EPRINC

The Shale Gas Revolution

Lucian Pugliaresi
Energy Policy Research Foundation, Inc.

Presentation on behalf of the

Japan Oil, Gas, and Metals Corporation

Tokyo

February 2, 2010

January 28, 2010
Davos, Switzerland

Unconventional gas will transform the entire energy production landscape in the United States.....and alters the U.S. energy outlook for probably a hundred years*

Tony Hayward
Chief Executive Officer
BP plc

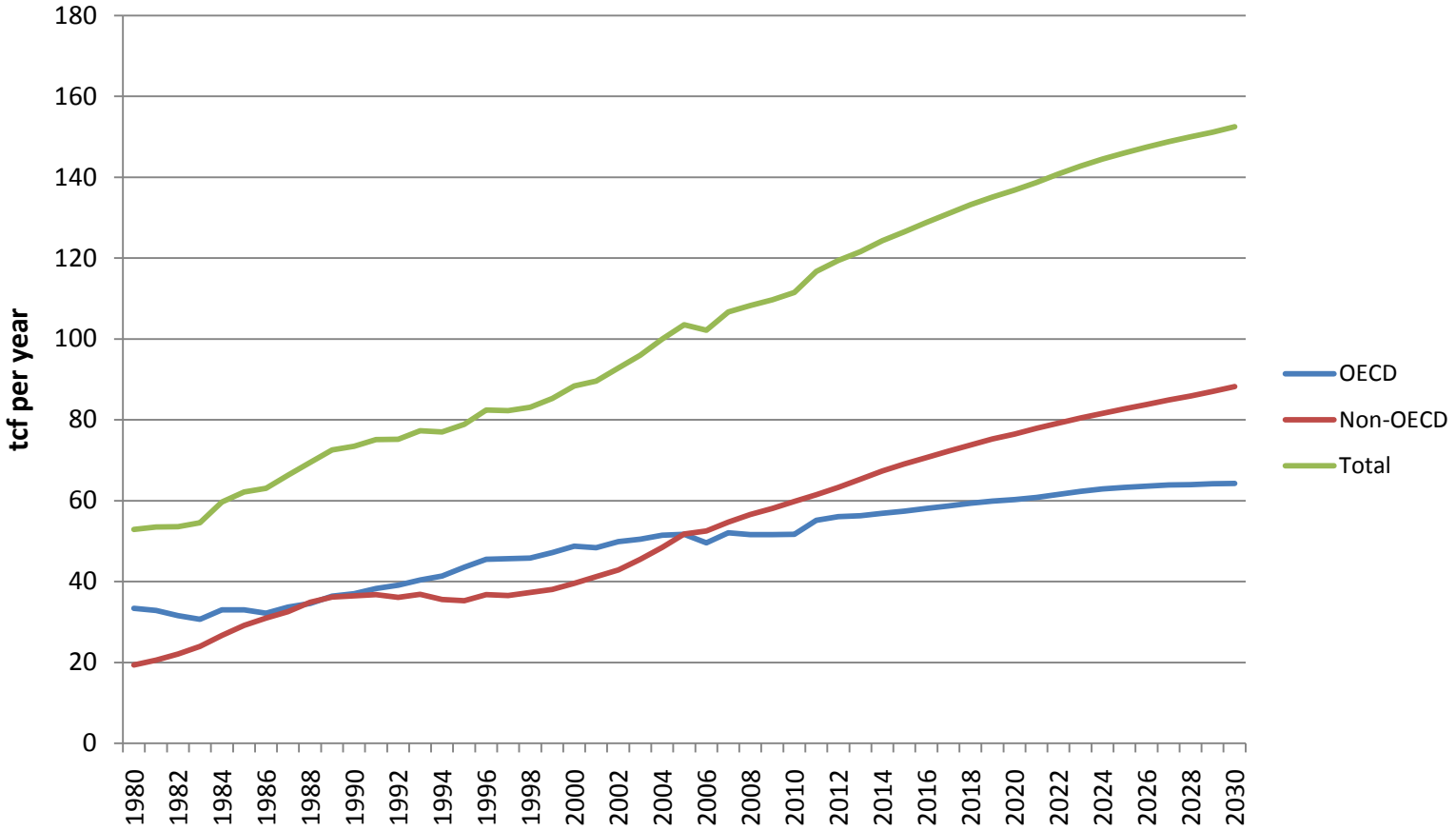
In 2009 the United States became the world's largest producer of natural gas

EPRINC

Overview

- Natural gas markets around the world are undergoing rapid and fundamental shifts in supply, demand, and pricing
- European importers are reducing imports from Gazprom and in many cases dropping to (or maybe below) take-or-pay contract minimums.
  - Turning to lower cost LNG spot cargos when available
- At the same time, supply of liquefied natural gas (LNG) has increased globally…
- …and the outlook for natural gas production in the U.S. has changed radically with a breakthrough in the production of gas from shale rock formations
- Surge in U.S. shale gas production is gaining interest worldwide
- World markets are saturated with natural gas, pressuring prices

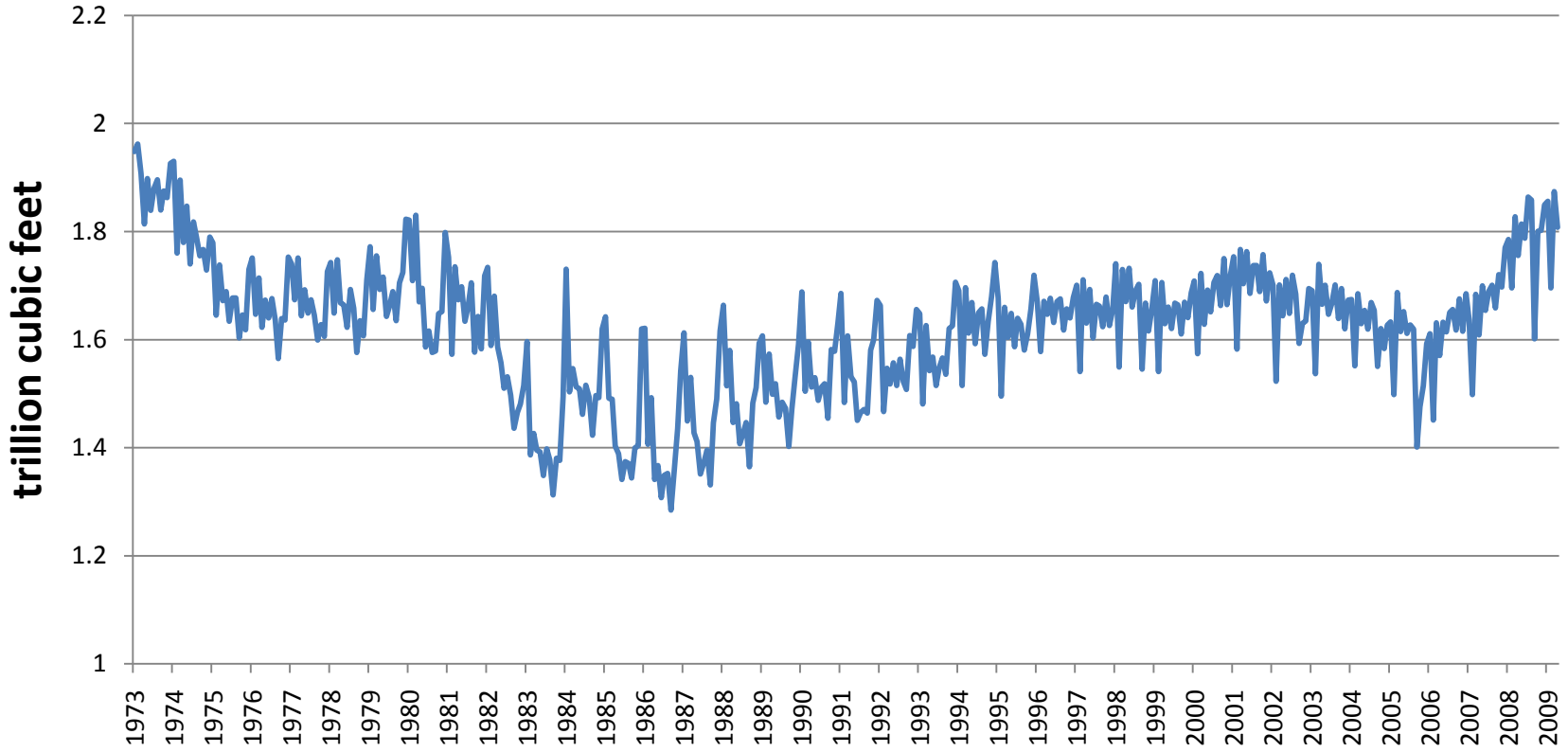
Natural Gas Consumption Through 2030



Source: EIA International Energy Outlook 2009

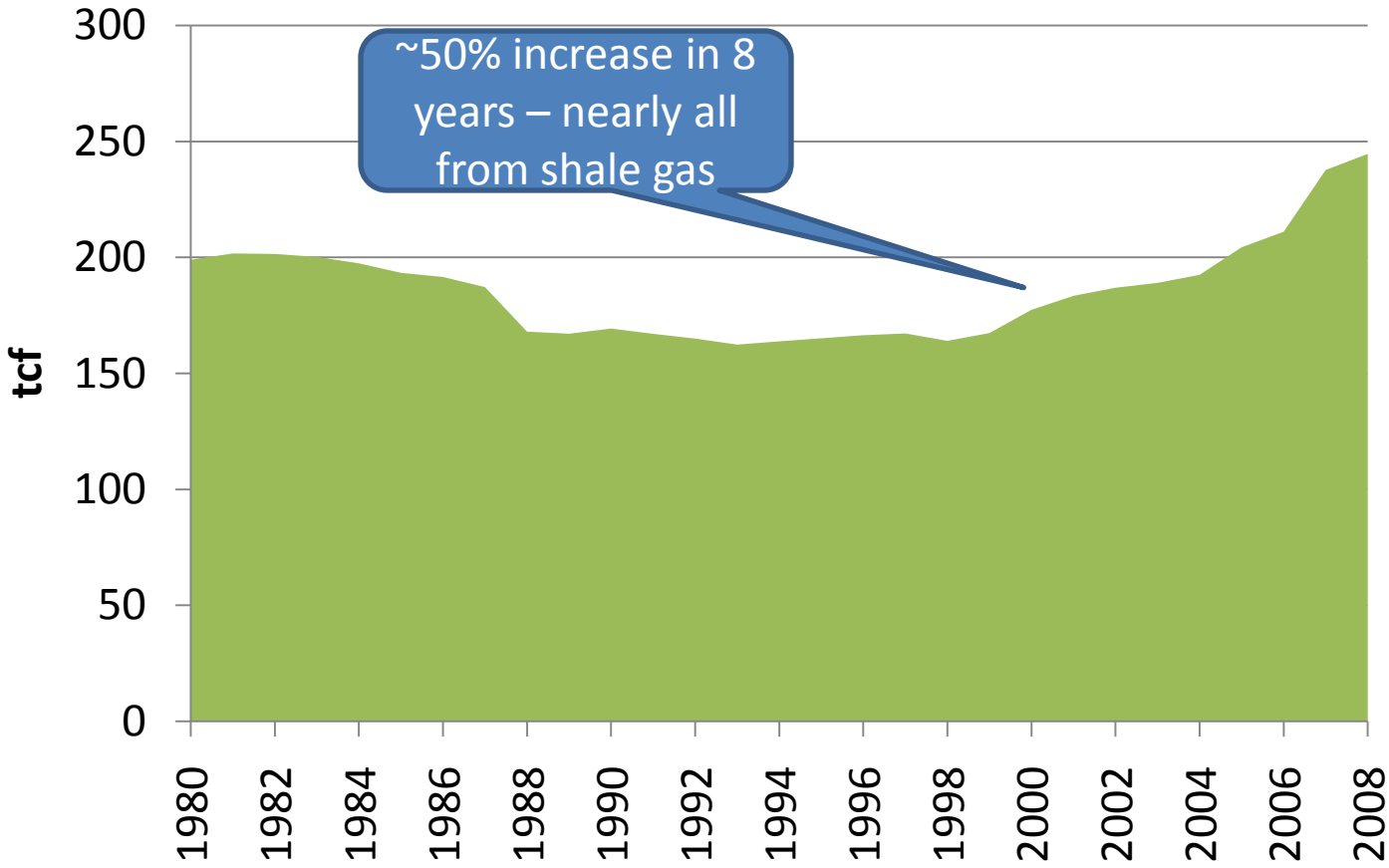
EPRINC

U.S. Monthly Marketed Natural Gas Production 1973 - 2009



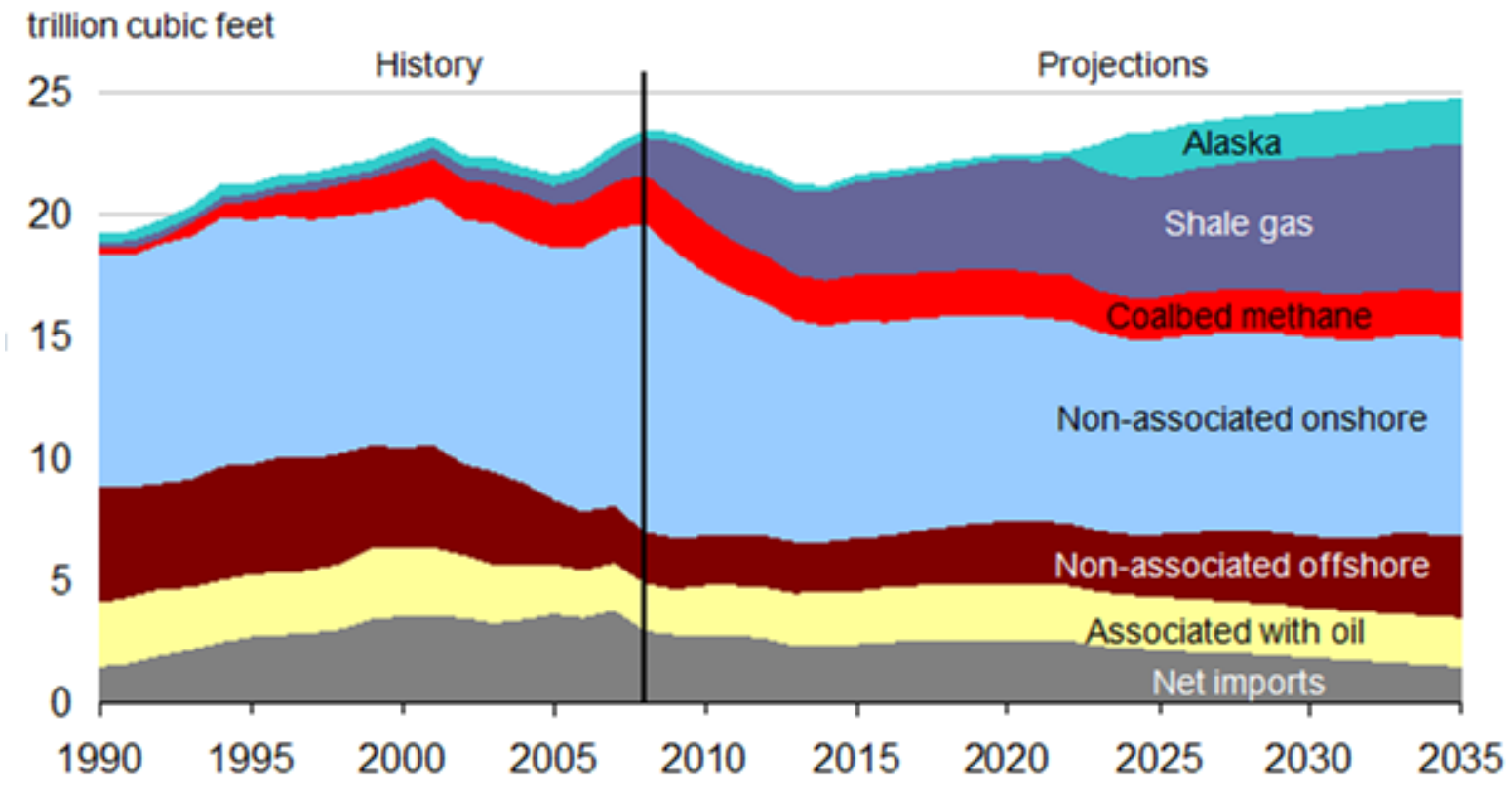
Source: EIA Data

U.S. Proven Gas Reserves Since 1980



EPRINC

EIA 2010 Natural Gas Production Forecast



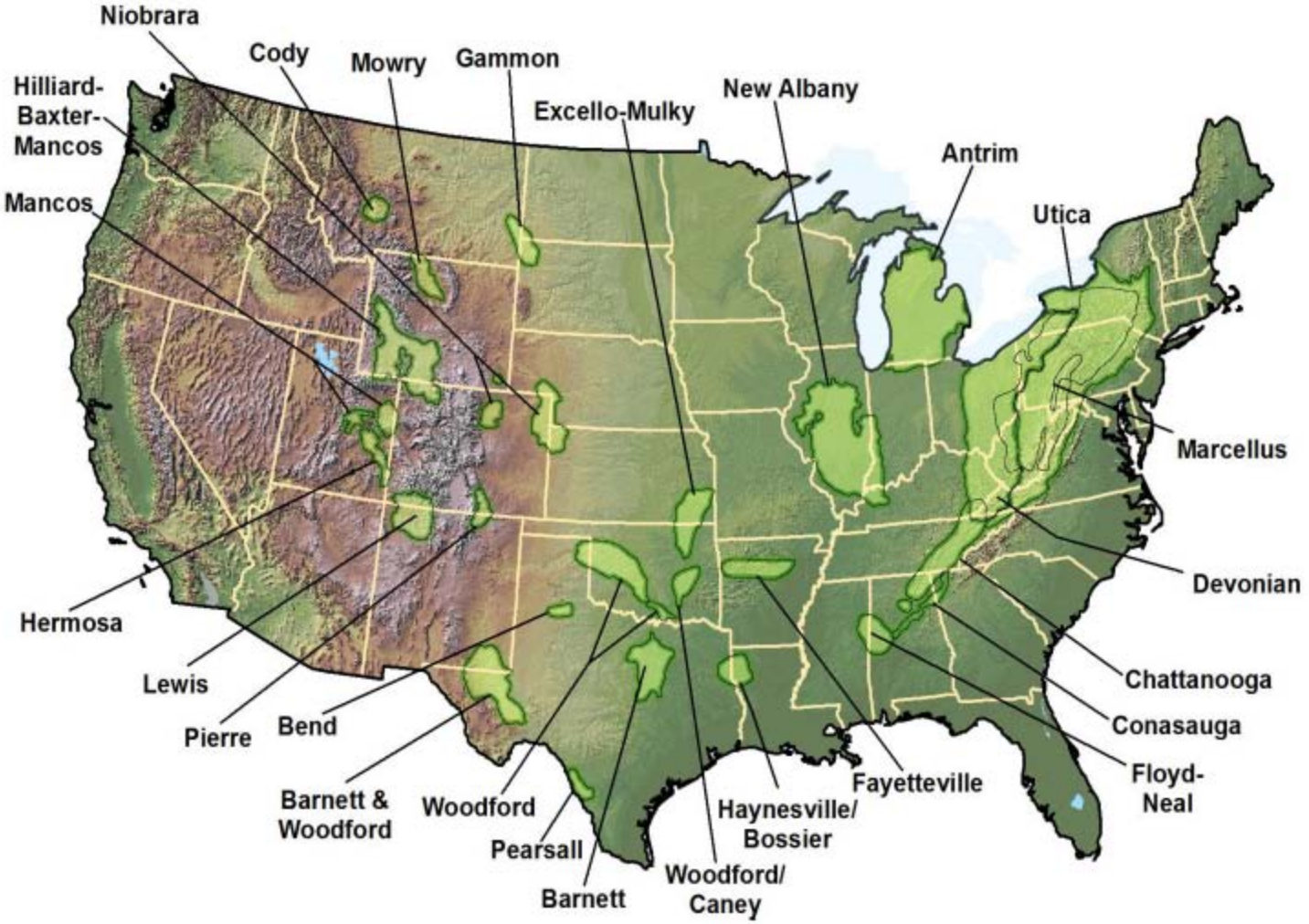
EPRINC

Shale Gas Revolution in North America

- Rise in North American gas production in recent years is due to the growing role of the unconventional natural gas, mainly shale gas.

- Due to improvements in drilling technology and well-completion methods, U.S. and Canadian gas shale plays currently account for about 10% of the natural gas supply of both countries

U.S. Shale Basins



Source: DOE

Shale Production Technology

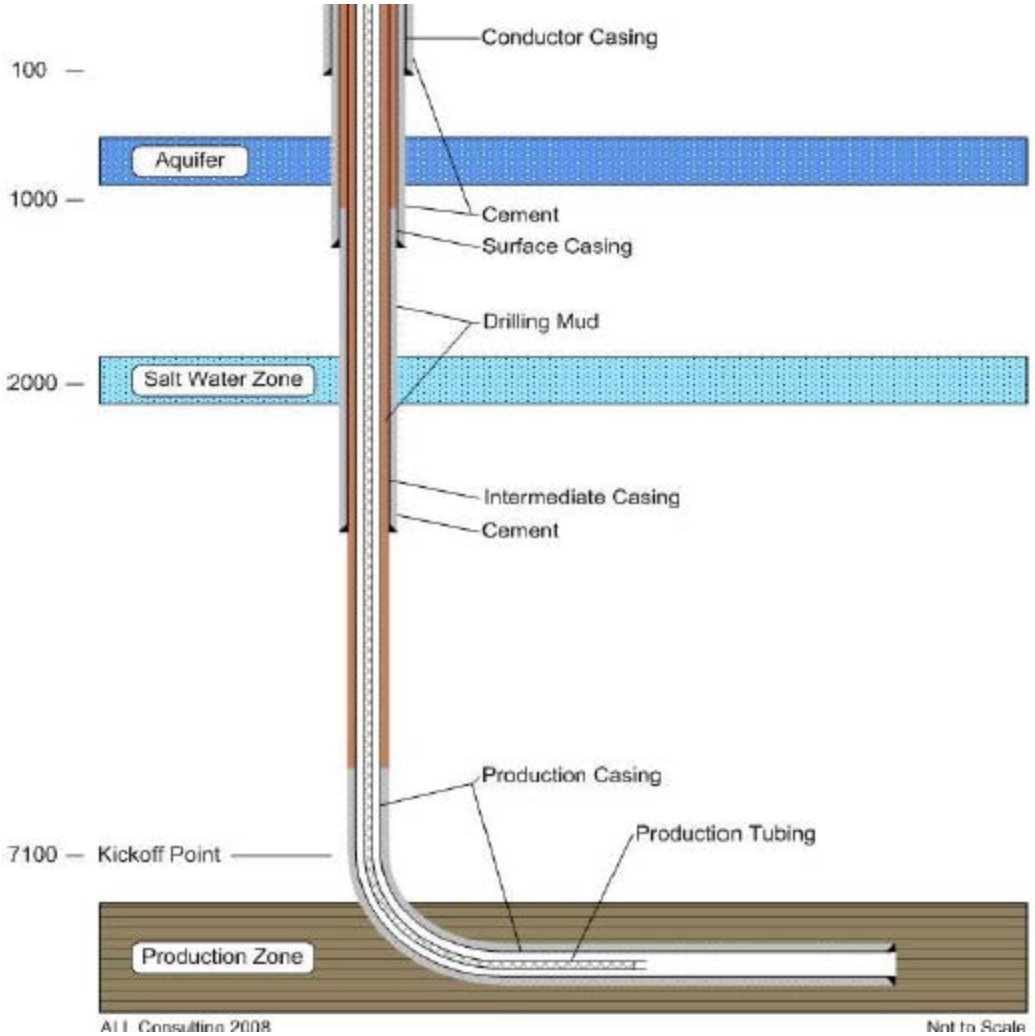
- Horizontal drilling enables producers to hit the “sweet spot” of a shale formation

- Horizontal drilling is often combined with hydraulic fracturing, where rock formations are broken apart and pumped with slick water and sand at a high pressure to break the sediment and release the gas

- Wells initially produce gas at a very high rate, then flow quickly tapers off and stabilizes

- Wells in the recent past that took 60 days to develop can now be completed in 28 days

Casing Zones and Cement Programs

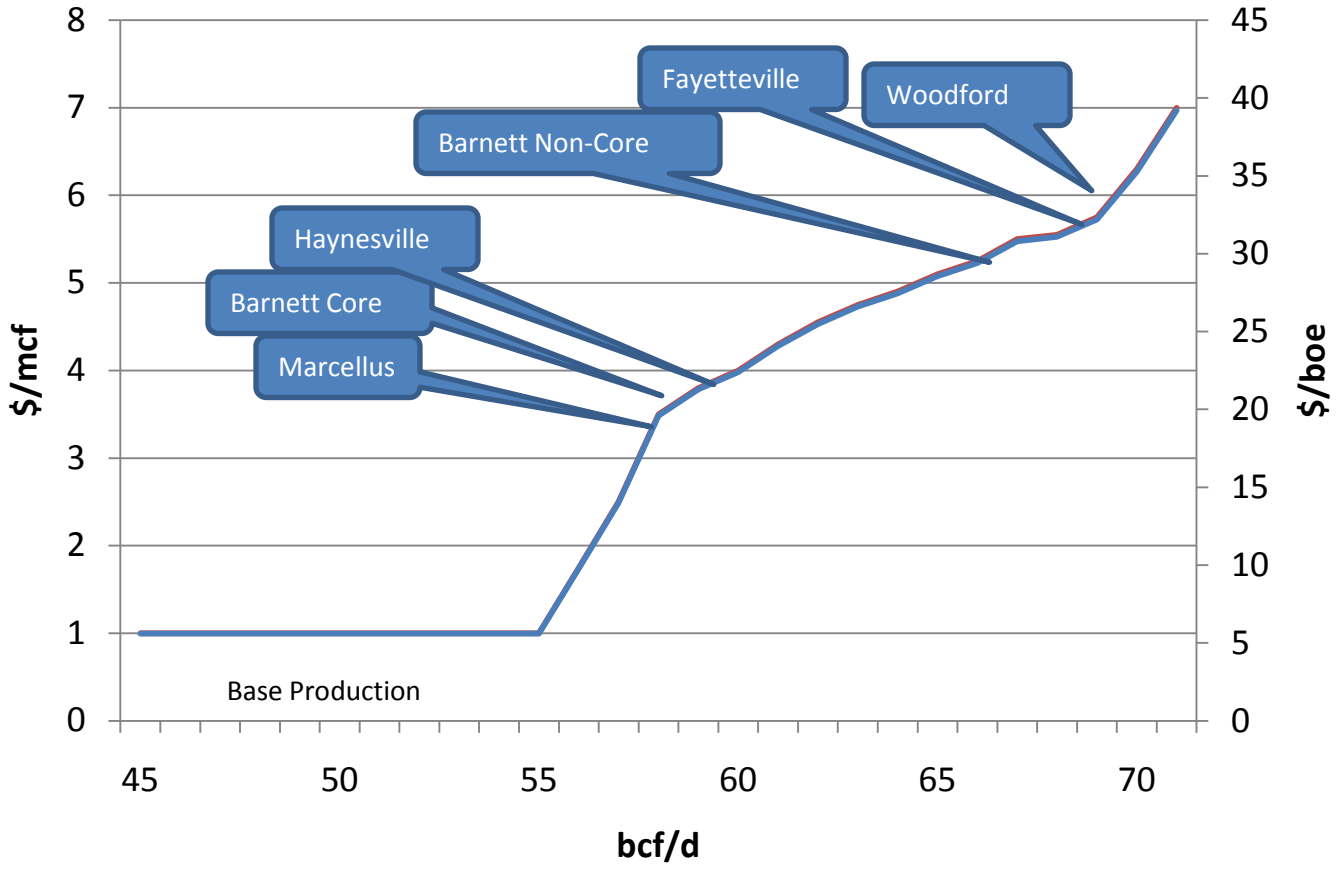


Source: DOE Shale Primer

Hydraulic Fracturing of Marcellus Shale

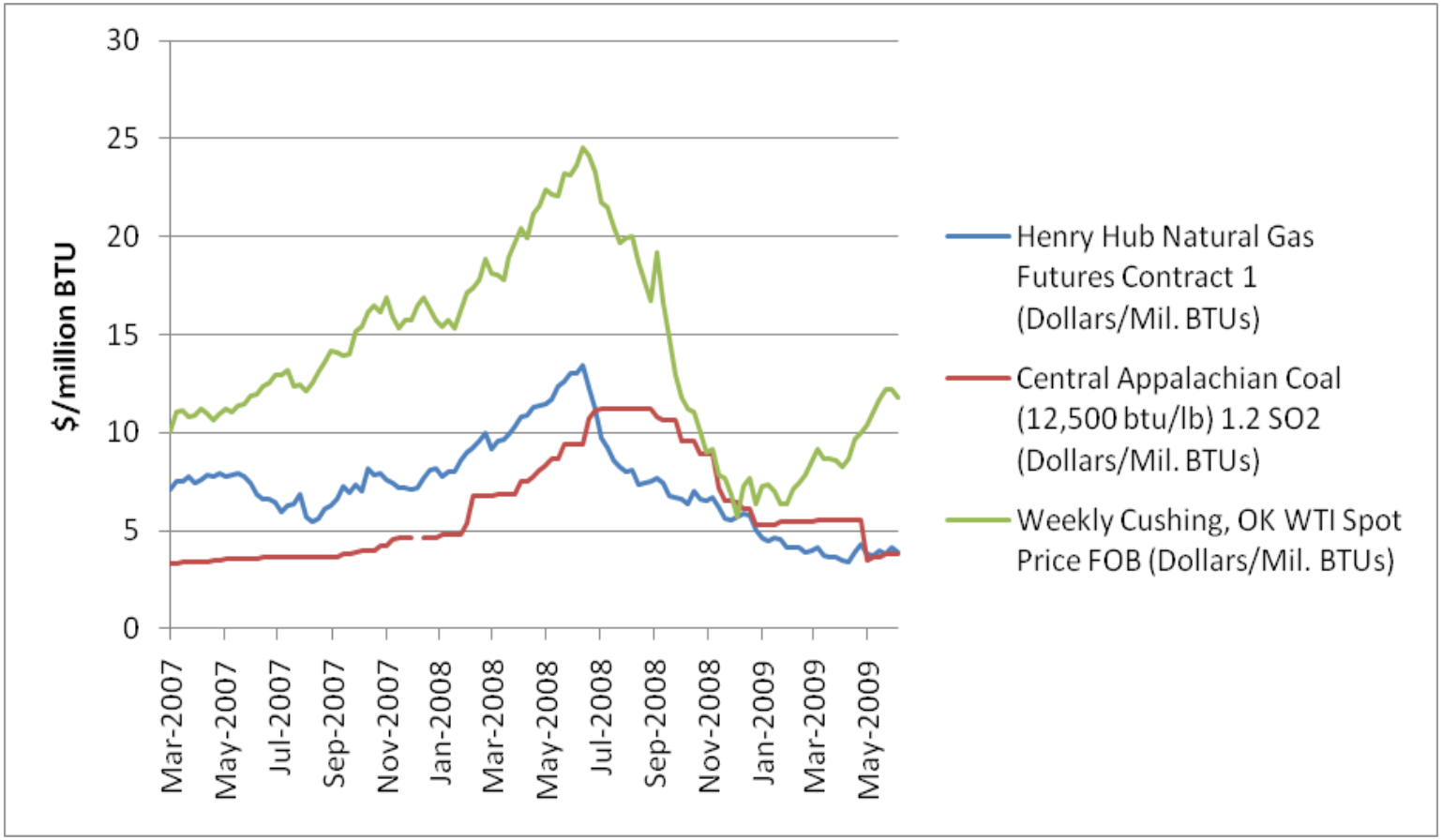
Source: DOE Shale Primer, Chesapeake

U.S. Shale Supply Cost Curve



Source: Wood Makenzie, EPRINC calculations

Coal, Oil, and Gas Prices in the U.S.



Challenges Remain
(but they can be overcome)

- Barriers to developing shale gas and bringing it to the market outside of North America remain significant, including:
  - difficult geologic formations
  - shortage of adequate infrastructure
  - variations in size and maturity of basins
  - physical access
  - exploitation costs
  - environmental concerns
  - regulatory and institutional constraints

EPRINC

The Evolving Industry

- Global economic downturn has slowed down the capital-intensive development of unconventional resources

- Production has held up even as gas prices dipped below $3/MMBtu. It is unclear whether production would be sustained under such conditions in the long term.

- Uncertainties remain about projecting shale gas production in the U.S. – decline rates have been difficult to predict

- Environmental concerns regarding chemicals sometimes used in the fracturing process.

- More experience and time is needed to establish the decline rates and production lifespan of shale gas wells

Environmental Concerns

- There are two major environmental concerns facing shale gas production.

- Both relate to the hydraulic fracturing process and worries over the possible contamination of underground drinking water.

Hydraulic Fracturing and Well Casing

- Hydraulic fracturing usually occurs below water aquifers – fracturing fluid is pumped down the well at high pressure to create pores in the shale rock.
  - Therefore wells must be drilled through the water aquifer.
  - Environmentalists worry that the well casing could leak fracturing chemicals and contaminate the aquifer.
  - There is little evidence to support this concern

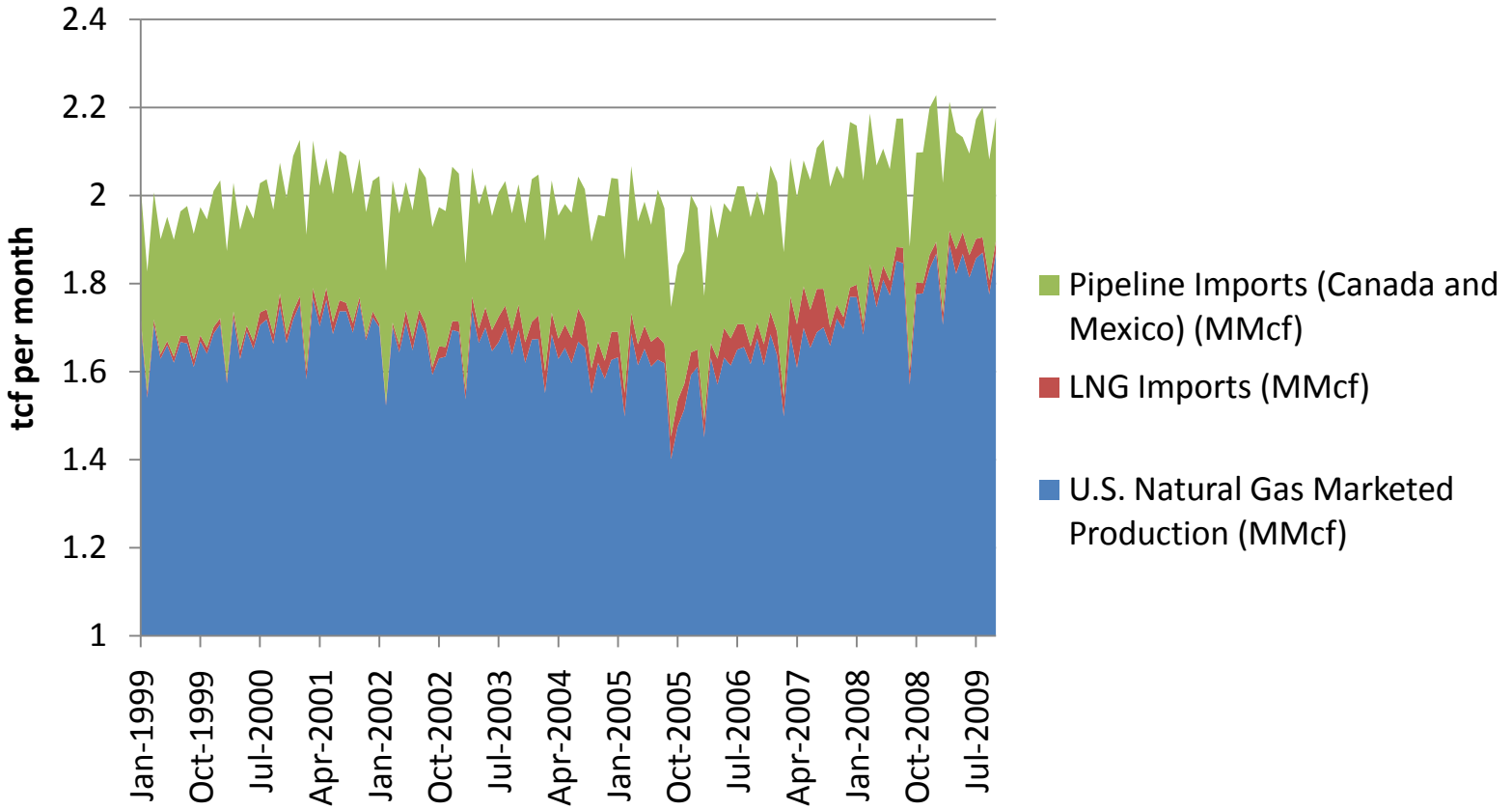
Fracturing Water Treatment and Disposal

- The hydraulic fracturing process uses millions of gallons of water and often produces additional water.
  - This water may contain various chemicals, from both the fracturing process and produced water, that is not potable and must be treated.
  - Currently this is done by storing water in pits. Environmentalists worry that this water could leak through the ground and contaminate aquifers.
- There are several options for dealing with this concern, including:
  - Onsite treatment
  - Onsite tank storage
  - Removal by tanker trucks

Possible Fracturing Legislation

- A recent Congressional hearing on the ExxonMobil-XTO merger made it clear that the Federal Government does not intend to ban hydraulic fracturing
  - Federal regulation is possible and could involve disclosure of chemicals, although regulation may continue to be left up to the states.
- New York State has opposed hydraulic fracturing in the New York City watershed
  - Chesapeake has agreed to put off drilling the watershed
- Meanwhile, Pennsylvania has strongly supported shale gas development.
  - It has brought thousands of jobs and billions in revenue to the state
  - NY is struggling financially and may eventually support development, albeit with further regulation

U.S. Nat Gas Production and Imports



Source: EIA Data

Foreign Interest in Shale Gas

U.S. Shale Industry Draws Foreign Investment

- BP acquired part of Oklahoma's Woodford shale gas play from Chesapeake Energy in 2008 for $3.65 billion

- EnCana and Royal Dutch Shell began developing the Haynesville Shale in Louisiana and Texas

- StatoilHydro and Chesapeake Energy jointly develop Marcellus shale basin and 14 different shale plays in other countries

- ExxonMobil began exporting its expertise and know-how from its North American shale gas operations to European gas markets

- Total's invested $2.3 billion in Chesapeake's acreage in Barnett and other plays

Potential for Shale Outside North America

- China and much of Europe possess shale formations similar to those found in the U.S.
  - However, the potential for large-scale gas production remains unknown – significant production is about a decade away

- Exploration in Europe is being carried out largely by joint ventures with companies that have experience in North American Shale
- Exploration in China is at an earlier stage than European exploration
- Successful shale development could have huge implications for historical exporters (Gazprom)

European Shale Exploration Sites

From the Economist

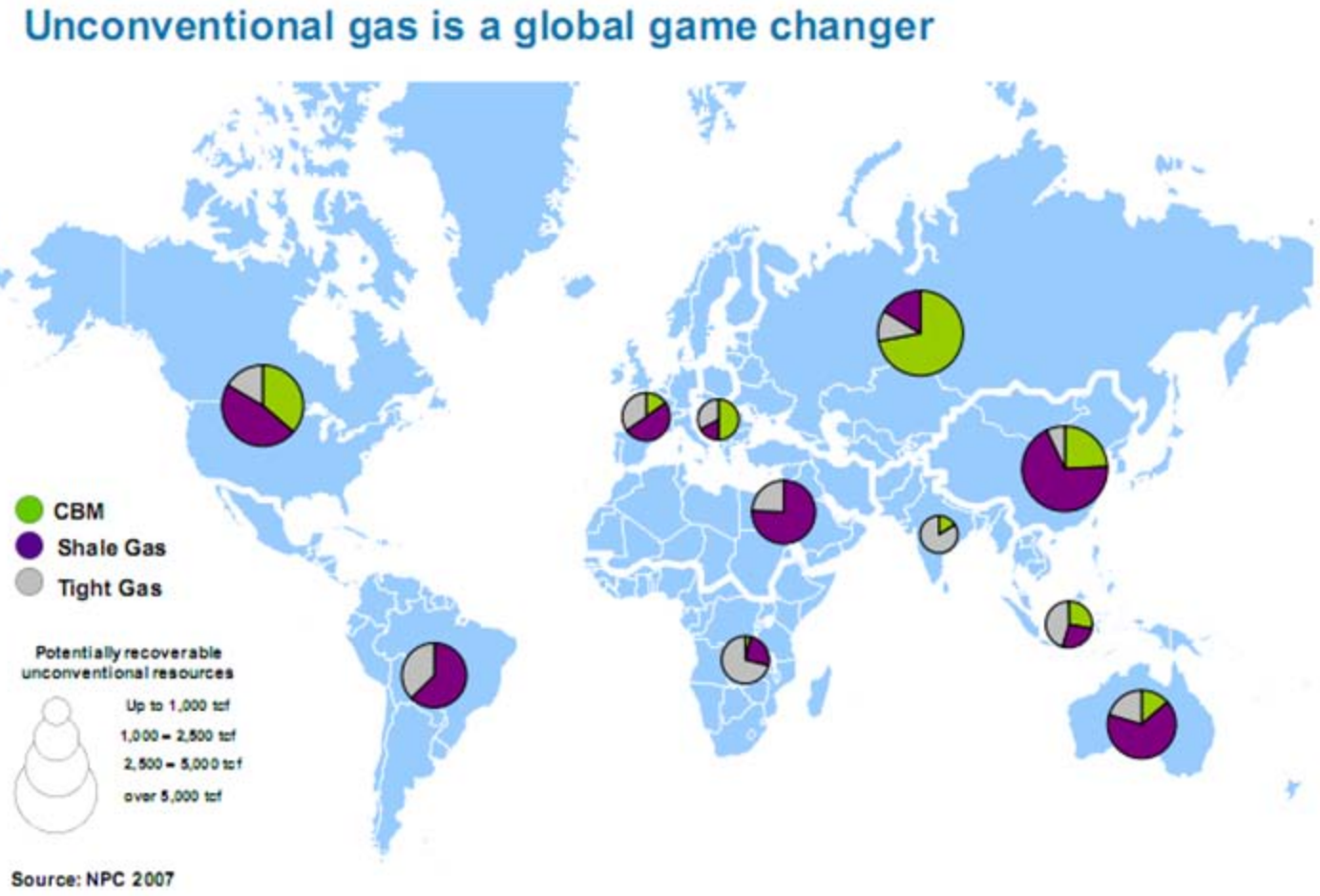
Exploration in Europe and China – Utilizing American Experience

- A major reason for European and IOC investment in U.S. shale is experience…
- ExxonMobil is active in Germany and Hungary
  - Exxon has struggled with early exploration in Hungary – this may have influenced their acquisition of XTO
- ConocoPhillips and 3 Legs Resources exploring in Poland
  - Polish shale similar to Barnett in Texas
- Shell carrying out exploration in Sweden
- Total and UK Devon active in France
- China has recently agreed to deals with Shell and BP to explore in China

Constraints to European Development

- Very early in E&P process
  - European companies do not have the same amount of experience as their U.S. counterparts and Europe lacks the type of small, independent companies that initiated U.S. shale development
  - Also lack logistical infrastructure to bring new production to market
- Geology is similar, but not identical to North America
- Higher population density means makes access more difficult
  - This may cause additional transportation problems

Unconventional Reserves Around the World



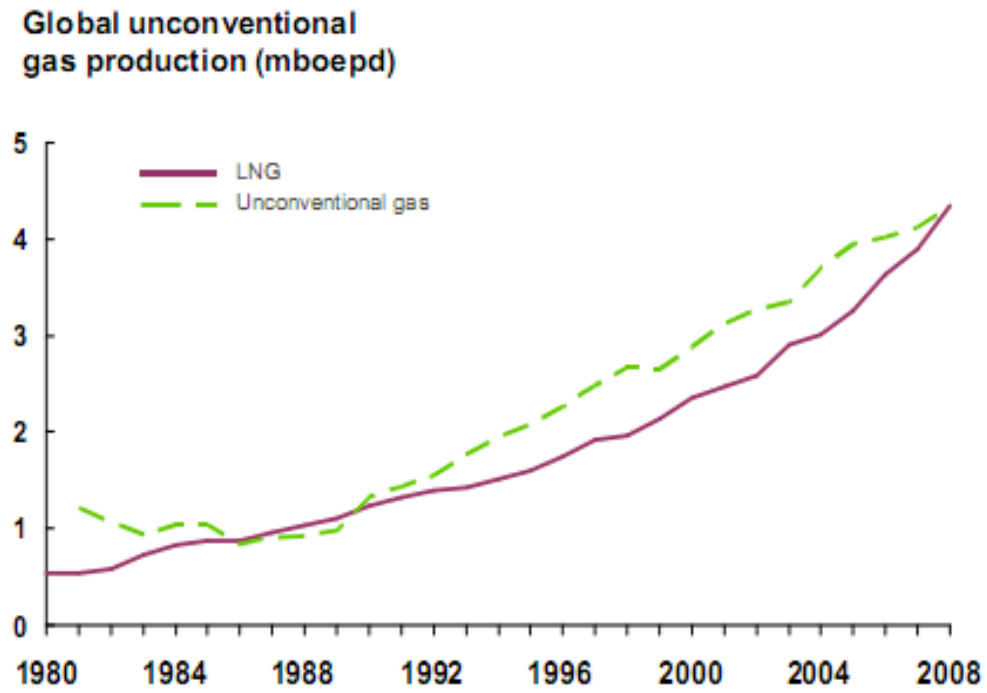
Source: Statoil

LNG

&

Natural Gas Pricing

World LNG and Unconventional Gas Production

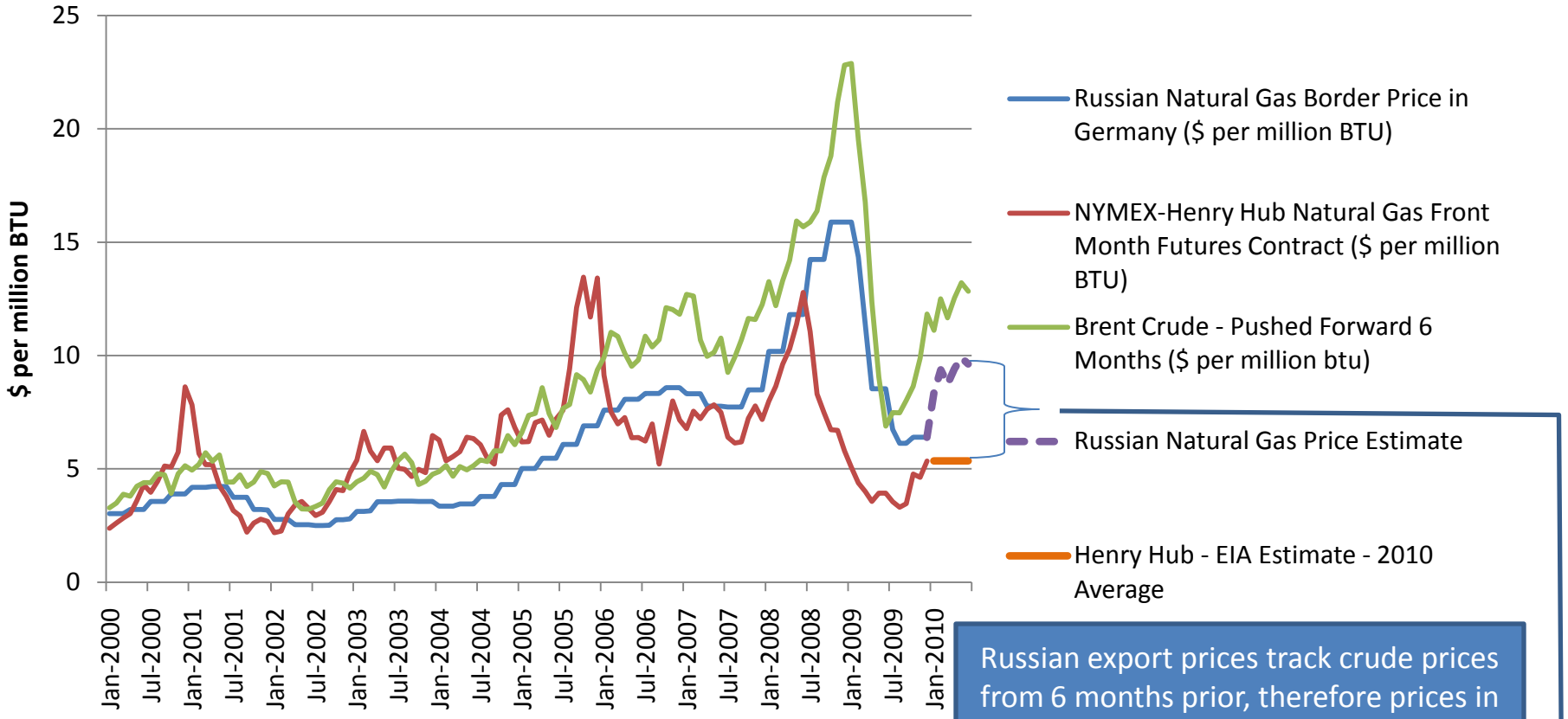


- 10% of global gas production (most of it in the US)
- 44% of US gas production
- Australia, India, Indonesia, and other places
- Europe now receiving attention

Source: SH

EPRINC

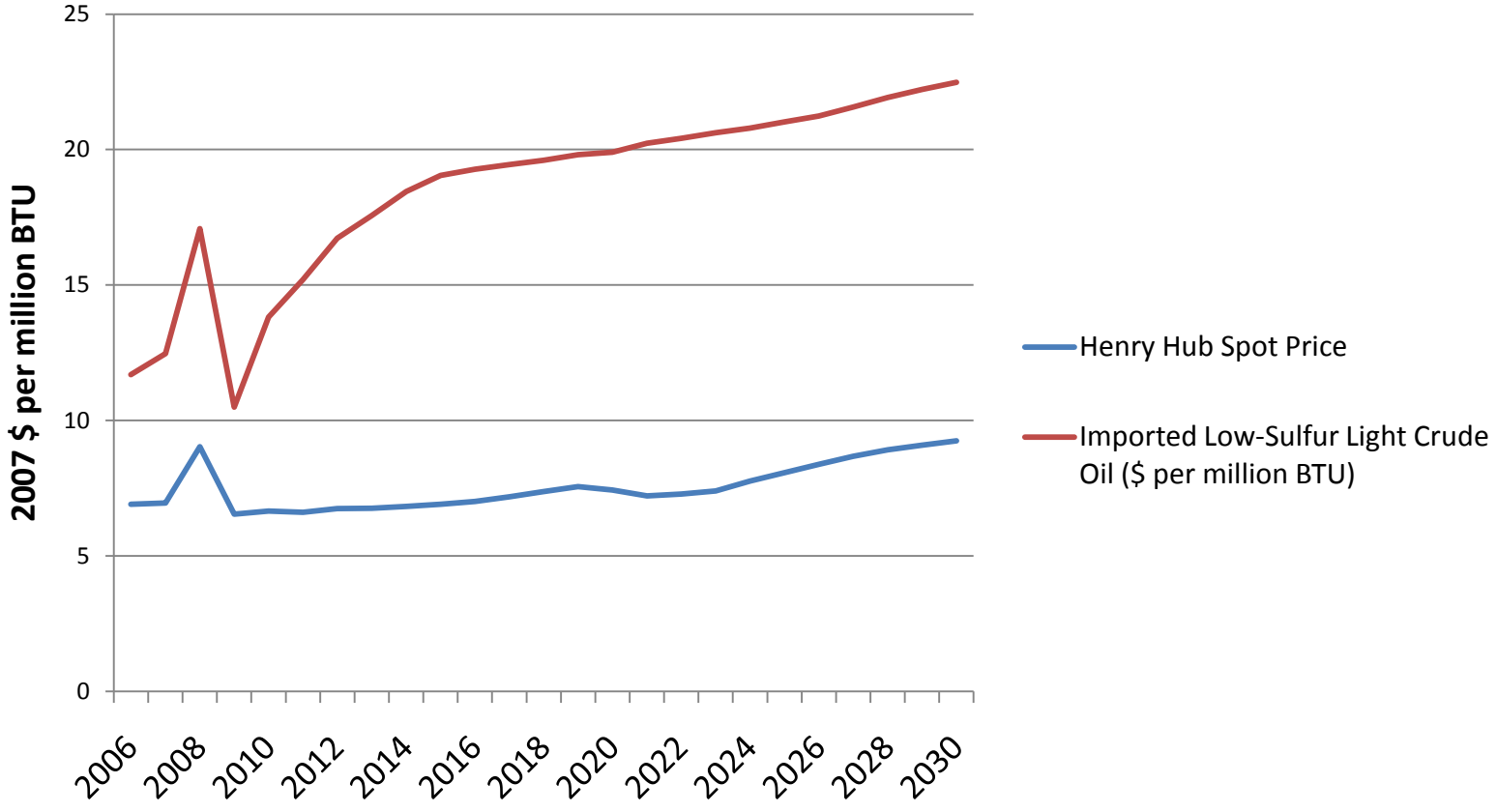
Russian Export and U.S. Henry Hub Gas Prices vs. Oil



Russian export prices track crude prices from 6 months prior, therefore prices in H1 2010 will reflect crude's late 2009 rebound and Russian gas will likely cost twice as much as Henry Hub in 2010.

Source: EIA Data, IMF Data, EPRINC Calculations

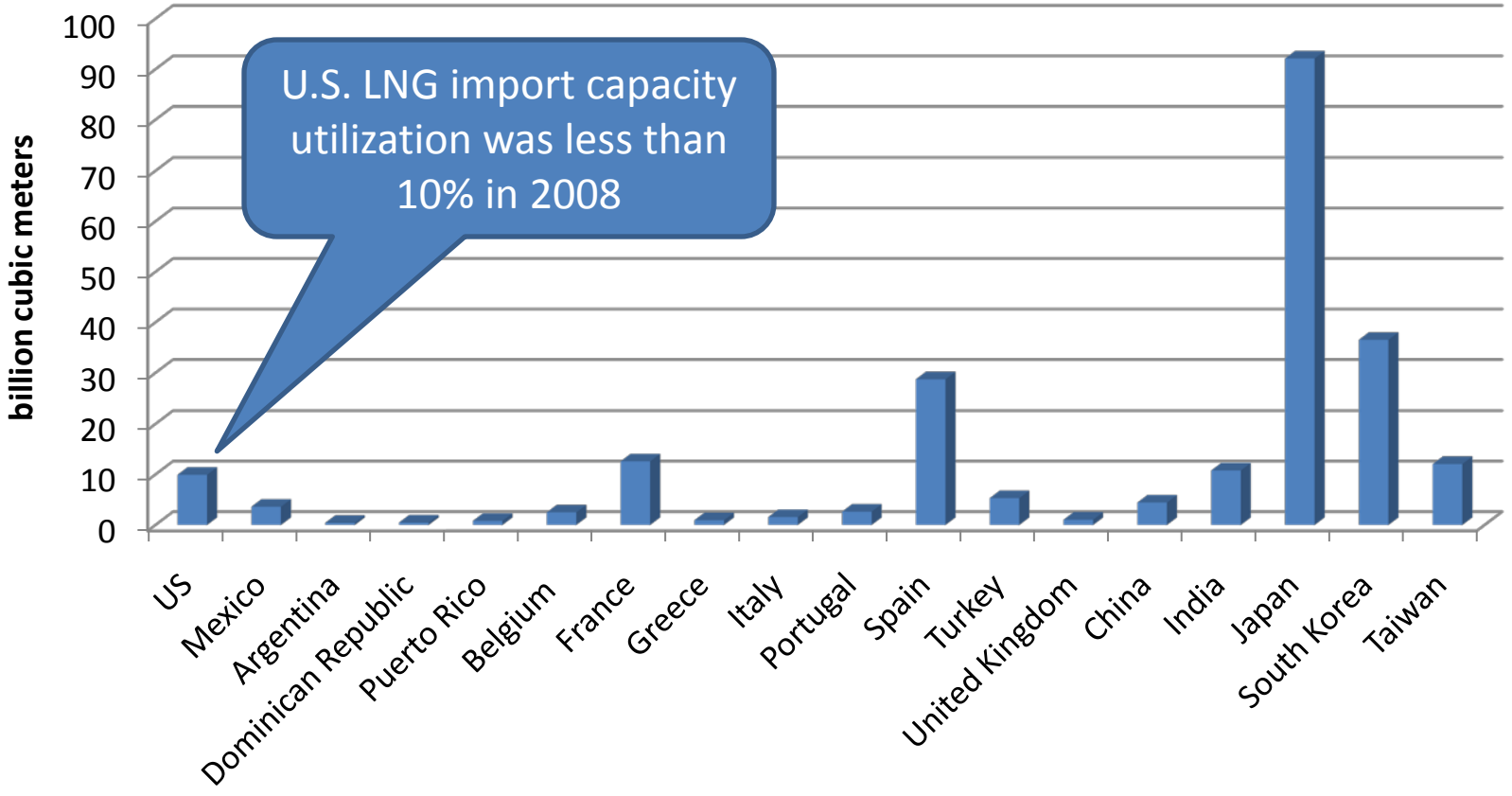
Natural Gas and Crude Oil Prices Through 2030



Source: EIA Annual Energy Outlook 2009

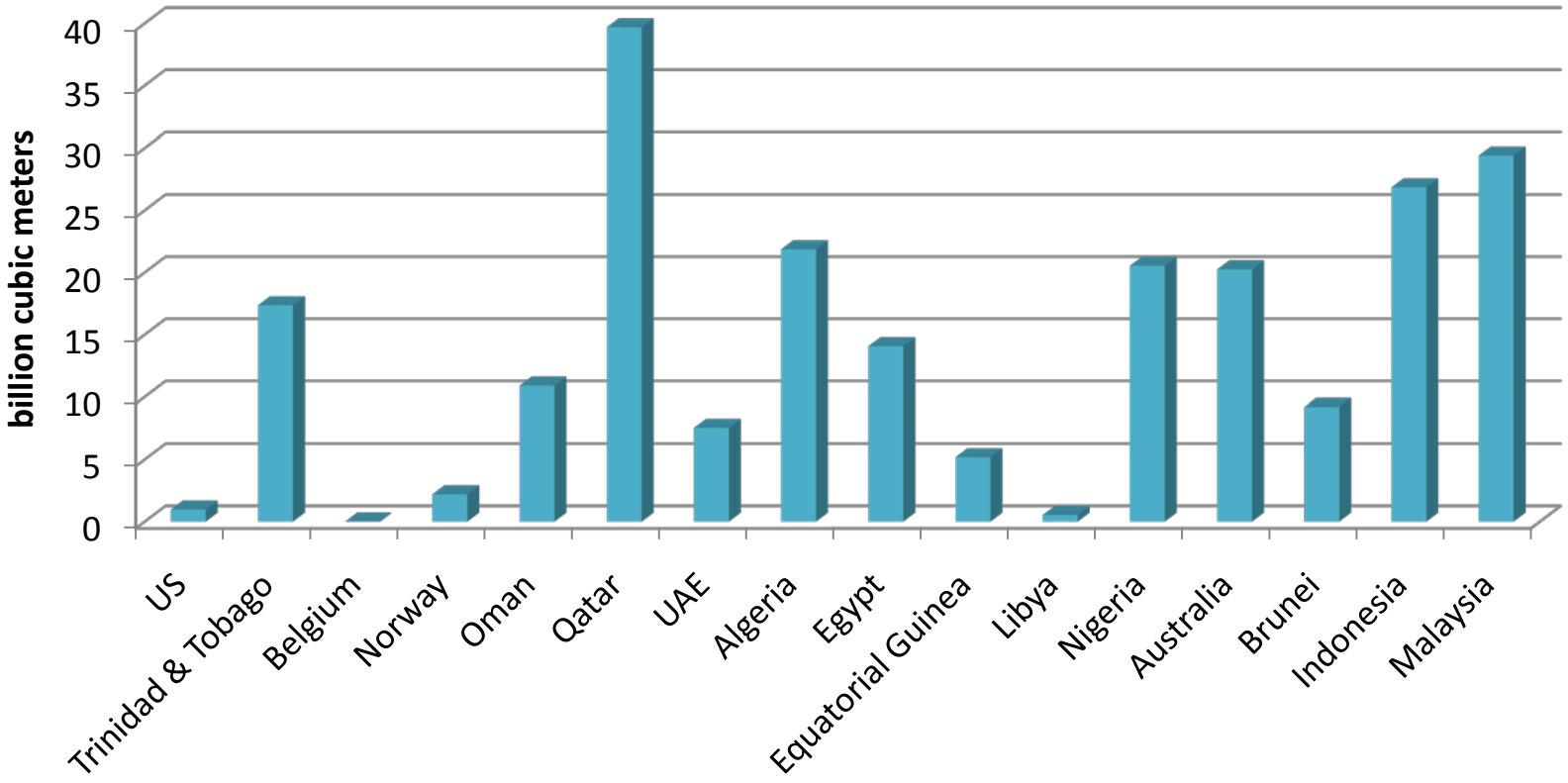
EPRINC

Total LNG Imports - 2008



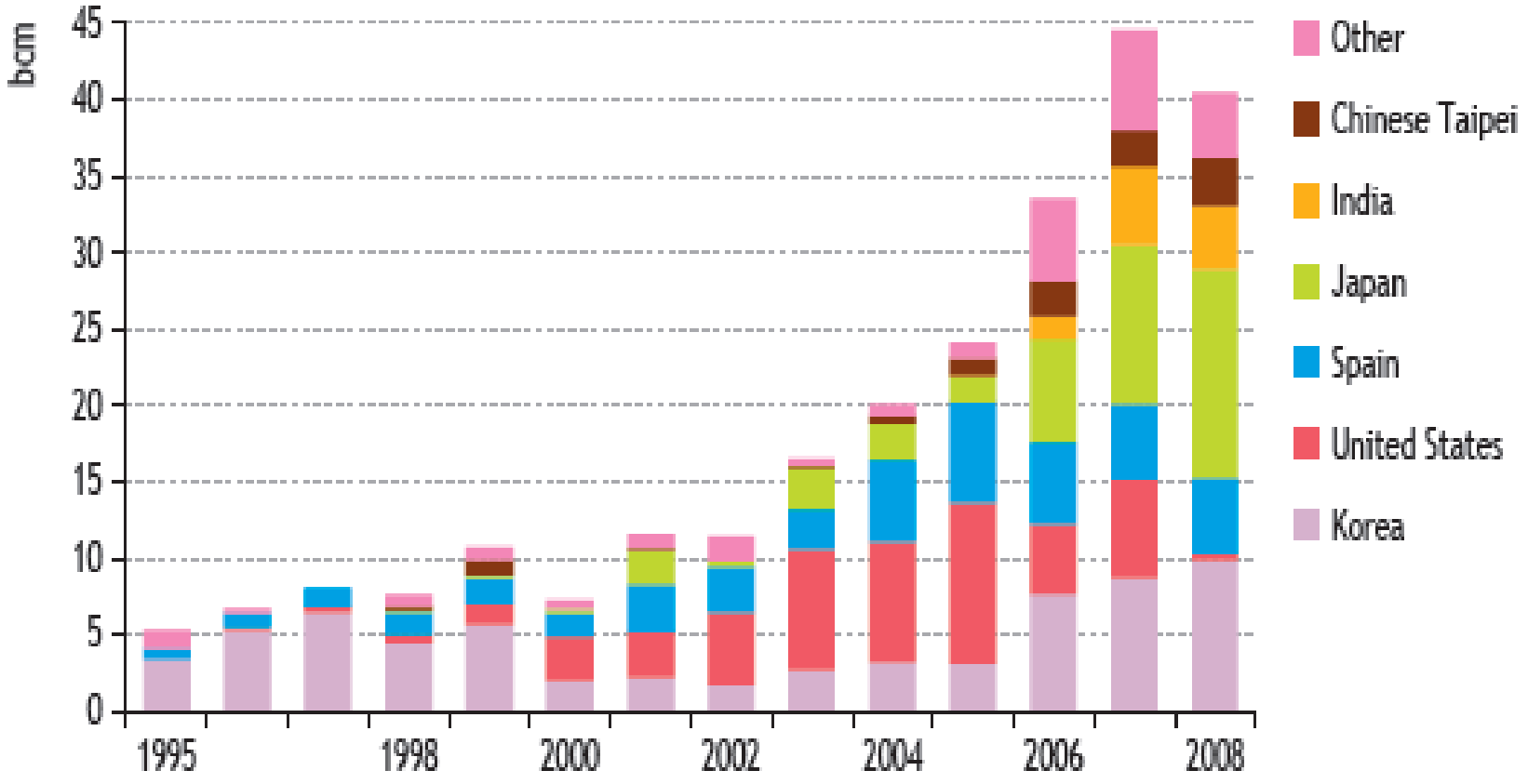
Source: BP Statistical Review 2009, OGJ Data, EPRINC Calculations

Total LNG Exports - 2008



Source: BP Statistical Review 2009

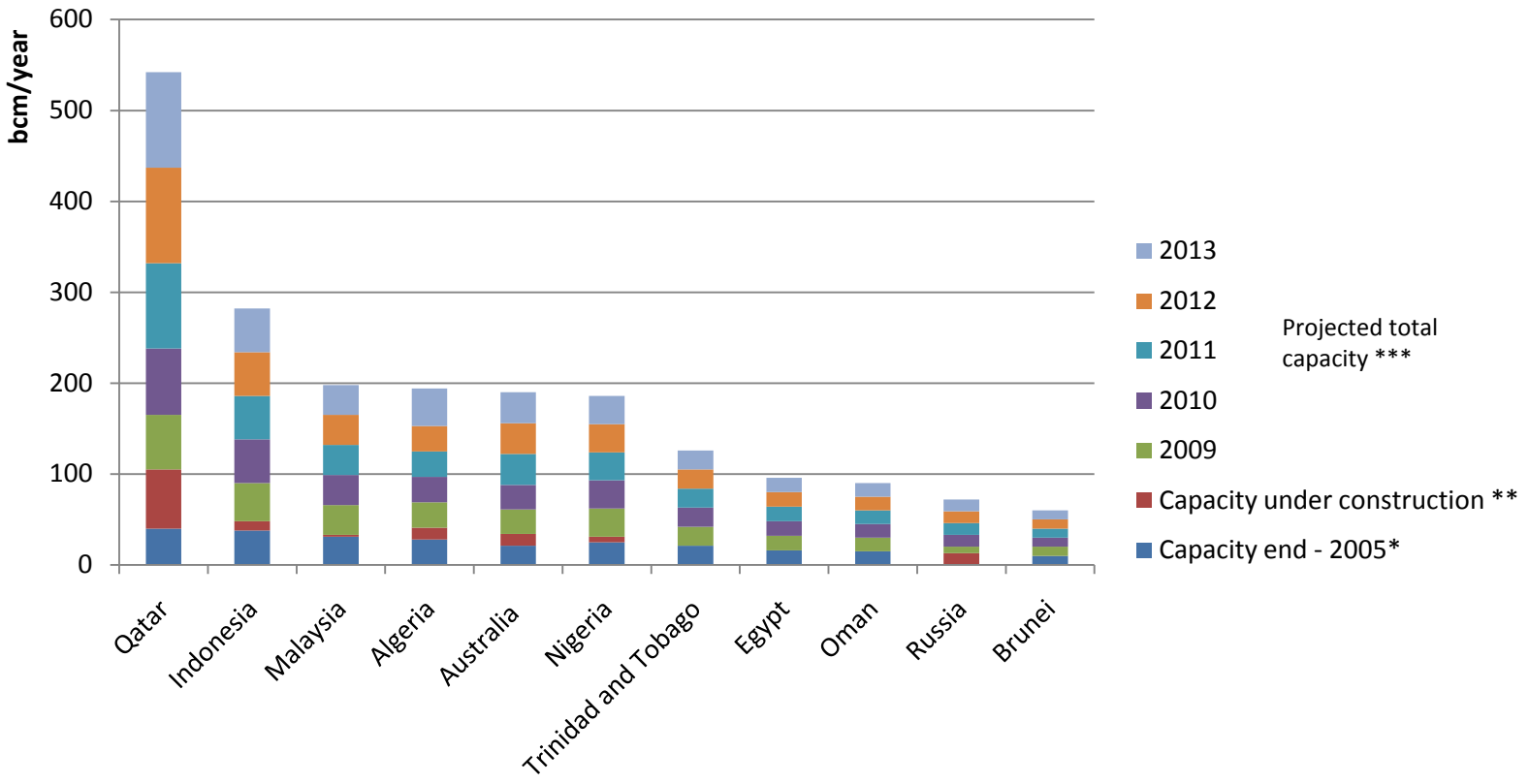
Spot LNG Trade by Country



Source: CIIGNL (2009)

EPRINC

LNG Liquefaction Capacities Through 2015



Source: IEA Data

LNG Trade and Implications

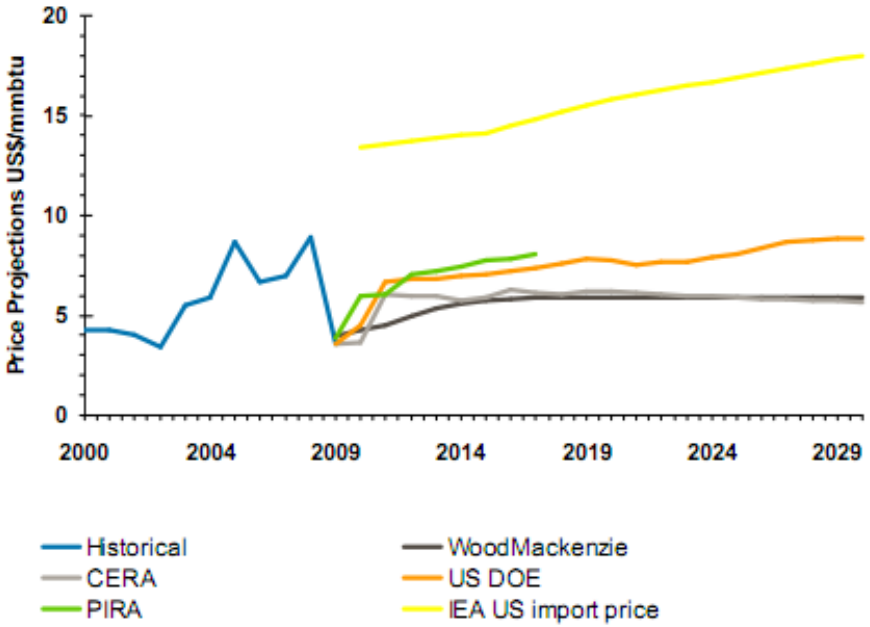
- LNG shipments that were redirected from North American markets to Europe have helped to keep spot prices lower than prices indexed to crude oil

- Some European gas customers are seeking renegotiation of long-term contracts, potentially changing the current oil-linked natural gas price index

- Successful North American development of unconventional gas resources has already and is anticipated to reduce U.S. and Canadian LNG imports.

Range of U.S. Gas Price Projections

Gas price projections (US)

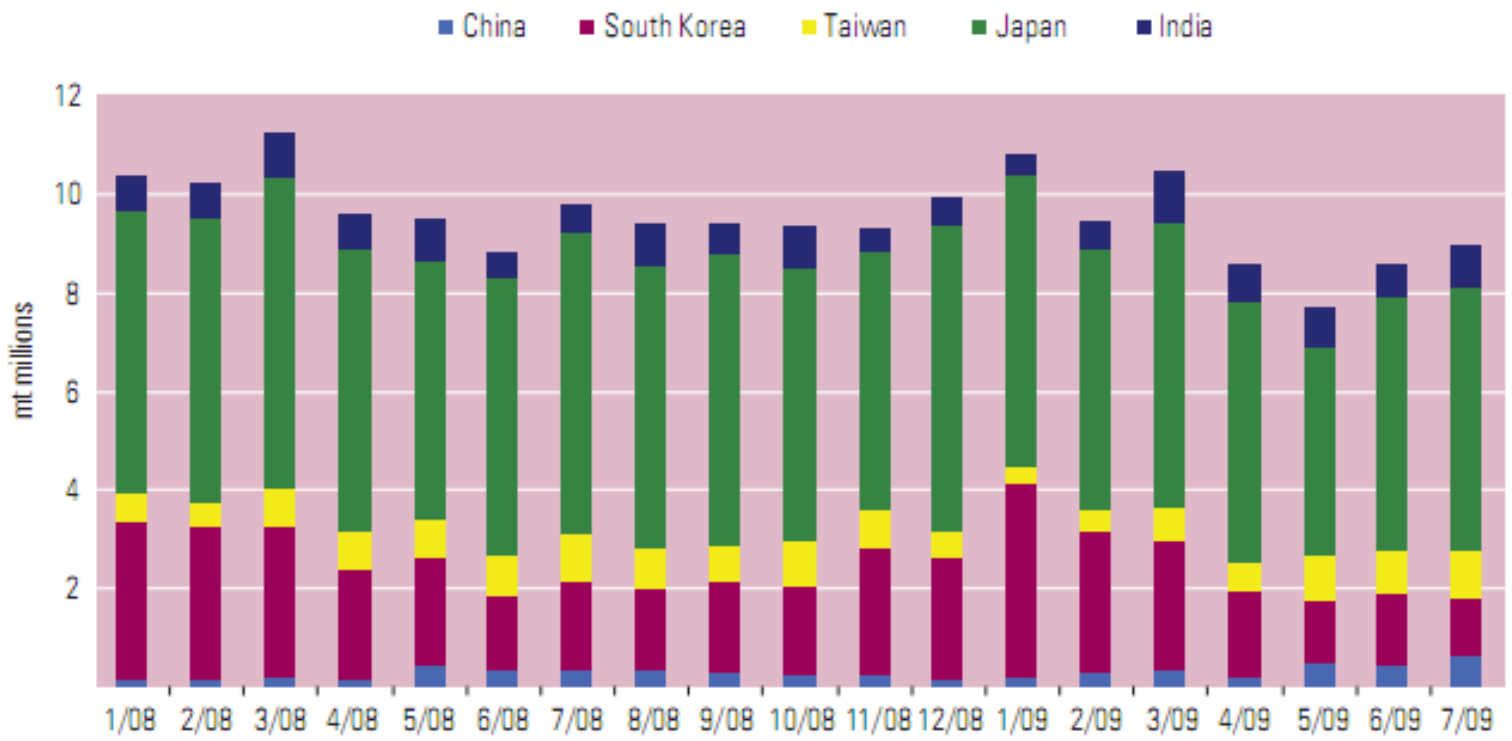


- New consensus view US$4 – 8/mmbtu!
- Driven by marginal cost of supply of unconventional gas (US)
- Impact of climate change, alternative fuels now more unknown

Source: Statoil

Asian LNG Imports – 2008 and 2009

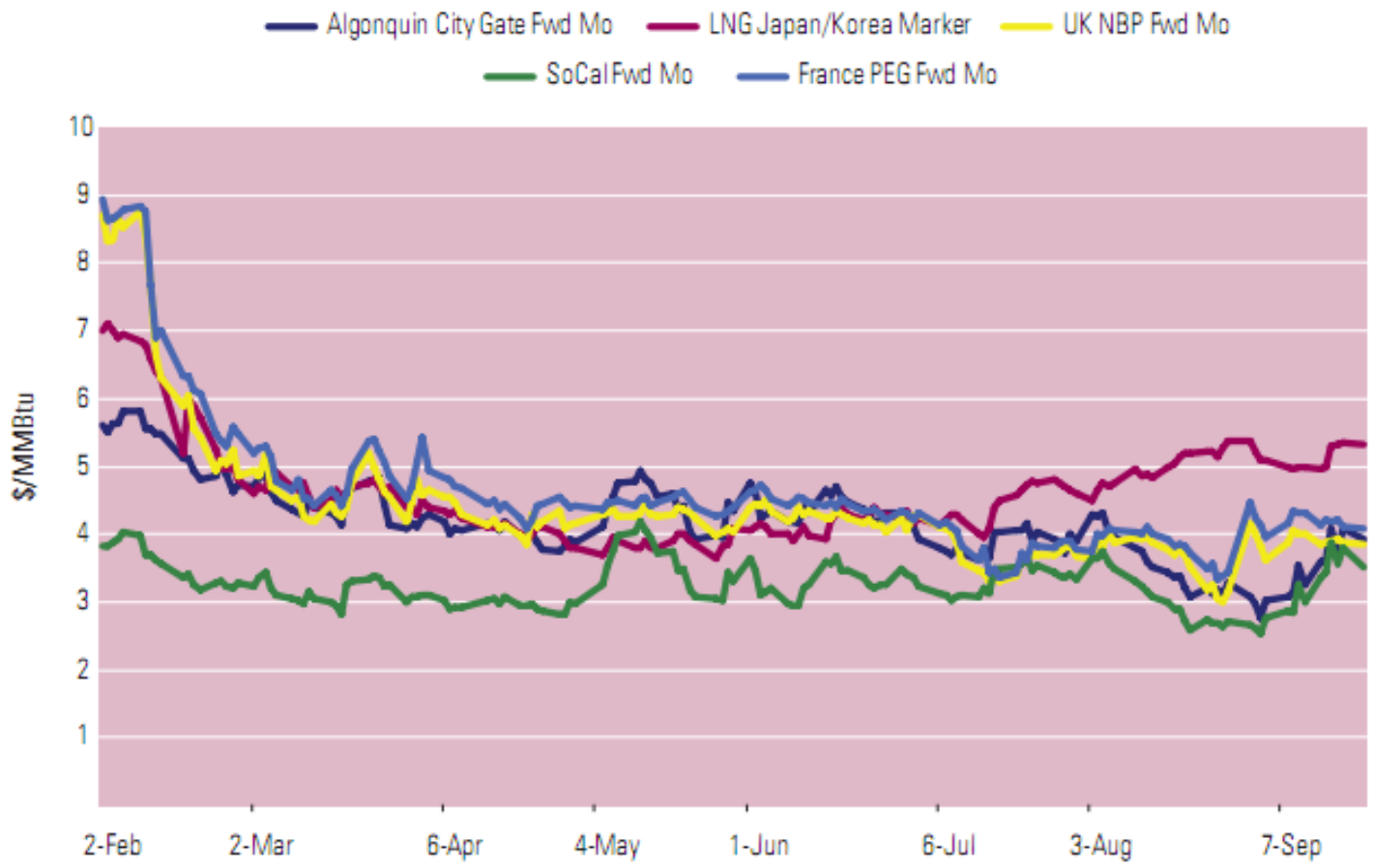
2. Total Asian LNG imports, 2008-9.



Source: Platts

Global Gas Prices – 2009

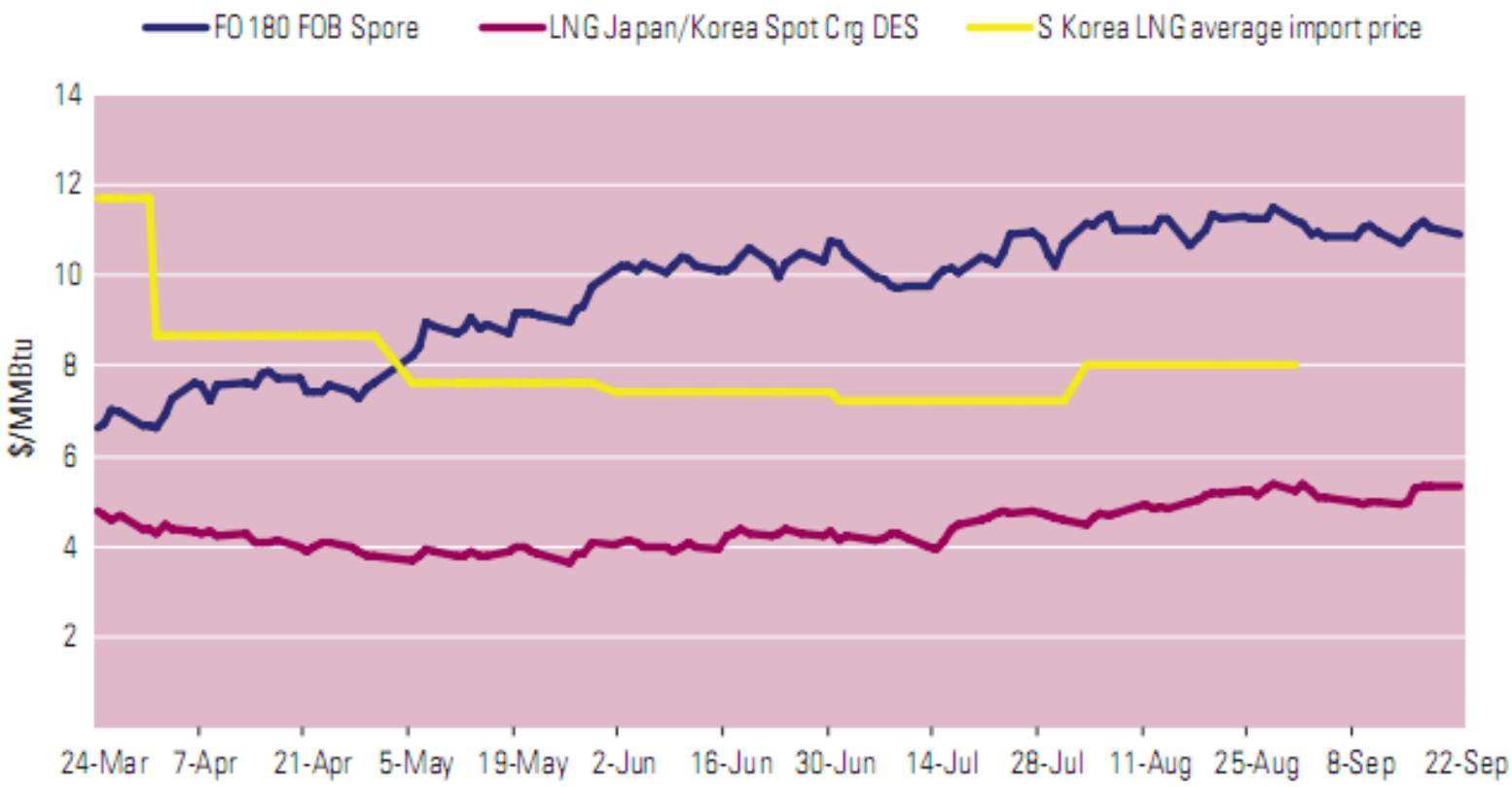
1. Global gas prices, 2009.



Source: Platts

Fuel Oil vs. Spot LNG -- 2009

4. Fuel oil vs term, spot LNG.



Source: Platts

Will GTL Make a Comeback?

Gas-to-Liquids Technology

- Turning natural gas in liquid petroleum products
  - GTL technologies are often derived from the Fischer-Tropsch process (although several methods exist)
  - Combines natural gas molecules to form liquids: largely middle distillates and along with napthas/gasoline and lubricants
    - Overall, the process results in a very clean and very high value barrel of liquids
    - No "bottom of the barrel products"
- The technology still faces many technological and capital cost hurdles
  - Energy waste presents significant questions regarding the process's long-term economic viability
    - Some current technologies yield only 60% of the energy content

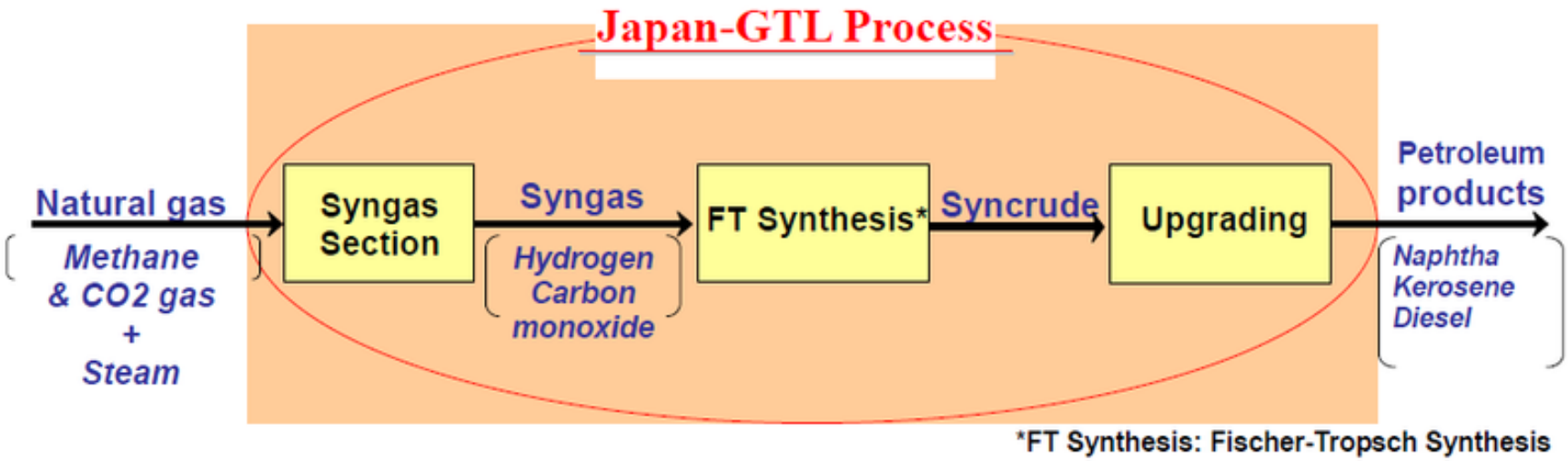
Why GTLs?

- Monetize stranded gas and associated gas
- Transform Natural Gas into a more valuable product
- Liquids can be transported more easily than gas, therefore reaching additional markets
- Some countries (Japan) wish to switch liquid fuels dependency from crude oil to natural gas
- GTL fuels burn more cleanly than crude derived fuels
- **Shift in Gas Market Pricing Makes GTL and DME Research a Priority?**

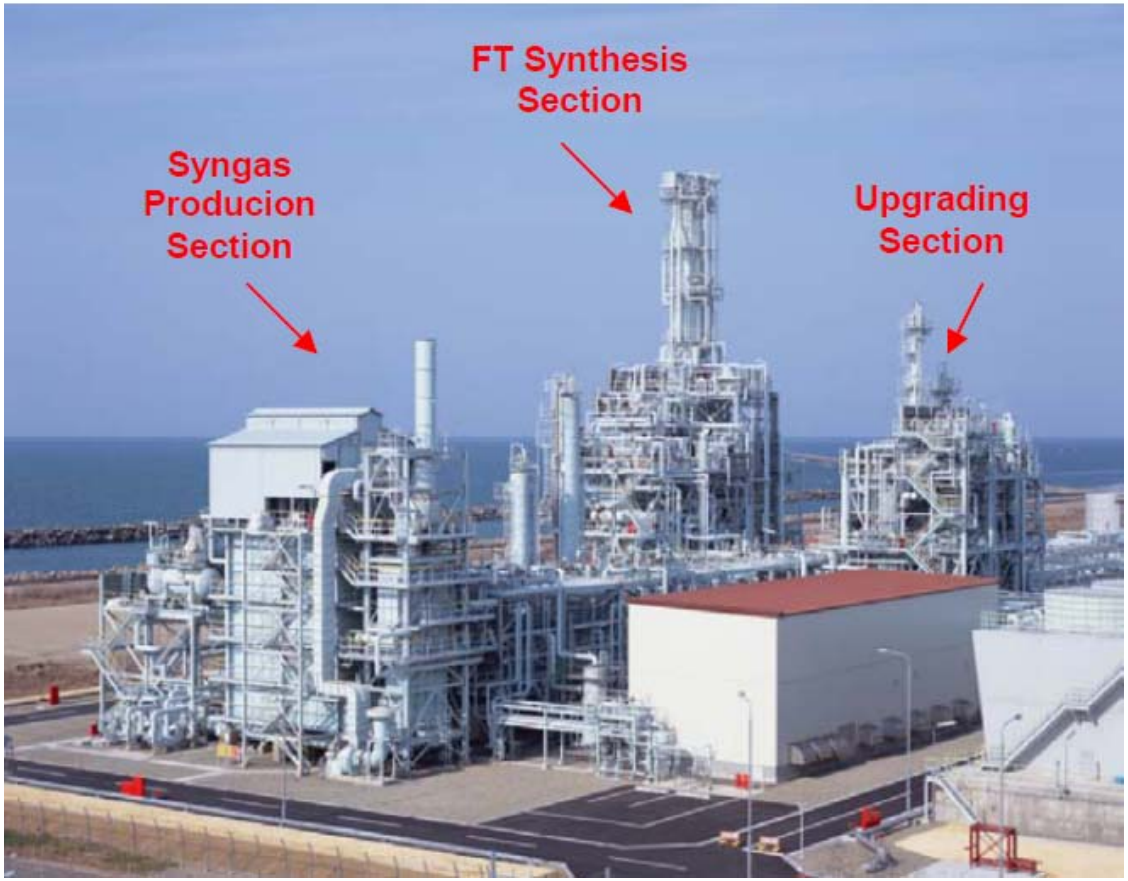
Niigata Demo Plant

- JV between Nippon Oil, JOGMEC, JAPEX, INPEX, and Chiyoda
  - 500 b/d
- Completion: April 2009
- Cost: 36 billion yen (~ $400 million)
- Designed not for commercial production but to research Japanese technology and to determine whether such technology can be scaled economically
  - Successor to Yufutsu Pilot Plant
  - Can handle gas with high CO2 content

Niigata Japan GTL Process



Niigata Japan GTL Plant



Crude vs. GTL Finished Products

	Refined Brent (vol%)	GTL-FT (vol%)
LPG	3	
Naptha + Gasoline	37	15-25
Distillates	40	50-80
Fuel Oils	40	
Lubes + Wax		0-30

Source: BP, E-MetaVentures, Inc. from IAEE Annual Int'l Conference, 2003

A Brief History of GTLs

- SASOL developed GTL technology in the 1950's using the FT process.
  - Interest grew from the 1980's to early 2000's
  - SASOL is still a leader in GTL technology
  - Several IOCs currently constructing large plants
- Most commercial GTL plants operate in South Africa, Qatar, and Malaysia
- Demo plants scattered throughout the world, from the U.S. to Japan

GTL Plants Under Construction

- Two common themes:
  - Over-budget
  - Behind Schedule
- Projections for capital cost improvements made in the early 2000's have not materialized
  - Construction has been delayed across the board and projects are coming in significantly over budget
    - Unforeseen technical challenges have played a large role
    - Many planned projects have been cancelled
  - Per barrel costs for projects under construction are several times greater than those of a new crude oil refinery

Shell Pearl

- Shell and Qatar Gas constructing plant in Ras Laffan, Qatar with capacity of:
  - 140,000 b/d of liquids
  - 120,000 boe of LPGs, condensates, and ethane
- Expected Completion: late 2010-2011
- Initial Projected Cost: $6 billion
- Final Expected Cost: $18-$19 billion
  - Cost per barrel of liquids: $129,000 – $136,000

A Modern, Commercial Plant: ORYX

- SASOL and QATAR Petroleum
  - Capacity has grown to over 32,000 b/d
- Plant was completed in 2006 but production did not begin in earnest until 2009
  - Faced catalyst problems
- Cost: $1 billion
  - Cost per barrel: $31,250
  - Cost is deceivingly low because plant was delayed for several years

Chevron Escravos

- Facing issues similar to that of Shell's Pearl – over budget
- Chevron and SASOL project in Nigeria.
  - 34,000 b/d of liquids
  - Uses SASOL Slurry Phase Technology
- Expected Completion: 2012
- Initial Projected Cost: $1.7 billion
- Final Expected Cost: $6.9 billion
  - Cost per barrel of liquids: $202,000

World GTL/Petrotrin – Small Scale GTL

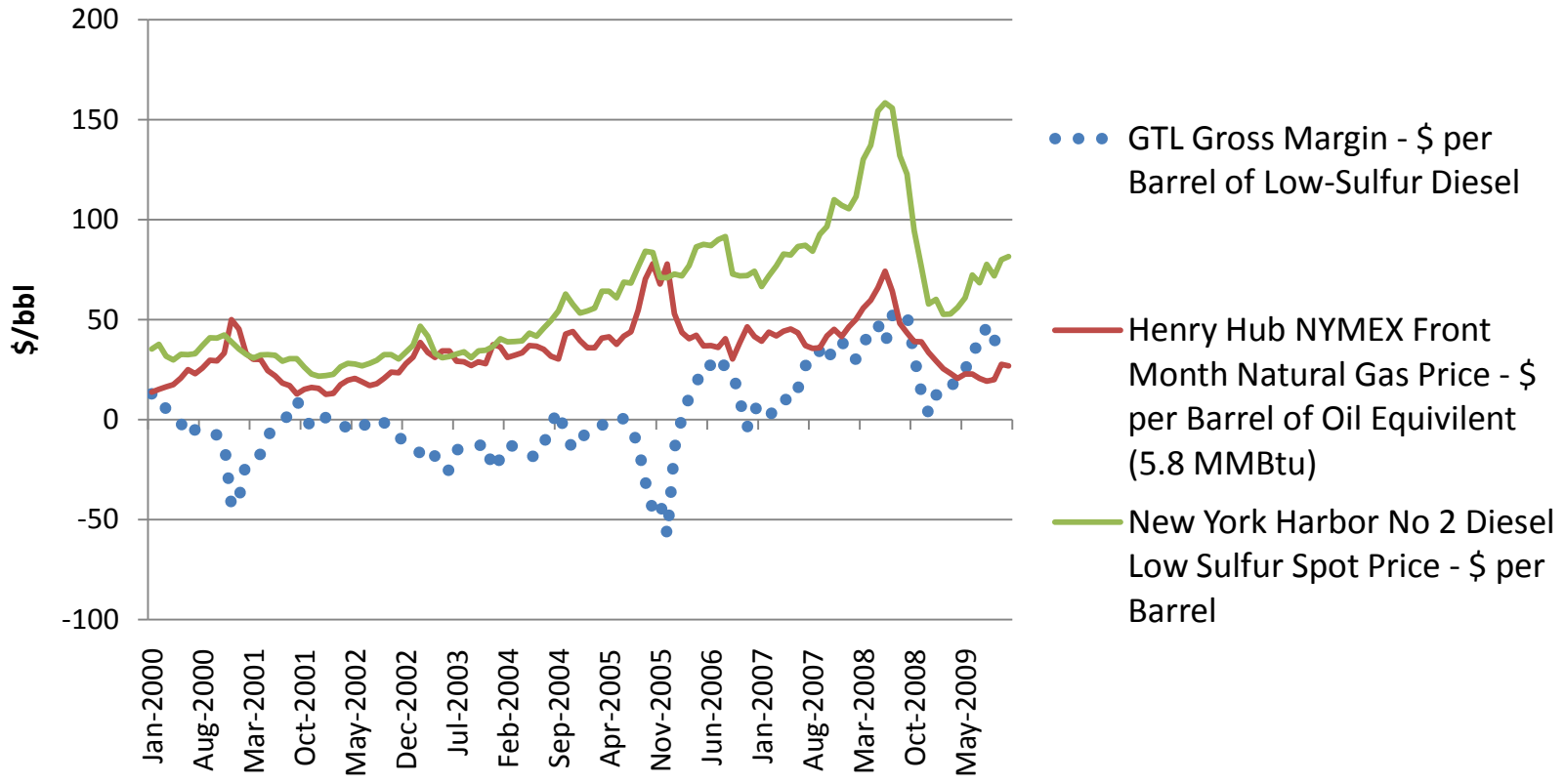
- Trinidad and Tobago
  - 2,250 b/d
- Expected Completion: 2010?
- Initial Projected Cost: $150 million
- Final Expected Cost: $445 million
  - Cost per barrel of liquids: $197,000

Capital Cost Barrier

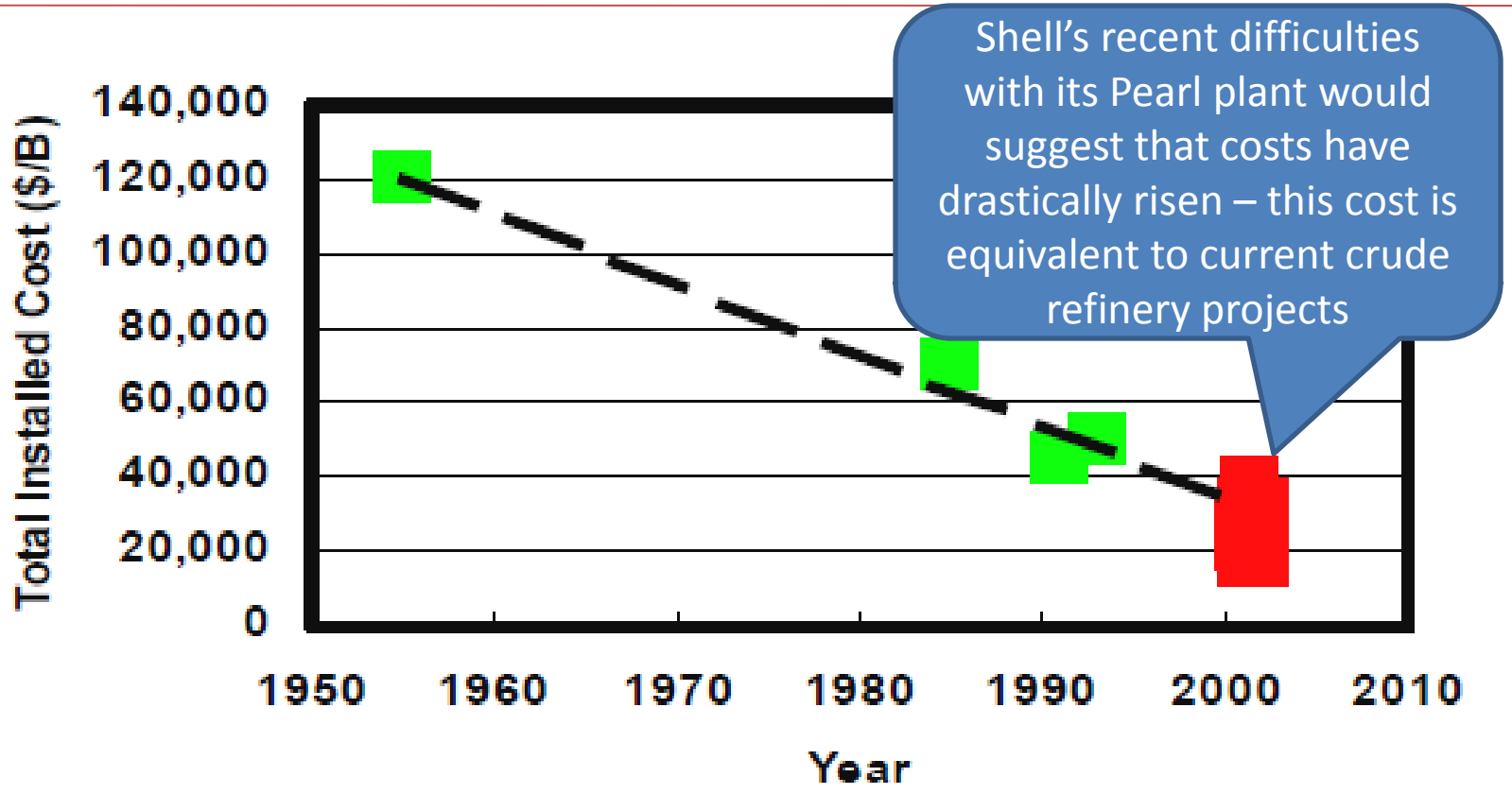
- Saudi Arabia is building three new crude oil refineries, for domestic consumption and exports
  - Each is 400,000 b/d
  - All should be completed by 2013
  - Cost is around $10 - $12 billion, or $25,000 - $30,000 per barrel of capacity
- Meanwhile, GTL plants under construction cost $100,000 - $200,000 per barrel of capacity
  - To be successful, capital costs must come down and gas must remain discounted to crude oil (and the technology must be refined)

GTL & DME Gross Margins

Gross GTL Margins – 1 barrel of low sulfur diesel minus natural gas feedstock costs



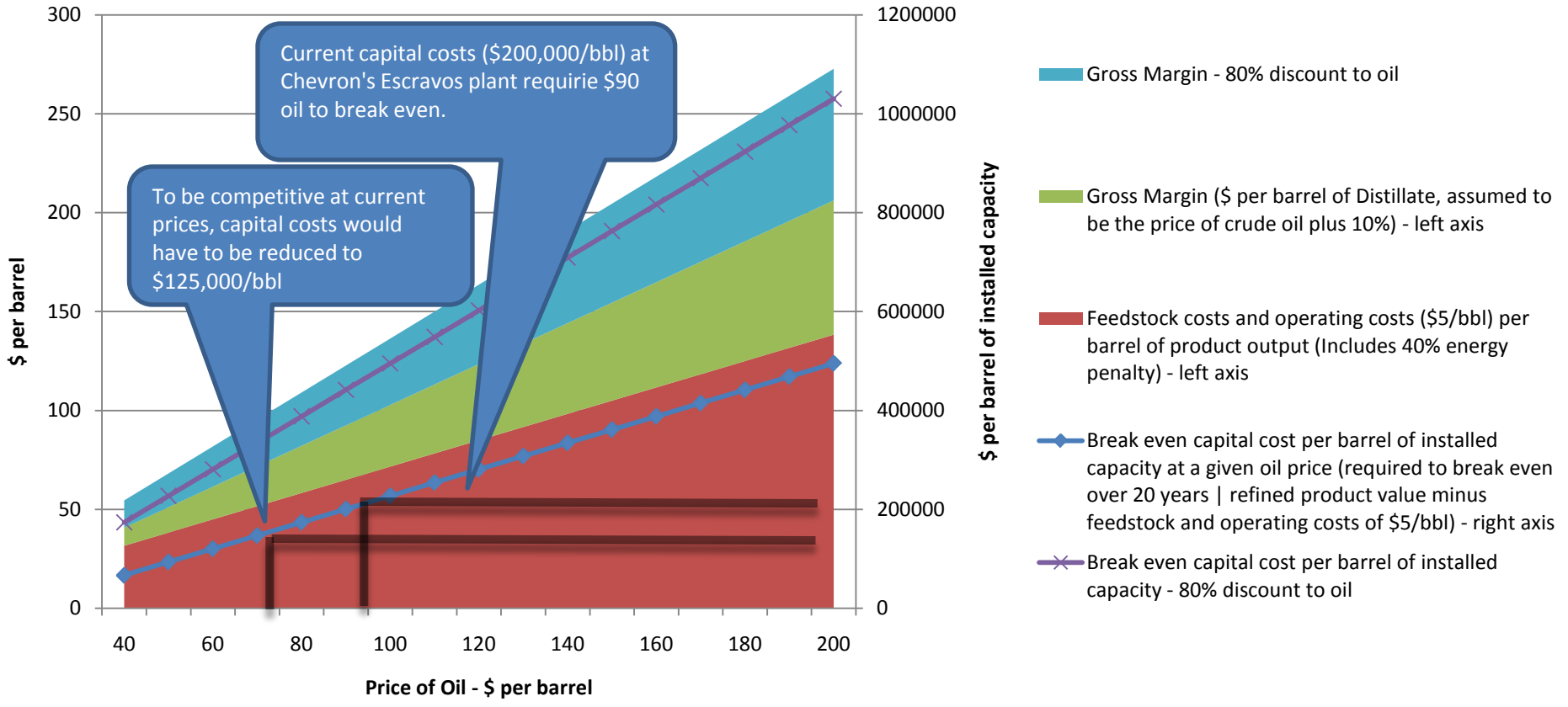
Are GTL Capital Costs on the Decline?



Source: E-MetaVentures, Inc. from IAEE Annual Int'l Conference, 2003

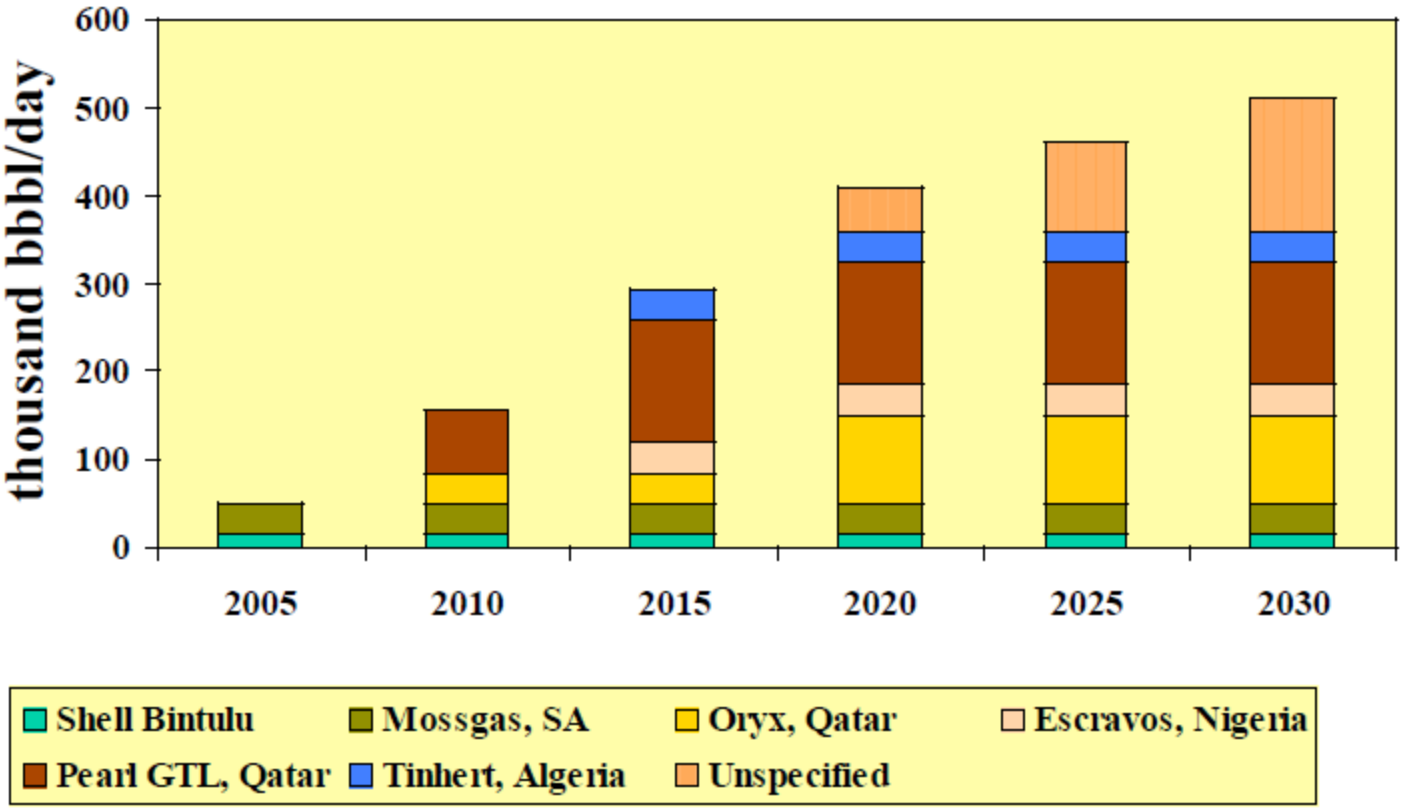
EPRINC

Capital Costs and the Gas Crude Spread*



*EPRINC preliminary estimates

Projected GTL Capacity - NPC



Source: NPC

EPRINC

CHANGE IS COMING!

Gas to Oil Pricing Likely to Become Permanently De-Linked

Stability of Indices No Longer Assured ---- " S" Curve More Robust than Most, but Pressure for Change Will Remain (Europe – Gazprom Index No Longer Workable)

Gas Rich Scenario Can Reduce the Cost of GHG Controls

Strategic Shifts: Russia and Central Asia Natural Gas Leverage on the Decline – Greater Openess to Foreign Investment

Shale/Uncoventional Gas Technology Migration Will Accelerate –
Reserve Growth Likely to Continue

Long Term Prospects for GTL and DME Will Continue to Improve