

US and Russian Natural Gas and World Impacts

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Dennis Silverman
Physics and Astronomy
UC Irvine

Replacing Coal With Natural Gas

- **Greenhouse Gas Reduction by Switching from Coal to Natural Gas**
- For the same total energy, natural gas CH₄ gives only half as much CO₂ as coal does.
- Coal is somewhat pure carbon C, each atom of which burns to a CO₂ molecule.
- When a molecule of CH₄ burns, the hydrogens H also burn to water, H₂O, giving as much energy as the included carbon C does. That carbon also makes one CO₂ molecule, but you get twice the energy from CH₄.
- Replacing old 33% efficient coal plants by new combined cycle natural gas plants at 60% efficiency will [reduce CO₂ emissions for the same electricity by 72%](#), (Dennis Silverman's blog) That is, only 28% of the previous CO₂ is produced. See also [Richard Muller's lecture](#).
- Coal now generates 18% of total energy. Natural gas is 27%, and petroleum is 36%. Renewables are 9% and nuclear is 8%.
- Replacing all coal by combined cycle natural gas reduces overall CO₂ pollution by 23%. That by itself reduces CO₂ by more than clean renewables (including hydro) combined with nuclear power does (17%).
- The replacement is already occurring since natural gas is now cheaper than coal.
- There has been a 47% increase in US electricity generated using natural gas since 2005.

Serious Problems With Coal

- Coal burning releases Sulfur, causing sulfuric acid or acid rain which damages buildings, forests, and people. Natural gas comparatively zero.
- Coal produces nitrous oxides that lead to photochemical smog. Natural gas emits 1/5 of that, for same amount of heat.
- Coal is the source of most mercury in the environment.
- Coal emits very small (<2.5 micron) particulates that leads to premature deaths for 3 million annually (75,000 in US). Natural gas emits 1/400 as much.
- Coal leaves ash mountains that can at times enter water resources.
- Coal strip mining of mountain tops leaves residue that washes down to pollute rivers and damage ecosystems.

World Goals on Greenhouse Gas (GHG) Emissions.

- New EPA regulations on coal fired plants are designed to lower their pollution 30% by 2030.
- New coal plants can pass the regulations. Older plants can be replaced by natural gas, or support renewables or other pollution free sources.
- Overall goal is to lower US greenhouse gas emissions 17% by 2020 over that of 2005.
- The next goal is to lower US emissions by 30% by 2030. We are already halfway there.
- The new GHG agreement with China is that we will achieve 26%-28% reduction by 2025, consistent with the 2030 goal.
- China will peak its GHG production in 2030, and move to 20% clean energy of renewables with nuclear by then. They already have twice the renewables of the US and are planning dozens of reactors. China is already 10% clean, and had planned 15% by 2020.
- If China converted their 80% coal to new 60% efficient natural gas plants, they could cut emissions by 56%.
- The European Union Goal is to lower emissions 40% by 2030 over their 1990 value. They are also halfway there.
- Part of the lowering for the US and Europe is also from the downturns in the economy, and the shifting of manufacturing to China.

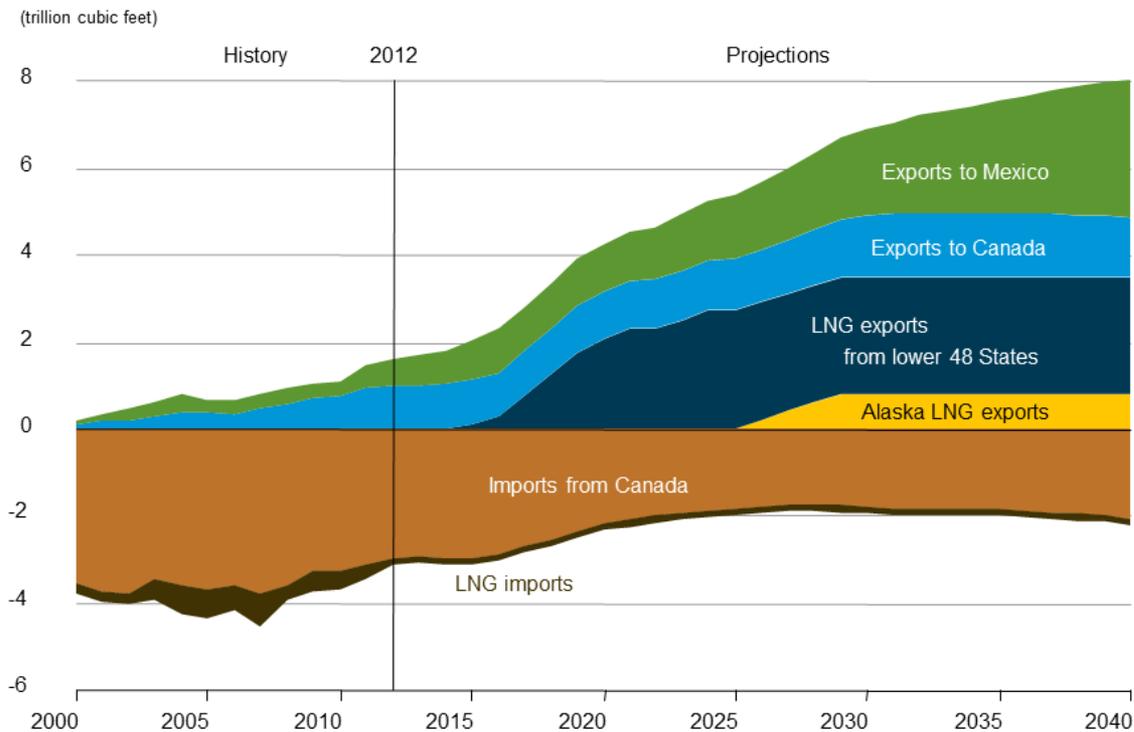
US Will be Energy Independent In Natural Gas by 2018

US Natural Gas Exports to 2040

By 2040, Net 6 Tcf Exports. Present Use 24 Tcf.

Just the US withdrawal from the import market will have an effect .
Maybe 3 Tcf of exports will bring in \$10 billion per Tcf in Europe.

Figure 4. U.S. natural gas imports and exports, 2000-40



Breaking News: World Wide Petroleum Price Drops

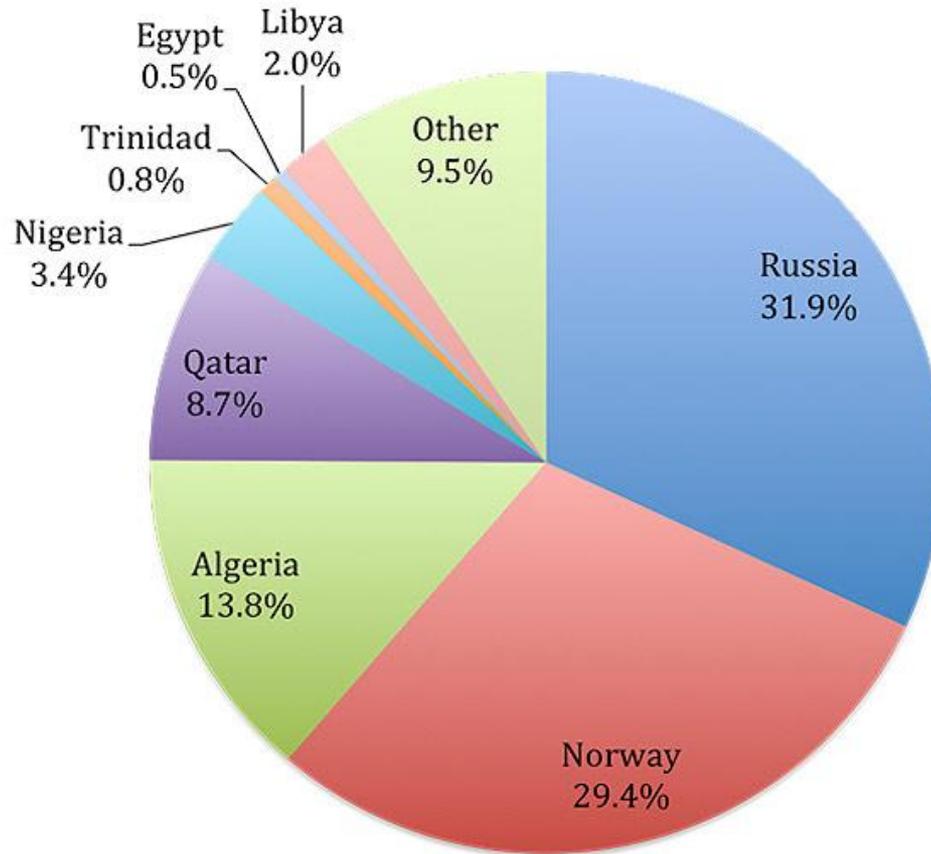
- There has recently been a 25% drop in the price of petroleum.
- US gasoline has dropped to \$3.00 a gallon.
- This is because of less demand, and OPEC holding the supply constant.
- OPEC is supposedly aiming for a 40% drop in price, down to say \$70 a barrel, at which US and Canadian shale sands oil will no longer be profitable.
- If shale production shuts down, then OPEC can again raise prices.
- This is causing havoc in Russia, whose government depends 53% on oil profits.
- Also causes problems in Iran, whose government depends 75% on oil profits.
- The exchange value of the Russian Ruble has fallen 40% this year.

Germany, Italy, France, Poland Pipelines Go Through Ukraine



Europe Receives 32% of its Gas Imports from Russia

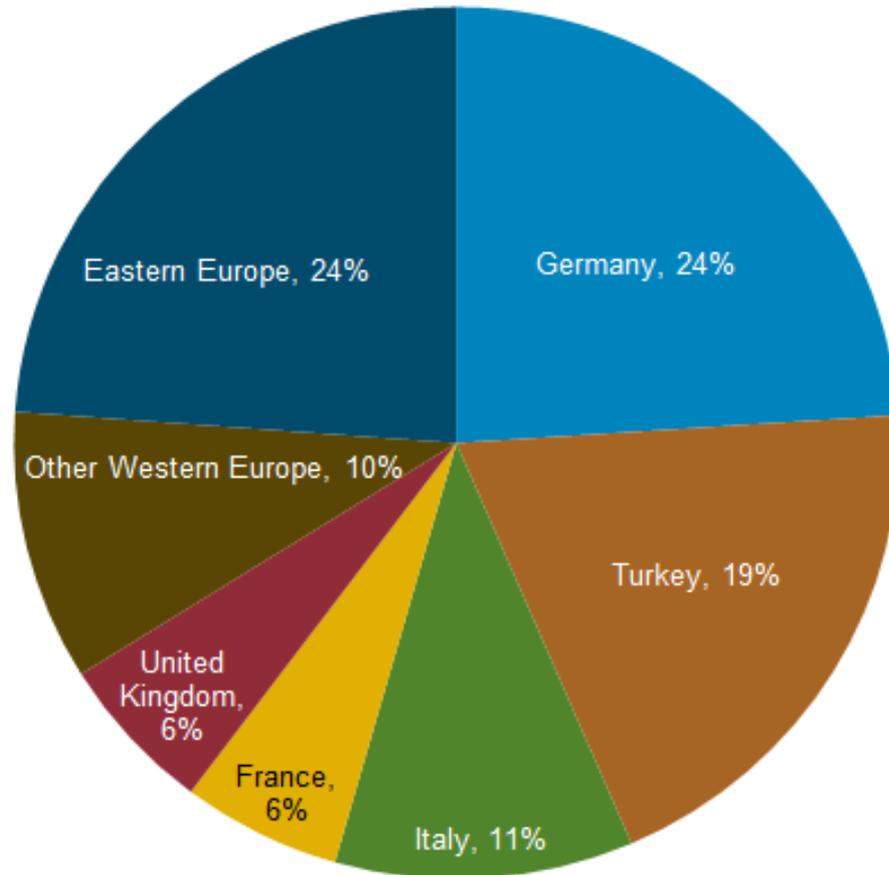
EU Natural gas imports by country of origin (2012)



Russian Gas Exports by Country

Russia Produces 23 Tcf Per Year, Exports 6.6 Tcf
Over 50% of Russia's Budget Funded from Oil and Gas Exports

Share of Russia's natural gas exports by destination, 2012



Source: Eastern Block Energy, U.S. Energy Information Administration

Russian Natural Gas to China and Japan

New 30 year, \$400 billion deal to offset EU withdrawals, and rise of US natural gas exports. 1.3 Tcf per year. New Altai pipeline deal in West China for 1.0 Tcf per year. Russia also looking to China for technology and other trade.

Japan now trying for pipeline to Tokyo at 0.7 Tcf per year.

Russia Charges about \$10 billion per Tcf. 2.5 times the US price.

China now Russia's largest trading partner. But US is China's largest.

Kovyktinskoye and Chayandinskoye.

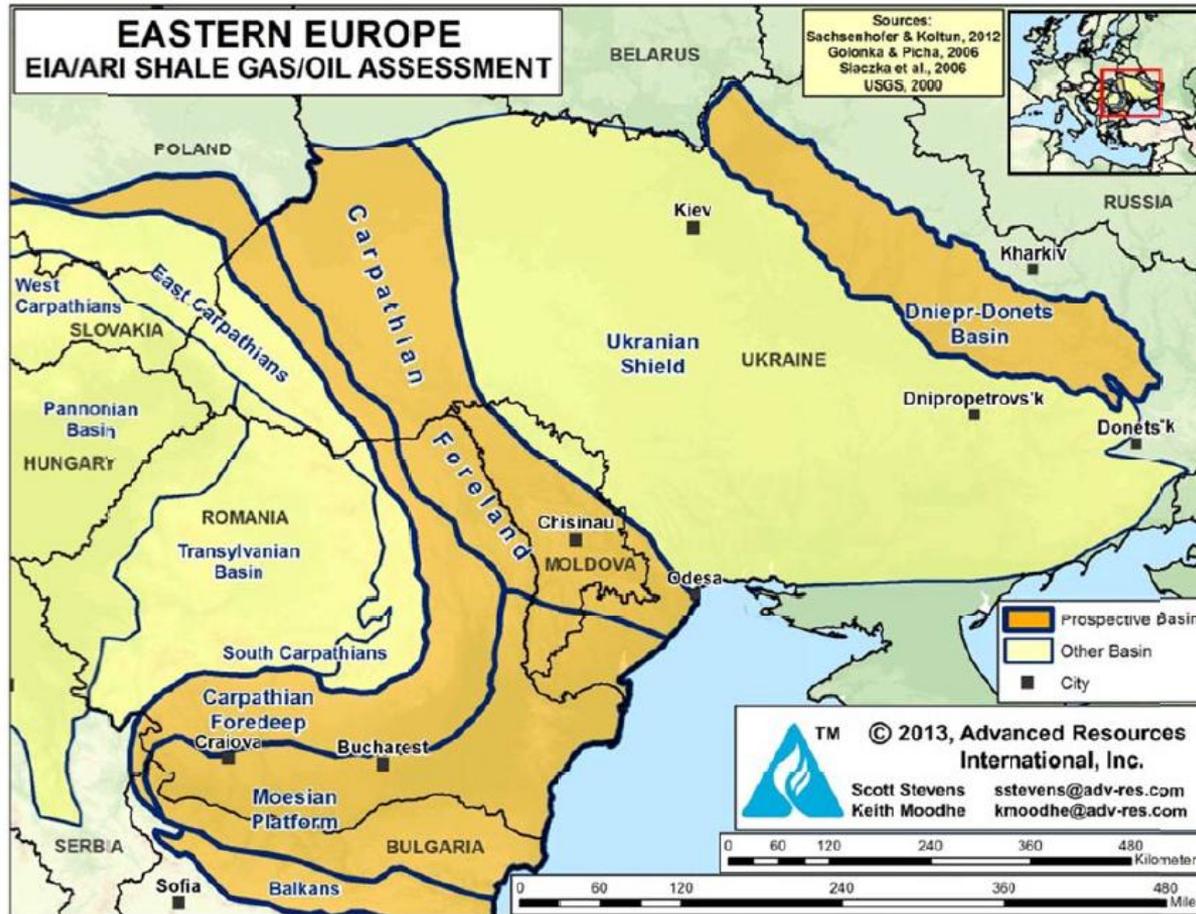
"Power of Shanghai" Gas Pipeline to Supply China



Russia's Recent Aggression and Fuel Resources

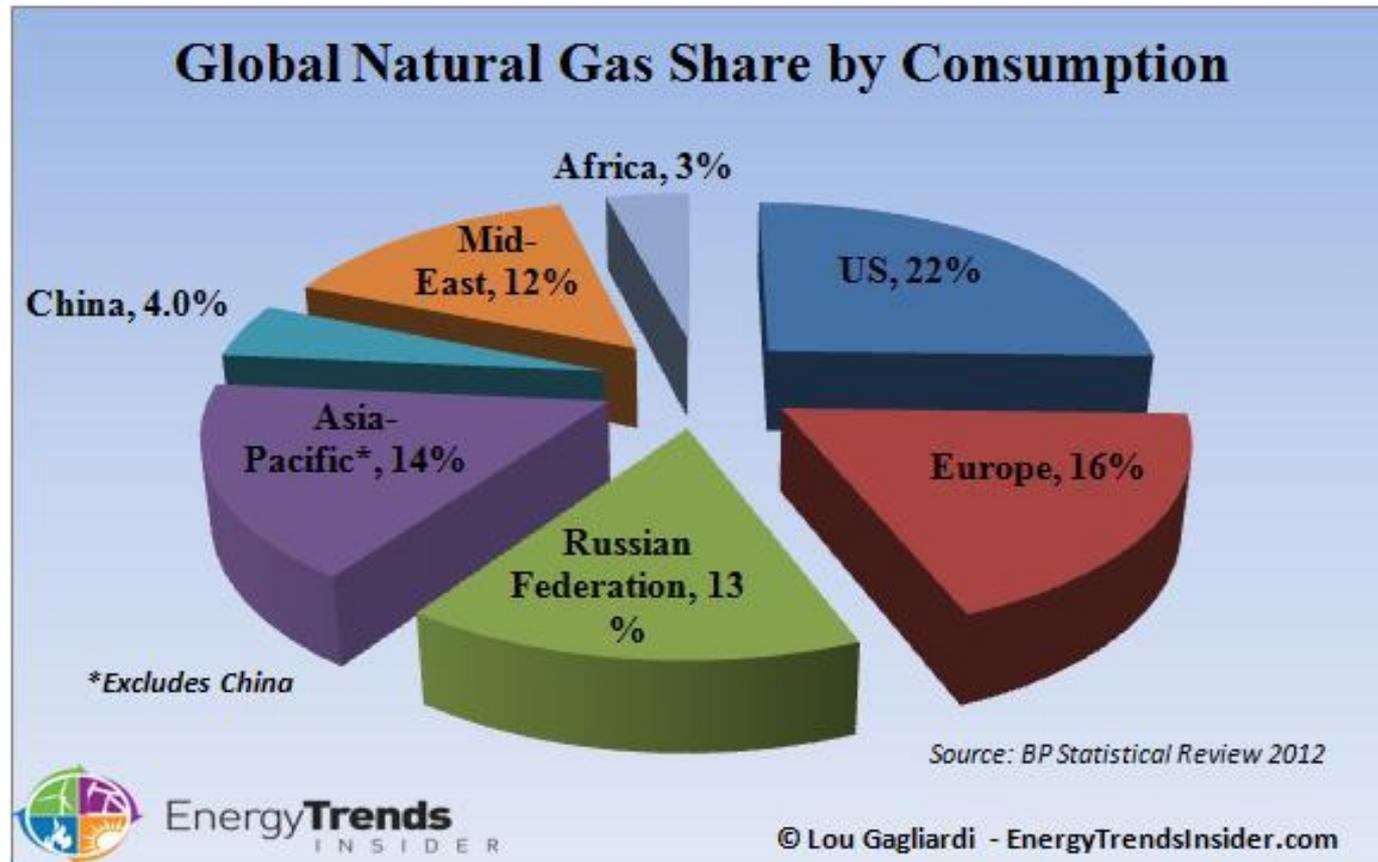
Crimean Waters (200 mile limit) holds \$1 Trillion in Oil

Russians Occupy East Ukraine and Eye Moldova Shale Plays



World Gas Consumption by Region

As the biggest consumer of natural gas, the US would be most sensitive to outside influence without our own sources.



Natural Gas Total Proven World Reserves 7,000 Tcf

US Has Only About 5%

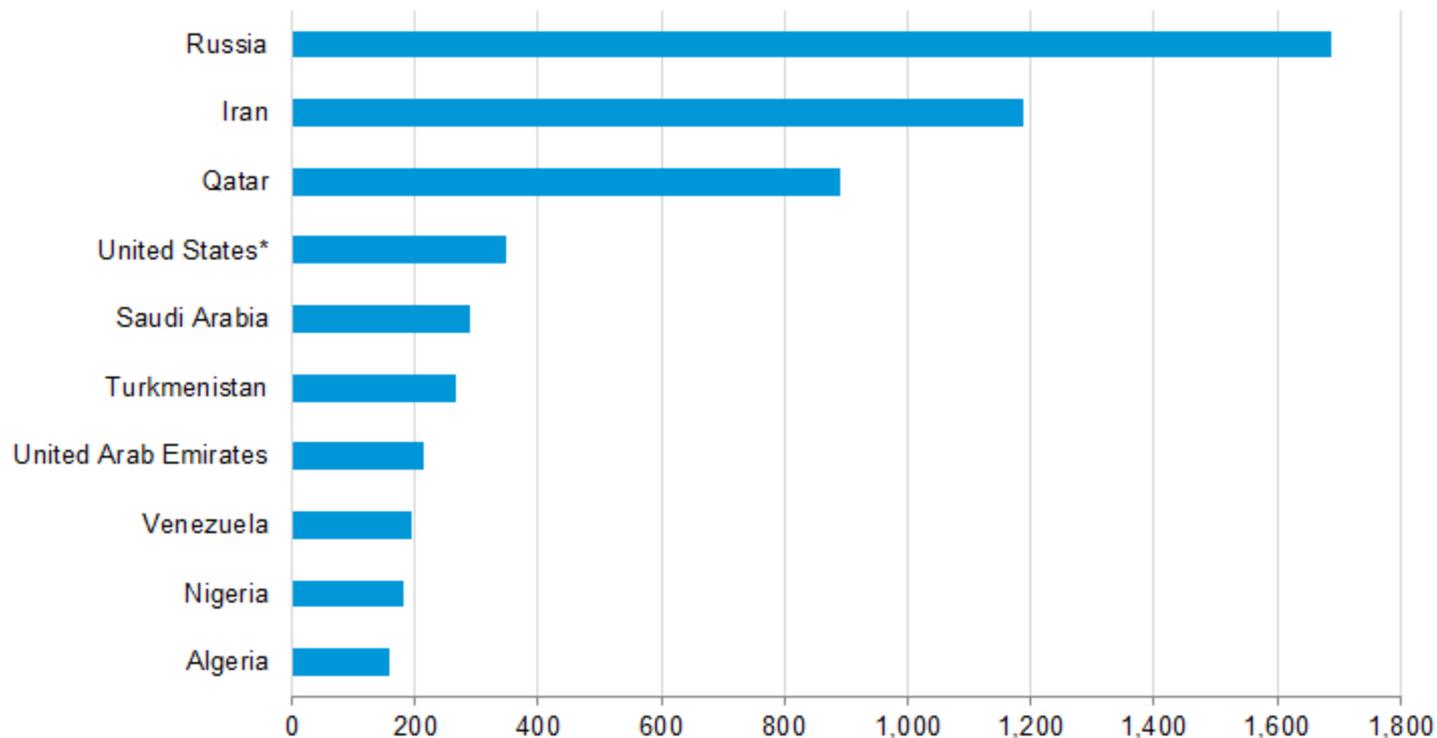
US Technically Recoverable is 2,300 Tcf, Including 900 Tcf From Shale

Shown for US is Proven of 334 Tcf

World Consumption is 120 Tcf in 2012

Largest proven natural gas reserves holders

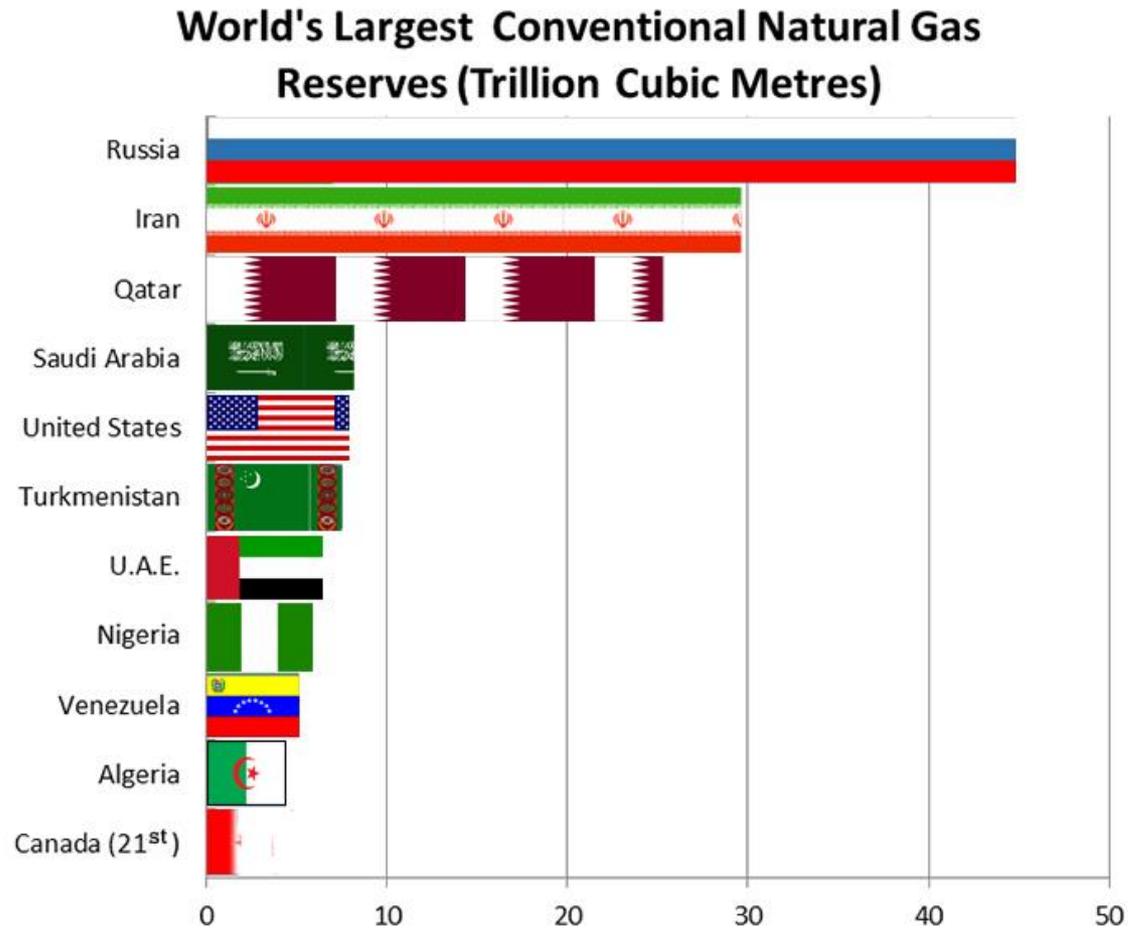
trillion cubic feet



Note: The United States reserves are wet gas reserves as of December 2011

Source: United States: U.S. Energy Information Administration; Other Countries: Oil and Gas Journal 2013

Russia and Iran Not Friendly, With 40% of World Reserves
Qatar, Saudi Arabia and U.A.E. (20% of Reserves)
on Persian Gulf, can be blockaded by Iran
World Reserves 200 Trillion Cubic Meters Total

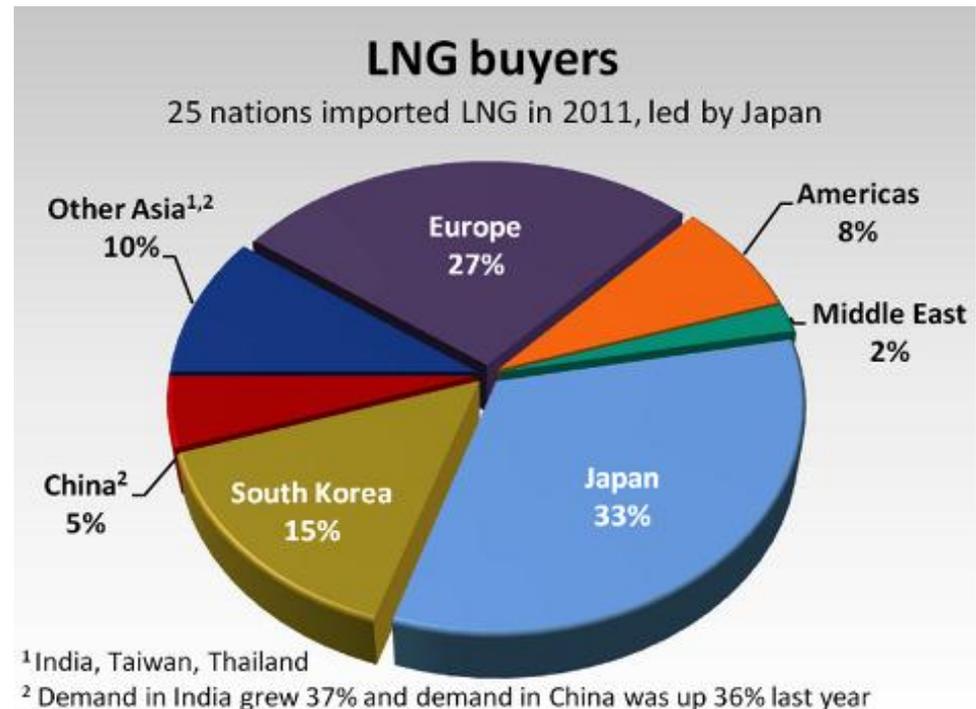


Fracking May Avoid an OPEC for Natural Gas

- When OPEC restricted sales of oil, it drove the price of crude up from \$20 a barrel to \$100 a barrel.
- A barrel holds 42 gallons.
- So the price of crude rose from about \$0.50 a gallon to \$2.50 a gallon, an increase of \$2.00 per gallon.
- Since US oil companies can sell worldwide, they raised their price to the international price, and so the price of our gasoline rose also.
- Seven of the top 10 natural gas reserves countries are in OPEC.
- Each of the top 10 countries also have their own political or religious agendas.
- Maybe, the availability of natural gas in many more countries due to fracking will stop OPEC and Russia from dictating increased prices worldwide.
- However, when we export more gas and sell it where it is 2.5 times the price as in the US, it may raise our home prices, as it did for gasoline.

Liquefied Natural Gas and World Supply

- LNG is natural gas compressed by a factor of 600, at minus 260 degrees F.
- LNG tankers come in 5, 7.5, or 9 million cubic feet sizes, or 5.7 Bcf of natural gas for the largest.
- To transport a trillion cubic feet of gas a year requires about 200 tanker trips a year, and ports to handle them.
- There are about 12 Tcf a year of natural gas through LNG, about 10% of world methane supply.
- Qatar produces about a third of that.



Methane as a Greenhouse Gas

- Methane is 9% of US greenhouse gas emissions.
- Its lifetime in the atmosphere is twelve years, and it is destroyed by atmospheric OH.
- About 40% of methane comes from wetlands, including rice farming.
- About 20% comes from energy production.
- About 20% comes from livestock (cow burping).
- If averaged over a 100 years, it is 34 times more potent than CO₂ by mass.
- CO₂, however, lasts hundreds of years, so this factor can be further divided by CO₂ lifetime in centuries.
- You often see that if averaged over 20 years, methane is a factor of 86, but this is not relevant in comparison to CO₂.
- What is important is to cut CO₂ from coal, and to keep fugitive emissions of methane very low.

But Natural Gas is a Potent Greenhouse Gas?

- A standard argument of a threat to reducing greenhouse gases is that CH₄ is 34 times as powerful a greenhouse gas per unit weight as CO₂ is over 100 years. So natural gas leakage has to be less than 3% to get any greenhouse reduction by the switch.
- That actually is incorrect, since the comparison should be per molecule released, and including efficiency of power plants.
- Also, CO₂ lives longer in the atmosphere than a century.
- [For example](#), if CO₂ lives 200 years, and we replace old coal plants with combined cycle natural gas plants, then even with 10% CH₄ leakage, we still get about 50% savings in emissions by switching.
- Or, controlling methane emissions is said to only add a penny to the cost of gas (\$4 per 1,000 cubic feet or 10 therms.)
- The EPA is considering fracking regulations. Republicans trying to strip EPA of GHG regulations, since they deny global warming.

Greenhouse Gas Reduction Replacing Old Coal with New Natural Gas Plants, Including Methane Leakage

Table for CO2 lifetimes of 100 or 200 years

Leakage at 0%, 3%, 5%, or 10%

Previous 3% Breakeven Replaced by 62% or 67% Reduction

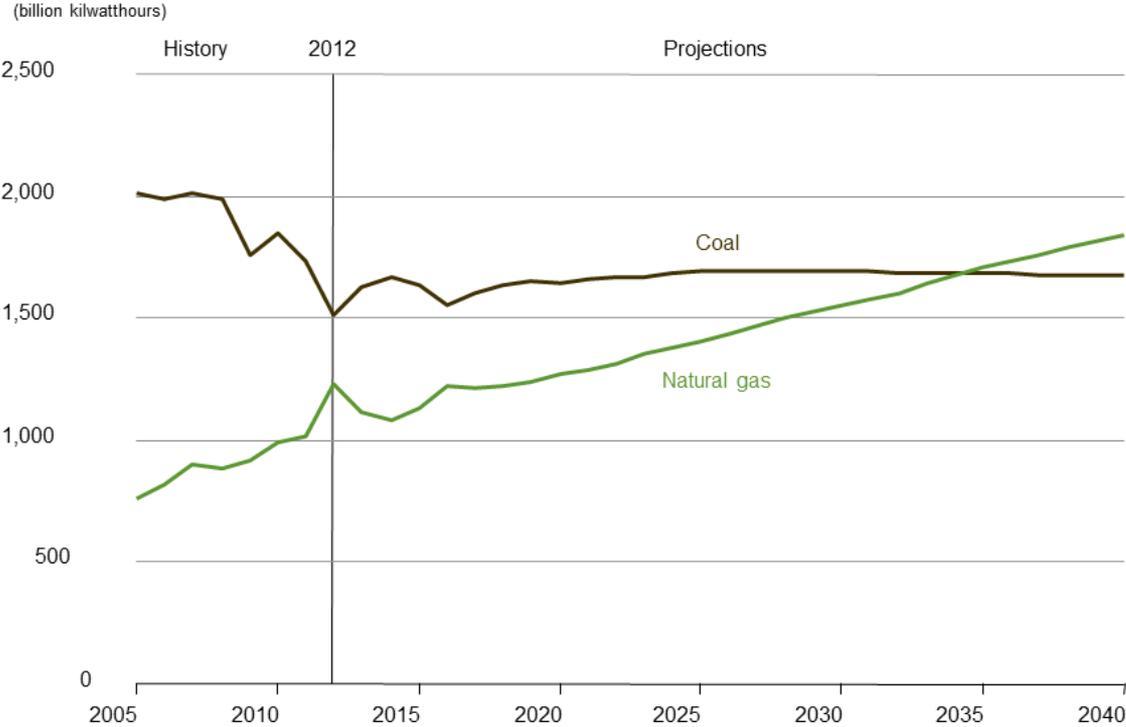
Leakage ->	0%	3%	5%	10%
CO2 100 years	72%	62%	55%	38%
CO2 200 years	72%	67%	60%	55%

Contrarian UC Irvine Analysis

- A new analysis by a UC Irvine ESS team of Steven Davis points out that cheap natural gas will allow people to use more power to squander the savings from the switch away from coal.
- It would also delay the development of renewable power (or nuclear), and the net greenhouse gas reduction will be mostly negated. The only way to avoid that is to institute a carbon tax, they conclude.
- Renewables will be treated in another semester of this energy sequence. We may also get a talk by one of the authors of that paper.
- Rebuttal: Since electric efficiency is regulated in lights and appliances, and people are educated to save energy, and industries like the green label and cost savings, squandering power is actually harder to do than it sounds.
- Renewables require natural gas in a symbiotic relationship to level out power delivery.
- California already sells pollution permits and expects \$5 billion a year from it.
- As we increase exports of natural gas and use more, the price will rise.

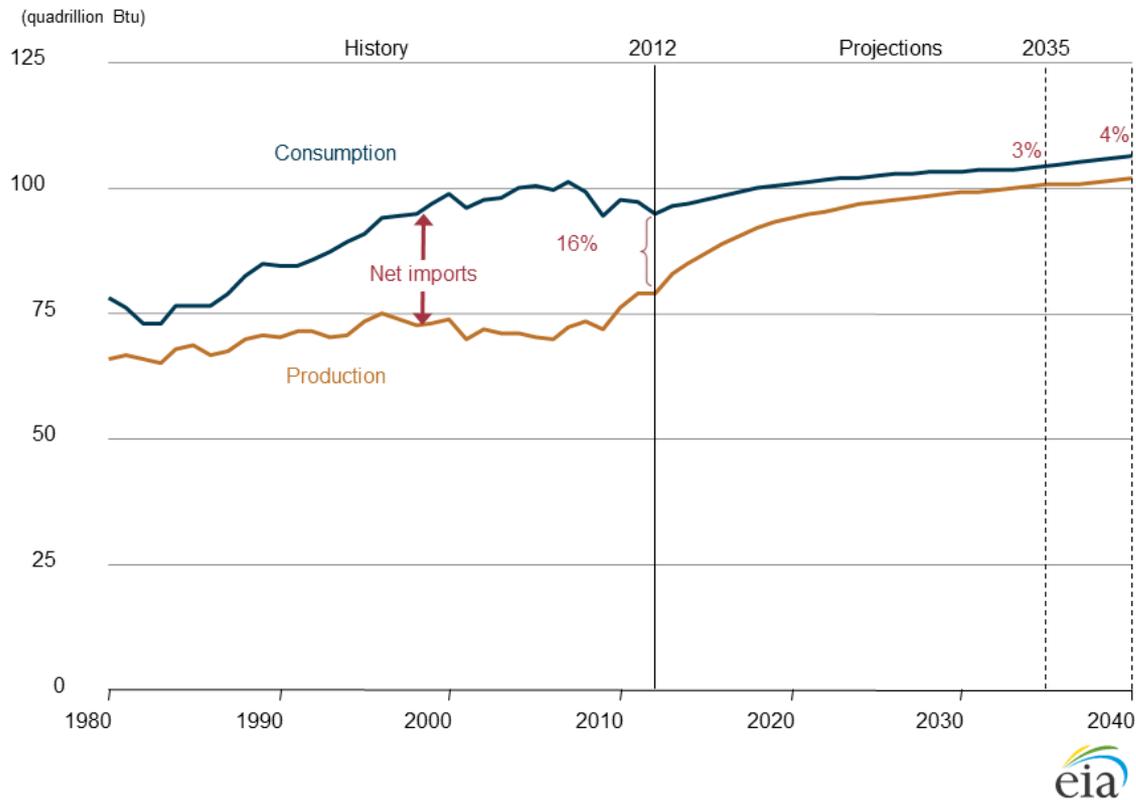
Electricity from Natural Gas and Coal

Figure 3. Electricity generation from natural gas and coal, 2005-2040



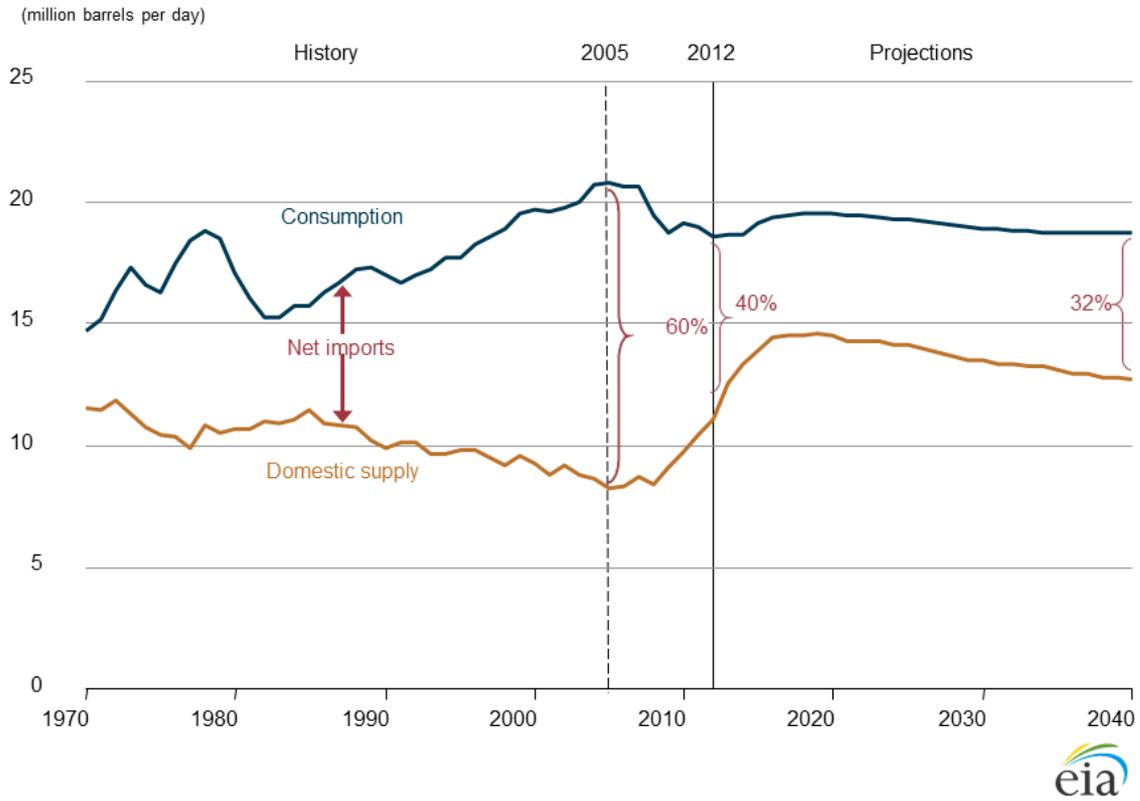
Total Energy Imports Disappearing

Figure 10. Total energy production and consumption, 1980-2040



Rise of Fracking Oil

Figure 12. U.S. petroleum and other liquid fuels supply, 1970-2040



Energy Production by Fossil Fuels

Figure 11. U.S. energy production by fuel, 1980-2040

