Shale Gas: a revolution in the energy sector.

PRESENTED BY

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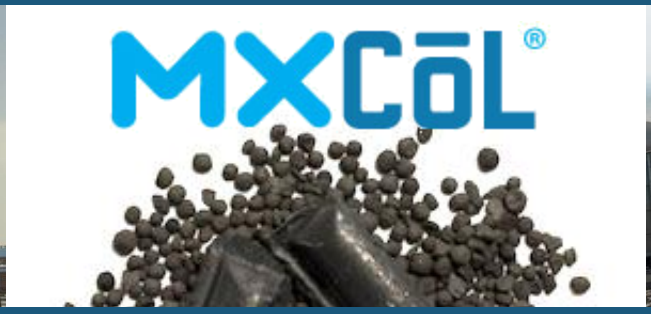
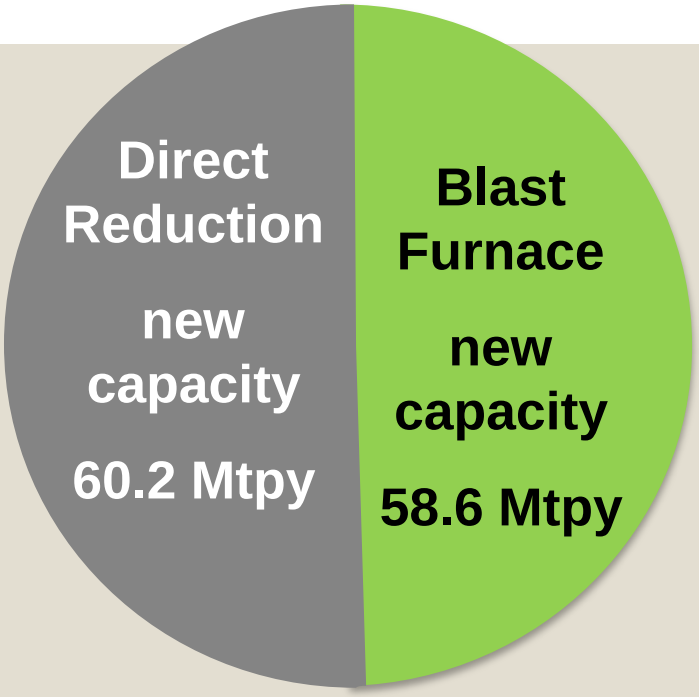
MIDREX TECHNOLOGIES, INC.

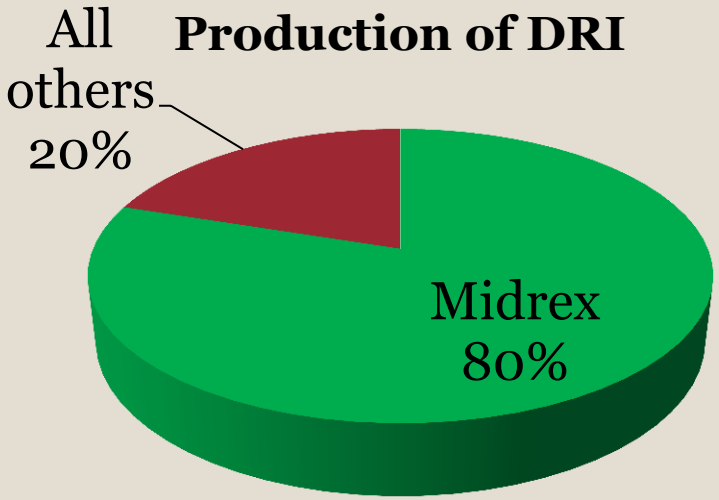
WSD/MB STEEL SURVIVAL STRATEGIES
TECHNOLOGY SESSION
SWISSOTEL, ISTANBUL
5 FEBRUARY 2013



Significance of Direct Reduction and of Midrex

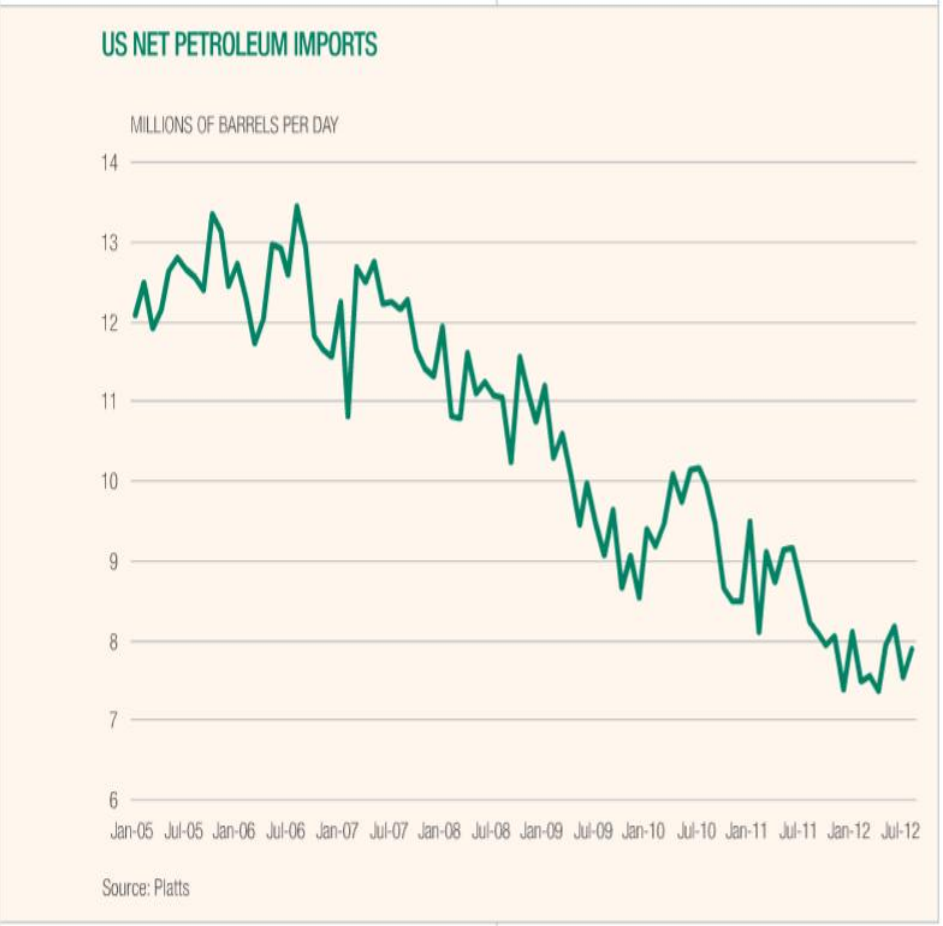
Direct reduction represents over one-half of new ironmaking capacity outside China for 1994-2010





The MIDREX® Direct Reduction Plants Produce 80% of the world's gas-based DRI

Let's start with one of the conclusions….



As recently as the summer of 2008, net petroleum imports into the United States were at an **annualized rate of ½ TRILLION dollars per year.**

Today,it is believed **the United States will be a net EXPORTER of energy by about 2020.**

This is a major modification to the world's economy.

The shale gas revolution will continue to have effects of this magnitude as it spreads Around the globe.

Where coal comes from.
And also where oil and gas come from.

Coal bearing rocks = shale gas bearing rocks

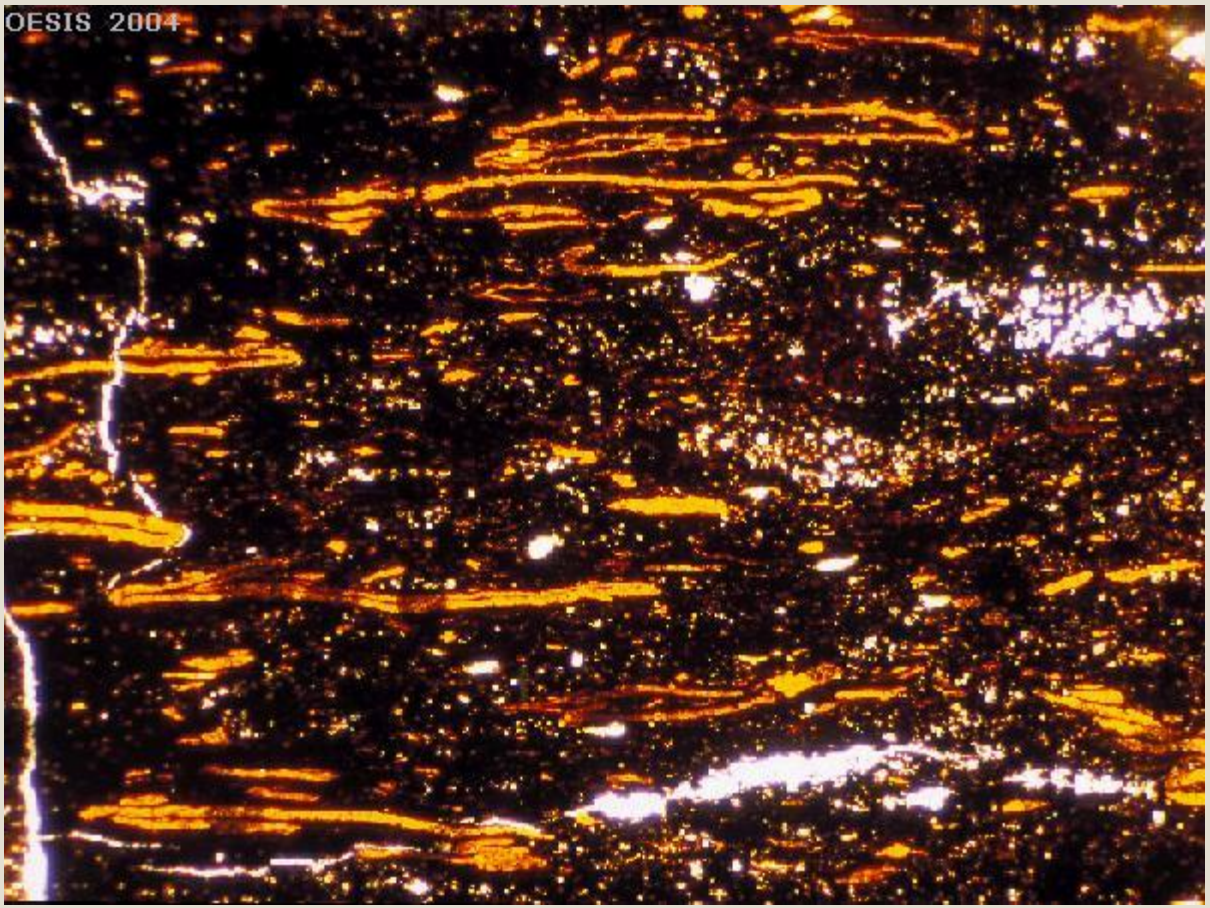
- Coal and petroleum and natural gas all derive from the same general types of geology; sedimentary basins.
- So, even if you don't have traditional petroleum and gas resources, **IF** you have coal bearing rocks, you very likely will also have shale gas nearby.

The shale and the coal are not discreet and separated, like they appear in the grade school texts.
They're mixed together at all scales of size from microscopic up to the size of city blocks.
Sometimes the coal has shale in it. Sometimes the shale has coal in it. Under heat and pressure and with a little bit of water around, the heavy hydrocarbons in coal can break down to produce lighter hydrocarbons, including METHANE.
IF the shale has enough coal in it to be "black shale", there might be enough methane to be of commercial interest.
And **IF** the shale is coarse grained and porous enough to allow gases to move through it, perhaps the methane can be collected.

These are important "if's". Currently, even with the enormous technological breakthroughs it is typically possible to collect about 5% to 10% of the gas in shale. The CEO of Exxon says he believes further advances in technology will allow us to recover perhaps 10% to 20% within the next few decades. The major advance that is needed is to more thoroughly fracture the rock and to do so over a larger volume of rock.

Look at all the little seams of shale

Shale and coal are mixed at all scales all the way down to micron sized



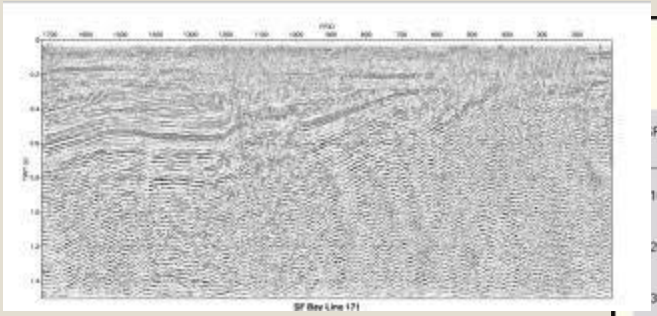
Five technologies

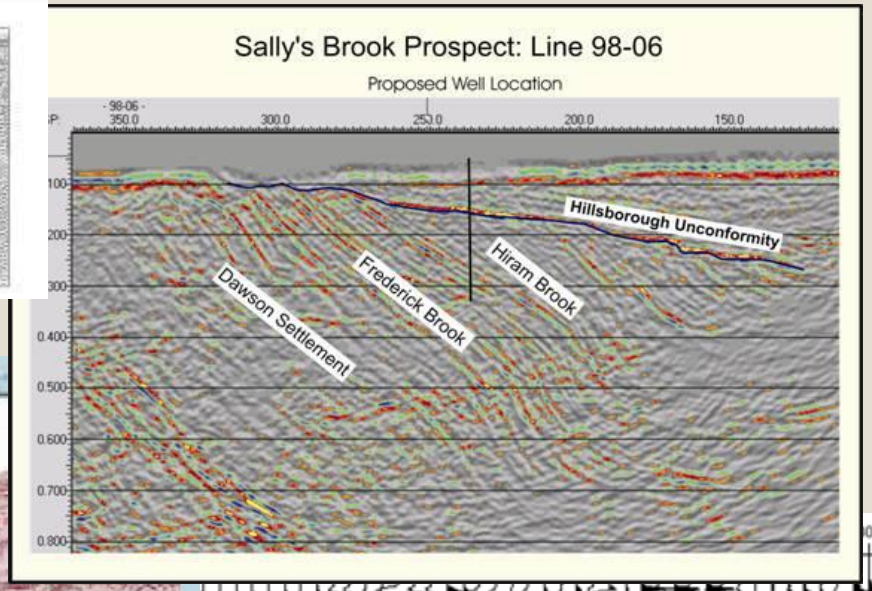
- **BIG, fast computers …. Large scale computation, much higher resolution and accuracy of seismic imaging**
- **Multi-hole wells**
- **Directional and Horizontal drilling**
- **Downhole instrumentation**
- **Fraccing … hydraulic fracturing of SOURCE ROCK**

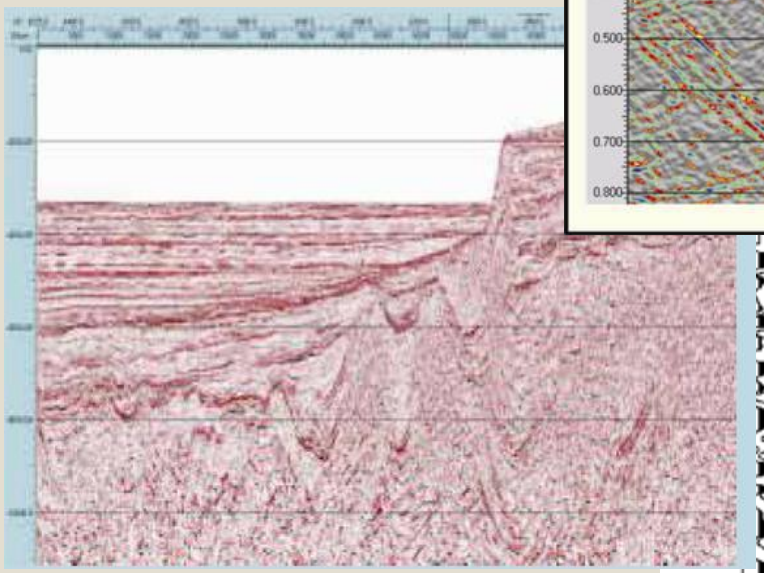
…… THE MOTHER LODE

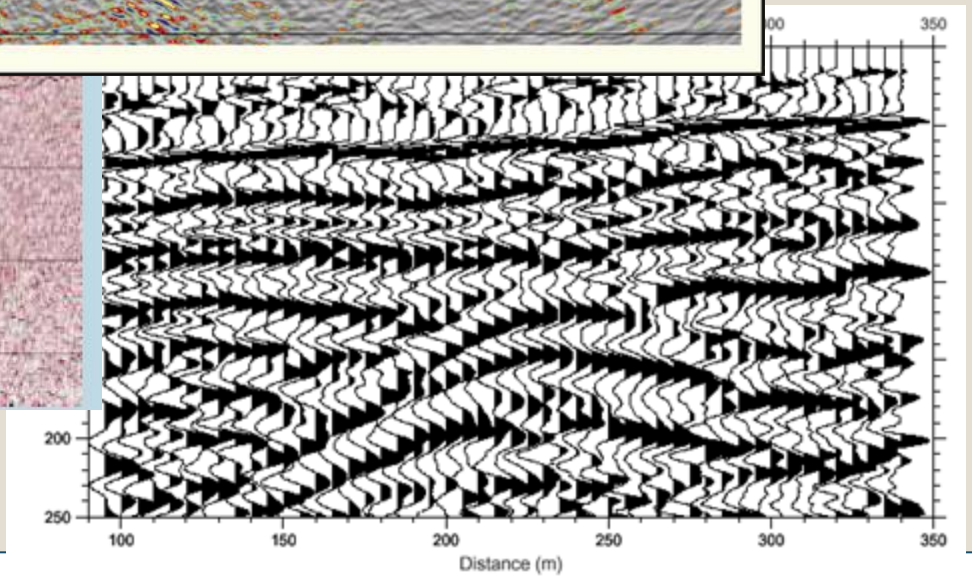
- **Let's add a sixth technology: fraccing's 'little brother', propping …. The pumping of sand into the fractures to hold them open**

Seismic reflection data until just a few years ago

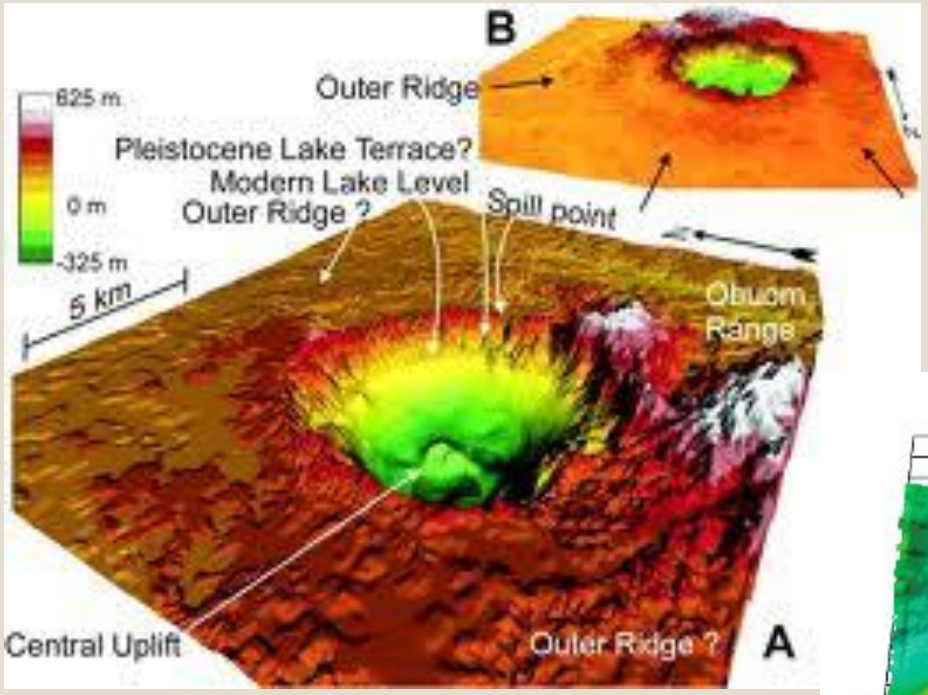


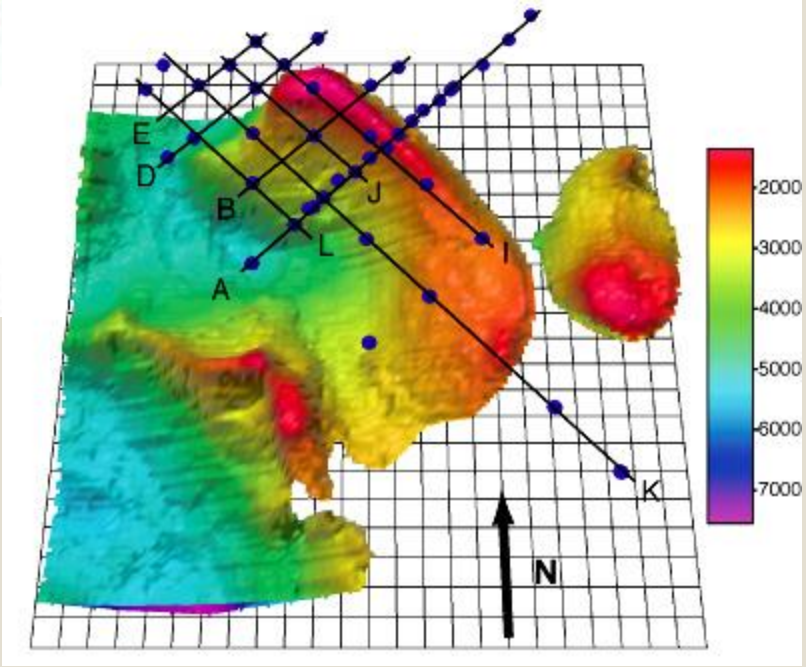




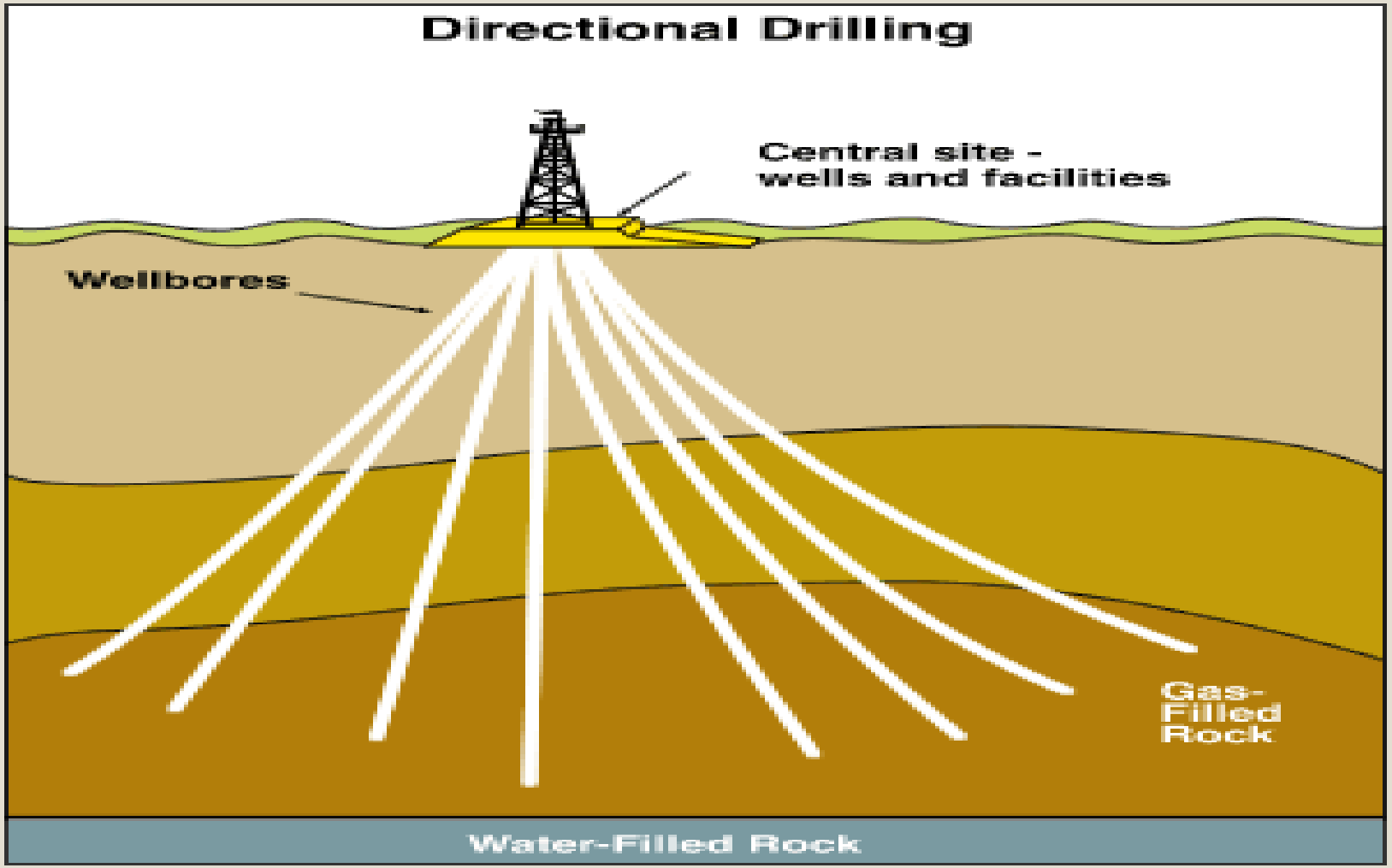


today



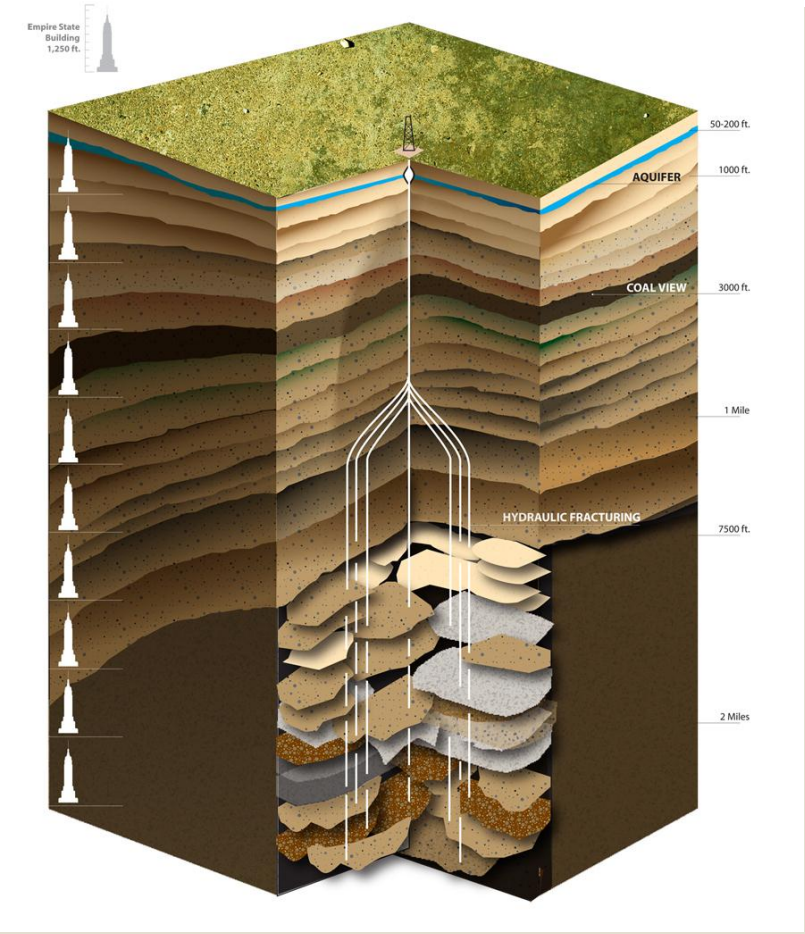


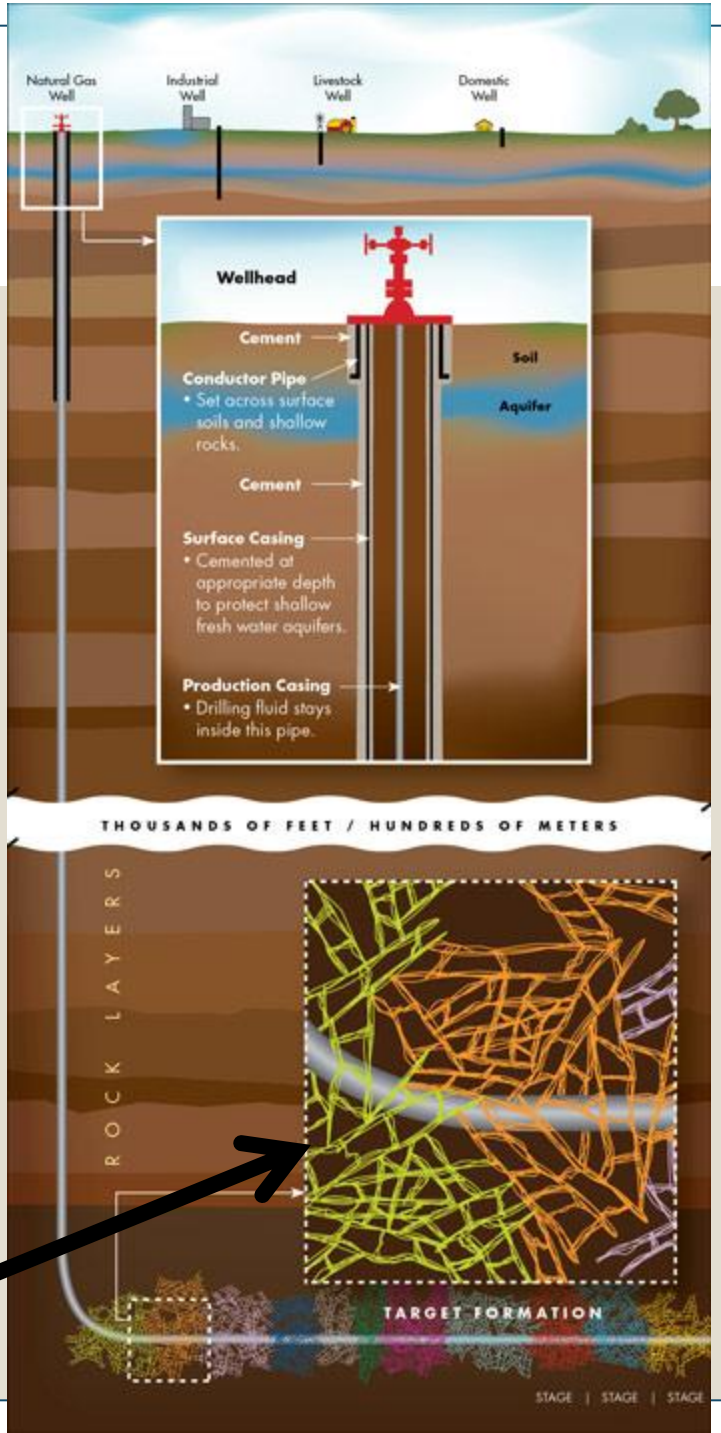
Multi-hole wells and directional drilling



Fraccing (sp?)

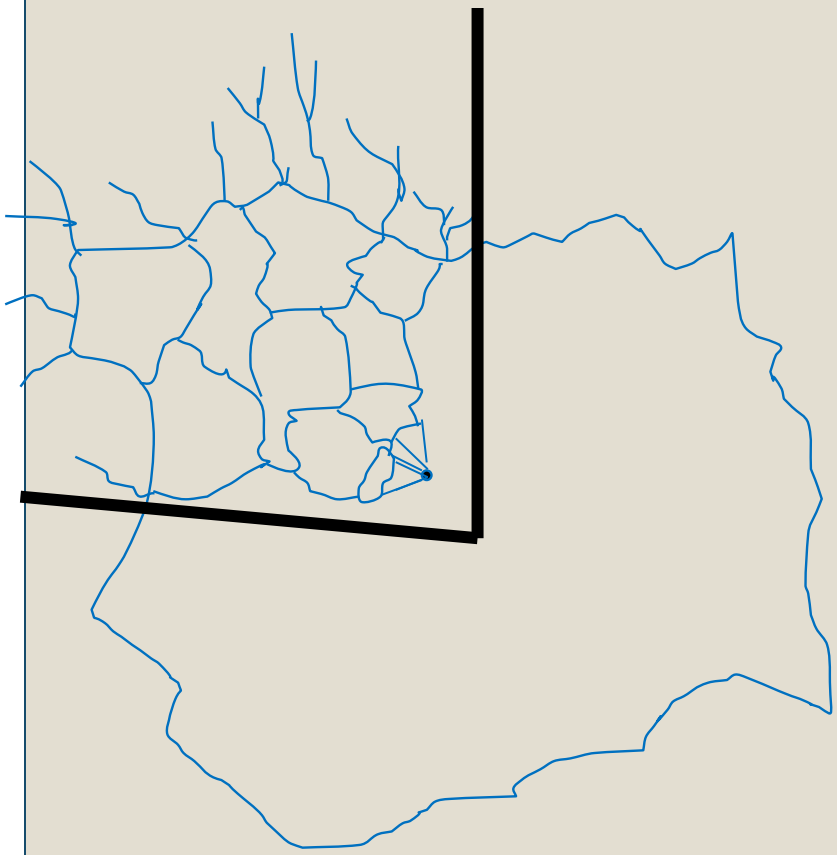
MIDREX

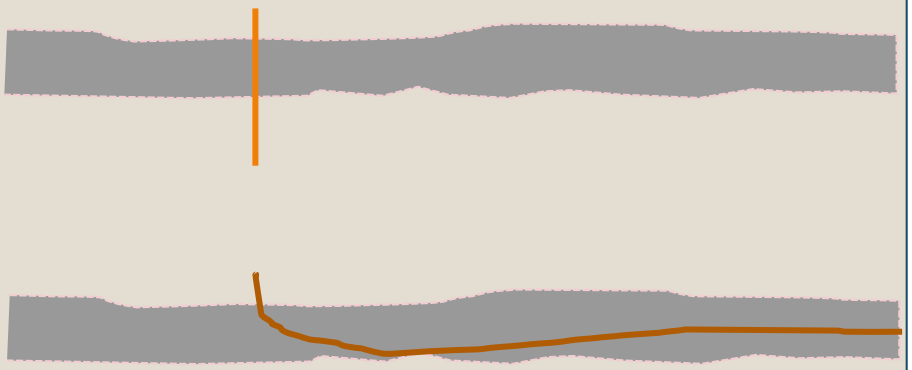




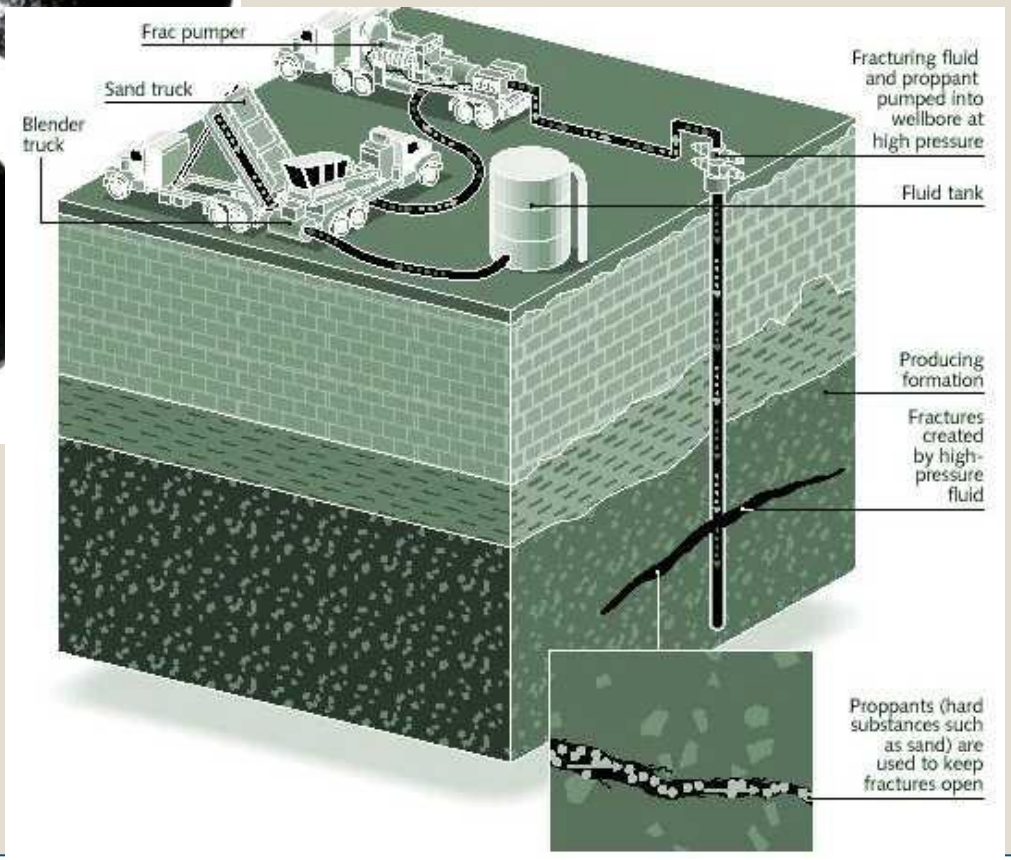
When they do it right

The key is the surface area of the hole you drill as you pass through the ‘pay zone’





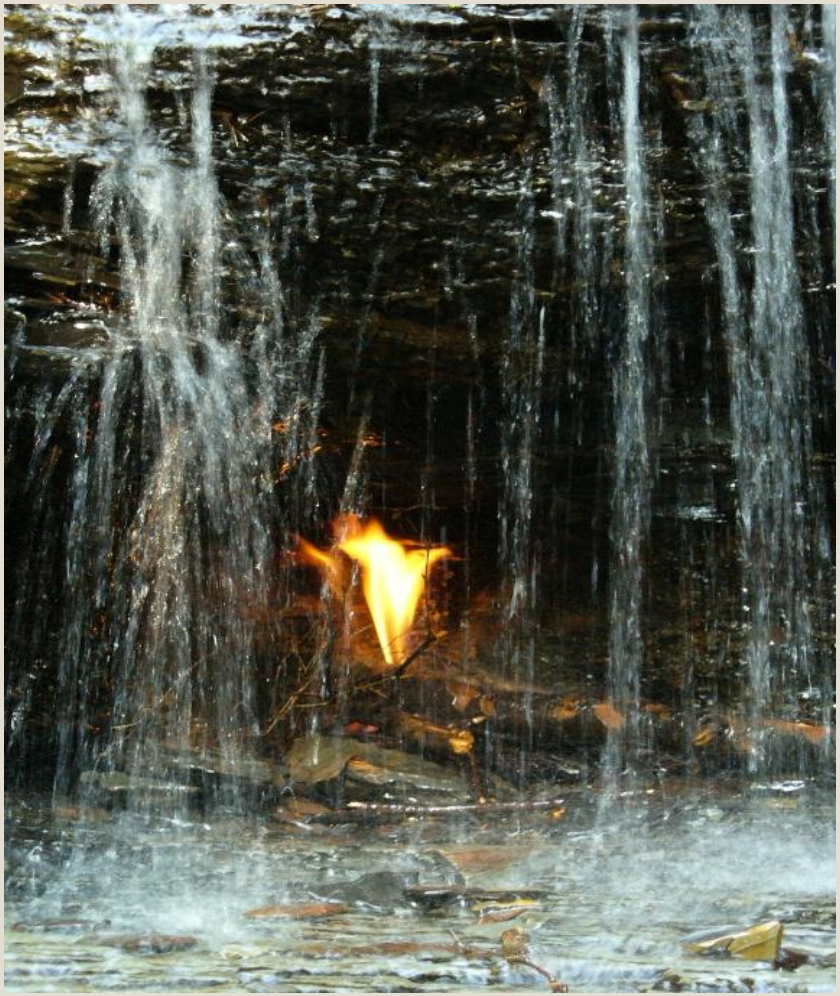
And then, they pump some magic sand into the cracks



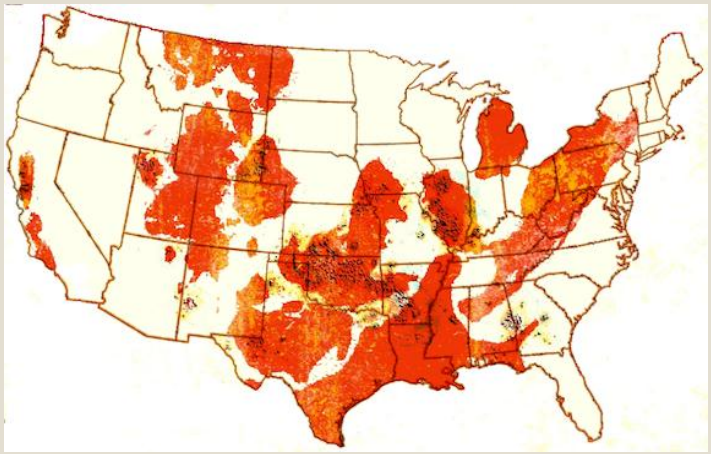
Let's talk about environmental problems

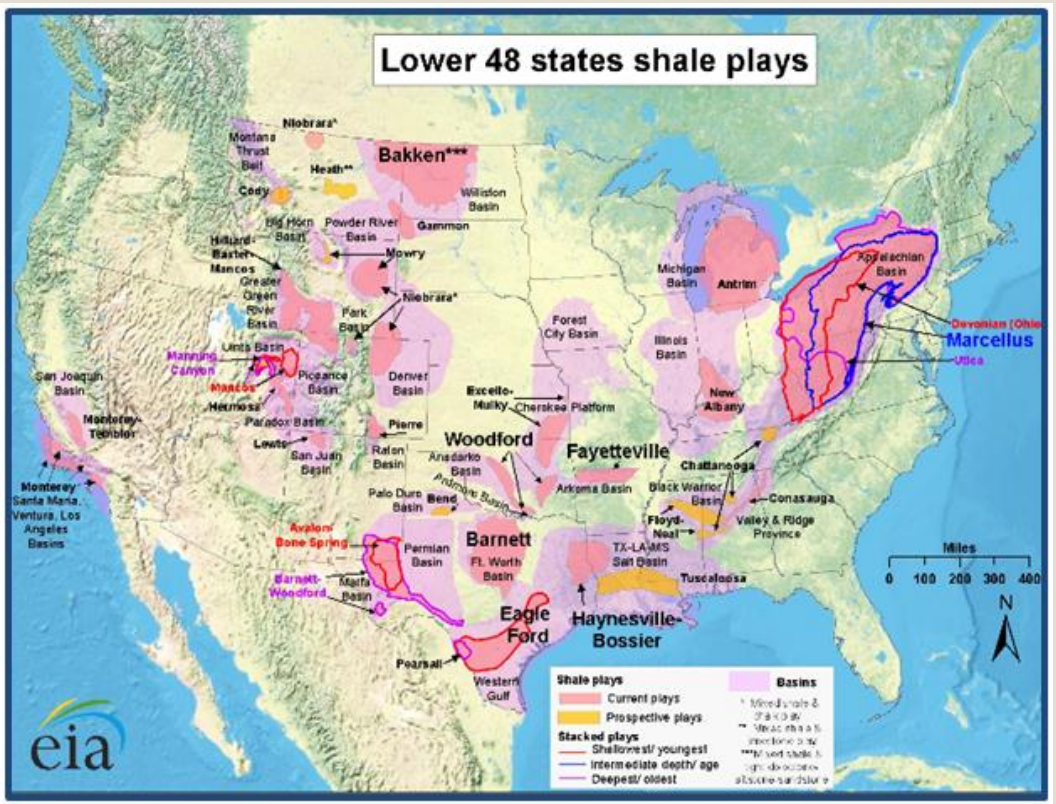
- Today, nearly half of the U.S.'s onshore natural gas is coming from shale gas and other "tight formations"
- Yes, there is risk of …
  - Improper cementing, that is sealing, of wells which leads to possible contamination of ground water
  - Earthquakes
  - Trucks driving across fields and through the woods
- But, perhaps the biggest real concern is that methane tends to leak out of pipe connections when they're poorly done or decayed by age and rust

In Shale Gas Country, methane leaks from the ground naturally. Someone lights this seep in the middle of a waterfall every year. It is about 10 miles south of Buffalo, New York.



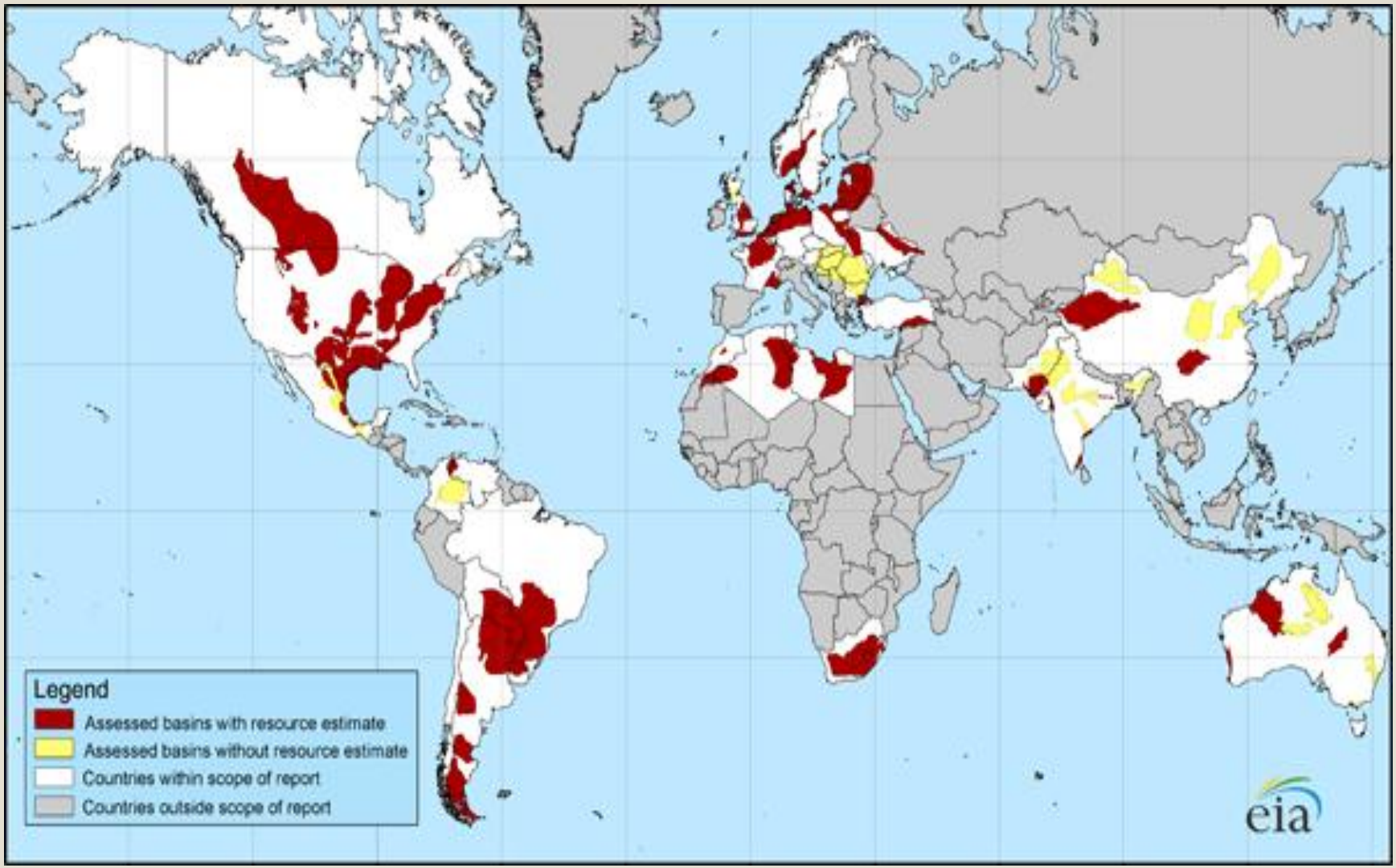
Where is shale gas? Wherever there is coal.





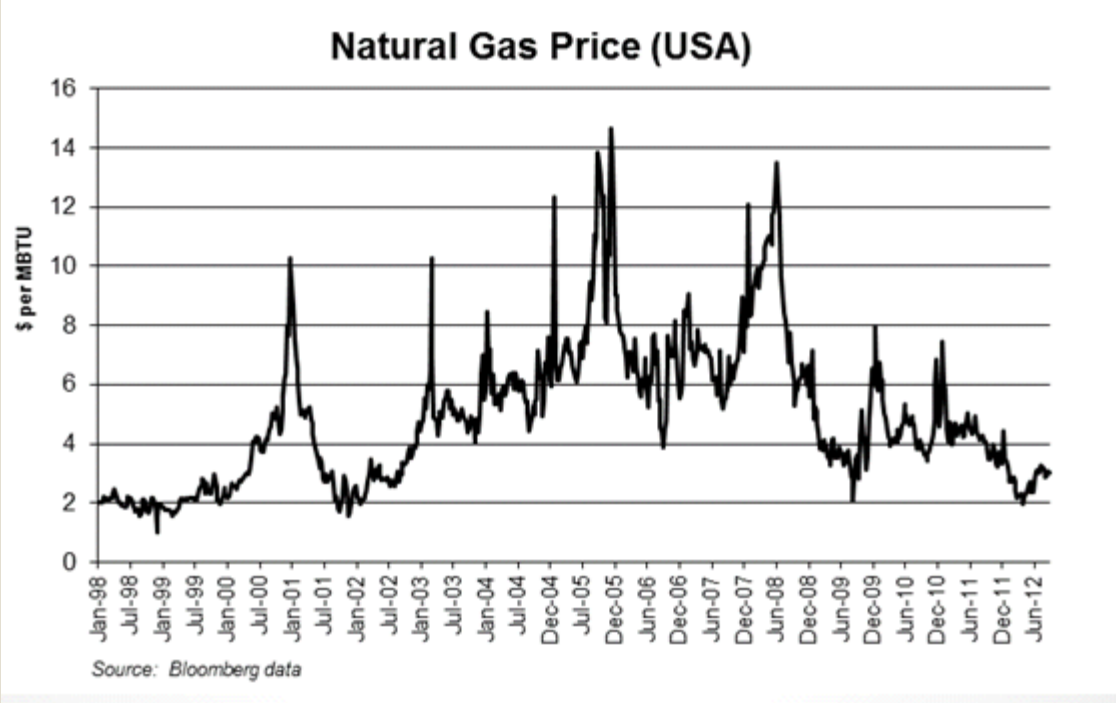
Map by the Energy Information Administration showing the breadth of shale gas operations in the Lower Forty-eight.

An even bigger part of the story

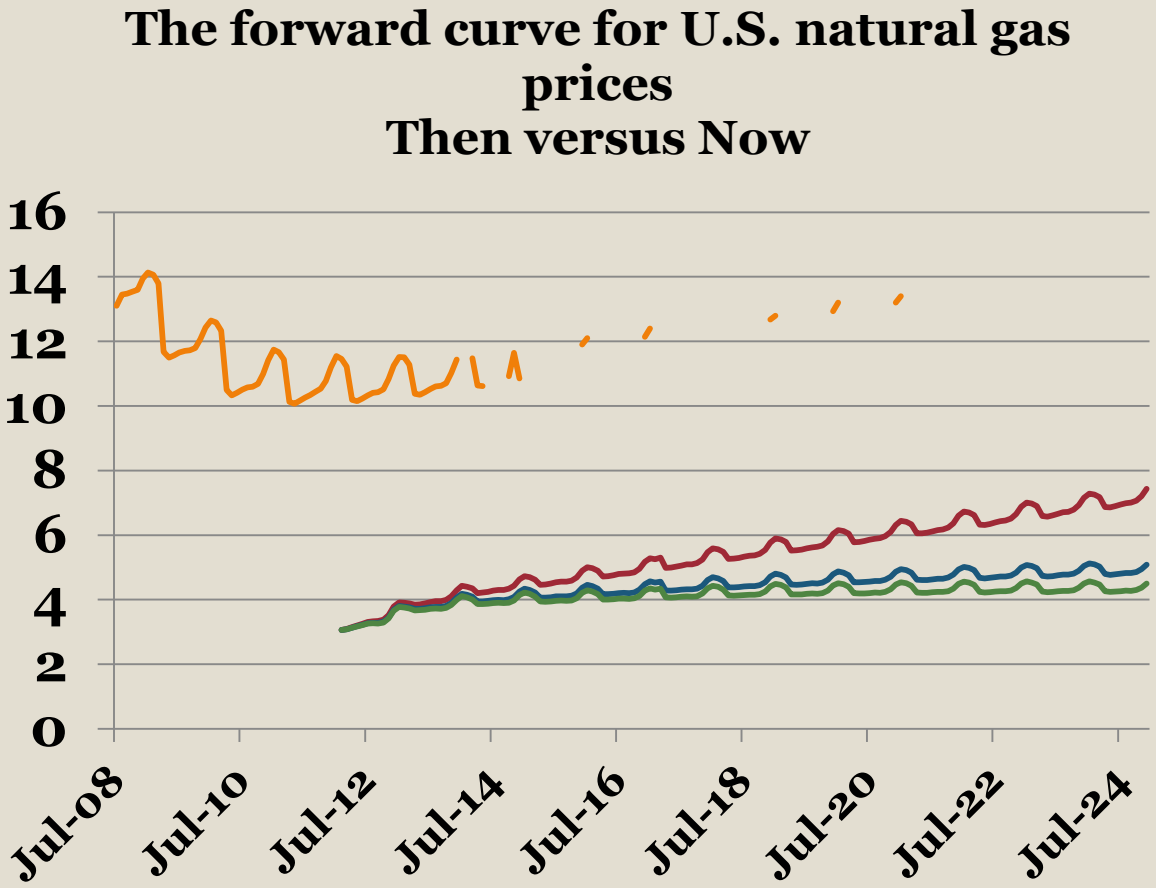


Price of Henry Hub NG

- End of 1st half 2008, gas was selling for over $12 per million btu's
- Yesterday, at noon, the contract for delivery of gas in May 2013 was trading at $3.40 per million btu's



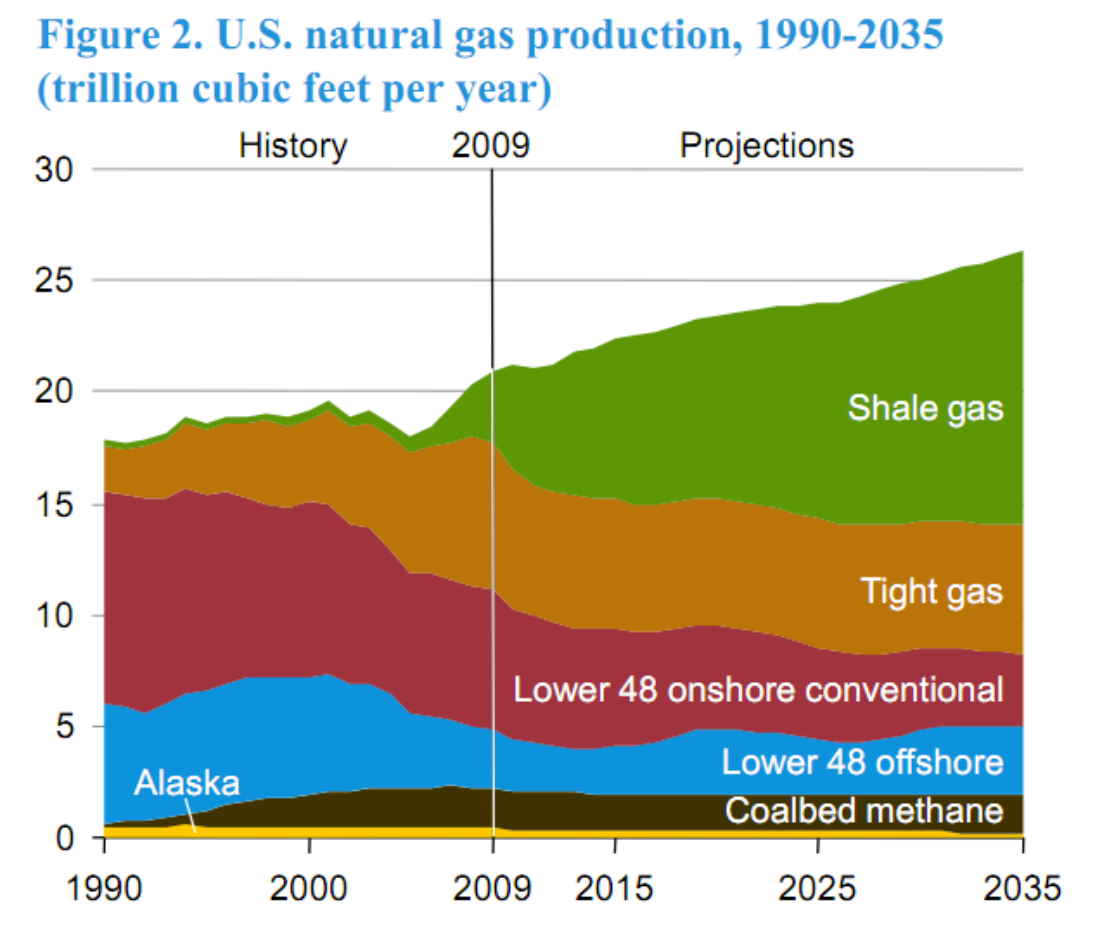
But that wasn't the big story, this is.



Now, consider inflation. Contracts are settled in current dollars. How much is a 2024 dollar going to be worth?
Lower two lines are 2012 dollars if inflation runs at 3% and 4%.

We've only just started producing shale gas on a truly national scale.

Note: small amounts were being produced decades ago.



The techniques for developing a shale gas well are just an extension of the techniques used for quite some time to get gas from "tight formations".

- So, what does this mean for our steel industry?
- Is there anything special about the United States which has made its situation any different?

The United States

- One enormous difference.

  - In general, mineral rights in other nations are held by governments. In the U.S., they're held by individuals. I own the mineral rights in my garden right down to the center of the earth.

  (lots of iron and nickel down there, and it's metallic iron and metallic nickel …. I'm sitting on nearly 4T Dollars worth of Ni !!!!)

- So, what does this mean for our steel industry?

- **First, there's going to be an awful lot of seamless pipe needed.**

- World Steel Dynamics has identified a little over $2B of investment in the US steel industry directly related to shale gas, and a comparable amount announced but not yet fully contracted.

- For the general U.S. economy it is generally estimated the economic boost generated by so much lower cost fuel is worth about one-half percent per year growth in GDP. Since our real growth rate is running at between 1.5% and 2%, that half percent is quite significant.

- "In my 50 years of following the energy business, this is by far the biggest event that I've seen," says John Deutch, an MIT professor and a former CIA director who last year chaired a Department of Energy subcommittee on shale gas.

  - Fortune magazine

- And if we can get that seamless in place and on schedule,

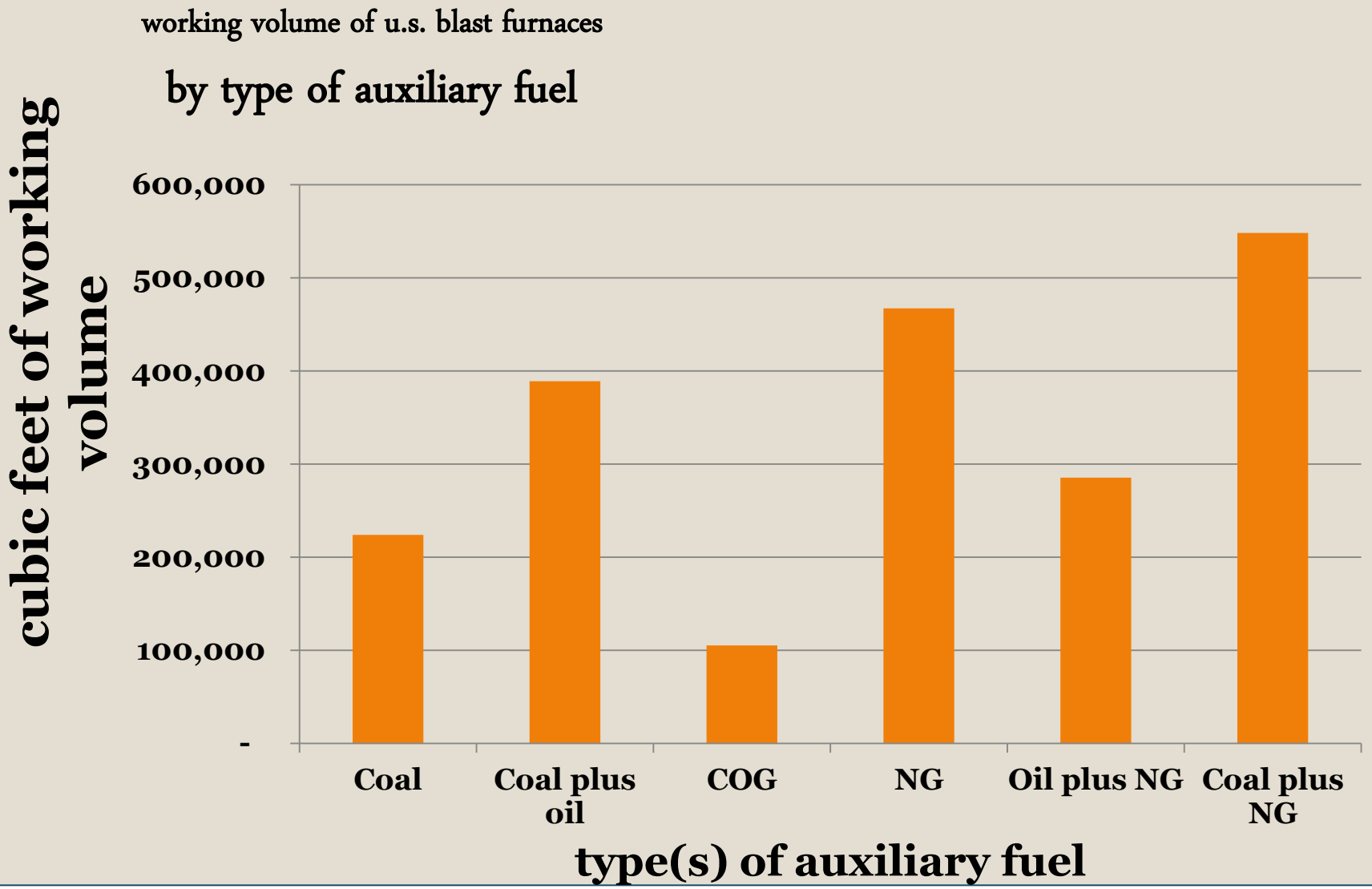
WE'RE GOING TO HAVE TWICE, YES THAT'S RIGHT, TWICE AS MUCH NATURAL GAS AVAILABLE IN 2020, AS WE'D PREVIOUSLY EXPECTED TO HAVE !!!!!!!!!!!!!!!

Ironmaking uses A LOT of energy

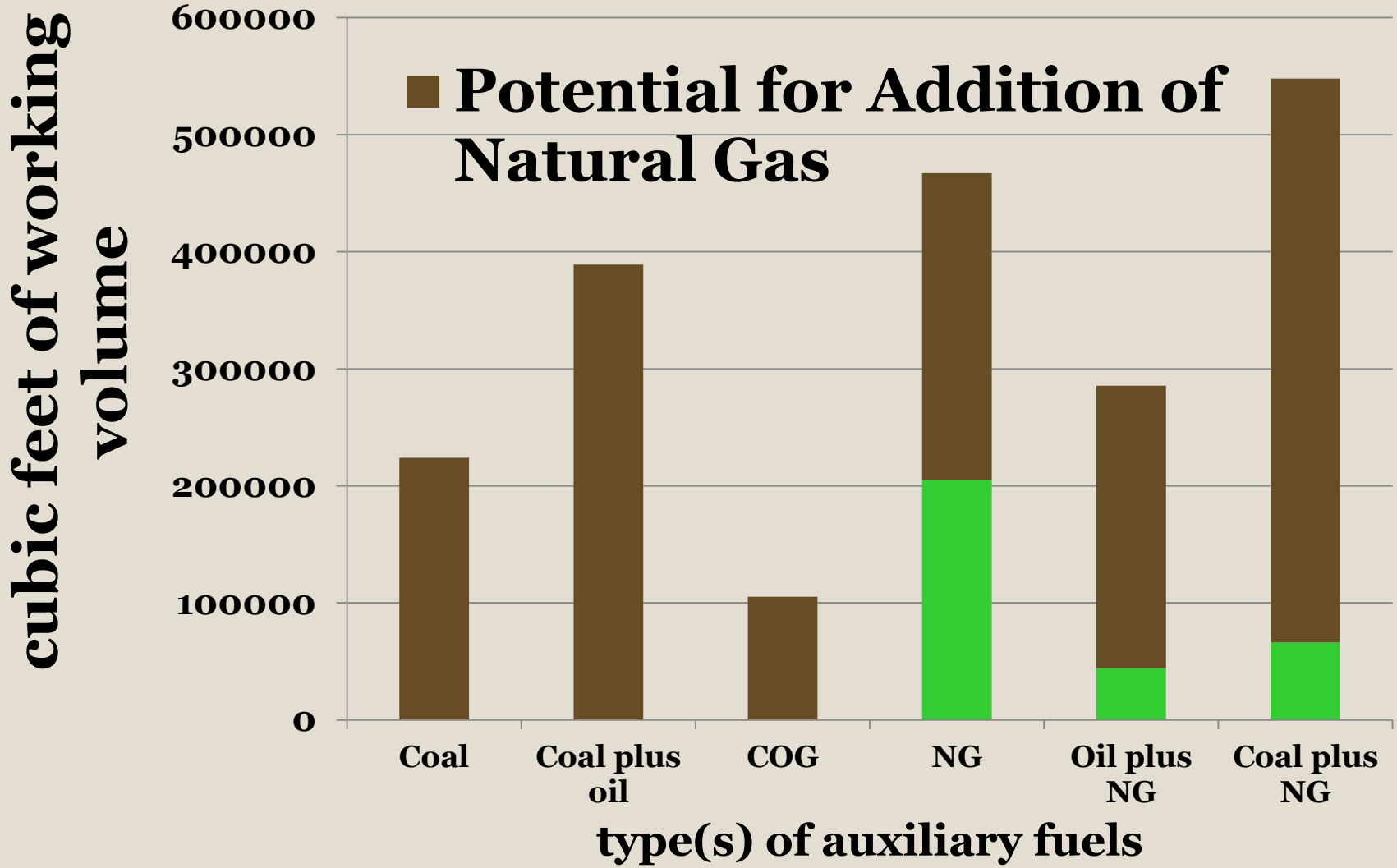
- **The steel works of this planet use six or seven per cent of all of the world's energy !!!!!!!!!!**
- Blast furnaces use the lion's share of it.

Trivia: The grand total of all automobiles and trucks in the world only use about 12% of the world's energy.

We're not going to lessen the amount of coke needed by the blast furnaces. There are sound technical reasons why they need it. BUT, we are going to see a big shift in auxiliary fuel toward NG. Typical auxiliary fuel consumption is about 150 to 200 kg per ton of hot metal.



Application of Natural Gas Relative to 'Best' Available Demonstrated Practice U.S. Blast Furnaces



European blast furnaces:

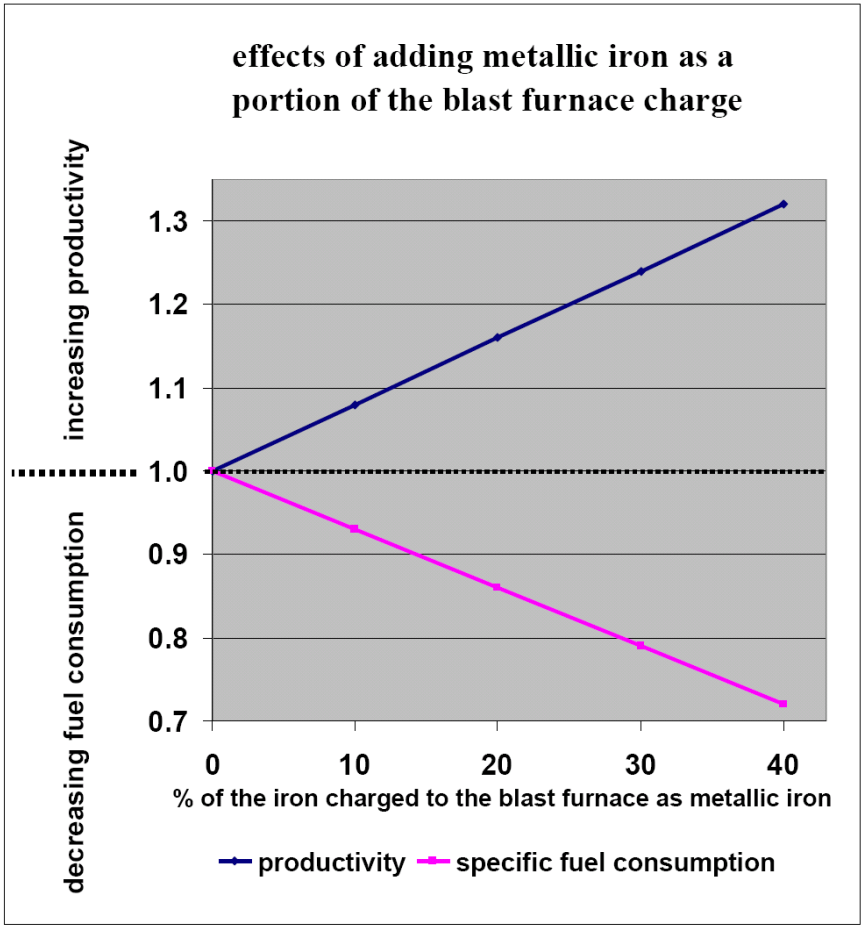
With the exception of a tiny share in France, Western Europe does not use natural gas as an auxiliary fuel. In contrast, it is the standard for Eastern Europe.

	approximate total volume of blast furnaces (m3)	fraction of auxiliary fuel that is natural gas
GERMANY	46,000	None
FRANCE	21,700	about 2 or 3%
BELGIUM	10,500	None
NETHERLANDS	7,600	None
UNITED KINGDOM	14,300	None
ITALY	11,300	None
SPAIN	6,500	None
AUSTRIA	9,600	None
SWEDEN	4,600	None
FINLAND	3,300	None
TURKEY	11,300	about one-fourth
POLAND	9,700	over half
CZECH REPUBLIC	6,100	None
SLOVAKIA	7,450	None
ROMANIA	6,700	?
HUNGARY	4,200	all
BOSNIA HERZEGOVIA	2,200	?
SERBIA & MONTENEGRO	3,200	half
RUSSIA	86,600	over 90%
UKRAINE	71,500	over 90%

‘Virtual natural gas’

- HBI added to the charge of a blast furnace is just like any other addition of metallic iron to the charge.
- All you need to do is melt the iron; it’s already reduced to the metallic state; the energy has been added prior to charging the blast furnace.
- AK Steel in Middletown, Ohio has been doing this for twenty years.
- Over the next decades, we will see this practice spread worldwide.

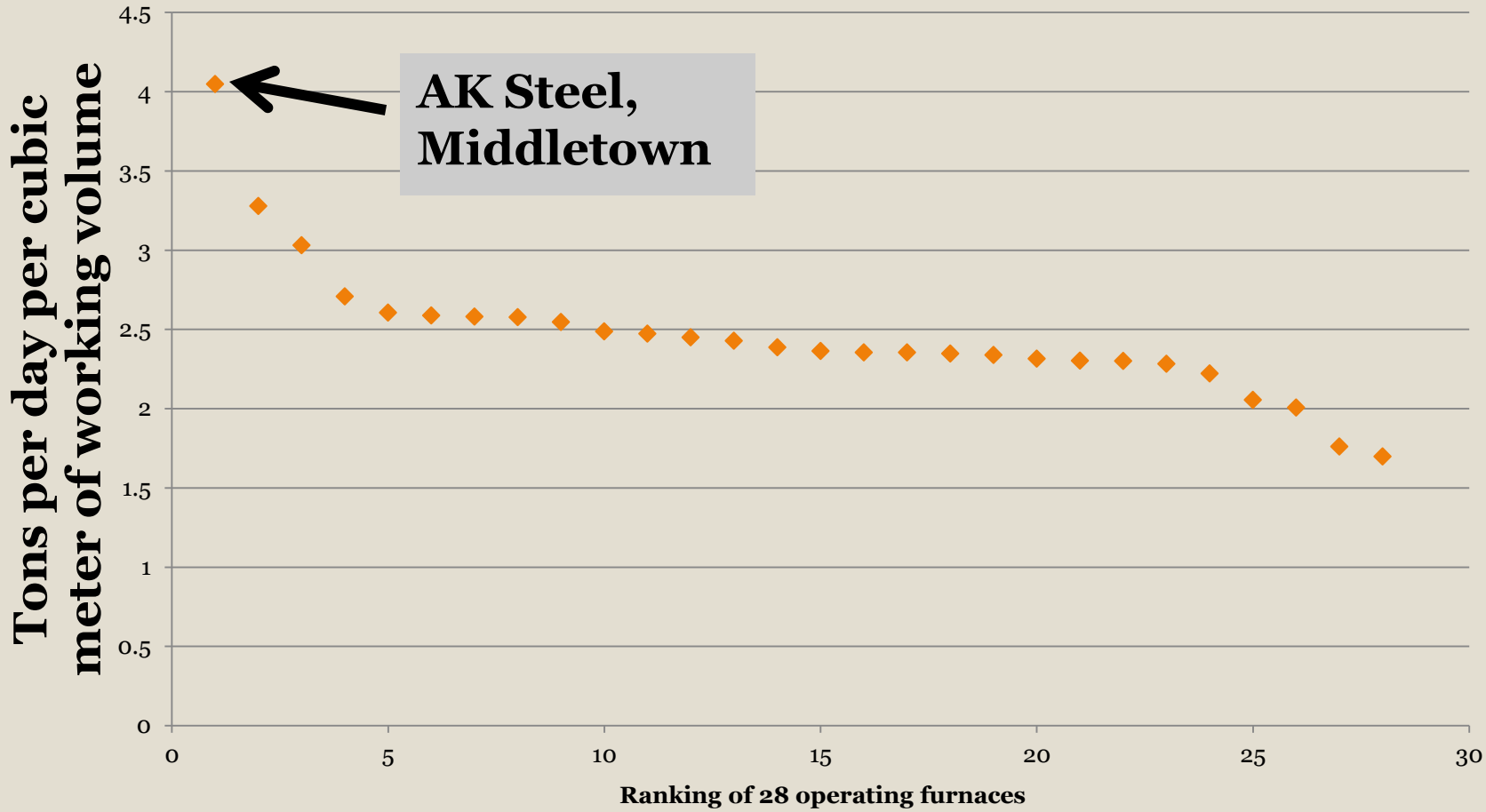
A very beneficial side effect of “virtual natural gas”



By the way, for that share of the iron that passes through the DR plant on its way to becoming blast furnace hot metal, the CO2 generation is cut in half.

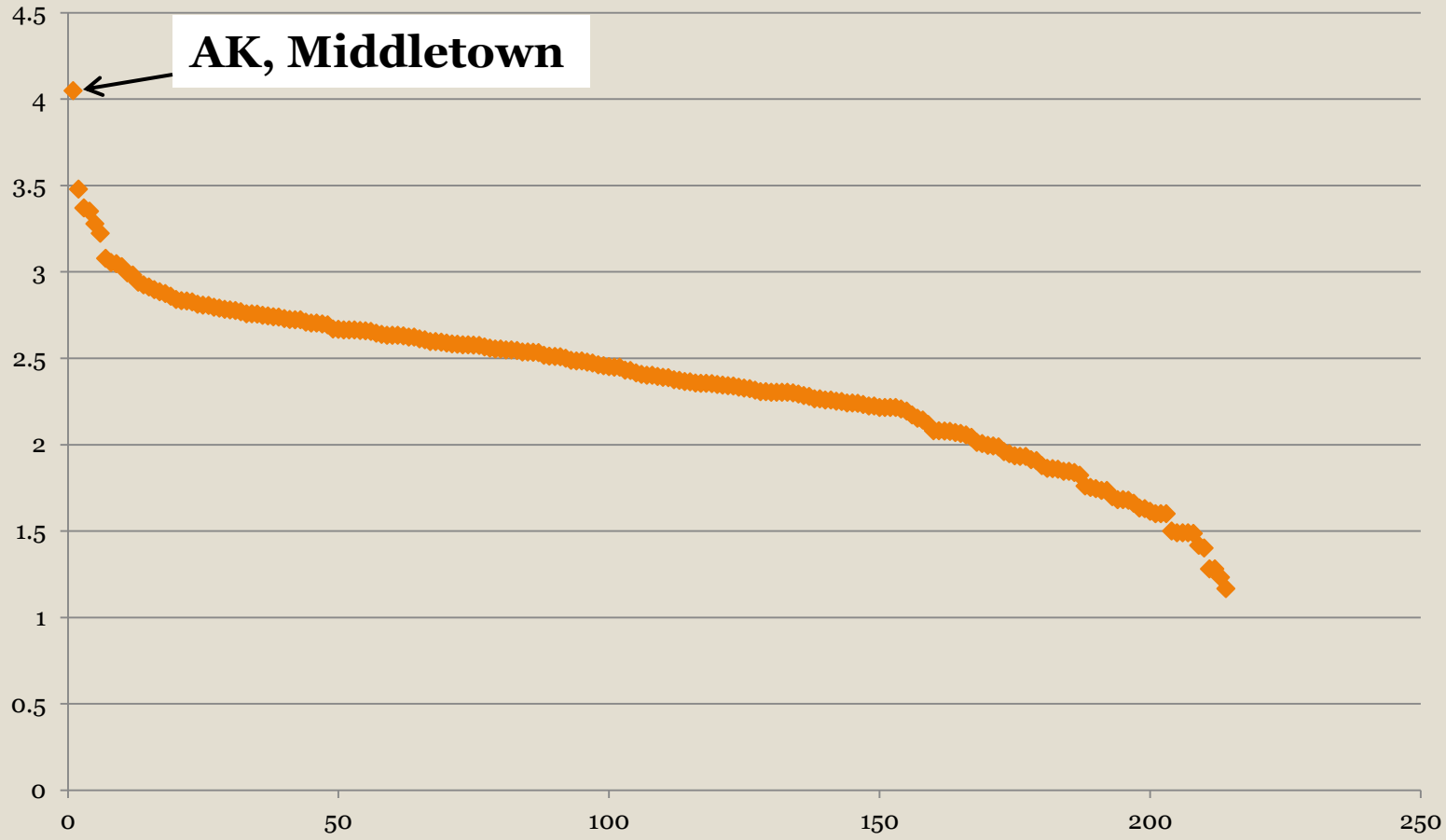
U.S. Blast Furnaces ranked by specific productivity

t/d/m3



And, for the world

tons per day per cubic meter of working volume



CO_2

- **Iron, when reduced in a Direct Reduction furnace and then melted in a Blast Furnace, causes generation of only ½ the carbon dioxide of iron reduced and melted in a blast furnace.**

Thank you.

The crystal staircase of the Dolmabace palace.

Just across the street from the Swissotel.