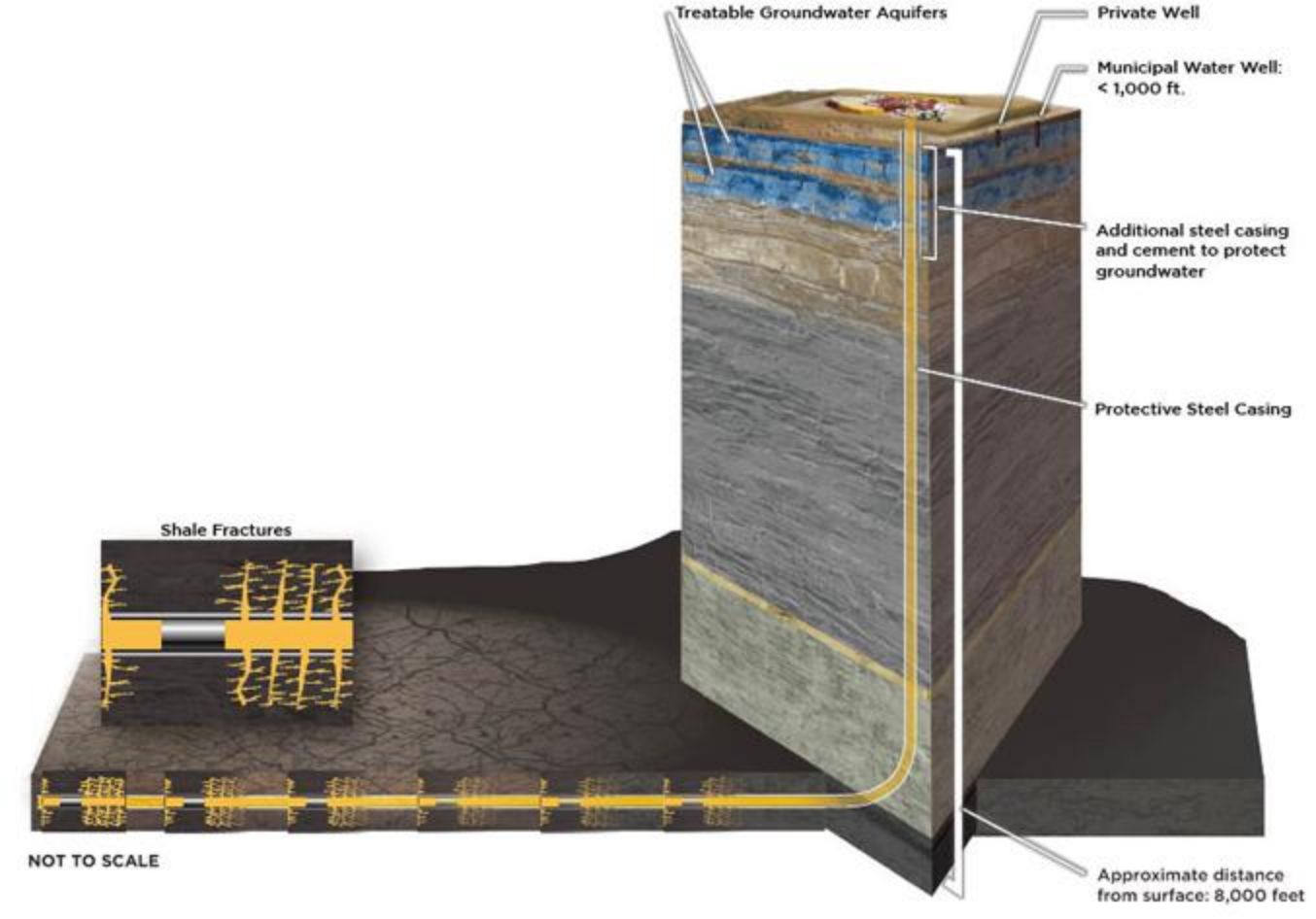
Or This?

What the Public Thinks



Source: Robert Wagner campaign for Vermont Senator 2012

The Reality of Shale Fracturing



Source: Chesapeake Energy

Environmental Impacts Related to Hydraulic Fracturing

- Water requirements – 4 to 11 million gallons required per frac job!
  - 500 or more wells drilled in each play every year
  - 3.5 billion gallons per year or average 9.5 million gallons per day
  - Withdrawals from surface waters in New York State are 9 to 10 billion gallons per day for all uses.
  - Within the Delaware River Basin, 150 million gallons/day for power generation
- Produced water
  - Disposal or reuse
- Traffic and Noise

Photo by Laura Atkins

Not All Environmental Impacts are Caused by Fracturing

- Surface water contamination
  - Poor handling of produced water, i.e. dumping it into a river
  - Storing produced water in an open pit
- Ground water contamination
  - Could result from poor cement job around surface casing (not unique to shale gas wells)
  - Leaking water storage pit
  - Methane in a coal seam or shallow organic-rich layer is most likely source of methane in well water
- Air pollution near shale gas sites
  - Vapor venting from storage tanks or pipelines
  - Volatile compounds evaporating from produced water storage pits
- Greenhouse gas emissions
  - Methane leaking from pipelines and surface facilities

The road to shale is paved with good intentions!

- Environmental issues are not going away
- Industry PR efforts are met with skepticism – viewed as more “Big Oil” propaganda
- Is confrontation the only way to deal with the issues?
  - Environmental concerns are legitimate
  - Properly designed regulations level the playing field
- Some Encouraging Signs
  - State of Texas new law requiring fracture fluid disclosure is supported by industry
  - Range Resources sampling water wells in vicinity of Marcellus Shale drilling location
  - US DOE Shale Gas Subcommittee Report
    - Industry and policy experts appointed to the committee
    - American Natural Gas Association tentatively endorsed it

Shale Gas Subcommittee Recommendations

Government

- Establish ground water database
- Improve communications between State & Federal Agencies
- Undertake basic research

Industry

- Develop best practices, help code them as regulations
- Measure and reduce air emissions
- Treat and/or reuse produced water
- Disclose fracture fluid composition

Benefits

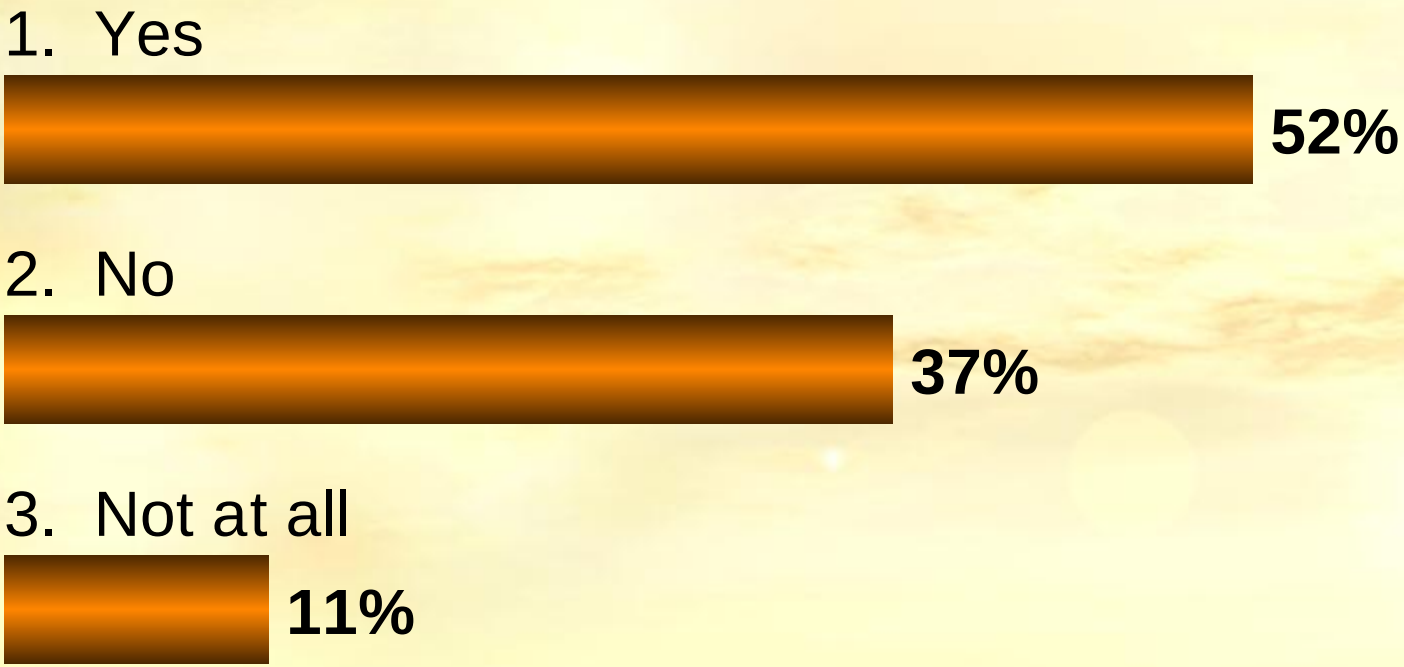
- For the industry, better efficiency
- For regulators, sharing data will
- help craft sound policies
- For the public, higher level of confidence with regulatory oversight

The Journey Can Succeed!

- Shale gas is indeed a game changer in North America
  - Production will continue to grow
  - Opportunities for companies involved in all aspects of shale gas – upstream, midstream and downstream
- Other countries will benefit from North American shale gas experience
  - Potential is huge
  - Challenges can be overcome
  - Opportunities are great for first movers and those with a longer term view
- Environmental issues must be addressed
  - Public concerns are legitimate
  - Industry should develop best practices and cooperate with regulators

ARS

Have your views on Shale Gas developments on the capital project business changed?



43RD ANNUAL ECC CONFERENCE

engineering and construction contracting association

JOURNEY INTO UNCHARTED TERRITORIES

September 7-10, 2011

JW Marriott Desert Ridge, Phoenix, AZ

How are owners, contractors and suppliers adapting to successfully execute projects and reposition their businesses in the ever evolving project environment?

REPOSITIONING THE PROJECTS BUSINESS IN A WORLD WITH CHANGING BOUNDARIES