The Coming Natural Gas Crisis
Summary

Natural gas use is rapidly increasing while reserves are rapidly declining. As recently as five years ago, producers and consumers of natural gas thought that natural gas was the abundant and non-polluting fuel of the future. Electric utilities were encouraged to use natural gas as the fuel for almost all new power plants. Now, natural gas depletion is a recognized fact for all of North America.

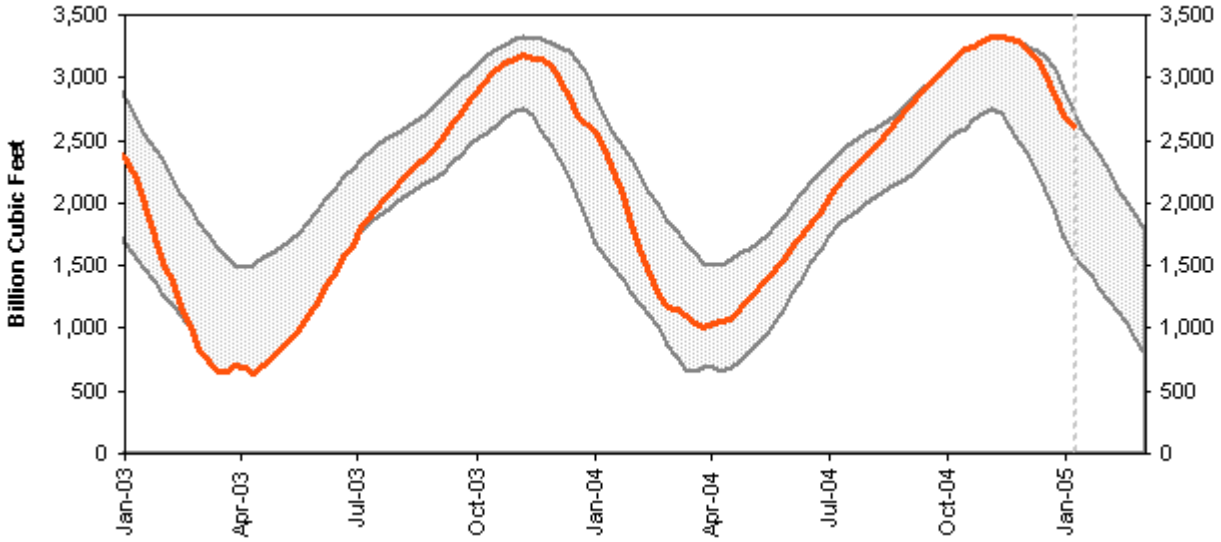
The United States imports significant amounts of natural gas from Canada. This will not continue much longer. Both countries are uniquely vulnerable to natural gas depletion because consumption is high compared to reserves. North America does not have its fair share of natural gas. South America is only slightly better off. Most of the world's natural gas is in the Middle East and the former Soviet Union. It is expensive to ship natural gas across oceans in LNG ships, but soon that will be the only option.

Two possible natural gas crises

There is a strong potential for a natural gas crisis in the near term, that is within months or a few years. Arguments appearing in Supply Crisis Looms, by W. J. Simpson, closely resemble the arguments put forth here. [1] The same is true of When markets fail – America leaps off the gas cliff without a parachute by Julian Darcy. [11] The two articles could not be more different. The first is written calmly by an industry insider, the second is written passionately by an industry outsider. But both are well researched and both reach the same conclusion.
The coming short term natural gas crisis

Natural gas consumption is highly seasonal. It is high during the winter heating season and low during the summer, although the increased use of natural gas to make electricity is starting to change this pattern. Hot weather increases natural gas consumption because air conditioning requires electricity. Natural gas production is not seasonal, leading to the requirement of gas storage. Certain geological formations found in Louisiana are used as giant natural gas tanks. The tanks are fullest in October at the beginning of the heating season and emptiest in March at the end of the heating seasons. The Energy Information Administration (EIA) publishes a graph which is updated weekly [5].

Storage Report



Weekly Natural Gas Storage Report

The red line shows actual natural gas in storage, while the gray area shows the range observed in recent years. In this example, reserves were alarmingly low in April and March of 2003.

There are two scenarios that could lead to a serious natural gas shortage in the near future. The first involves weather. A hot summer followed by a cold winter would do it. The summer of 2003 was not especially hot allowing the replenishment of stored natural gas. That fall was mild and there was enough natural gas in storage for that current heating season. A crisis was averted only by luck. It could have been different. Natural gas demand has fallen a little in 2003 due to high prices. Some fertilizer production has already stopped permanently. Economists call this demand destruction. Some boilers are designed so they can run on oil or gas and they have switched to whatever is cheaper. Natural gas demand will not drop much more because the new gas turbine electric generators cannot switch. Gas fired heating systems cannot easily switch to oil. [10][3]

The second scenario involves Canada. Canada has nearly the same reserves to production ratio as the United States and Canada uses gas for heating to the same extent as the United States. Given the prospect of declining production, Canadians may decide they need their natural gas for domestic use. In addition, natural gas is important for the production of synthetic oil from the bitumen extracted from Athabaska tar sands. The amount of natural gas exported by Canada will decline and it appears that the decline started in 2003. [6]

Why are so few aware of this predictable crisis?

Like the coming oil crisis, the coming gas crisis does not seem to show up on the radar screen of the general public. Yet the basic facts are not in dispute. Nothing is being done to avert the crisis because the public is not aware of any crisis. However a few very public figures have issued unusually clear warnings after observing the alarmingly low reserves in May 2003.

"I'm quite surprised at how little attention the natural gas problem has been getting, because it is a very serious problem."
--Alan Greenspan, May 21, 2003

Spencer Abraham remains concerned about natural gas supplies in the United States, and he expressed those concerns at the Natural Gas Summit, held in late June in Washington, D.C. Noting that U.S. natural gas storage is 32 percent below last year's level, and 22 percent below the previous five-year average, Secretary Abraham warned that next winter's heating bills could increase as much as 19 percent in the Midwest. "It is a national concern that will touch every American,"
--Secretary of Energy, Spencer Abraham, July 1, 2003

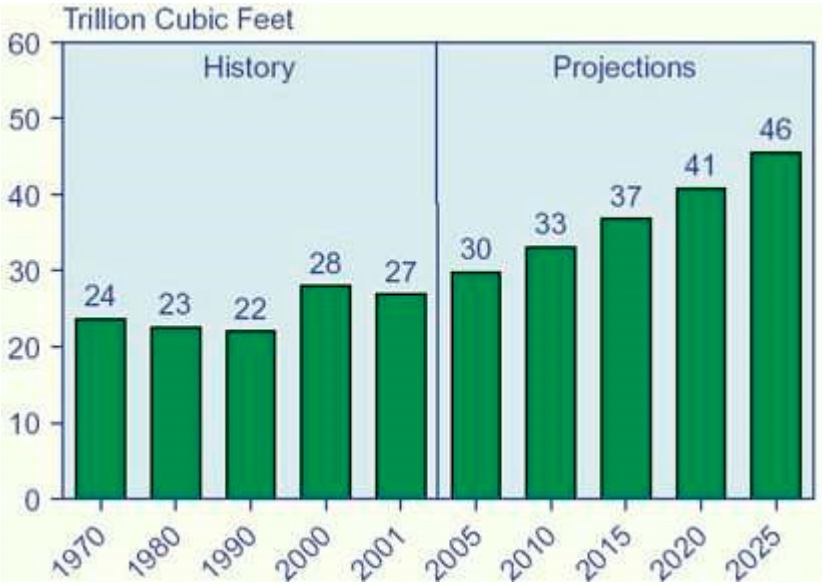
Abraham was right. Natural gas increased by much more than 19% in December 2003.
The coming long term natural gas crisis

There is also a strong potential for a natural gas crisis in the longer term, that is within 5 or 10 years.

North America will probably experience a natural gas shortage before any other region of the world. North America has only 4.6% of the world's gas reserves but consumes 30.3% of the world's production. The reserves to production ratio is only 9 years. It is easy to see that present consumption rates cannot be maintained for long without importing large amounts of LNG via LNG ships. Venezuela is nearby but reserves there are equal to only 7 years of United State's consumption. The LNG ships will soon be forced to make much longer voyages when Venezuela cannot meet the demand.[2]
Some Notes About LNG ships

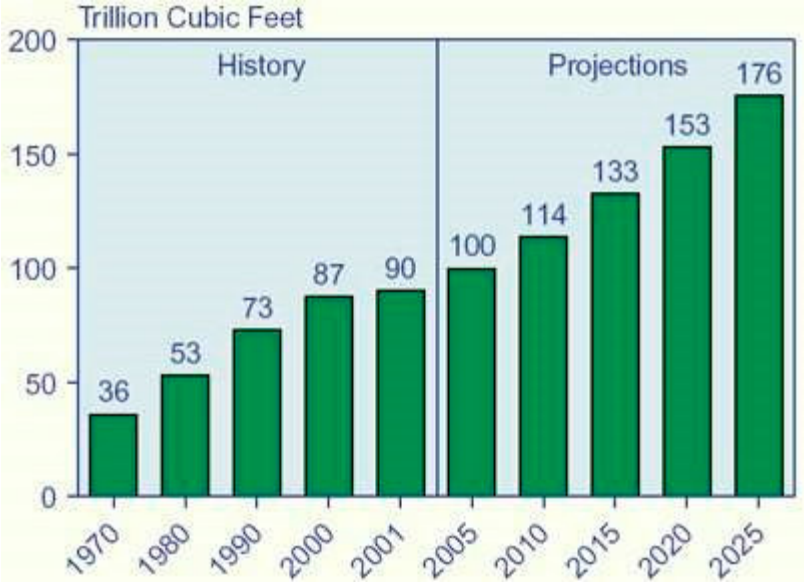
The volume of natural gas is reduced by a factor of 600 when it is liquefied. This volume reduction makes it feasible to transport natural gas via ship or truck, although liquefaction is expensive and energy intensive. LNG ships have large, insulated tanks capable of containing LNG at -161o C. LNG ships, of recent design, can carry 140,000 cubic meters of LNG and they cost $170 million each. There were 140 LNG ships in the world in 2003. Japan, South Korea, and Taiwan import all of their natural gas on LNG ships. One ship can carry enough natural gas to supply the needs of the United States for one hour. Europe gets some natural gas via LNG ships. Europe has the possibility of getting natural gas via pipeline from the Middle East, Algeria, and even Nigeria. None of these options are available to the United States because pipelines cannot cross oceans. There are three LNG ship terminals on the east coast, one on the gulf coast, and none on the west coast. There is a proposal to build a terminal in Mexico, just south of San Diego. Many more will be needed within ten years. Alaska, Venezuela, Eastern Siberia, Algeria, and Nigeria will probably be important sources of LNG in the near term. [4] The Middle East and the former Soviet Union will be the important suppliers in the near and far term.

A loaded LNG ship carries an incredible amount of chemical energy. The chemical energy in a loaded LNG ship is equal to the explosive power of 55 Hiroshima size nuclear bombs. An attack on an LNG ship could release this energy in a ball of fire covering square miles. An LNG disaster killed 128 people and devastated a square mile in Cleveland in 1944. This disaster has made the LNG industry very cautious and this caution is reflected in the design of LNG ships and LNG handling facilities. LNG ships are double hulled, for example. The LNG industry has an excellent safety record. There is some concern that an accident or a terrorist attack could be devastating. [7]



The EIA (Energy Information Administration) projects that the United States will consume 46 trillion cubic feet of natural gas in 2025, compared to 27 trillion cubic feet in 2001. In 2025 the western hemisphere will be producing very little natural gas. China is growing ever more economically powerful and China will have probably consumed most of the natural gas in Eastern Siberia by 2025. Nigeria does not have enough natural gas to last until 2025 at current production rates. [4]

That leaves the FSU and the Middle East as suppliers of LNG in 2025. They have 75% of the world's natural gas in 2003 and so they will be the only plausible suppliers in 2025. Some of the liquefaction facilities will be on the Mediterranean and in Africa, but most will be on the Persian Gulf. Some of the LNG ships will reach the west coast by sailing the Indian and Pacific oceans, and some will reach the east coast by sailing the North and South Atlantic oceans. In either case, the LNG ships will sail 27,000 miles, round trip, to make one delivery to the United States. Each LNG ship will deliver, at most, about 4 loads in a year. This is based on a reasonable estimate of the time for loading, unloading, maintenance, and sailing. These numbers determine that 3924 LNG ships will be required in 2025. The cost of the ships alone will be $667 billion. This compares with $400 billion for the defense budget.



The EIA projects world demand of 176 trillion cubic feet in 2025. [4] This seems reasonable. It looks like a straight line projection from past numbers. There must be a presumption of low cost supplies, peace, and prosperity. These numbers do not mean that the EIA knows where the natural gas will come from. In any case, the system comprised of LNG ships, liquefaction terminals, and regasification terminals would be very expensive.

World reserves of natural gas reserves for the world were estimated at 5501 trillion cubic in 2002. [2] The majority of that will be gone in 2025 if EIA projections turn out to be correct. Consumption at the average rate of 140 TCF per year for 21 years would do that. If the same straight line projections are continued for 5 more years, the natural gas will be gone around 2032. It follows that peak production must occur before 2032. Efforts to increase natural gas production will fail well before 2032. Natural gas distribution may become problematic. It would be hard to predict the year of peak natural gas production. But it is possible to say, with assurance, that increasing natural gas production cannot be maintained beyond 2025.
What can be done about these predictable crises?

Options are limited for the short-term crisis: hope for mild winters, cool summers, and practice conservation.

Japan, South Korea, and Taiwan already get their natural gas entirely via LNG ships. The United States soon will be forced to do the same. Conservation would be a good idea.

Natural gas will be mostly gone before the middle of the century in any likely scenario. The energy for the substitutes must come from sunlight or nuclear power. It is time to develop these substitutes. Extreme efforts at conservation will be required live with sustainable energy.

[1] http://www.petroleumnews.com/cgi-bin/start.cgi/homeauto.html Petroleum News is a magazine catering to the oil and gas industry of North America. Click here to see Supply Crisis Looms which appeared in the May 2003 issue. This is an HTML file on this website so the link is unbreakable. It is significant that an article appearing in an industry magazine agrees with planetforlife and predicts the same crisis using similar arguments.

[2] http://www.bp.com/ British Petroleum (BP) is a major oil company that publishes oil reserves data from the Oil and Gas Journal in its annual Statistical Review of World Energy 2003. The data do not reflect the company's own assessments--it is simply republished data. The Review is widely referenced because it is convenient, complete, colorful and very well done. It is also big at 2.2 megabytes. BP's CEO, The Lord Browne of Madingley, is irascible and quotable. He says that BP now stands for "beyond petroleum." BP's new logo, which looks like a leafy sun, would seem to bear him out. BP is in the LNG business.

[3] http://www.simmonsco-intl.com/default.asp Simmons Company International has a very large website with many useful resources. Go to "Simmons News" to read what Matthew Simmons said March 2003 when he testified before the Senate Committee on Energy and Natural Resources. The Bush-Cheney team is aware of the issue of peak oil because international oil

investment banker Matthew Simmons, who has written extensively and forcefully on depletion issues, was an advisor to Vice President Cheney's Energy Task Force in 2001. This loads fast but the rest are slow loading PDF files. Also at the same website, view North American Natural Gas: Looking for the Relief Valve presented in April 2003 by Roger D. Read.

[4] http://www.eia.doe.gov/oiaf/ieo/nat_gas.html Official energy statistics from the U.S. government about natural gas.

[5] http://tonto.eia.doe.gov/oog/info/ngs/ngs.html The Department of Energy publishes a graph showing the amount of natural gas in storage. It is updated on a weekly basis.

[6] http://www.financialsense.com/editorials/powers/2003/1030.html An editorial entitled The Natural Gas Production Treadmill by Bill Powers. An excellent summary of the Natural gas problem for all of North America.

[7] http://www.timrileylaw.com/LNG.htm Website of Tim Riley, "Consumer Protection Advocate & Personal Injury Attorney." This intentionally alarming website points out that the chemical energy in a loaded LNG ship is equal to the explosive power of 55 Hiroshima size nuclear bombs. This figure is in substantial agreement with planetforlife calculations.

[10] http://www.renewwisconsin.org/ Renew Wisconsin is an excellent starting point. Learn about natural gas, oil, and renewable energy sources. A network of clean energy businesses, educators, utility managers, builders, farmers, state agency officials, environmental advocates, and concerned citizens.

[11] http://postcarbon.org/ When markets fail – America leaps off the gas cliff without a parachute, by Julian Darley. Presented at the US Natural Gas (crisis) Summit, June, 2003. A background to natural gas problems in North America.

http://www.naturalgasfacts.org/links/index.html American Petroleum Institute natural gas facts. Many useful links.

Click here to see Alaskan Natural Gas: How Real An Alternative Is It? by Joseph P. Mathew. The practical and economic considerations of building a natural gas line to Alaska. This is an HTML file on this website, so the link is unbreakable.

http://www.energypulse.net/centers/author.cfm?at_id=114 Energy Pulse provides "Insight, Analysis and Commentary on the Global Power Industry." Andrew Weissman writes lengthy and in-depth articles about natural gas, LNG and electricity generation. Highly recommended.

http://www.lngoneworld.com/lngv1.nsf/portal/index.html LNG OneWorld is devoted to the LNG industry. You can find the speed, the capacity, and the name of every LNG ship in the world here. You have to register to access this site.

The science underlying the natural gas crisis

The United States is uniquely vulnerable to natural gas depletion. The appetite of the United States is great and the domestic natural gas reserves are small. Soon, most of the natural gas used in the United States will be imported from the other side of the Earth. The western hemisphere has only a small part of the world's natural gas, and that part is being rapidly depleted. Facts about natural gas in North America

Natural gas is a very desirable source of energy because it produces almost no pollutants or ash when burned. On a weight basis it has more energy content than gasoline. The energy comes from ancient sunlight. Natural gas is mainly methane, the simplest possible hydrocarbon. The greenhouse gas, carbon dioxide, is emitted when it is burned, but only half the amount that coal would produce for the same energy content. Unlike coal mining, the production of natural gas does not usually damage the environment. Pipeline transport of natural gas is common although it costs more to transport natural gas via pipelines compared to oil.

Natural gas is used primarily for heating. However, the rolling blackouts in California have stimulated the construction of new electricity generation capacity--almost all of it running on natural gas. In 1993 natural gas was used to generate 9% of the electrical power consumed in the United States. In 2003 that figure was 18%. [2] Natural gas is also the starting point for countless chemicals and plastics--the most important of which is nitrogen fertilizer. Modern agriculture utterly depends on nitrogen fertilizers. There would be world wide famine without nitrogen fertilizers. [3]

There are about 6 million BTUs in a barrel of oil. In 2003, oil costs $30 per barrel, while natural gas costs $5 for a million BTUs. The 6 to 1 ratio means you get about the same energy for each dollar. Electric power plants that use boilers to make steam can often use either fuel, depending on costs. The efficiency is the same in either case, about 38%, but natural gas produces less pollution. Many of the new electric power plants use gas turbines which achieve 60%, and more if the waste heat is used. However, gas turbines cannot switch to oil or coal. In the case of electricity generation, natural gas can command a premium price.

The United States consumed 26% of the world's production of natural gas in 2002 although it had only 3.3% of the world's proven reserves. Including Canada and Mexico brings the total to only 4.6%. Coincidentally, both Canada and the United States have proven reserves equal to 9 years at current production rates. Mexico has only 7 years. The United States produced 84% of the natural gas it consumed while Canada supplied 15% via pipelines. The remaining 1% was imported as liquefied natural gas (LNG) via LNG ship. It is clear that North America will be importing large amounts of natural gas in the near future, although North America is currently almost self-sufficient for natural gas. At 9%, North America's natural gas reserves are paltry. By contrast, the former Soviet Union (FSU) and the Middle East have 39% and 36% respectively.[1] [4]

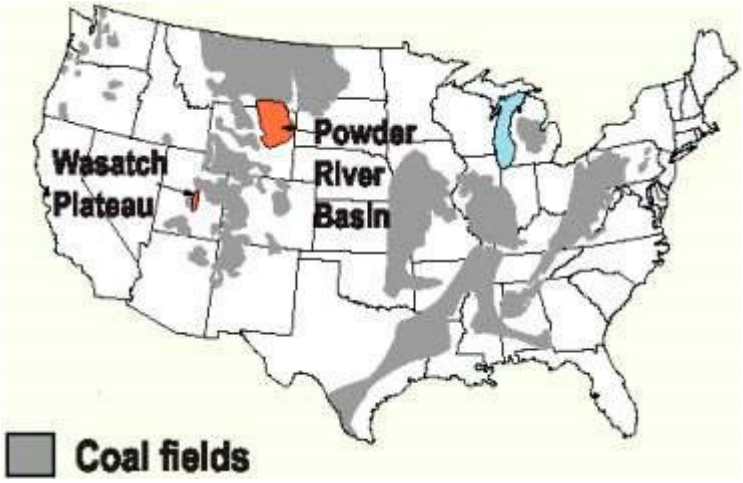
Central and South America together have 4.7% of the world's proven natural gas reserves. Venezuela has the lion's share at 2.7%. This is very convenient for the United States because the sea routes to Venezuela for the LNG ships are short.[1]
Conventional Natural Gas

Natural gas is often associated with the production of oil. It has no economic value unless it can be shipped via pipeline or LNG ship. In the Middle East, it is still commonly "flared" which is to say burned. Compared to oil, natural gas is more expensive to transport whether via pipeline or by LNG ship. Prior to 1980, the price of natural gas mainly reflected the cost of transport since the wellhead price was near zero.

There is a possibility that natural gas will be found in very deep wells in the Gulf of Mexico. Oil decomposes into natural gas at the temperatures found below 9000 feet, so only gas exists at these depths. Drilling becomes very expensive and the produced gas often contains toxic hydrogen sulfide.
Unconventional Gas [5]

Unconventional gas includes coal bed methane (CBM), tight gas, shale gas, and gas hydrates. It includes "stranded gas" (gas located too far from a pipeline to be economic). It also includes low quality gas (natural gas mixed with nonflammable gas or toxic hydrogen sulfide).

Coal Bed Methane (CBM)



Coal underlies huge areas of the United States and all coal fields contain at least some methane. Currently, CBM accounts for 7.5 percent of U.S. natural gas production, a figure that is likely to increase. Recent estimates indicate more than 700 trillion cubic feet (TCF) of CBM in place, with over 100 TCF economically recoverable--a 4.5 year supply at present rates of consumption. Canada may have significant CBM resources.

Methane extraction from coal beds is complex and messy. First the coal is depressurized by removing water. This releases methane from a volume of coal. The amount depends on cracks in the coal. Many wells are required because each well can access the methane in only a small volume of coal. The removed water is sometimes potable but it is often contaminated by coal dust, heavy metals, or salt. Many people object to the compressors, pumps, towers, pipes, and contaminated water associated with CBM extraction.

Tight Gas and Shale Gas

Natural gas is mostly easily produced when it is found in cavities. However, large quantities may be found in sand or porous rocks. Wells drilled into these formations produce gas but only very slowly. Some shales also produce gas when fractured. Fractures can be produced by hydraulic pressure or explosives. Nuclear bombs have been used experimentally to produce 0fractures in gas bearing shales in the American Southwest. [16] Tight gas and shale gas could be important in the future.

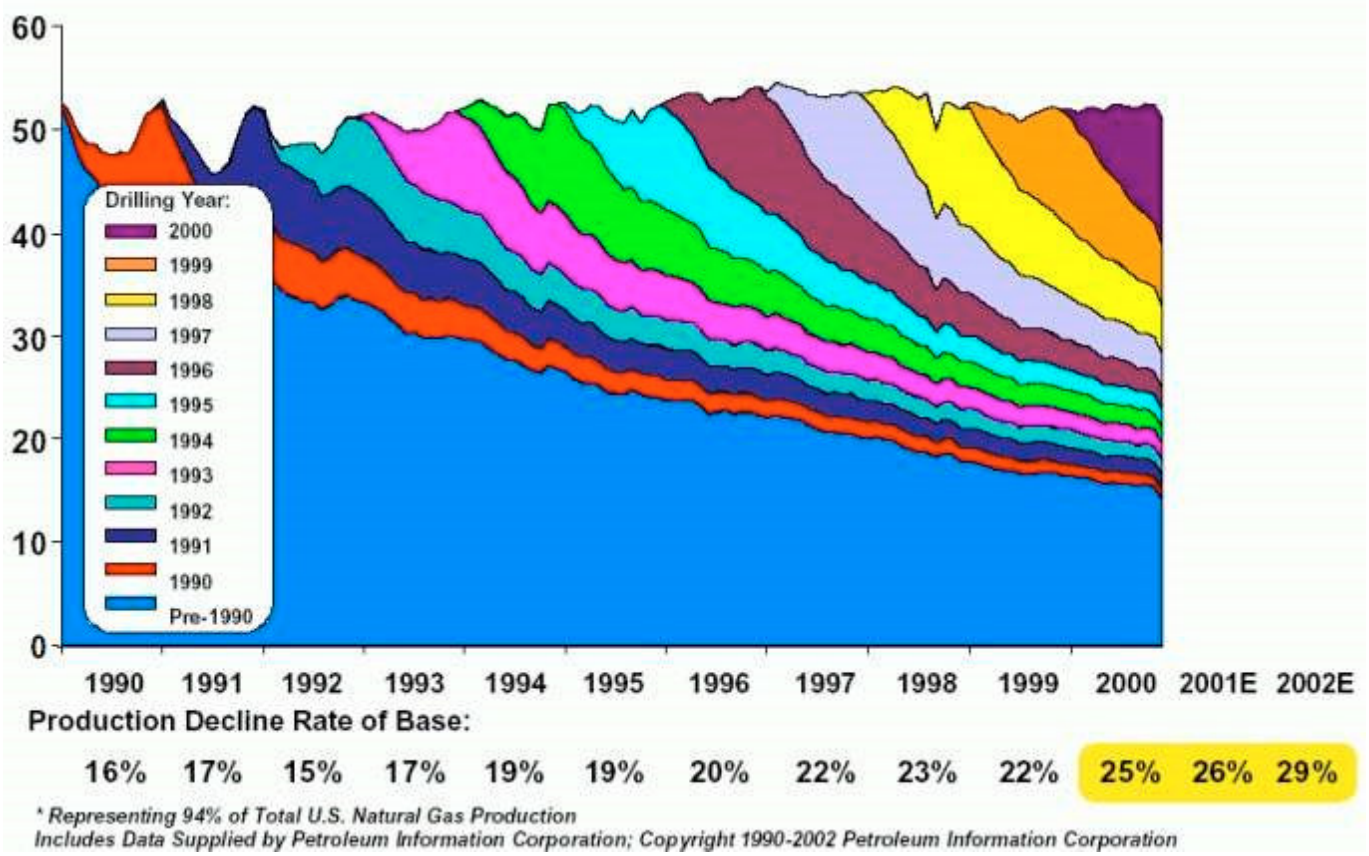
Methane Hydrates

In deep and cold water, natural gas forms a solid called methane hydrate. Huge quantities of methane hydrate are believed to exist world's oceans. However, no concentrated deposits have ever been found. Research continues but no natural gas is currently produced from methane hydrate.

It does not appear that unconventional gas will be abundant or cheap enough to replace conventional natural gas.

Gas Production in North America

Natural gas prices have been high enough since 1980 to justify a major drilling effort in all of North America. This effort, surprising almost everyone, has not paid off. Here is a chart that illustrates what is happening in the United States.



Declining Gas Wells

The top line shows total gas production. The colored bands show the contribution of gas wells segregated by age. The production of every gas well declines with age. But the surprising thing is that the new gas wells are declining much faster than the old ones. Gas production has remained nearly constant despite the contributions of the new gas wells.

Texas is a mature gas production province. In 1998, and in every subsequent year, it took less than a year for the production rate of a new gas well to fall 50%. New reserves were discovered in 2002 but the discoveries equaled only a quarter of consumption. It is clear; new gas wells will have to be drilled faster and faster just to keep production constant. Think of 6 straws drawing on the same milkshake.

Natural gas wells are productive even when the gas is almost gone because natural gas can move freely within a cavity. By contrast, oil wells produce more slowly when the oil is almost gone because oil moves more slowly through the oil bearing rock or sand as pressure diminishes. It is likely that Texas gas production will fall off a cliff in a few years. Other United States gas producing areas are only a little less exploited.

Canada's natural gas exports were 1% less in 2002 compared to 2001. According to the Energy Information Agency (EIA), Canada's contribution will be 11% less in 2003. Canada has a gas well depletion problem too. Ladyfern was Canada's most productive gas field. It was discovered near an existing pipeline and it was rapidly exploited. Now, production from Ladyfern is down 70%. Canadian gas discoveries were very small in 2002. Canada will not be able to take up the slack. [4][11]

Alaskan natural gas will not be able to take up the slack. Alaska has proven reserves equal to two years of United States consumption. A gas pipeline to Alaska would probably not pay for itself. A pipeline would take at least 5 years to build in any case. Transport by LNG ship might actually be cheaper. [13]

[1] http://www.bp.com/ British Petroleum (BP) is a major oil company that publishes oil reserves data from the Oil and Gas Journal in its annual Statistical Review of World Energy 2003. The data do not reflect the company's own assessments--it is simply republished data. The Review is widely referenced because it is convenient, complete, colorful and very well done. It is also big at 2.2 megabytes. BP's CEO, The Lord Browne of Madingley, is irascible and quotable. He says that BP now stands for "beyond petroleum." BP's new logo, which looks like a leafy sun, would seem to bear him out.

[2] http://www.eia.doe.gov/ Energy Information Agency (EIA), a part of the Department of Energy (DOE). This is official energy statistics from the U.S. government.

[3] http://www.princeton.edu/~hos/mike/texts/readmach/zmaczynski.htm The Haber process is used to make ammonia from natural gas. Almost all nitrogen fertilizer is made from ammonia. The improvement in crop yields resulting from nitrogen fertilizer is the reason why there is not widespread famine in the world today. Ammonia is also the starting point for almost all explosives. World War I would have petered out for lack of explosives except for the application of the newly invented Haber process.

It seems the Haber process both creates and destroys.

[4] http://www.financialsense.com/editorials/powers/2003/1030.html An editorial entitled The Natural Gas Production Treadmill by Bill Powers. An excellent summary of the Natural gas problem for all of North America.

[5] Click here to see Energy in the XXIst century--Unconventional Oil and gas, by J. J. George Stosur. This is based on a lecture to the Society of Petroleum Engineers by the author. This is a 248k PDF file on this website, so the link is unbreakable.

[6] http://www.naturalgasfacts.org/links/index.html American Petroleum Institute natural gas facts. Many useful links.

[11] Click here to see a history of Canada's natural gas industry and an explanation of why it is in decline.

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[14] http://www.petroleumnews.com/cgi-bin/start.cgi/homeauto.html Petroleum News is a magazine catering to the Oil and Gas industry of North America. Click here to see Supply Crisis Looms which appeared in the May 2003 issue. This is a short HTML file on this website so the link is unbreakable. It is significant that an article appearing in an industry magazine agrees with planetforlife and predicts the same crisis using similar arguments.

[16] Memoirs, A Twentieth-Century Journey in Science and Politics by Edward Teller. Edward Teller is known as the father of the hydrogen bomb. Teller was a nuclear enthusiast. He also proposed that nuclear bombs be used to make sea harbors in Alaska and a sea level Panama Canal. He also convinced president Reagan to initiate the Strategic Defense Initiative (Star Wars) project.