Will Unconventional Natural Gas Save Us?

Posted by Dave Cohen on March 10, 2006 - 1:41pm
Topic: Supply/Production
Tags: coal bed methane, deep gas, lng, methane hydrates, natural gas imports, shale gas, tight gas, unconventional natural gas [list all tags]

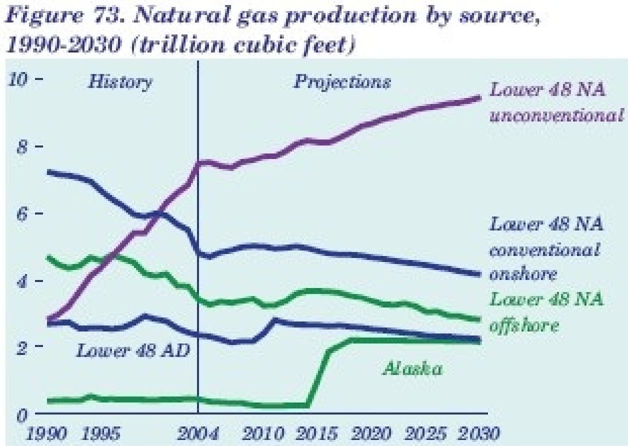
Here we go again, this story is about natural gas supplies in North America and the US in particular. Lately, TOD has had some posts on Liquified Natural Gas (LNG) imports as the way to solve the North American natural gas crisis (here, here and here). The point of these posts concerning LNG is that there are real unavoidable concerns that LNG imports will not provide us with sufficient supply to meet inelastic demand soon enough by 2010 or even come anywhere close to meeting these supply problems in the period beyond the end of this decade. Beyond oil and the apparent world-wide peak in light sweet crude, the more I think about our energy problems, the more I come to the conclusion that natural gas shortages in North America are imminent in the timeframe beginning now and for the forseeable future (perhaps 5 to 10 years out or beyond). The damage this could do to the US economy is enormous. In my view, there is a real crisis pending so this post examines another whole part of the equation in future projections for providing natural gas to meet projected demand involving drilling for Unconventional Natural Gas Resources (pdf)-- an **overview** of what these resources are. The importance of unconventional gas (pdf) is expected to grow out to 2025.

I hope you'll bear with me here. This is one of those really long posts I do from time to time to try to understand an important issue I didn't know much about. I even try here and there to emulate HO's "techie talk" tradition here on TOD though with, I'm sure, limited success.

Generally speaking, the EIA expects increases in US natural gas supply to come from three new sources.

- Liquified Natural Gas (LNG)
- The proposed Alaska pipeline
- Unconventional Gas in the Lower 48

Consider this graph from the EIA AEO 2006 report on future US domestic natural gas supply (pdf).



EIA domestic US natural gas supply -- Figure 1

Here's a relevant quote from the National Energy Technology Laboratory (NETL)

> Despite seemingly large resources, we are becoming increasingly dependent on imports (imports' share of gas supply has tripled since 1985, and imports' share of oil supply has jumped to almost 60% from 27% in 1985). More importantly, the domestic industry has been unable to increase production despite strong price incentives and increased drilling.
>
> The root cause of this difficulty is the progressive change and difficulty in producing the remaining resource base. Industry has picked much of the Nation's "low-hanging fruit," and remaining resources are increasingly found both in deeper, more remote, more complex reservoirs (high cost and high risk), or in shallow, drilling-intensive, low-productivity reservoirs....

and also this quote from the EIA AEO 2006 overview.

> Lower 48 production of unconventional natural gas is expected to be a major contributor to growth in U.S. natural gas supplies. Unconventional natural gas production is projected to account for 45 percent of domestic U.S. natural gas production in 2030, as compared with the AEO2005 reference case projection of 39 percent in 2025. In AEO2006, however, unconventional natural gas production is lower in the mid-term (between 2006 and 2020) than was projected in AEO2005. The lower levels of production in AEO2006 before 2021 reflect a decline in overall natural gas consumption in response to higher prices. Starting in 2021, the projected levels of unconventional natural gas production in the AEO2006 reference case are higher than those in AEO2005, reaching 9.5 trillion cubic feet in 2030.

Note from *Figure 1* that conventional gas production from shallow-depth (onshore or off), permeable and porous deposits are depleting rapidly and will play less and less a part of the US supply no matter how many wells are drilled. You can also see that offshore production from the Gulf of Mexico will peak around 2012 or so and decline thereafter. *Lower 48 AD* in *Figure 1* refers to "production of associated-dissolved (AD) natural gas from lower 48 crude oil reserves" and declines from 2.4 trillion cubic feet in 2004 to 2.3 trillion cubic feet in 2030 according the EIA. So, there are two rising trends in this graph: 1) Alaskan supply (assuming the pipeline) after about 2014 and 2) unconventional gas recovery over time. Of course, LNG imports are not shown here and have been adequately covered in other TOD posts.

This story is attempts to explain what *unconventional natural gas* is and how much its production will affect future US supply. This seems appropriate in so far as HO has mentioned the Barnett Shale Gas project lately. As *Figure 1* indicates, expectations are high. What can we expect from production of domestic natural gas from unconventional sources to meet increasing US demand over the next 20 years?

First, let's list what the unconventional natural gas sources are.

- Coal Bed Methane
- Deep Gas (onshore or offshore in the GOM)
- Tight Gas Sands
- Shale Gas (from Devonian or Carboniferous sediments)
- Geopressurized Zones
- Methane Hydrates
- Coal gasification to make *syngas* (added to this list)

What constitutes an "unconventional source" is fluid and depends on economics (price) and technology, as our **overview** source cited above makes clear.

> So what exactly is unconventional gas? A precise answer to that question is hard to find. What was unconventional yesterday, may through some technological advance, or ingenious new process, become conventional tomorrow. In the broadest sense, unconventional natural gas is gas that is more difficult, and less economically sound, to extract, usually because the technology to reach it has not been developed fully, or is too expensive.....
>
> Therefore, what is really considered unconventional natural gas changes over time, and from deposit to deposit. The economics of extraction play a role in determining whether or not a particular deposit may be unconventional, or simply to costly to extract....

Unconventional gas already plays an ever-expanding role in US production as this graphic from the World Oil (January 2006) publication What's New in Production makes clear.

Unconventional natural gas production -- Figure 2

As you can see, there is no mention of coal gasification, which has been discussed on some recent threads like Coal gasification in National Geographic. I had added this arbitrarily to the list just *emphasize* that as far as I can see, production of syngas *does not figure much* in the future natural gas supply equation at least as the EIA is concerned. This may change, however. In addition, though the NETL has research program for methane hydrates, this source will not be a part of future US supply. My general analogy in this case is that the other unconventional natural gas sources are akin to the Canadian tar sands--they are in production and that production will increase. Coal gasification is a bit further along in the prototype stage but will not substantially add to future US supply. Production of natural gas from methane hydrates or geopressurized geothermal aquifers reside on the pie-in-the-sky part of the spectrum. Both of these sources seem to have just about the same status as oil production from kerogen embedded in marl rock, a source that is also known as oil shales. I doubt there is any prospect of increasing the North

American natural gas supply from either source by 2025.

This post will focus on the unconventional natural gas resources referred to as *Coal Bed Methane*, *Shale Gas*, *Tight Gas* and *Deep Gas*. Below I provide a description of what the issues and current status are for each unconventional sources considered here. But before going into some detail, it is worth noting that the Rocky Mountain region does and will continue to play a pivotal role in future unconventional gas production as this quote from Tight Gas Technologies for the Rocky Mountains indicates. Read this pdf document from NETL's GasTIPs for the details.

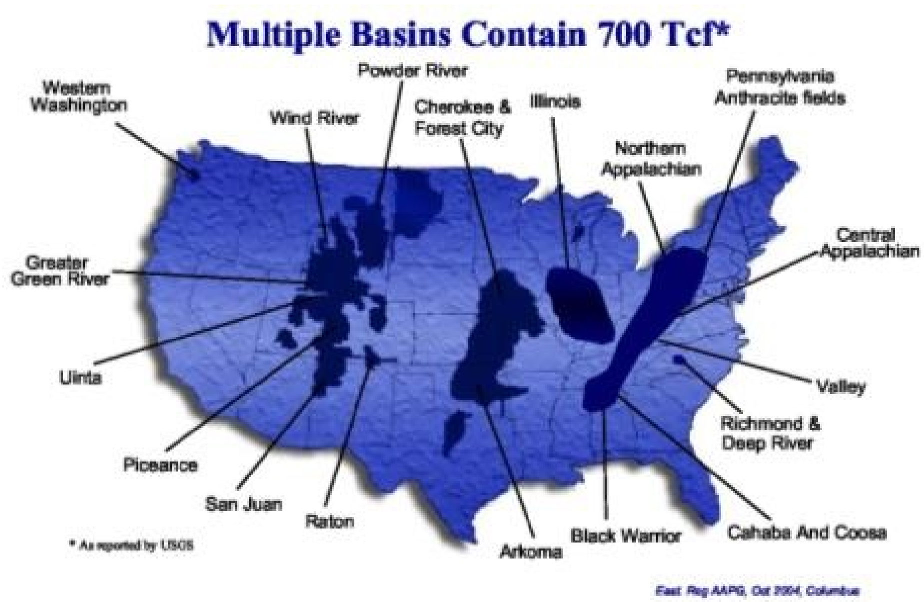
> As new discoveries from conventional supplies decline, future supplies of natural gas will increasingly have to come from unconventional reservoirs - and several Rocky Mountain basins (Greater Green River, Piceance, Wind River, and Uinta) contain significant volumes of such resources (tight gas sands and coal seams in particular).

Coal Bed Methane

NETL provides an excellent summary of the nature and production of Coal Bed Methane (CBM).

> Once a nuisance and mine safety hazard [a story from HO], coalbed natural gas (CBNG) —also referred to as coalbed methane—has become a valuable part of our Nation's energy portfolio. CBNG production has increased during the last 15 years and now accounts for about a twelfth of U.S. natural gas production. As America's natural gas demand grows substantially over the next two decades, CBNG will become increasingly important for ensuring adequate and secure natural gas supplies for the United States.
>
> CBNG is the gas found in coal deposits. It consists mostly of methane but may also contain trace amounts of carbon dioxide and/or nitrogen. Most coalbeds are permeated with methane, and a cubic foot of coal can contain six or seven times the volume of natural gas that exists in a cubic foot of a conventional sandstone reservoir.

They also provide a nice map of where this resource can be found.



Sources of Coal Bed Methane -- Figure 3

Note that of those 700 tcf, only 100 Tcf are considered to be economically recoverable. But estimates vary a bit. This nice presentation, Overview of Unconventional Natural Gas and its Impact on Supply (pdf) estimates that 300 tcf are technically recoverable and that 110 tcf can be produced by 2020.

So, this would all appear to be good news. But in reality, production of Coal Bed Methane is fraught with problems. Here, we'll concentrate on production in Wyoming's Powder River Basin because these problems are evident there. A remarkable story from Forbes, a partial reprint from Oxford Analytica (pay for play) tells a remarkable story about CBM production and outlines the associated problems. Here are brief descriptions of those problems.

- Well Spacing --

  > For example, in the Powder River Basin of Wyoming, an area of approximately 9.1 million acres of formerly pristine rangeland, more than 15,000 wells have been drilled. Servicing these wells requires a network of 32,000 miles of roads and 73,000 miles of pipelines and power lines.

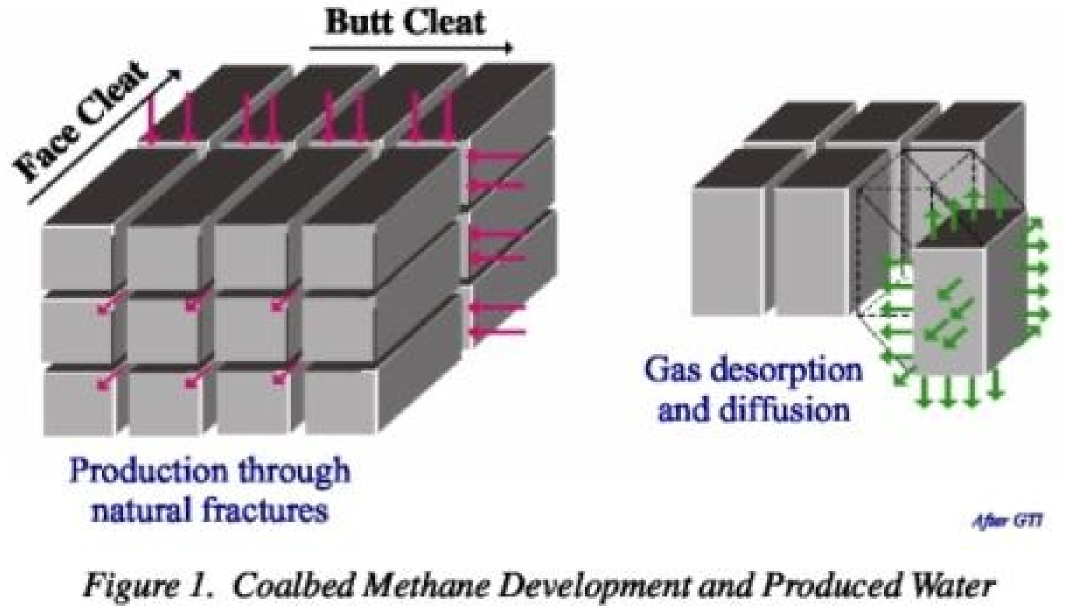
  Imagine this.

- Property rights -- it's simple really. Somebody lives there (they have the surface rights) but somebody else owns the mineral rights. And they have pretty much free reign to do whatever they want, including trashing the environment which residents cherish. Oh, you know that 10 acres out back you loved so much? Now there's a pipeline and a maintenance road running right through it...

- Government disputes -- "... the lion's share of the revenues generated by CBM exploitation will accrue to the federal and state level, while the direct impacts of development fall within local government jurisdiction". You get the idea.

- Water -- Last but not least. "The volume of water produced by CBM production is staggering. For example, in the Wyoming Powder River Basin alone, over 1.5 billion gallons of water is produced daily". Imagine this, too.

Let's look at the water problem in more detail following the great HO "techie talk" tradition. Again from the NETL article, here's a graph with some accompanying explanations.



Coal Bed Methane Production & Water -- Figure 4

From the NETL source.

> Vertical and horizontal wells, including multi-laterals, are used to develop CBNG resources. For the most part, the quality of a seam's cleat system (high-conductivity flow paths) will dictate the type of well completion and stimulation employed. In high-permeability settings, flow enhancement may not be required. In other situations, hydraulic fracturing and cavitation stimulations are used.
>
> Hydraulic fracturing is a process in which fluids, primarily water, are pumped at high pressure, creating a crack through which natural gas can flow easily into a well. The cavitation method involves enlarging the original wellbore and linking the wellbore with the cleat system within one or more coal seams. In all cases, water initially must be pumped out of the coals (dewatering) in order to reduce the reservoir pressure and allow the methane to desorb.

And where's all this water coming from? They put some in--and we can ask where do they get that--and they produce a lot more coming out. From [Coalbed Methane--An Untapped Energy Resource and an Environmental Concern](#).

> Most gas in coal is stored on the internal surfaces of organic matter. Because of its large internal surface area, coal stores 6 to 7 times more gas than the equivalent rock volume of a conventional gas reservoir. Gas content generally increases with coal rank, with depth of burial of the coalbed, and with reservoir pressure. Fractures, or cleats, that permeate coalbeds are usually filled with water; the deeper the coalbed, the less water is present, but the more saline it becomes. In order for gas to be released from the coal, its partial pressure must be reduced, and this is accomplished by removing water from the coalbed. Large amounts of water, sometimes saline, are produced from coalbed methane wells, especially in the early stages of production. While economic quantities of methane can be produced, water disposal options that are environmentally acceptable and yet economically feasible, are a concern. Water may be discharged on the surface if it is

> relatively fresh, but often it is injected into rock at a depth where the quality of the injected water is less than that of the host rock. Another alternative, not yet attempted, is to evaporate the water and collect the potentially saleable solid residues; this scheme might be feasible in regions having high evaporation rates.

To sum up, they inject fresh water for fracturing and then must pump out (*desorb*) all the now to some degree *saline* water that they injected and that was down there under the ground in the fractures (cleats). This leaves them with a considerable "water management" problem. By the way, high evaporation rates are not a problem in the Powder River Basin. Since there is other ground to cover, I'll leave it right there. Nevertheless, we see that with Coal Bed Methane production, there is no free lunch.

Shale Natural Gas

The big news has been the new "play" in the Barnett Shale. This is a case where it is fuzzy as to whether this should now be considered an "unconventional" source. Recent technological breakthroughs have made gas production economical due to *water fracturing* of the tight sedimentary shale rock at Barnett and *horizontal drilling*--otherwise, some people in Fort Worth would end up with natural gas wells in their backyards or living rooms. The way things are going, that may still happen since Fort Worth basically sits directly above the Barnett Shale gas deposits. Here's the story.

> And it's not enough just to induce fractures to allow the gas to flow, as Barnett drilling pioneer Mitchell Energy discovered after years of applying gel frac treatments to the rock.
>
> The gas did flow, but the pricey gel applications resulted in only so-so economics....
>
> The play took off with water fracing, but it's horizontal drilling that has propelled it into a true "boom," noted Mitchell alum and consulting geologist Dan Steward at Republic Energy, which was one of the play's earliest operators.
>
> "Horizontals have just swept through this thing," AAPG member Steward said. "As of 11-1-05, there were 2,135 permits issued for horizontals in the Barnett, with about 5 percent of these being duplicates because of things like changed locations.
>
> Mitchell engineers cracked the economic barrier in the late 1990s when they ascertained water fracs performed much the same as the gel fracs while dramatically lowering stimulation costs -- and a play was born....

Generally, there is great excitement (from the AAPG, 2001) about breakthroughs in shale gas production which is distributed in the US as shown in *Figure 3*.

Lower 48 Distribution of Shale Gas - Figure 5

Generally speaking,

> "Most shales have very low matrix permeabilities and require the presence of extensive natural fracture systems to sustain commercial gas production rates."
>
> In shale reservoirs, natural gas is stored three ways:
>
> - As free gas within the rock pores.
> - As adsorbed gas on organic material.
> - As free gas within the system of natural fractures

Finally, what is the current production and recoverable reserves estimates? As of 1999, yearly production was 380 billion cubic feet (bcf). Reserves were

> The shale gas resource base in the lower 48 states is significant. According to GTI, gas-in-place resource estimates for the five main gas shale plays total 581 trillion cubic feet of gas, and recoverable resource estimates range from 31 to 76 trillion cubic feet [tcf].
>
> These figures are considered conservative since *estimates for the Barnett Shale in the Fort Worth Basin* and the Lewis Shale are not available.

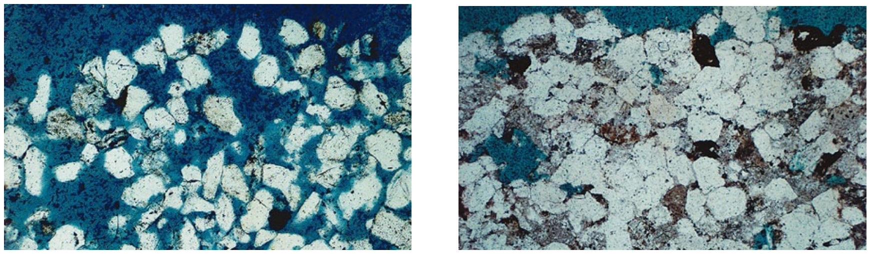
As *Figure 2* shows, production is increasing and looks to be a about 1.0 tcf now. The Barnett play may substantially increase that output in the next decade although that remains to be seen. Now that we've beaten the shale gas horse to death, let's move on in a determined fashion to...

Tight Natural Gas

From our overview source (link cited at the top), we learn that a *tight gas* (aka *low perm sandstone*) accumlation is

> ... gas that is stuck in a very tight formation underground, trapped in unusually impermeable, hard rock, or in a sandstone or limestone formation that is unusually impermeable and non-porous (tight sand)....

Here's what *tight* really means.

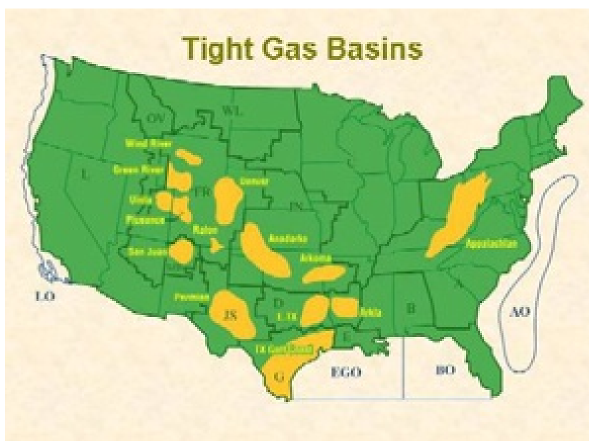


A normal reservoir (left) and tight reservoir (right) - Figure 6

However, as *Figure 2* shows, production from tight sands is currently higher than from any other unconventional gas source. From NETL, more is expected.

> Natural gas production from tight, low permeability sandstones (generally rocks with less than 1/10th of a millidarcy permeability), is expected to contribute significantly to the U.S. future gas supply. The DOE, USGS, and other organizations have completed resource assessments of U.S. basins with tight gas accumulations indicating that a vast (~6000 Tcf) in-place natural gas resource exists. However, there is still much that is not currently understood about the origin and development of these accumulations....

Wow. 6000 tcf is a lot of gas. Where is it?



Lower 48 Tight Gas Basins - Figure 7

So, again we ask what are the current production numbers or projections and what are the recoverable reserves? From this valuable document (which I refer to in the conclusion), we see where the current tight gas active gas plays are.

- The Bossier/Cotton Valley/Vernon fields in East Texas and Northern Louisiana. There are an estimated 6 tcf of recoverable reserves with an anticipated increase of 600-850 million cubic feet (mcf) per day.
- In the Rocky Mountain region, the Green River Basin, Piceance Basin and the Unita Basin comprise about 32 tcf of recoverable reserves with about another 0.9 mcf/day increase in production by 2010.
- The West Texas Canyon Sands with an undetermined recoverable reserves figure but an expected increase of 200 mcf/day by 2010.
- The Clinton-Medina development in Ohio with recoverable reserves of about 10 tcf and no estimate for increased future production.

These are modest numbers. Of all US natural gas resources, tight gas deposits make up the largest part. How much of this is recoverable? From the supply overview referenced in our discussion of Coal Bed Methane, 800 tcf is technically recoverable and about 140 Tcf is economically recoverable in the next 20 years.

To produce gas from tight sandstones, you must first find it. There are two major problems. First, you must locate tight gas zones with high natural fracture densities find via seismic & geophysical technologies. And second, you must avoid zones containing lots of water. Avoiding water production is an important consideration for producing this tight gas. From our Rocky Mountain source cited above, which sums up the technical challenges, we learn that

> The presence of mobile water and high water production rates continue to plague certain producing areas in the Rocky Mountains. For example, Union Pacific Resources (now Anadarko Petroleum Corporation) drilled a 2,300 foot lateral section, with over 1,600 feet in the Frontier Formation, at 15,000 feet in the GGRB near Table Rock Field (Rock Island 4H well). The well has produced 6.4 Bcf of gas in just under 3 years and is currently making nearly 4 million cubic feet per day, supporting the potential benefits of drilling horizontal wells to intersect natural fractures. However, the well has produced a significant amount of water, at times over 1,000 barrels per day, and the high rate of water production has affected gas recovery. Portions of the Mesaverde Formation in the Wamsutter area of the GGRB are also known to produce water, and in the Wind River Basin, significant water problems in hot plays like Cave Culch are beginning to make operators apprehensive....

So, production of tight gas from sandstones is not without its own difficulties. And now on to ...

Deep Gas

As *Figure 2* above indicates, *Deep Gas*, which is defined as deposits at depths of 15 thousand feet or more, is already a major contributor of unconventional gas production. As the NETL overview indicates (link cited above)

> The Deep Gas program targets resources that face tremendous technical and cost challenges related to an inability to image any but the largest deep prospects. Also, these deep reservoirs maintain high temperatures and pressures that exceed the capability of modern drilling and evaluation technologies. Deep reservoirs currently account for about 7% of domestic gas production but only about 1% of the Nation's gas wells drilled. Vast regions of the Nation remain virtually unexplored for deep gas.

This somewhat dated USGS document Summary of Deep Oil and Gas Wells in the United States Through 1998 lists producing deep gas plays at that time. I'm sure more have come onstream since. There are the usual two impediments to producing natural gas at great depths that involve such high temperature [HP] and high pressure [HP] conditions. First, the technology required to extract the gas at temperatures often greater than 200° C is a challenge. At those temperatures and pressures, the drilling equipment has a short time to obsolescence and must be switched out often. Naturally, this increases the costs of the extraction. Solving these problems present the biggest challenge for producing deep natural gas. Progess on these technological challenges are reviewed in the World Oil article cited above.

Taking a "techie talk" clue from HO, it is not simply a matter of sticking a drill bit in the ground and extracting the deep gas. There is a complex *bottomhole assembly* (BHA) attached to the drillstring. One part of the overall objective, as described by NETL is to "improve the data transmission rates possible for downhole to surface communication". This information is critical for guiding the extraction process. BHA includes both *measurement while drilling* (MWD) and *logging while drilling* (LWD). These operations also depend critically on the battery that powers the BHA.

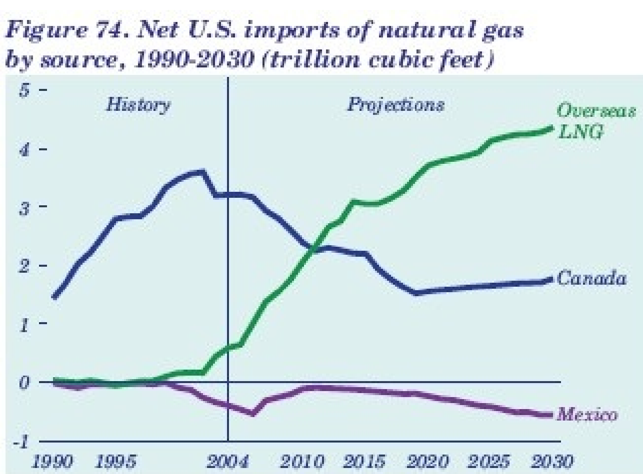
> It is these instrumented [BHA] tools that help the driller cut to the target in optimal time and identify drilling situations before they become problems. The tools are a great help, but come with certain tradeoffs.
>
> Most downhole tools operate on battery power, mainly lithium-ion (LI). For industry's use, LI cells have the densest energy capacity of the main battery types: lead-acid, nickel-cadmium and nickel-metal hydride. Because LI energy density is twice that of NiCad cells, a single 3.6-volt cell can be constructed, instead of wiring three 1.2-volt cells in series. A single battery makes for easier tool construction, as well as improving reliability.... For very deep wells, the instrumented BHA is critical, but battery life and higher temperatures constrain their use and force multiple trips to change out tools or batteries well ahead of bit replacement. Much research is underway to overcome these limits.

Finally, where does current US E&P expect to extract more deep gas? You guessed it--the Gulf of Mexico, a region which is somewhat prone to hurricanes as events last fall showed. This Mineral Management Services (MMS) document The Promise of Deep Gas in the Gulf of Mexico tells you what you need to know.

So as far as deep natural gas production goes, there are technical, cost and weather challenges that constrain its future production. It is entirely unclear whether the growth curve shown in *Figure 2* can be met going forward.

Conclusions

Compare this figure from the EIA AEO 2006 on natural gas imports with *Figure 1* on expected supplies from unconventional sources.



Natural Gas Imports To 2030 - Figure 8

As you can see, all natural gas imports are expected to contribute about 5.5 tcf by 2030 whereas unconventional gas production is just a little south of 10 tcf by that date. This gives you a relative idea of the comparative importance of the two in the long range projection for US supply. As you can see, our reliance on Canadian imports goes into severe decline starting about now in 2006. As an interesting footnote, consider this informative quote from the Forbes article cited above.

> In Canada, which currently supplies most U.S. gas imports, gas production reached 16.71 billion cubic feet per day (bcf/d) in 2004. However, these figures are expected to level off, or even shrink. Conventional production at current levels will not be able to supply increasing demand in North America...
>
> Canadian demand (7.7 bcf/d in 2004) is expected to increase substantially, **with the oil sands industry alone consuming 1 bcf/d by year-end**....

I thought you TOD readers would enjoy that one.

To finally conclude, unconventional natural gas production is the key to adequate future US supply and imports, though important in the near term, will not do the job. Gas from these sources is technically harder to produce and will no doubt cost more. Prices will go up in any scenario I can envision. And, we get the added benefit that we are trashing a large part of the environment of public lands as we develop these unconventional natural gas resources. But, as Jim Kuntsler signs his e-mails, *It's All Good*.