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The Impacts of Cap-and-Trade, RPS, and Electric Vehicles on the North American Natural Gas Market

Presentation at:
US Energy and Environment Policies and the World Energy Market

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June 18, 2010

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Current BIPP Study

- "Energy Market Consequences of Emerging Renewable and Carbon Dioxide Abatement Policies in the United States"
  - Development of the Rice World Energy Model (RWEM) – a derivative of the Rice World Gas Trade Model (RWGTM) – developed using *MarketPoint* software.
  - 2 year study with final reporting in September 2010.
- A scenario approach is being used to examine and compare various outcomes under different sets of assumptions.
  - Degree of CO2 emissions cuts (no clear policy yet, so we are choosing to investigate effects by degrees)
  - Safety valves and offset programs
  - The operating and capital costs of various end-use technologies (there is wide disagreement between government and industry here)
  - Elasticity of supply of various fuels
  - Elasticity of demand in different sectors
  - Rate of technological innovation (ongoing parallel study examining the effect of R&D spending on breakthroughs)
  - Regional policies versus harmonized federal and international policies.
  - "Carbon leakage"

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Modeling the Impacts of CO2 and Other Regulations

- A scenario approach is used (see Hartley and Medlock, "Energy Market Consequences of Emerging Renewable and Carbon Dioxide Abatement Policies in the United States" (2010)). Note that all scenarios use industry costs.
  - **Carbon Cap 1** – CO2 emissions are forced to fall to their 1990 levels by 2050. The manner of enforcement is through a cap-and-trade scheme in which trading begins in 2012. The CO2 permits allowed for trade are slowly decreased to the target level from the date at which CO2 permit trading begins. No assumptions about renewable portfolio standards or electric vehicles are explicitly made, although investments in renewables and electric vehicles are allowed.
  - **Carbon Cap 2** – Same as Carbon Cap 1 except CO2 emissions fall to 80% of their 1990 levels by 2050.
  - **Carbon Cap 3** – Same as Carbon Cap 1 except CO2 emissions fall to 50% of their 1990 levels by 2050.
  - **Carbon Cap 3 Offsets** – Same as Carbon Cap 3 except investment in offsets is allowed.
  - **Electric Car** – The electric car is adopted at a rate such that it represents 40 percent of vehicle fuel demand by 2050. Note penetration increases over time, reflecting the time it takes for vehicle stock turnover to occur. No assumptions are made about renewable portfolio standards or the existence of a CO2 market.
  - **RPS** – Renewable portfolio standards (RPS) are introduced such that renewable energy sources must account for 20 percent of electricity generation by 2030 and 40 percent by 2050. Also, ethanol must account for 20 percent of vehicle fuel by 2030. No assumptions are made regarding electric vehicles or cap-and-trade.
  - **Electric Car plus RPS** – The Electric Car case and the RPS case are combined.
  - **Portfolio** – This case combines assumptions made for the Electric Car case, the RPS case, and the Carbon Cap 3 case.

Some Key Points

- The price of CO_2 is ultimately determined by the cost of deploying capital that allows the utilization of technologies that lower CO_2 emissions.
  - If $100/ton is required to deploy Carbon Capture and Sequestration technologies (CCS) and CCS is the least cost option, then the CO_2 price will be $100/ton.
- Analysis indicates the following factors are very important to determining the outcome:
  - The elasticity of supply of fuels with lower carbon intensity
    - For example, if the supply curve for natural gas is very flat, then the price of CO_2 need only rise to the point at which natural gas substitutes for coal. (Note, this assumes natural gas is less expensive to deploy and use than other energy sources.)
    - Shale gas could prove very important in determining the CO_2 price.
  - Elasticity of demand for energy
    - If energy demand is very inelastic, so that consumers do not reduce demand very much when price increases, then the price of CO_2, *ceteris paribus*, will generally be higher to achieve a given reduction.

Some Key Points (cont.)

- Analysis indicates the following factors are very important to determining the outcome (cont.):
  - Assumptions regarding capital costs
    - In model runs using DOE cost estimates, the cost of deploying IGCC is sufficiently low to ensure that coal maintains market share. Increasing this cost raises the price of CO2 and reduces coal's long run market share.
  - Assumptions regarding long term load factors
    - If the capacity factors on wind increase, then wind becomes a more favorable option. This tends to lower the price of CO2. Thus, any technological innovation that raises the capacity factor of wind is favorable.
  - Assumptions regarding availability of new technologies
    - If new technologies are made available sooner and more cheaply, then the price of CO2 is directly influenced lower.

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Costs of Generation Technologies

- Substantial disagreement between government and industry!

Technology	Total Overnight Cost 2005 $/kW DOE Source	Total Overnight Cost 2005 $/kW Industry Sources	Industry Adjustment	Variable O&M 2005 $/kWh DOE Source	Fixed O&M 2005 $/kW DOE Source	Heat Rate BTU/kWh DOE Source
Scrubbed Coal New	$ 1,939	$ 3,080	*1.588*	$ 0.046	$ 25.94	9,200
w/ CCS	$ 2,993	$ 4,846	*1.619*	$ 0.061	$ 32.96	11,061
Integrated Coal-Gasification Combined Cycle	$ 2,241	$ 3,714	*1.657*	$ 0.029	$ 36.44	8,765
w/ CCS	$ 3,294	$ 5,480	*1.663*	$ 0.044	$ 43.46	10,781
Conventional Gas/Oil Comb Cycle (CC)	$ 907	$ 1,011	*1.115*	$ 0.021	$ 11.76	7,196
Advanced Gas Comb Cycle (CC)	$ 893	$ 996	*1.115*	$ 0.020	$ 11.03	6,752
w/ CCS	$ 1,781	$ 1,850	*1.038*	$ 0.029	$ 18.75	8,613
Conventional Combustion Turbine	$ 631	$ 747	*1.182*	$ 0.036	$ 11.41	10,810
Conventional Combustion Turbine (FO6)	$ 631	$ 747	*1.182*	$ 0.036	$ 11.41	10,810
Advanced Combustion Turbine	$ 597	$ 712	*1.192*	$ 0.032	$ 9.92	9,289
Advanced Combustion Turbine (FO6)	$ 597	$ 712	*1.192*	$ 0.032	$ 9.92	9,289
Fuel Cells	$ 5,051	$ 6,070	*1.202*	$ 0.479	$ 5.32	7,930
Advanced Nuclear	$ 3,127	$ 5,887	*1.883*	$ 0.005	$ 84.83	10,434
Distributed Generation Base	$ 1,291	$ 1,379	*1.068*	$ 0.071	$ 15.11	9,050
Distributed Generation Peak	$ 1,550	$ 1,628	*1.050*	$ 0.071	$ 15.11	10,069
Biomass	$ 3,539	$ 4,617	*1.305*	$ 0.067	$ 60.73	9,646
MSW Landfill Gas	$ 3,339	$ 4,425	*1.325*	$ 0.000	$ 107.66	13,648
Geothermal	$ 1,612	$ 1,612	*1.000*	$ -	$ 155.15	34,633
Conventional Hydropower	$ 2,113	$ 2,031	*0.961*	$ 0.024	$ 12.84	---
Wind	$ 1,812	$ 1,811	*1.000*	$ -	$ 28.55	---
Wind Offshore	$ 3,629	$ 3,351	*0.923*	$ -	$ 84.32	---
Solar Thermal	$ 4,741	$ 4,619	*0.974*	$ -	$ 53.51	---
Photovoltaic	$ 5,690	$ 5,208	*0.915*	$ -	$ 11.01	---

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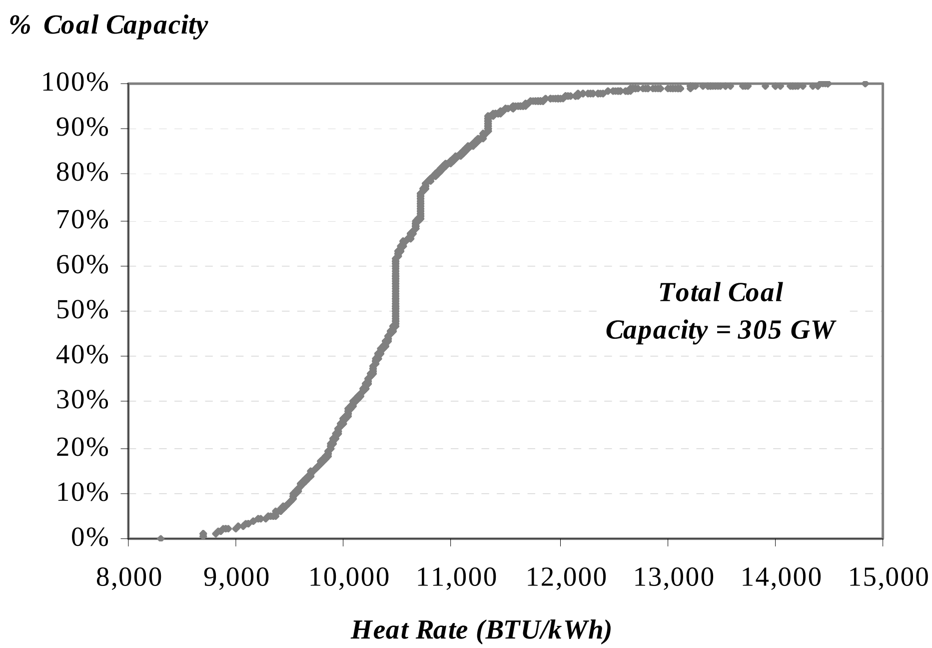
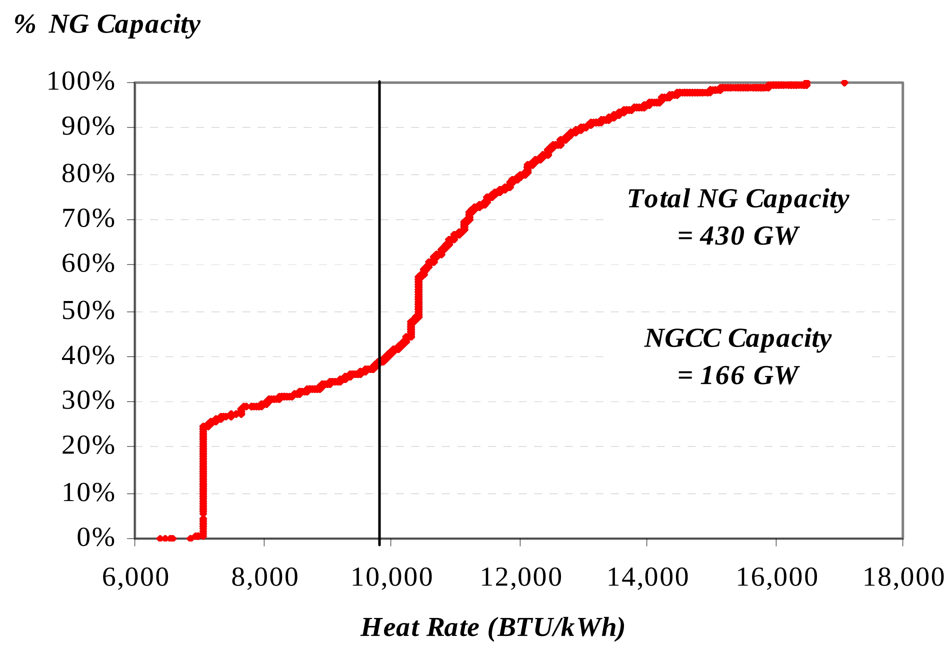
The Potential for Gas to Displace Coal in Power

- The distribution of capacity by heat rate indicate that implementing a carbon price can alter the near term competitive dispatch of coal versus gas.
- 17% of coal capacity has HR > 11,500. The HR of NGCC capacity < 7,500.
  - If P_{coal} = \$1/mmbtu and P_{ng} = \$5/mmbtu, we displace of 17% of coal capacity with a P_{CO2} = \$38. The price jumps to \$70 if we must build new NGCC facilities. We displace 50% when P_{CO2} = \$82, and 100% when P_{CO2} = \$118. BUT, as P_{ng} increases relative to P_{coal}, P_{CO2} also rises.





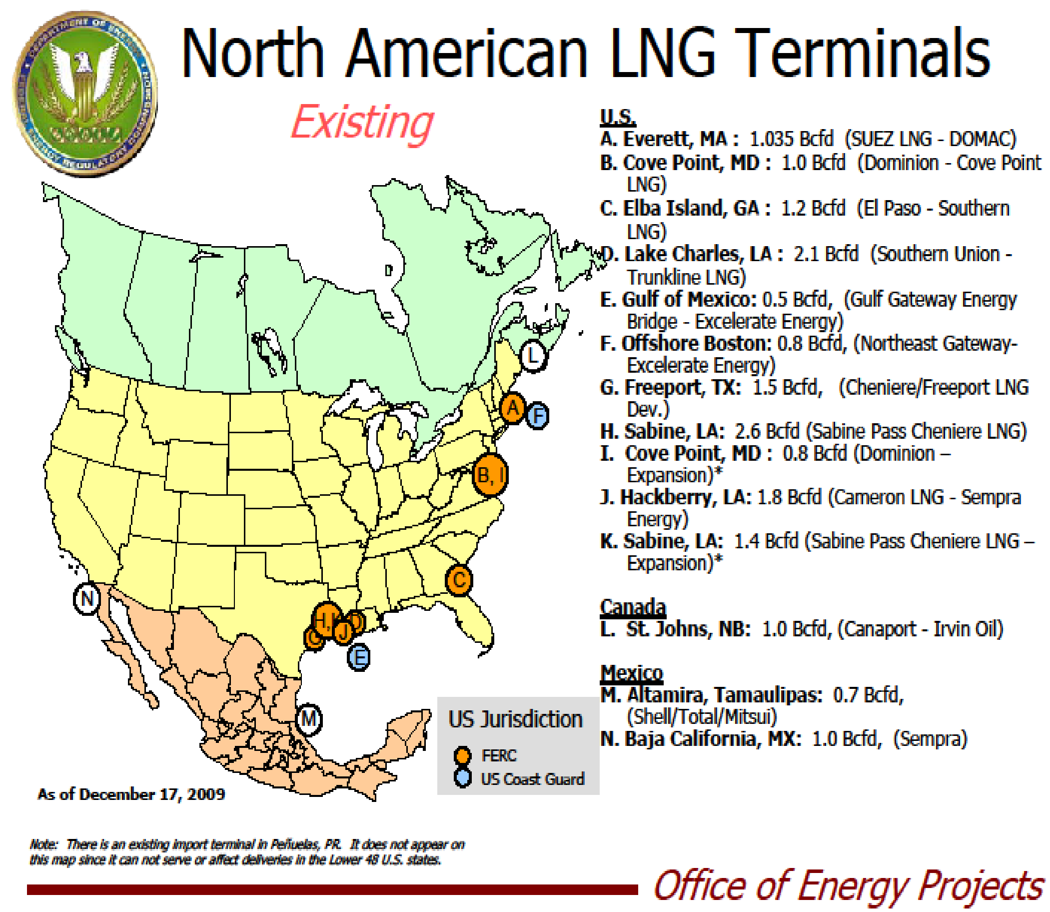
Key Findings

- In all cases analyzed, the demand for natural gas in North America increases.
  - Largest increases are in the scenarios in which carbon pricing does not encourage the adoption of CCS technologies but do encourage switching from coal to gas in the power sector. Thus, the capital cost of CCS is critical to determining this window.
  - Scenarios in which Electric Vehicles penetrate the transportation sector natural gas demand is favored as the primary electricity source.
  - RPS scenarios tend to curb growth in natural gas demand for two reasons…
    - Higher electricity prices generally lower overall demand.
    - Wind power takes market share for baseload from both natural gas and coal.
  - … but demand still grows.
- Demand for oil and coal vary substantially across policies.
  - Oil demand is reduced most by policies that mandate EVs
  - Coal demand is reduced most by policies that raise the price of carbon, but the reduction is non-linear. As carbon prices rise, CCS eventually becomes a commercially viable option which restores the use of coal.

A Focus on Natural Gas
and
The Important Role of Shale Gas

A Paradigm Shift

- The view of natural gas has changed dramatically in only 10 years
  - Most predictions were for a dramatic increase in LNG imports to North America and Europe.
  - Today, growth opportunities for LNG developers are seen in primarily in Asia.
- Many investments were made to expand LNG potential to North America in particular
  - At one point, 47 terminals were in the permitting phase.
  - Since 2000, 2 terminals were re-commissioned and expanded (Cove Point and Elba); 9 others were constructed.
  - In 2000, import capacity was just over 2 bcfd; It now stands at just over 17.4 bcfd.
  - By 2012, it could reach 20 bcfd.
- A similar story in Europe
  - In 2000, capacity was just over 7 bcfd; It is now over 14.5 bcfd.
  - By 2012, it could exceed 17 bcfd.
- Shale gas developments have since turned expectations upside-down



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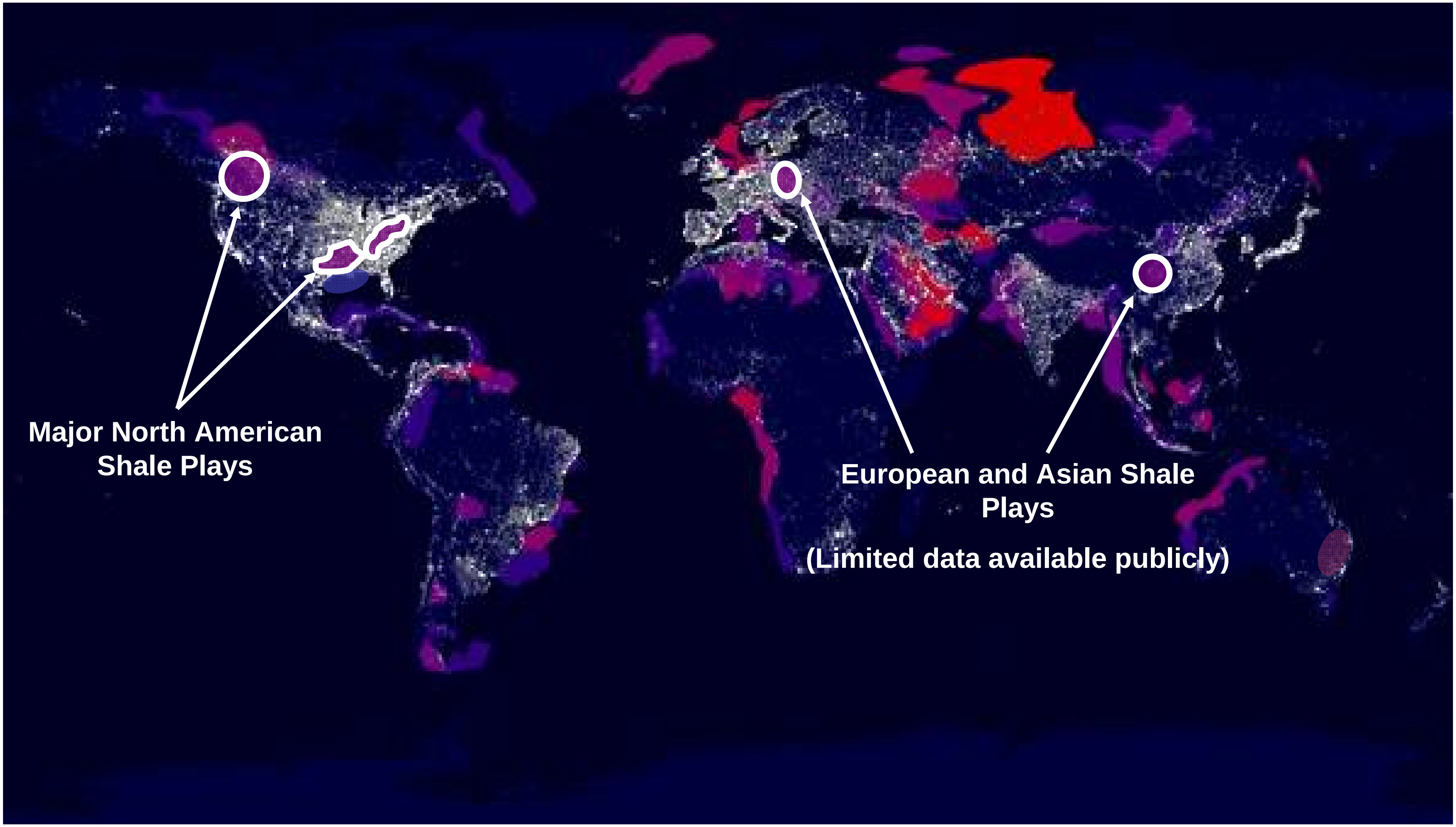
Shale is not confined to North America, and it has significant implications for the global gas market

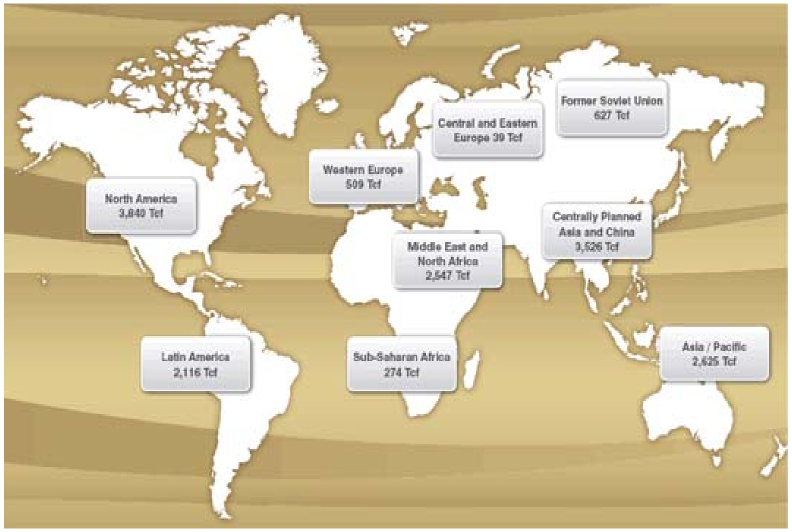


The Global Shale Gas Resource

- Knowledge of shale gas resource is not new
  - Rogner (1997) estimated over 16,000 tcf of shale gas resource in-place globally
  - Only a very small fraction (<10%) of this was deemed to be technically recoverable and even less so economically.
- Only recently have innovations made this resource accessible
  - Shale developments have been focused largely in North America where high prices have encouraged cost-reducing innovations.
  - IEA recently estimated about 40% of the estimates resource in-place by Rogner (1997) will ultimately be technically recoverable.
  - Recent assessment by Advanced Resources International (2010) notes a greater resource in-place estimate than Rogner (1997), with most of the addition coming in North America and Europe.
- ***We learn as we advance in this play!***

Rogner (1997)

Region	Resource In-Place (tcf)	Resource In-Place (tcm)
North America	3,842	109
Latin America	2,117	60
Europe	549	15
Former USSR	627	18
China and India	3,528	100
Australasia	2,313	66
MENA	2,548	72
Other	588	17
Total	**16,112**	**457**



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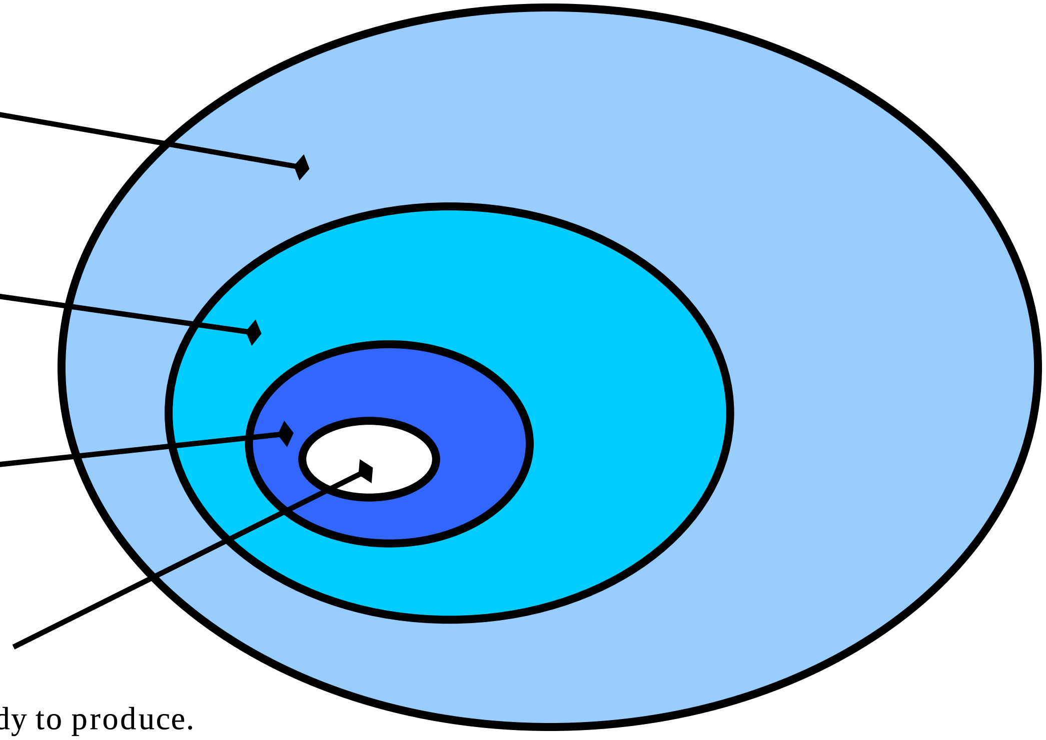
"Resource" vs. "Reserve"

- Often, the press and many industry analysts characterize the recent estimates of shale gas in North America as "reserves".
- This is an incorrect representation! It is important to understand what these assessments are actually estimating.
- With shale gas, GIP numbers are very large. **The X-factor is cost.**



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North American Shale Gas

- Note, in 2005, most estimates placed the resource at about 140 tcf.
- Some estimates are much higher
  - (2008) Navigant Consulting, Inc. estimated a mean of about 520 tcf.
  - (2009) Estimate from PGC over 680 tcf.
  - (2010) ARI estimate of over 1000 tcf.
- Resource assessment is large. Our work at BIPP indicates a technically recoverable resource of 583 tcf.
- We learn more as time passes!

Source: Energy Information Administration based on data from various published studies
Updated: May 28, 2009

	Mean Technically Recoverable Resource (tcf)	Breakeven Price
Antrim	13.2	$ 6.00
Devonian/Ohio	169.6	
Utica	5.4	$ 7.00
Marcellus	134.2	
Marcellus T1	47.0	$ 4.75
Marcellus T2	42.9	$ 5.75
Marcellus T3	44.3	$ 7.00
NW Ohio	2.7	$ 7.00
Devonian Siltstone and Shale	1.3	$ 7.00
Catskill Sandstones	11.7	$ 7.00
Berea Sandstones	6.8	$ 7.00
Big Sandy (Huron)	6.3	$ 6.00
Nora/Haysi (Huron)	1.2	$ 6.50
New Albany	3.8	$ 7.50
Floyd/Chatanooga	2.1	$ 6.25
Haynesville	90.0	
Haynesville T1	36.0	$ 4.25
Haynesville T2	31.5	$ 5.00
Haynesville T3	22.5	$ 6.50
Fayetteville	36.0	$ 5.00
Woodford Arkoma	8.0	$ 5.75
Woodford Ardmore	4.2	$ 6.00
Barnett	54.0	
Barnett T1	32.2	$ 4.50
Barnett T2	21.8	$ 5.75
Barnett and Woodford	35.4	$ 7.00
Eagle Ford	20.0	$ 5.00
Palo Duro	4.7	$ 7.00
Lewis	10.2	$ 7.25
Bakken	1.8	$ 7.50
Niobrara (incl. Wattenburg)	1.3	$ 7.25
Hilliard/Baxter/Mancos	11.8	$ 7.25
Lewis	13.5	$ 7.25
Mowry	8.5	$ 7.25
Montney	35.0	$ 4.75
Horn River	50.0	$ 5.25
Utica	10.0	$ 7.00
Total US Shale	488.0	
Total Canadian Shale	95.0	
Total North America	583.0	

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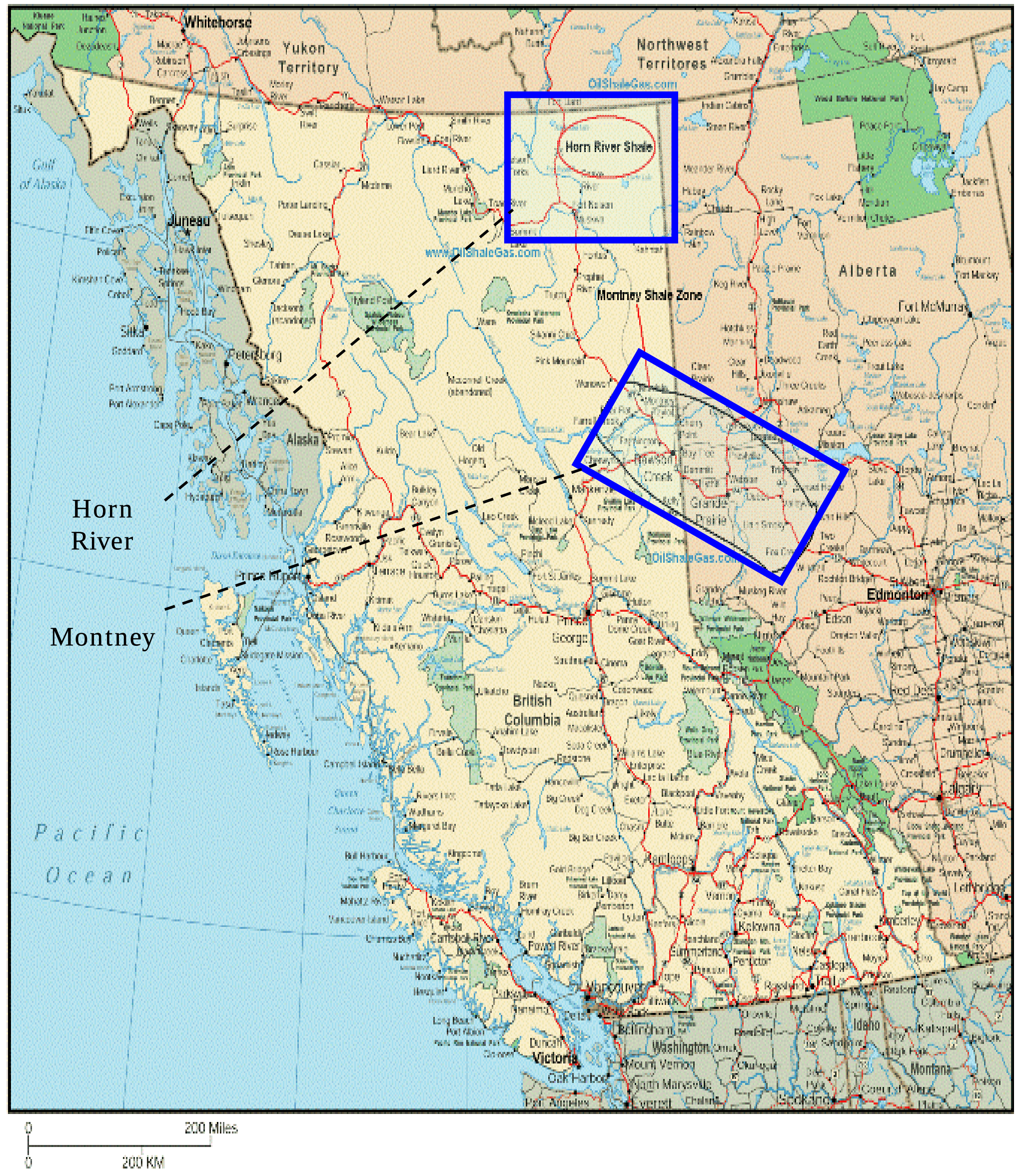
North American Shale Gas (cont.)

- Shale is also in Canada.
- Most active areas are in the Horn River and Montney plays in BC and Alberta.
- Supply potential in BC, in particular, has pushed the idea of LNG exports targeting the Asian market
  - Asia is an oil-indexed premium market.
  - Competing projects include pipelines from Russia and the Caspian States, as well as LNG from other locations.
  - BC is a basis disadvantaged market, but selling to Asia could provide much more value to developers.
- Utica Shale in Quebec (not pictured) has been compared by some to the Barnett.



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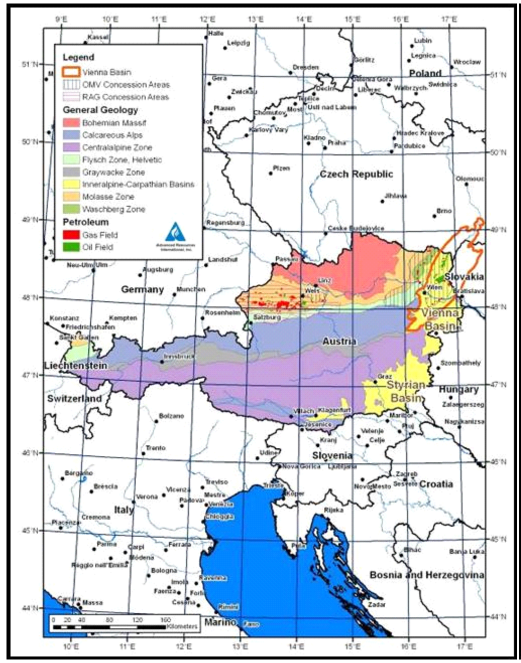
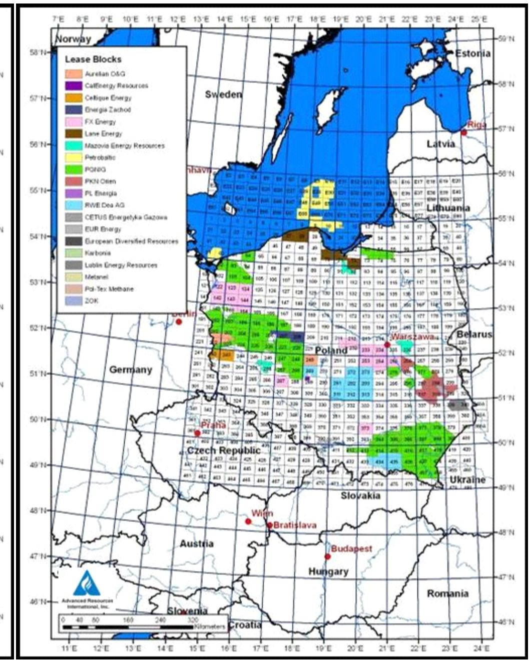
European Shale Gas

- In depth studies are underway, with on-going independent analysis of shale potential in Austria, Sweden, Poland, Romania, and Germany
- Rogner (1997) estimates
  - In-place: 549 tcf
  - Technically recoverable: No Data
- ARI estimates (2010)
  - In-place: 1000 tcf
  - Technically recoverable: 140 tcf
    - Alum Shale (Sweden), Silurian Shale (Poland), Mikulov Shale (Austria)
  - Europe also has an additional 35 tcf of technically recoverable CBM resource located primarily in Western European countries and Poland.
  - Quote from ARI report: “Our preliminary estimate for the gas resource endowment for Western and Eastern Europe, which we anticipate to grow with time and new data, is already twice Rogner’s estimate of 549 Tcf (15.6 Tcm).”

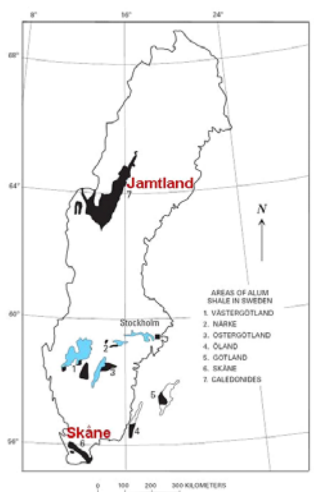
Austria



Poland *(by lease)*



Sweden



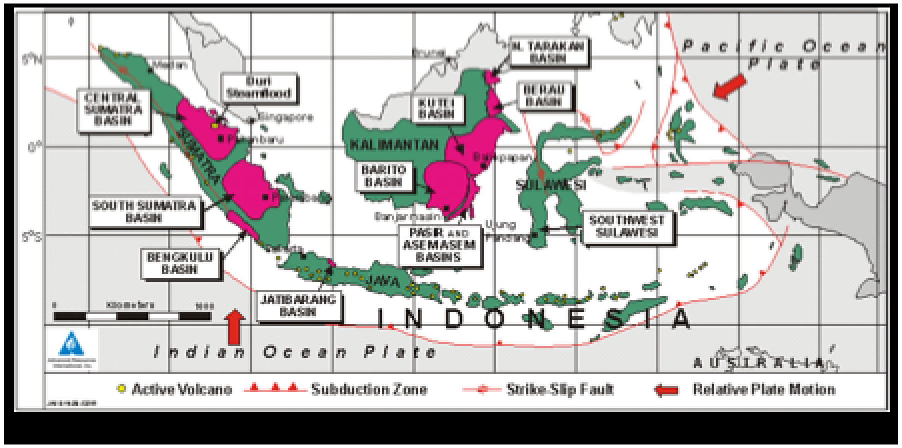
Source:

Graphics from ARI (2010)

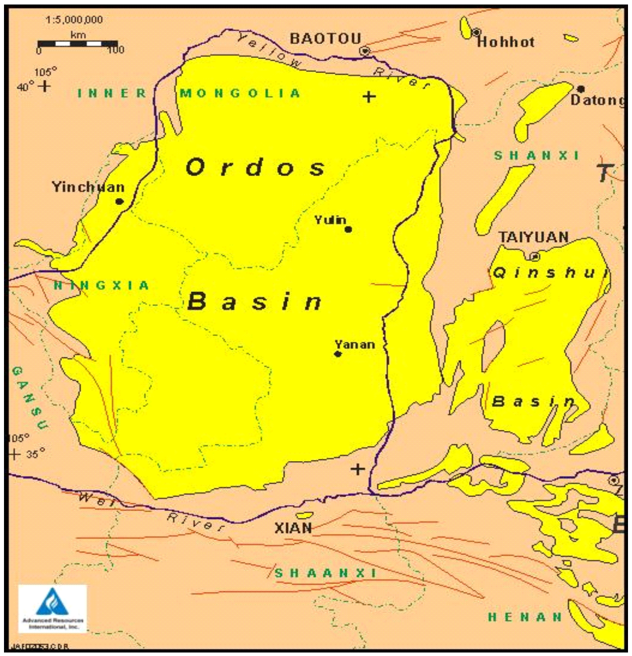
Asia/Pacific Shale and CBM

- Limited data availability
- Rogner (1997) estimates
  - China/India In-place: 3,530 tcf
  - Technically recoverable: No Data
- China and the U.S. Department of Energy have recently entered into a "U.S.-China Shale Gas Resource Initiative" to support gas shale development in China.
- CBM potential in the Asia-Pacific Region is large and generally better known (ARI, 2010).
  - Indonesia: 450 tcf (in-place)
    50 tcf (technically recoverable)
  - China: 1,270 tcf (in-place)
    100 tcf (technically recoverable)
  - India: 90 tcf (in-place)
    20 tcf (technically recoverable)
  - Australia: 1,000 tcf (in-place)
    120 tcf (technically recoverable

Indonesia (CBM)



China (CBM)



Source: Graphics from ARI (2010)

Modeling Results

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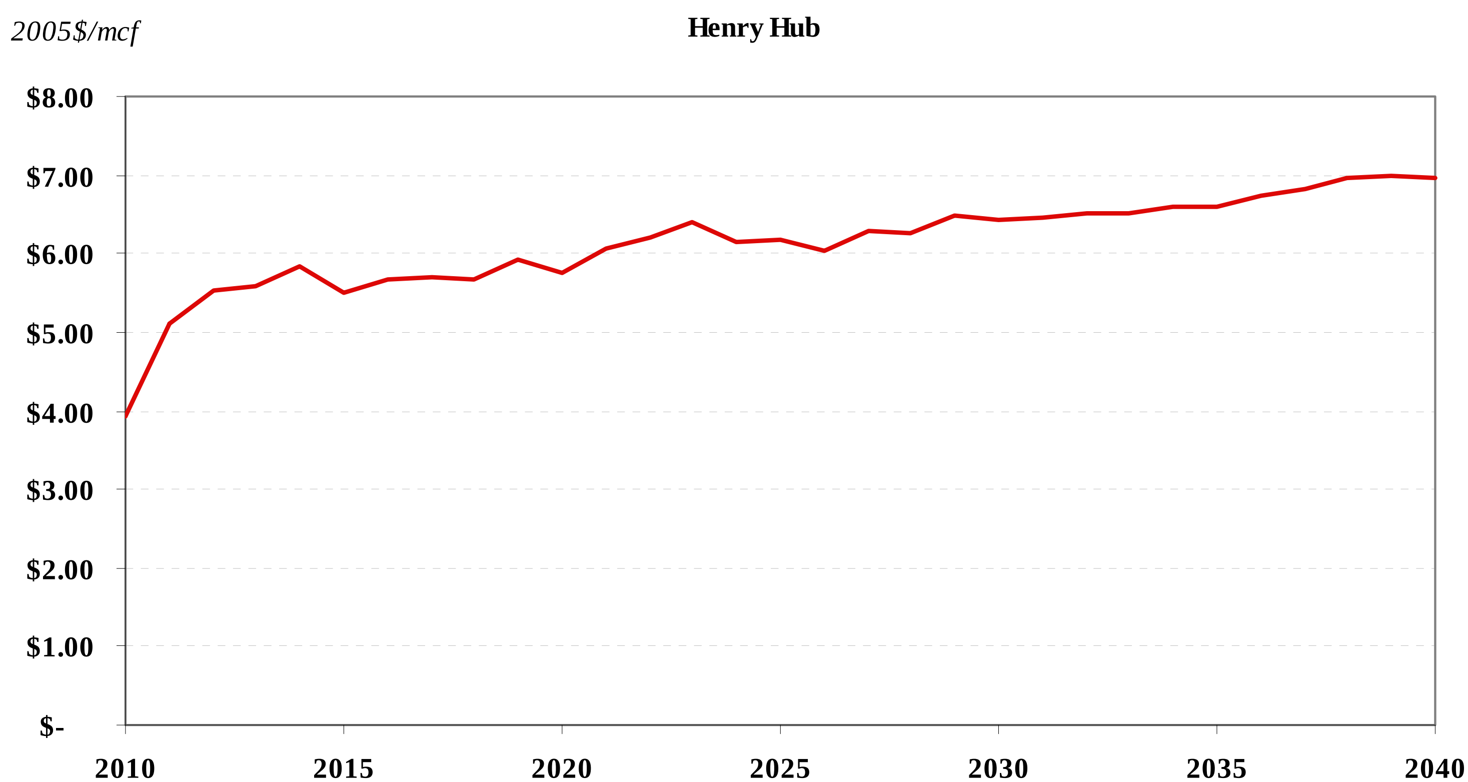
Henry Hub Natural Gas Price

- Long term prices at Henry Hub (averages, inflation adjusted)
  - 2010-2020: $ 5.47 2021-2030: $ 6.25 2031-2040: $ 6.71



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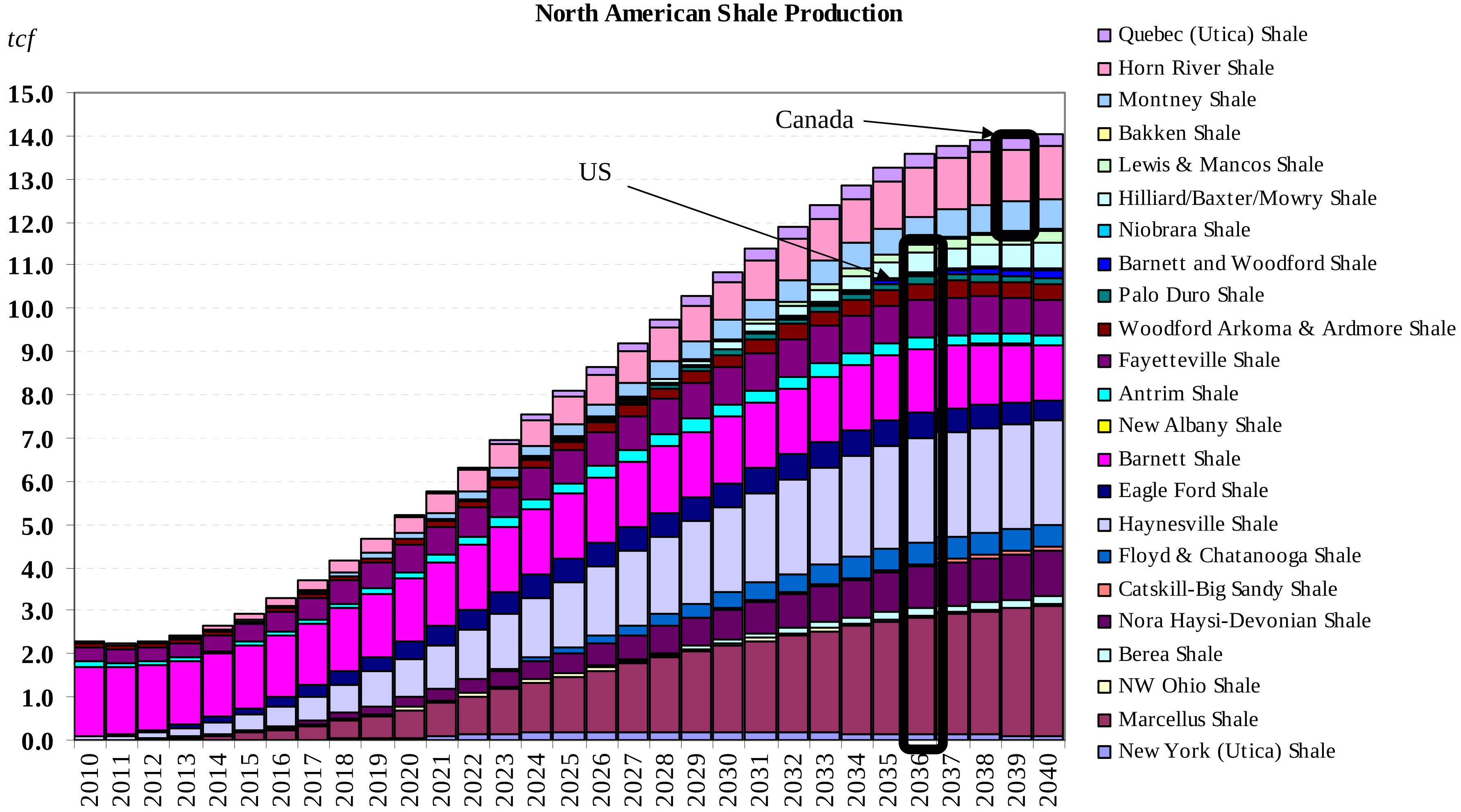
North American Shale Production



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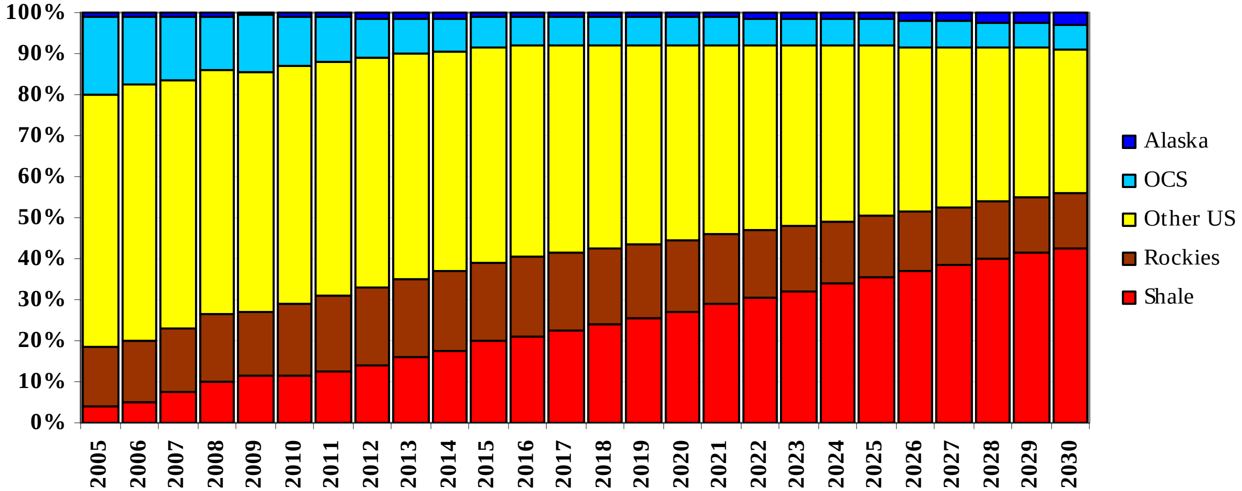
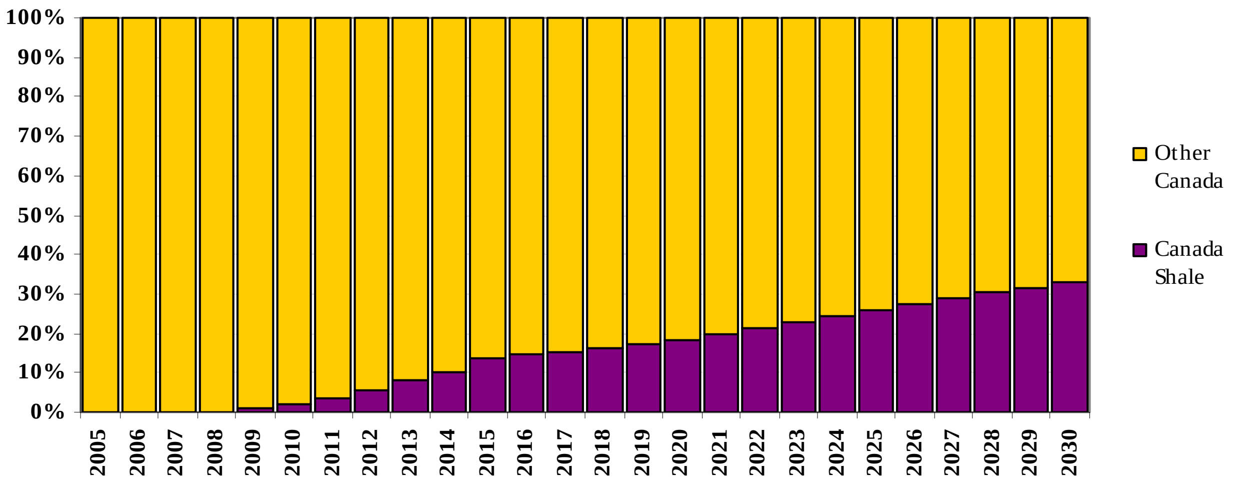
Composition of North American Production



- US shale production grows to about 45% of total production by 2030.



- Canadian shale production grows to about 1/3 of total output by 2030. This offsets declines in other resources as total production remains fairly flat.

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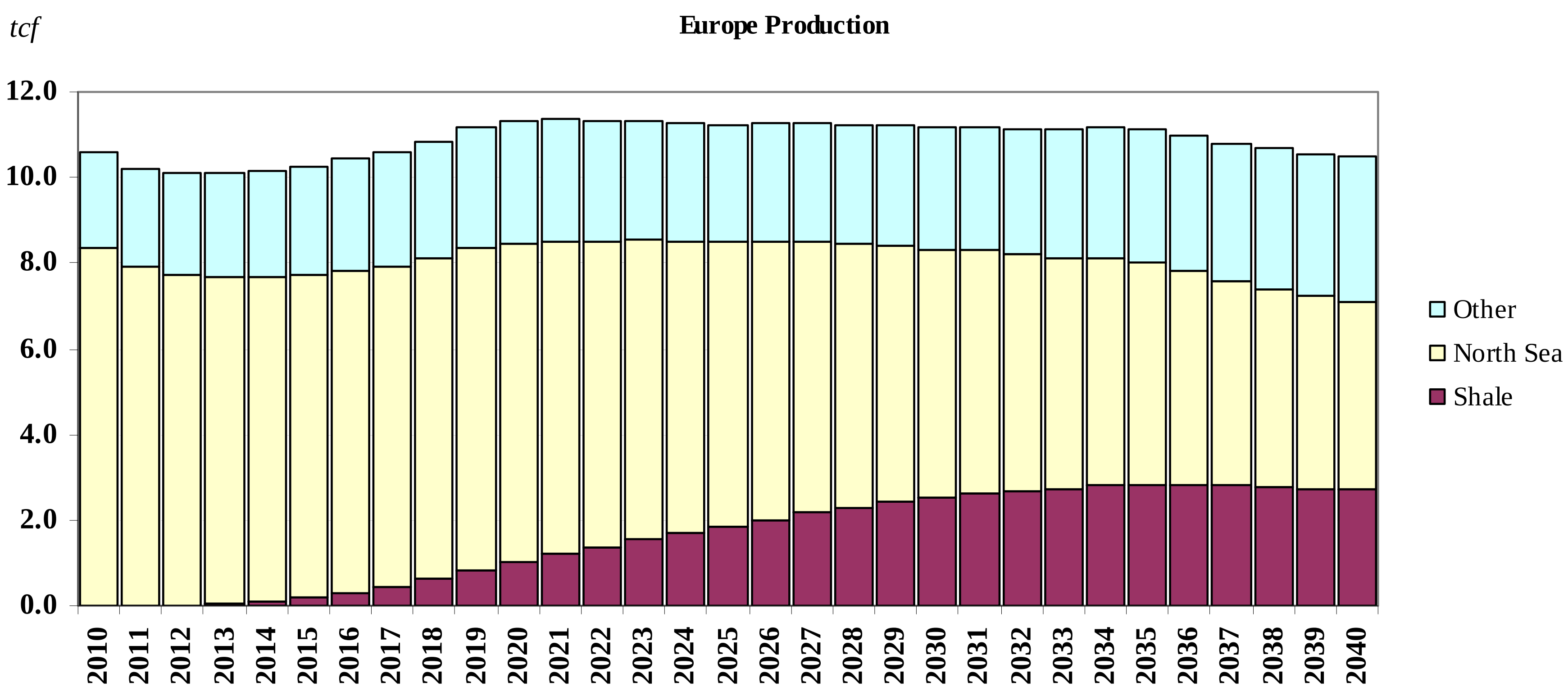
The Impact of European Shale Production

- European shale production grows to about 18% of total production by the mid-2030s. While this is not as strong as North America, it does offset the need for increased imports from Russia, North Africa, and via LNG. In fact, the impact of shale growth in Europe is tilted toward offsetting Russian imports, but it also lowers North Sea production at the margin, as well as other sources of imports.



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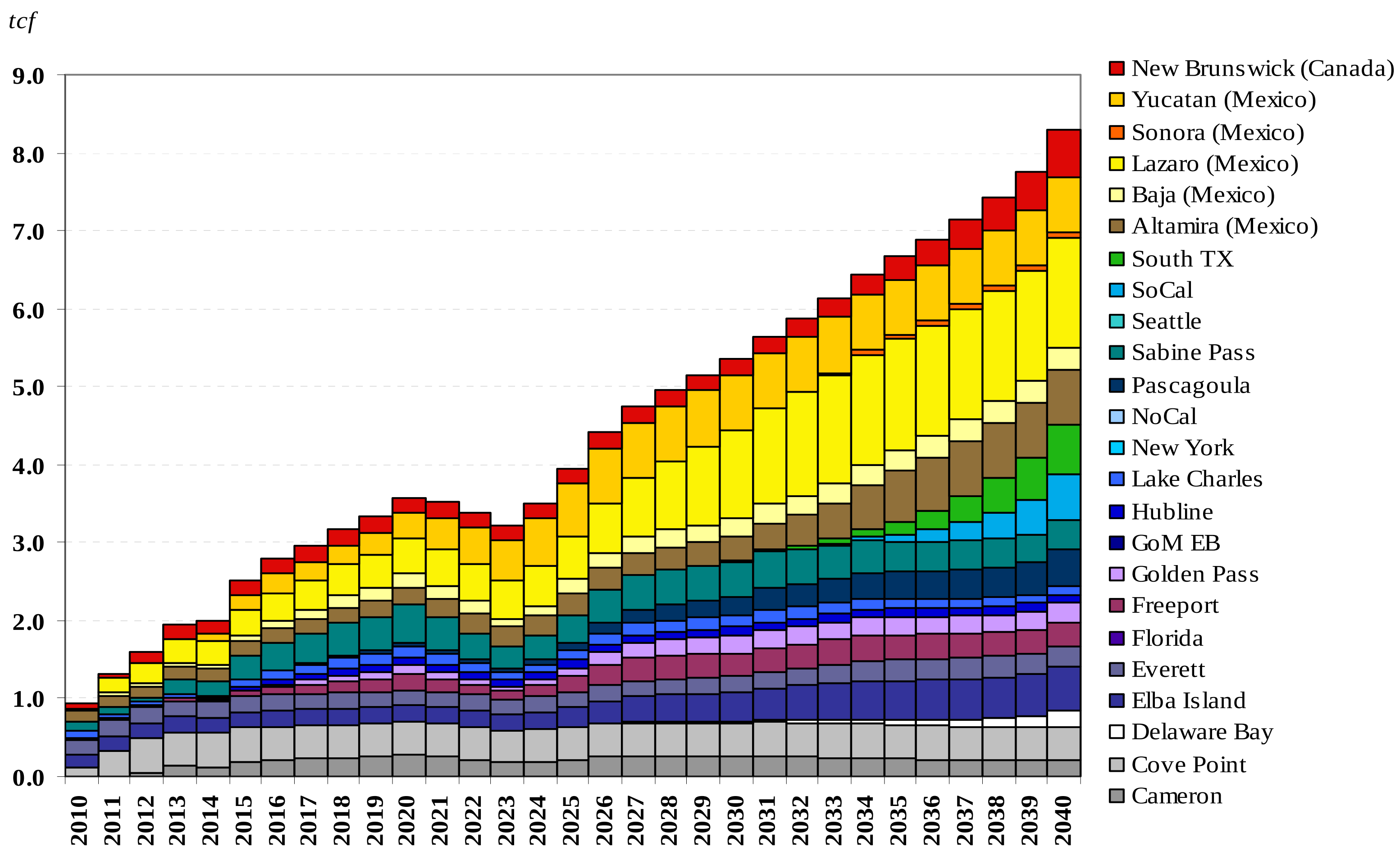
LNG Imports to the US

- Growth in domestic shale resources renders load factors very low.
  - Load factors approach an average of 25% by the late 2030s.



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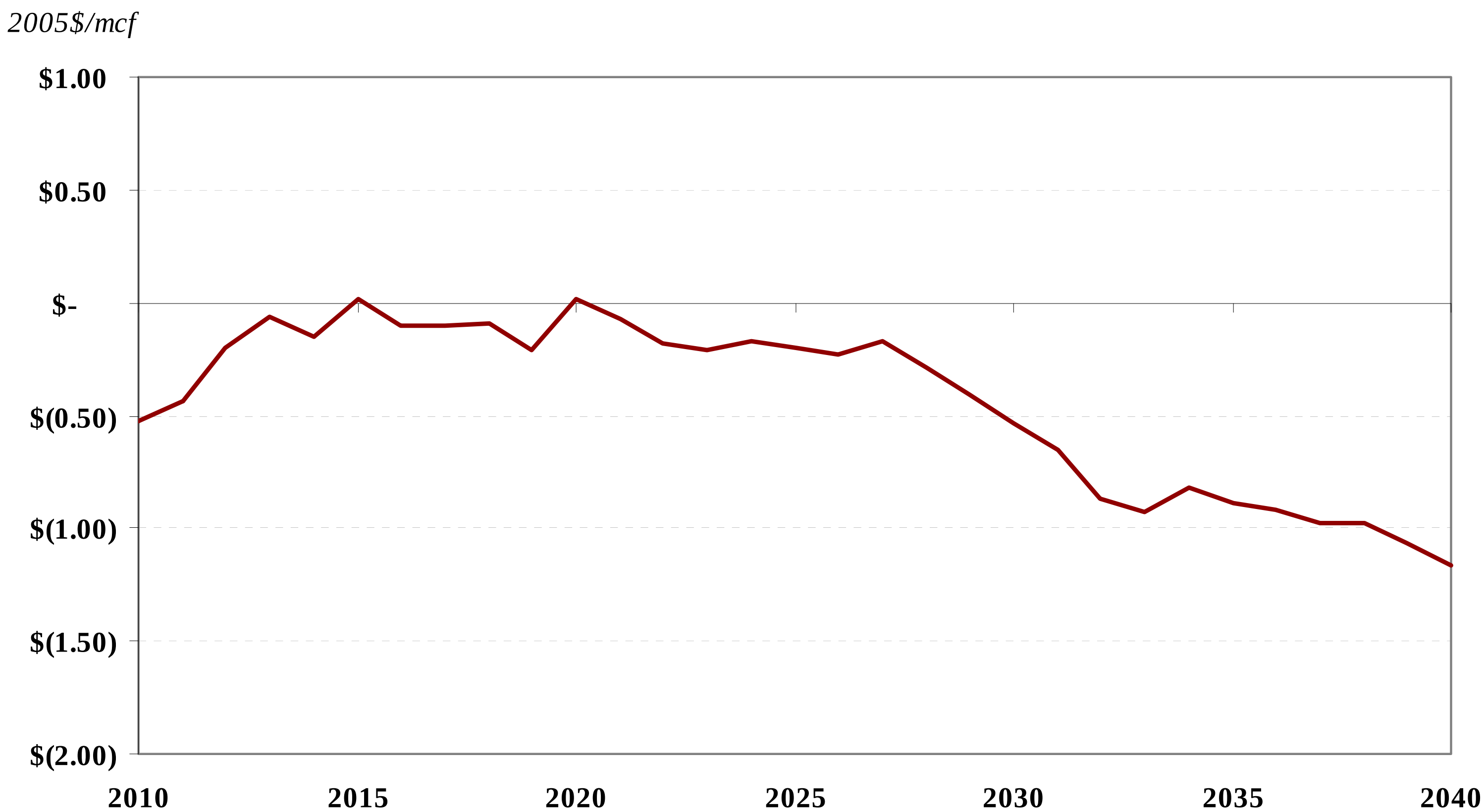
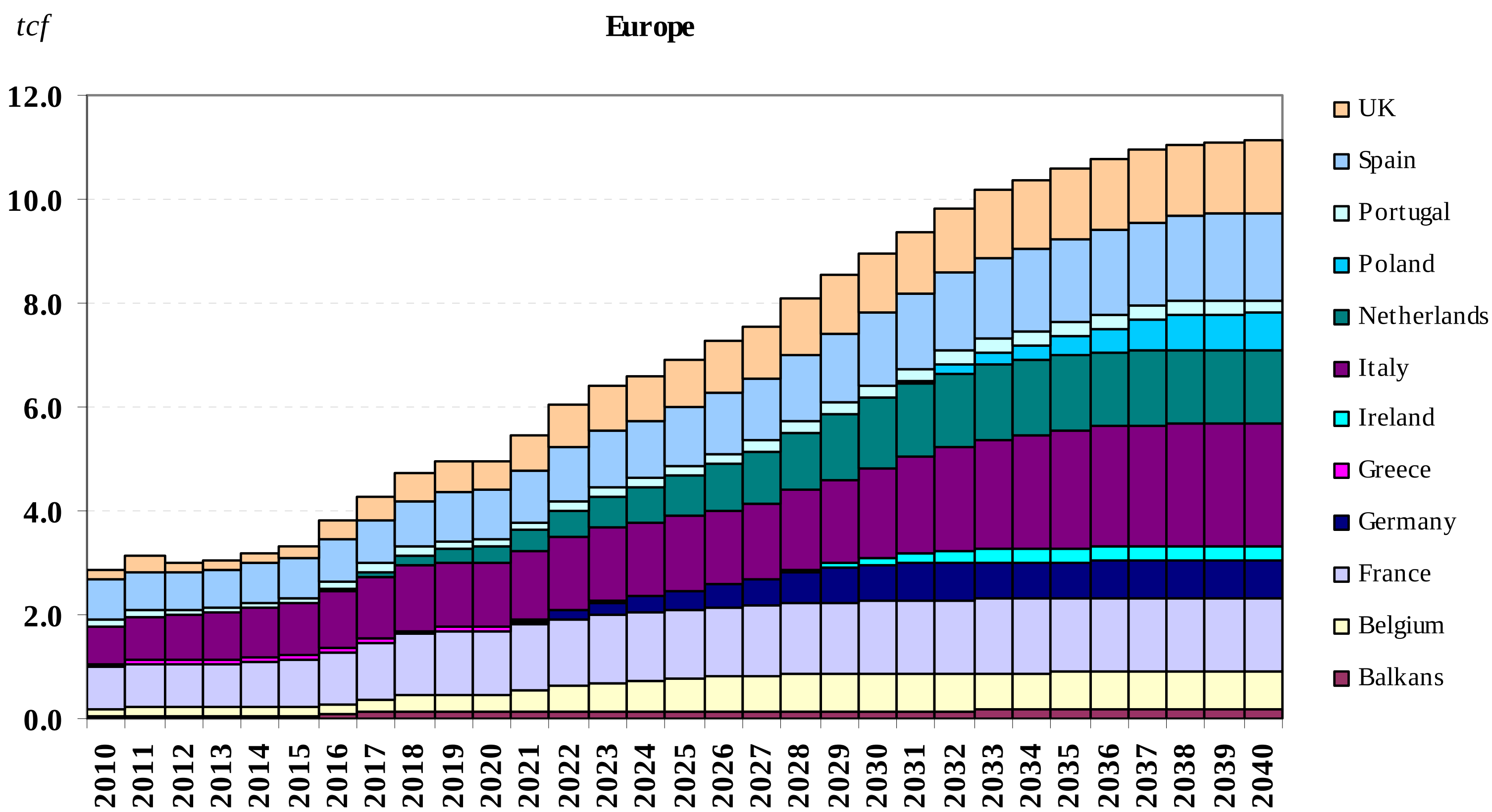
Regional Pricing

- The spread between Henry Hub and NBP widens (depicted as HH-NBP), thus favoring deliveries to non-Gulf Coast markets



LNG Imports to Europe

- Growth in LNG is an important source of diversification to Europe. Indigenous shale gas opportunities abate this to some extent, but the shale revolution is not as strong as in North America.



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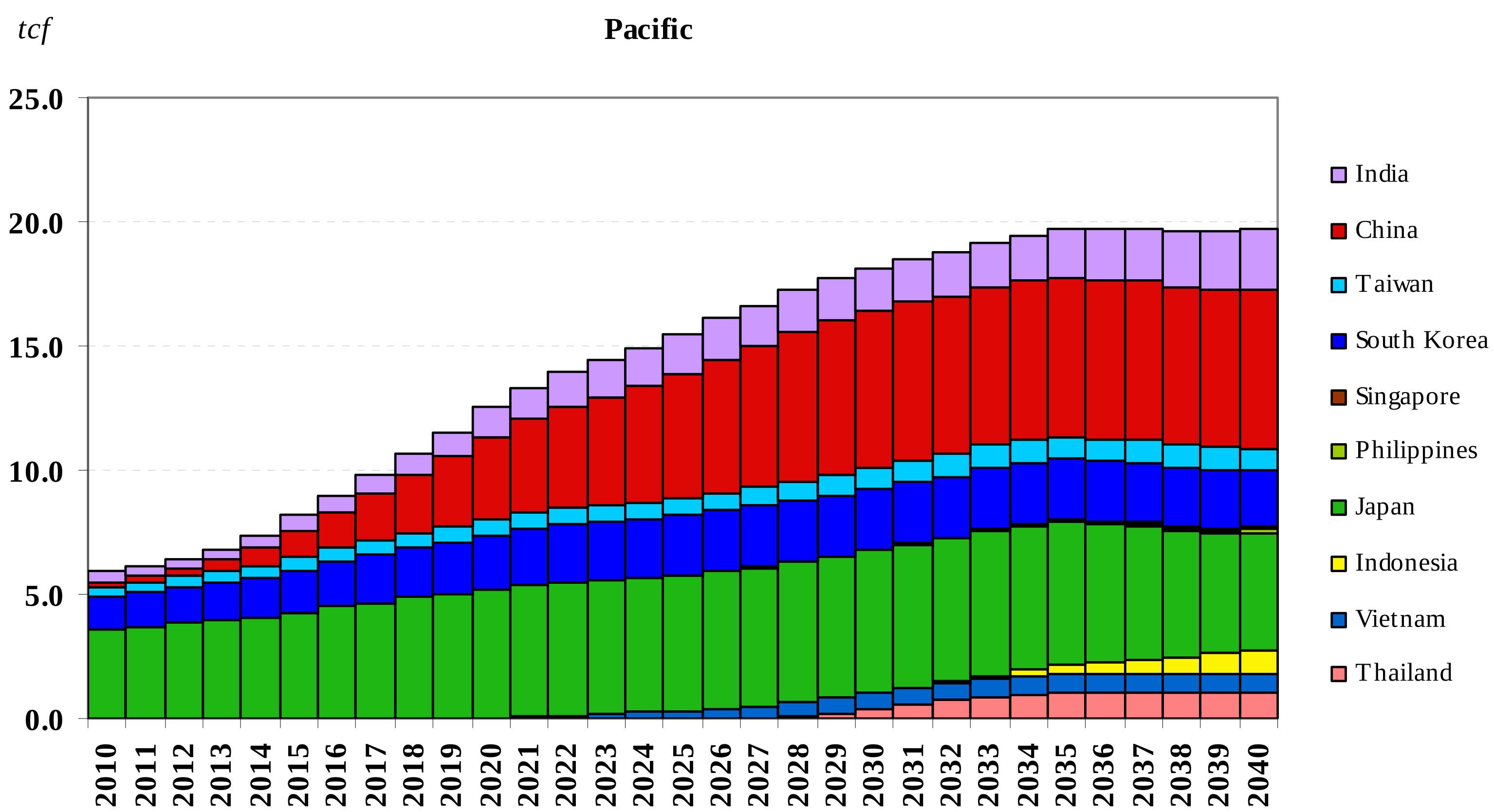
LNG Imports to Asia

- Strong demand growth creates a much needed sink for LNG supplies.
  - China leads in LNG import growth despite growth in pipeline imports and supplies from domestic unconventional sources.



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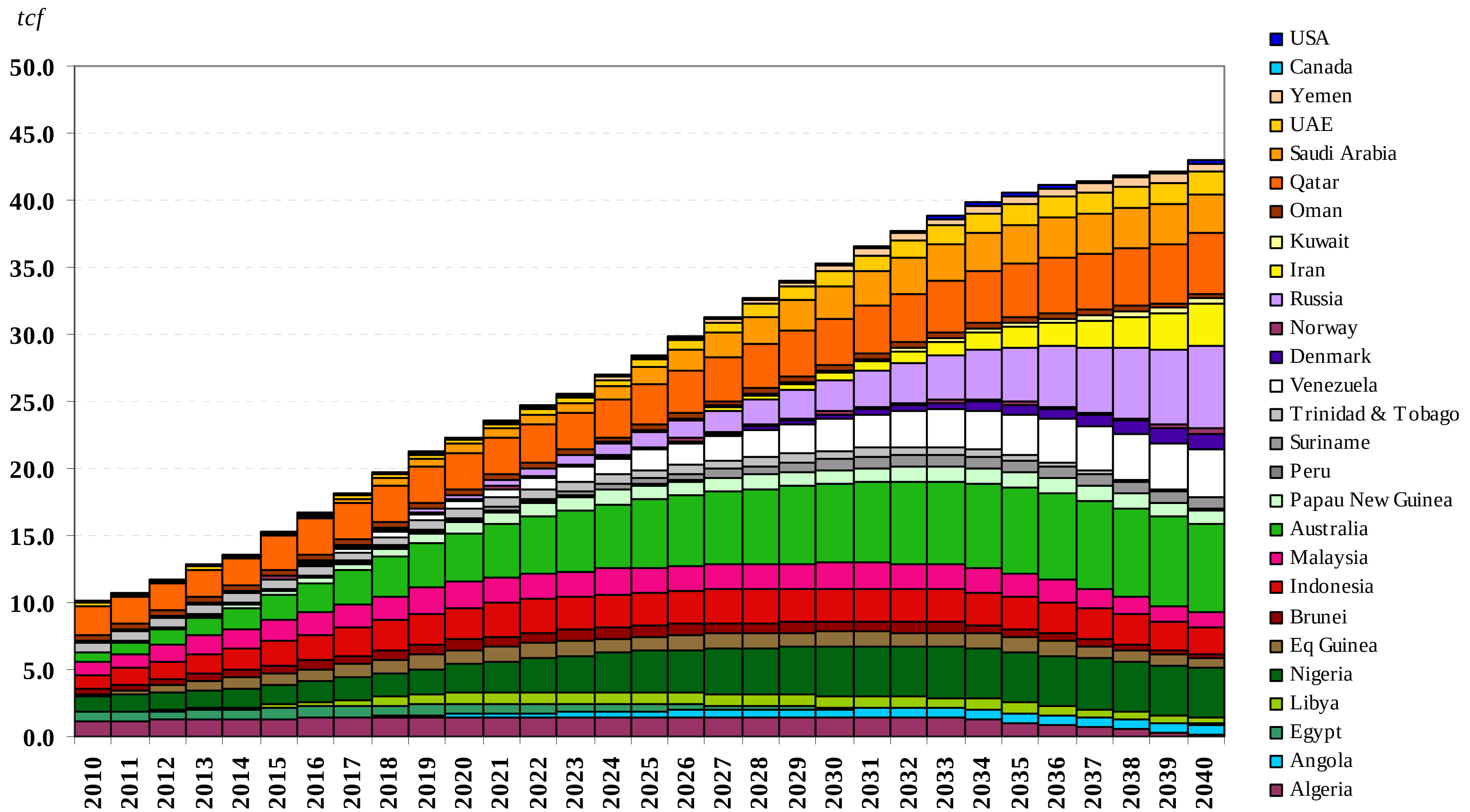
LNG Exports

- Strong growth longer term from Russia and Iran. Near term growth dominated by Qatar and Australia.



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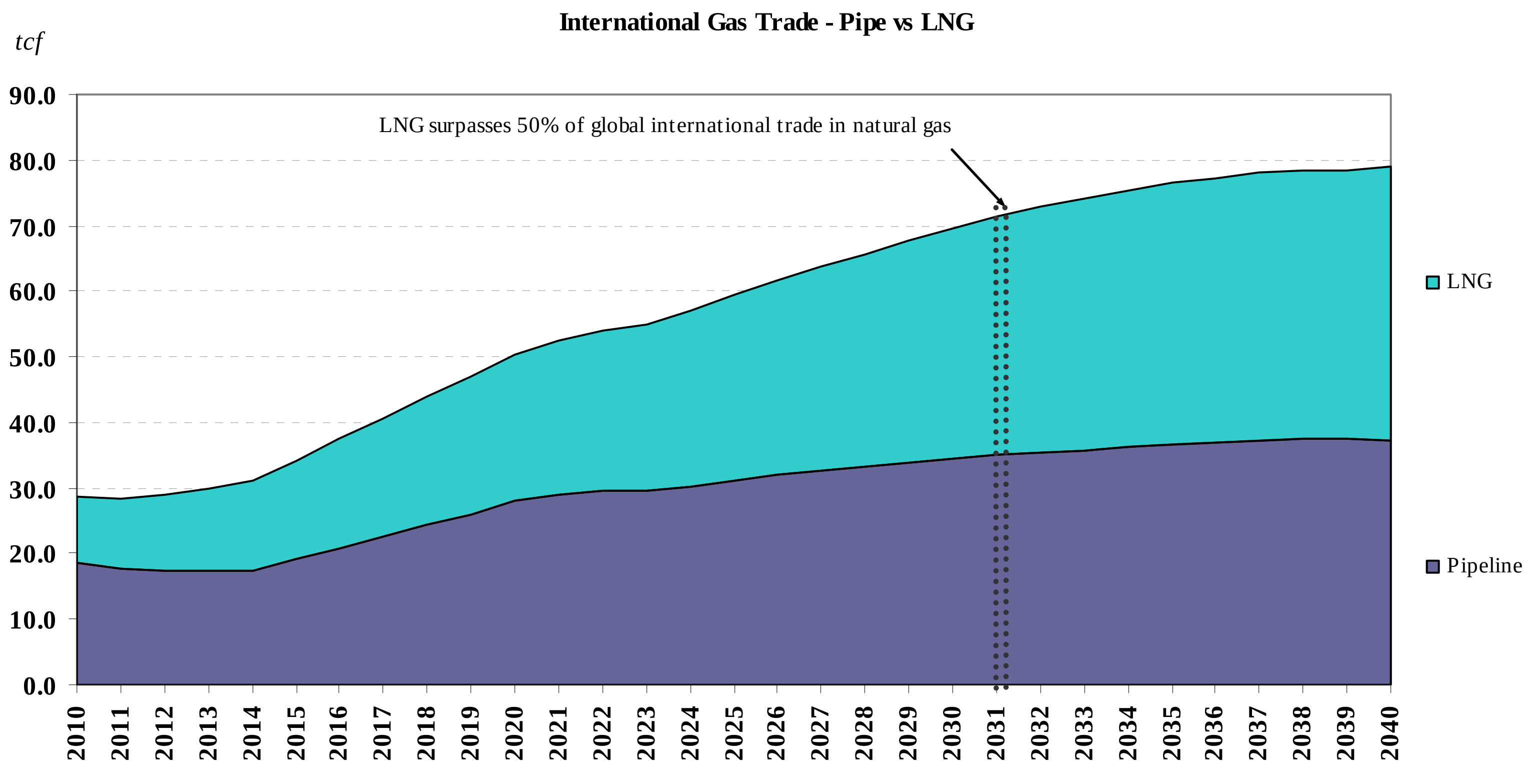
Global Gas Trade: LNG vs. Pipeline and Market Connectedness

- Globally, LNG growth is strong, reaching about 50% of total international natural gas trade by the early 2030s.
- Previously, regional disconnected markets become linked.



Scenario Results

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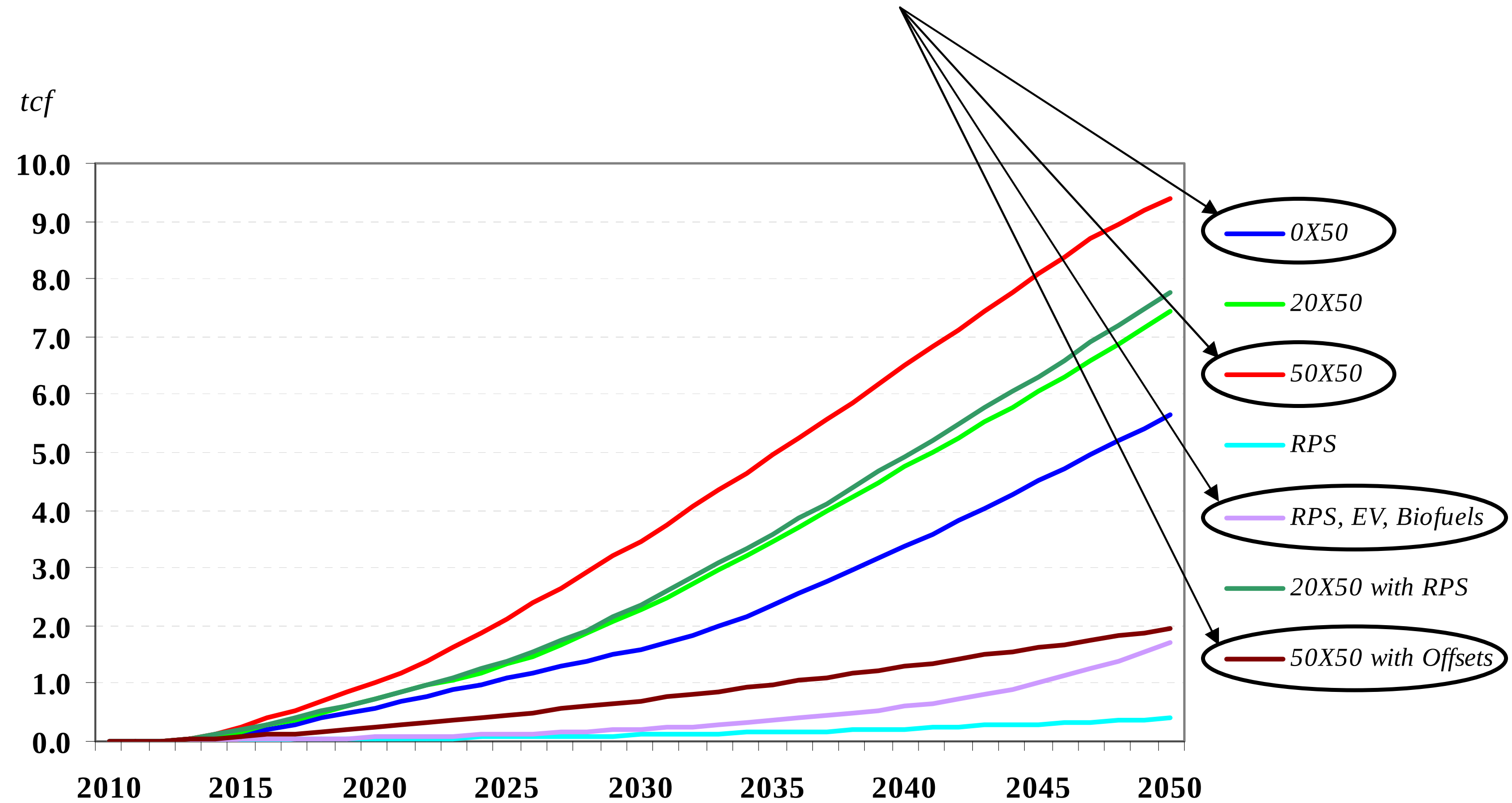
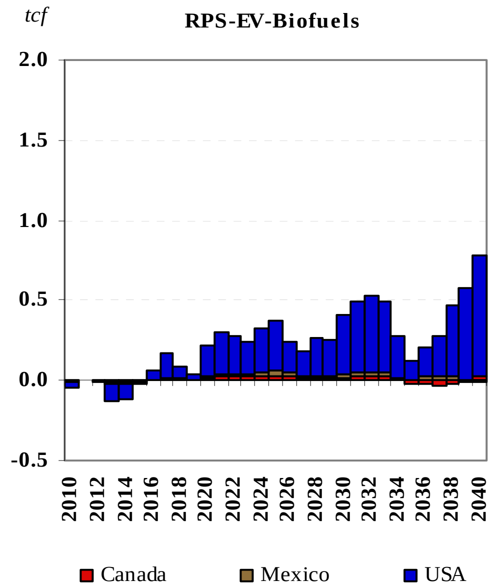
Natural Gas Demand Across Scenarios

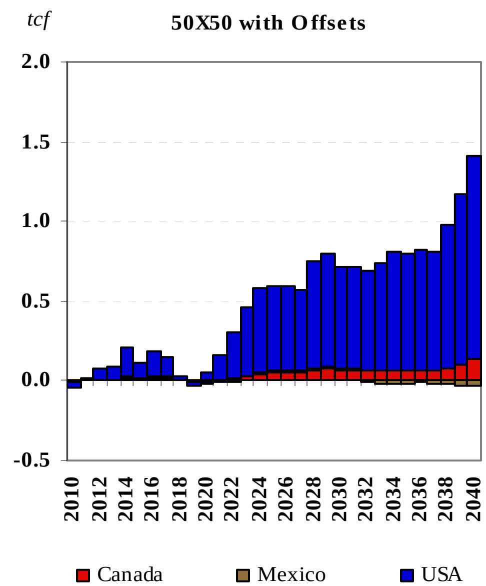
- Natural Gas demand impulse predicted by the scenario analyses performed in the RWEM.
  - We focus on a subset of these scenarios.

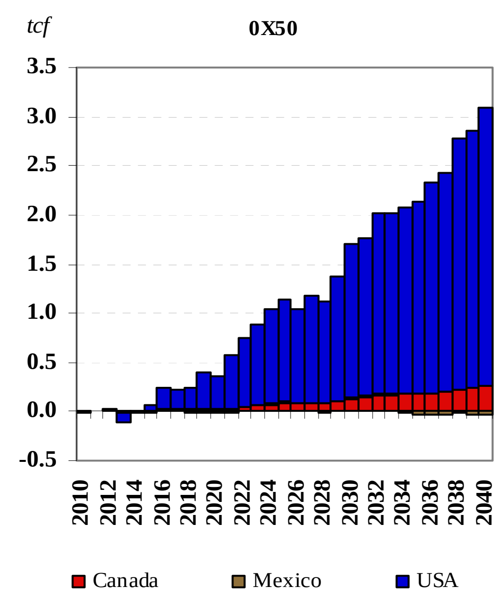


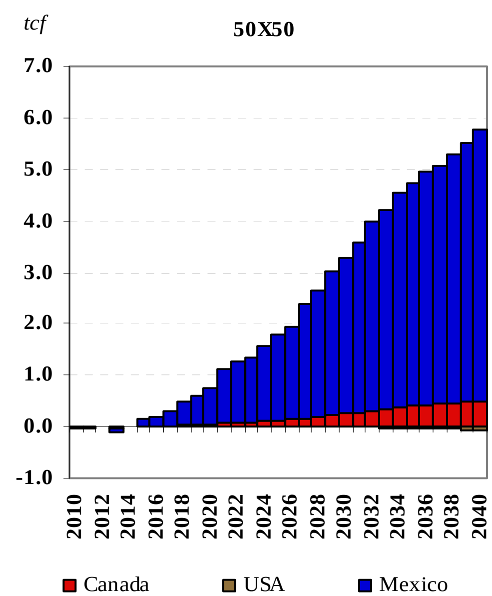
Natural Gas Demand Across Scenarios (cont.)

- Annual increment of demand in North America increases with the level of restriction









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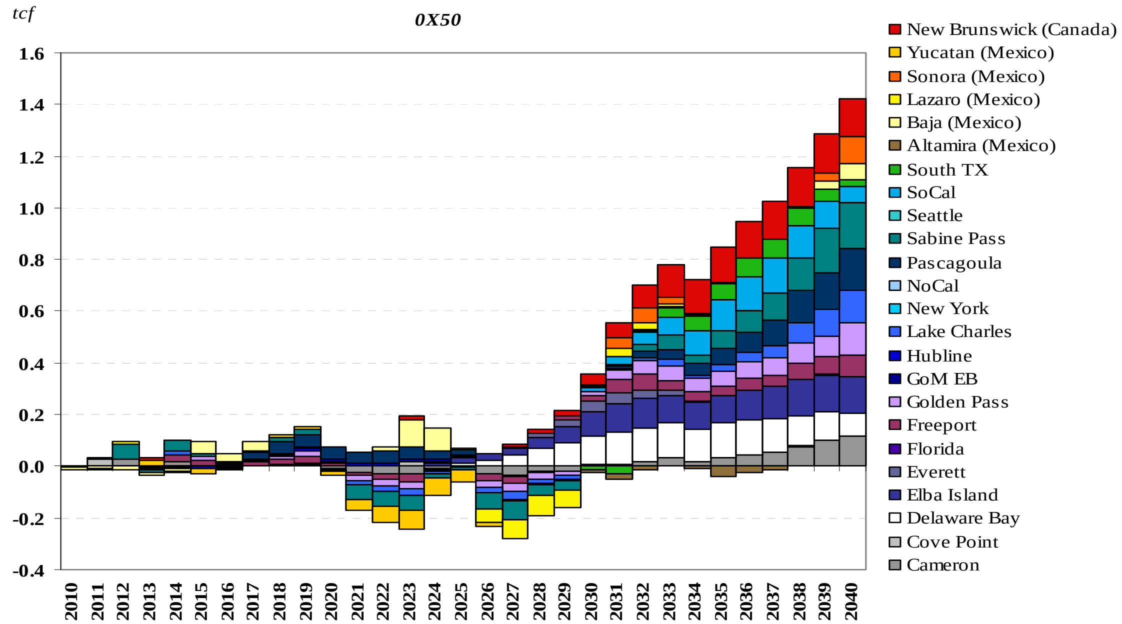
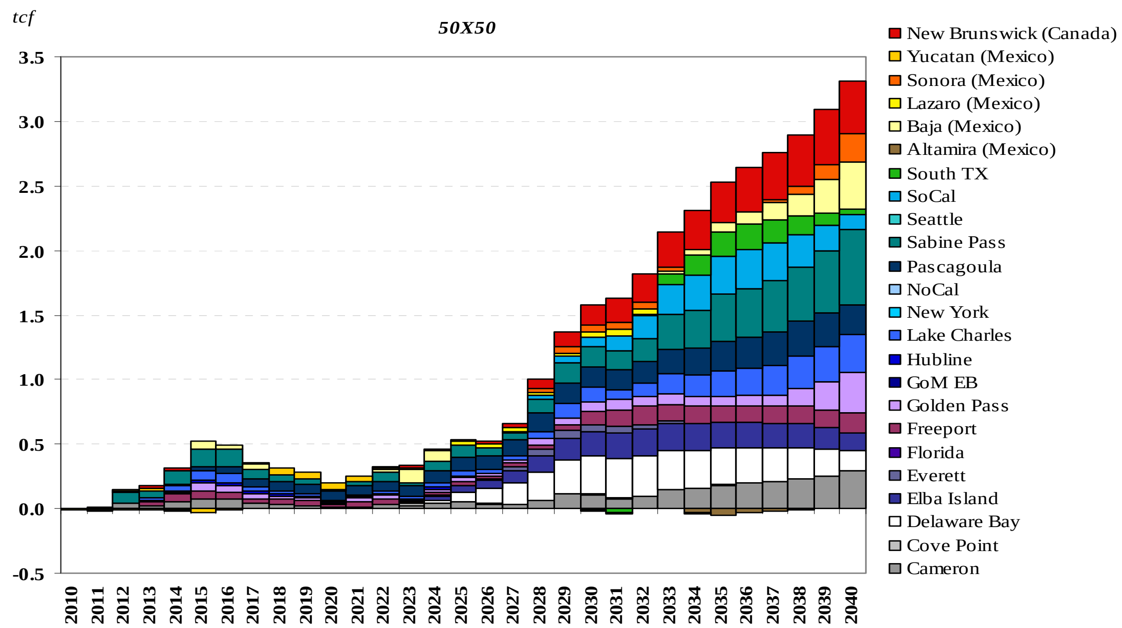
LNG Imports Across Scenarios

- Annual increment of LNG imports in North America increases with the level of restriction.
- There are some intertemporal effects as investment patterns change.





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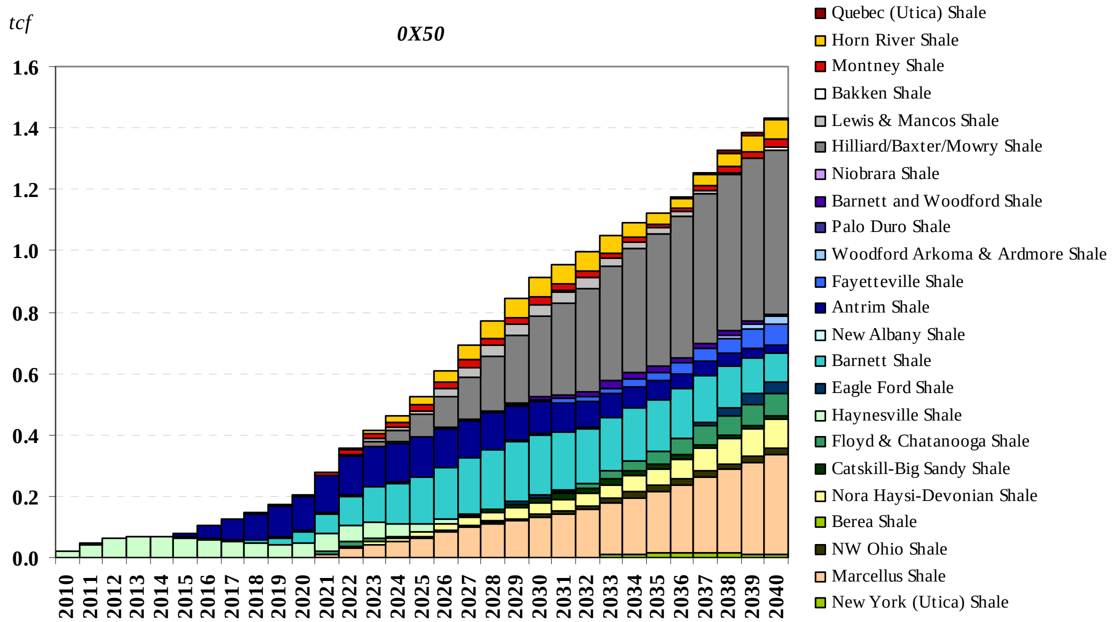
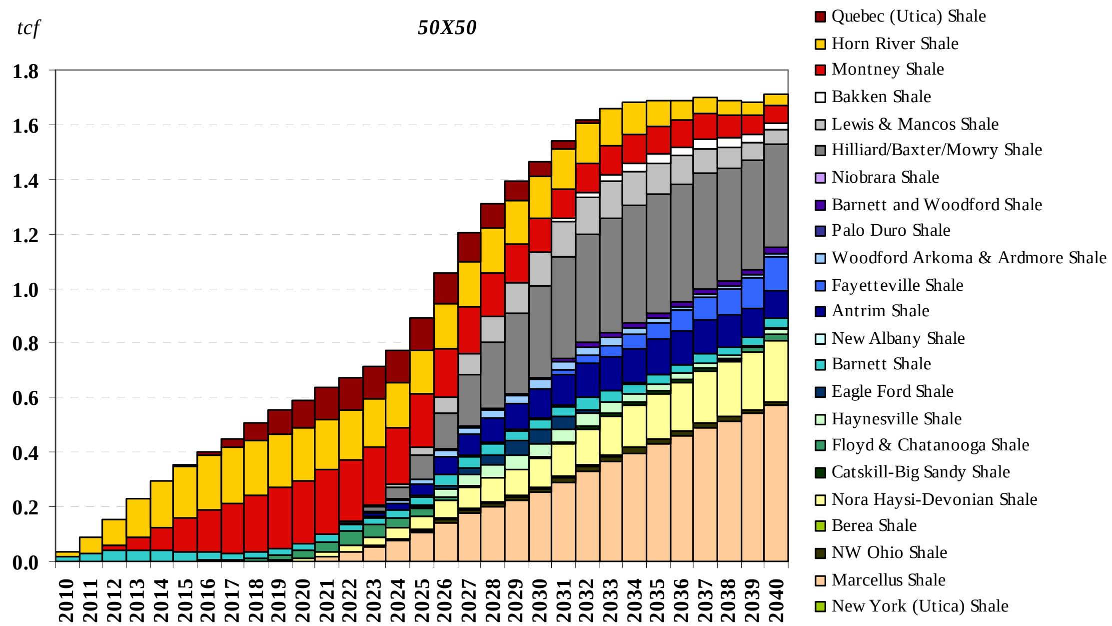
Shale Gas Production Across Scenarios

- Annual increment of shale gas production in North America increases with the level of restriction.
- There are some intertemporal effects as investment patterns change.
- Regional impacts also come into play.





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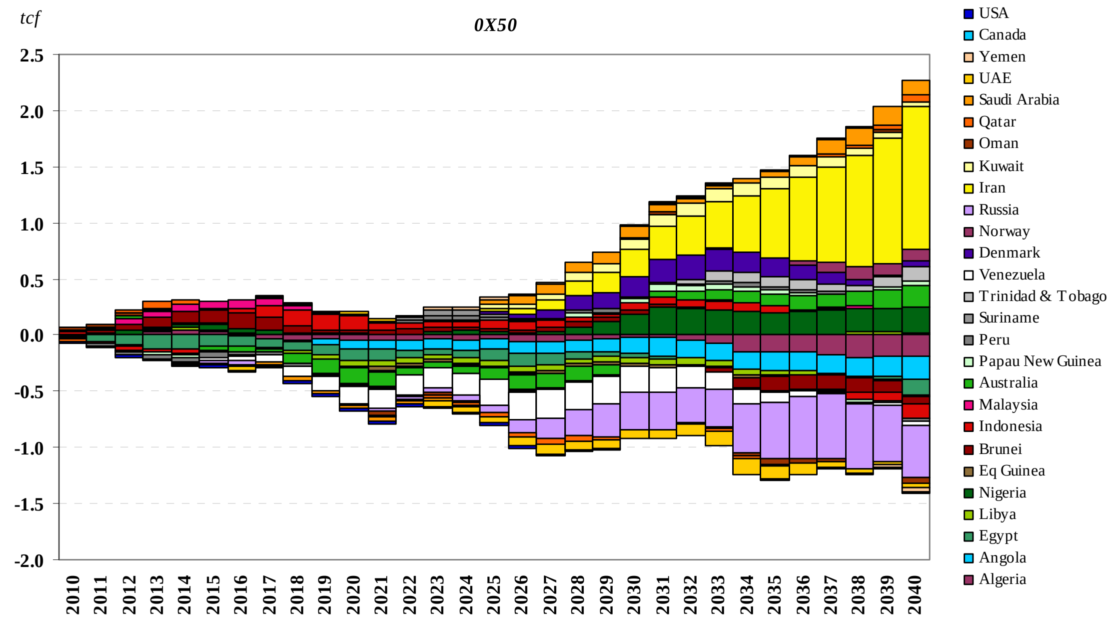
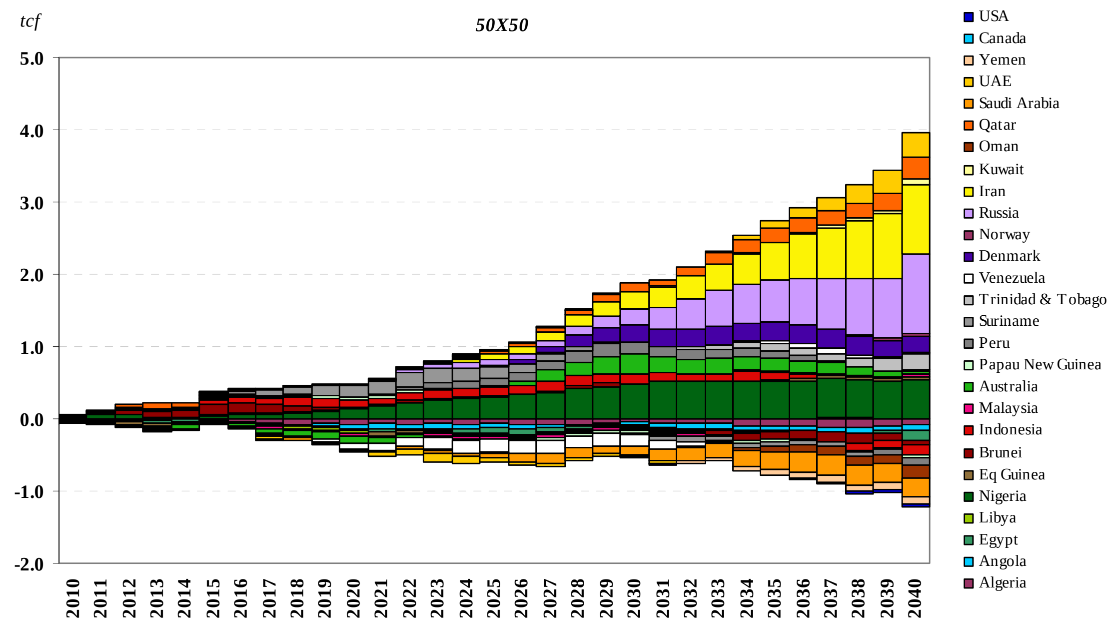
LNG Exports Across Scenarios

- Some countries are benefitted more than others.
- In particular, as the level of LNG imports in the US increases, the exports from Iran and Russia increase more than in other countries.

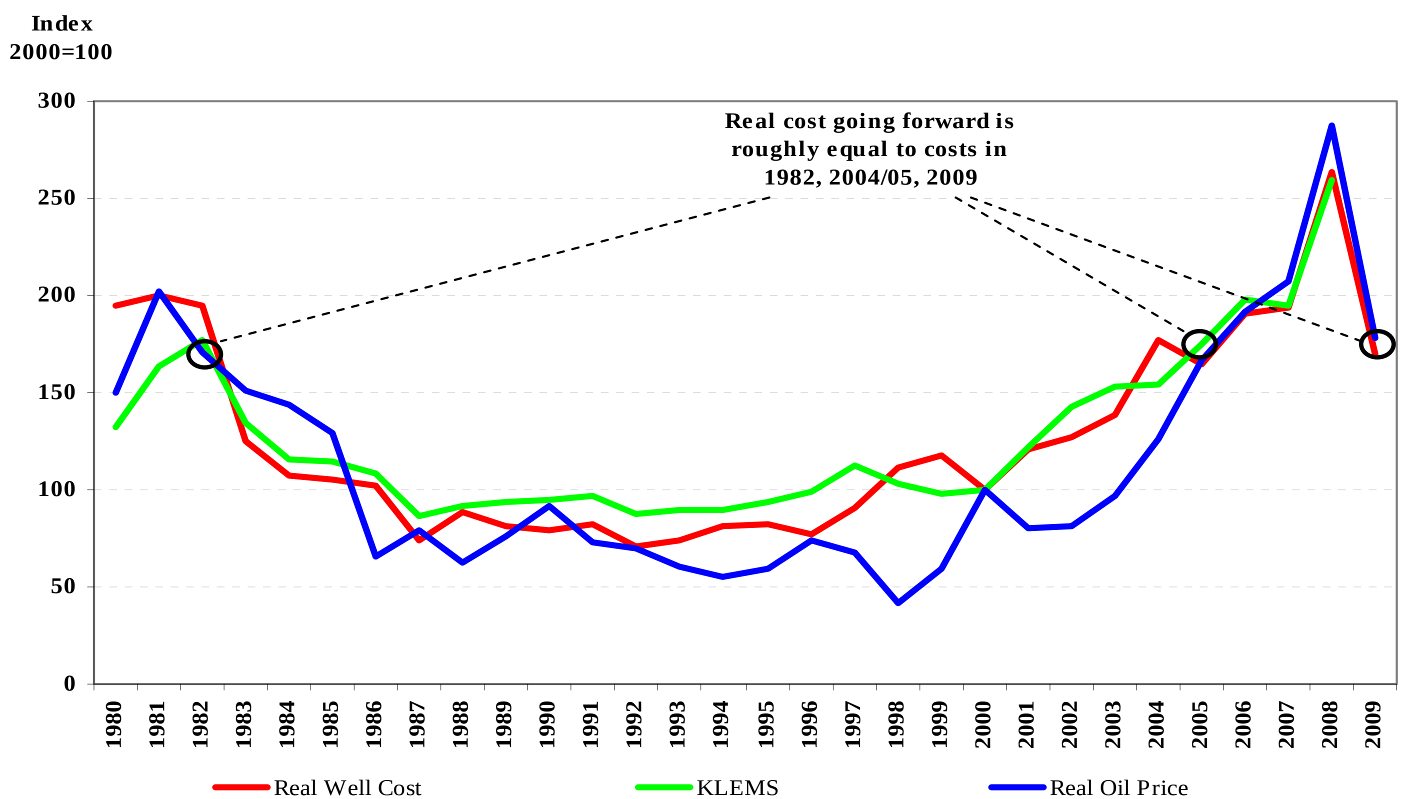




Appendix

A Comment on Development Costs

- We often discuss "breakeven costs", but it is important to put this into context...
- The cost environment is critical to understanding what prices will be. For example, F&D costs in the 1990s yield long run prices in the $3-$4 range.
- What will the cost of steel and cement be? What about field services?



Some Shale Gas Basics

Conventional versus Unconventional

- ***Conventional*** reservoirs produce from sands and carbonates (limestones and dolomites) that contain gas in interconnected pore spaces allowing flow to the wellbore.
- ***Unconventional*** reservoirs are characterized by low permeability, so it is necessary to stimulate the reservoir to create additional permeability and hence flow to the wellbore.
  - Tight Gas: Gas is sourced outside and migrates into the reservoir
  - CBM: Coal seams act as source and reservoir of natural gas
  - Shale: Gas is sourced and trapped in a low permeability shale. This is usually either a source or a saturated cap.
- Hydraulic fracturing is a preferred method of stimulation in shales, as well as tight gas formations and some CBM wells.
  - Shale well water requirements (3-6 million gallons per well)
- Some shales are more liquid-rich (e.g. - Eagle Ford)

Shale gas

- Production from shale is resembling a manufacturing process.
  - Geologic uncertainty is lower than with conventional wells
  - Fracing and production can be timed to meet better economics for each well. This has been facilitated by a reduction in time-to-drill to 12 days, in some cases fewer.
  - Stimulation and field development can begin to mimic a “just in time” process.
- Well productivity is growing due to innovations in the field.
  - IP rates are improving: Southwestern Energy saw a 350% increase from 2007-2009.
  - Longer laterals: in Woodford, increased from 5 stages covering 2,600 feet to 14 stages covering 6,500 feet in last 4 years.
  - Multi-well pads have also helped

Some Shale Characteristics

Source: DOE, Office of Fossil Energy, "Modern Shale Gas Development in the US"

EXHIBIT 11: COMPARISON OF DATA FOR THE GAS SHALES IN THE UNITED STATES

Gas Shale Basin	Barnett	Fayetteville	Haynesville	Marcellus	Woodford	Antrim	New Albany
Estimated Basin Area, square miles	5,000	9,000	9,000	95,000	11,000	12,000	43,500
Depth, ft	6, 500 - 8,500[82]	1,000 - 7,000[83]	10,500 - 13,500[84]	4,000 - 8,500[85]	6,000 - 11,000[86]	600 - 2,200[87]	500 - 2,000[88]
Net Thickness, ft	100 - 600[89]	20 - 200[90]	200[91] - 300[92]	50 - 200[93]	120 - 220[94]	70 - 120[95]	50 - 100[96]
Depth to Base of Treatable Water[#], ft	~1200	~500[97]	~400	~850	~400	~300	~400
Rock Column Thickness between Top of Pay and Bottom of Treatable Water, ft	5,300 - 7,300	500 - 6,500	10,100 - 13,100	2,125 - 7650	5,600 - 10,600	300 - 1,900	100 - 1,600
Total Organic Carbon, %	4.5[98]	4.0 - 9.8[99]	0.5 - 4.0[100]	3 - 12[101]	1 - 14[102]	1 - 20[103]	1 - 25[104]
Total Porosity, %	4 - 5[105]	2 - 8[106]	8 - 9[107]	10[108]	3 - 9[109]	9[110]	10 - 14[111]
Gas Content, scf/ton	300 - 350[112]	60 - 220[113]	100 - 330[114]	60 - 100[115]	200 - 300[116]	40 - 100[117]	40 - 80[118]
Water Production, Barrels water/day	N/A	N/A	N/A	N/A	N/A	5 - 500[119]	5 - 500[120]
Well spacing, acres	60 - 160[121]	80 - 160	40 - 560[122]	40 - 160[123]	640[124]	40 - 160[125]	80[126]
Original Gas-In-Place, tcf[127]	327	52	717	1,500	23	76	160
Technically Recoverable Resources, tcf[128]	44	41.6	251	262	11.4	20	19.2

NOTE: Information presented in this table, such as Original Gas-in-Place and Technically Recoverable Resources, is presented for general comparative purposes only. The numbers provided are based on the sources shown and this research did not include a resource evaluation. Rather, publically available data was obtained from a variety of sources and is presented for general characterization and comparison. Resource estimates for any basin may vary greatly depending on individual company experience, data available at the time the estimate was performed, and other factors. Furthermore, these estimates are likely to change as production methods and technologies improve.

Mcf = thousands of cubic feet of gas
scf = standard cubic feet of gas
tcf = trillions of cubic feet of gas
# = For the Depth to base of treatable water data, the data was based on depth data from state oil and gas agencies and state geological survey data.
N/A = Data not available

Hydraulic Fracturing:
Policy and Public Concern

Some Production Basics

- Shale gas is different from conventional gas formations in that no reservoir or trap is required. Production occurs from rock that spans large areas. The aim is to reduce pressure though fracturing and production so that gas is released from rock (shale) and flows to the wellbore.
- Shale formations are drilled horizontally and fracs are staged to increase the productivity of each well drilled.
- In any production endeavor, the water table is passed. Oil and gas wells usually require (1) conductor casing (pre-drilling), (2) surface casing (through the aquifer), (3) intermediate casing (deep to prevent well contamination), and (4) production casing (conduit for production). The production casing is the final casing for most wells, and it completely seals off the producing formation from water aquifers.

Hydraulic Fracturing

- The first commercial "frac" was performed by Halliburton in 1949. Despite what is indicated in the press, the technology is not new. The innovation is in the application of the process.
- Fracturing in CBM production is distinctly different than when used in shale. CBM deposits can coincide with aquifers. In fact, the documented cases of changes in water quality (as documented by Earthworks) almost all have to do with CBM developments.
- Fracturing has been used to increase flow to water wells
- Fracing fluid is primarily water and sand ("slick water"), or ceramics in newer applications in shales. Chemical cocktails are also created to add to the potency of the fracing fluid. Some of these chemicals are toxic.
- While some chemicals in the fracing fluid can become bound in the shale, the majority of the fluid returns through the wellbore.
  - Problems can arise in the disposal process. This is a preventable issue.
  - Problems can also arise when casings fail. This raises concerns in particularly sensitive areas.

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Hydraulic Fracturing (cont.)

- In 2004 the EPA found no evidence of contamination of drinking water from fracing activities. It did, nevertheless, enter into a MoA with CBM developers that precludes the use of diesel fuel in the fracking fluids.
- The US EPAs Underground Injection Control Program regulates
  - Injection of fluids (Class II wells) to enhance oil and gas production
  - Fracturing used in connection with Class II and Class V injection wells to "stimulate" (open pore space in a formation).
  - Hydraulic fracturing to produce CBM in Alabama.
- Is fracing appropriate everywhere? Perhaps technically but maybe not socially… Need to understand risks and weigh them against reward. Thus, any externalities must be considered and appropriately internalized.
- EPA study on hydraulic fracturing has been initiated
  - NY announced hydraulic fracturing moratorium until EPA study completed
  - Problems in PA: EOG well blow-out, Cabot in Dimock
- Full disclosure will likely be a critical piece of any regulation that may be forthcoming.