Risky Diet 2003

Natural Gas: The Next Energy Crisis

Center for Energy Efficiency
And
Renewable Technologies

Rich Ferguson, PhD
Research Director

September 2003

Executive Summary

On the heels of the 8-state, 2-country blackout that focused the attention of politicians and public alike on the inadequacies of our electric power system, it may seem odd to be publishing a report on the problems of natural gas. But the two are inextricably intertwined. Natural gas has become the fuel of choice for new electricity generation in the United States, and electricity generators are the fastest growing group of natural gas buyers. A crisis in natural gas supply will be felt throughout the electric power sector, and vice versa. And a crisis in natural gas supply is precisely what this report shows we have.

Last winter, for the second time in only three years, natural gas availability reached record lows in North America, and prices soared in response. The two price spikes cost American consumers more than $100 billion. After months of replenishing, gas storage this summer is still so low that prices remain at historic highs, and it's not certain that next winter's needs can be met.

The problem, moreover, is not the result of some temporary glitch in the weather, but a new and permanent condition. The evidence in this report demonstrates that cheap domestic sources of natural gas are disappearing, even as the demand for gas, in power plants and elsewhere, grows.

The Bush administration and the energy industry are proposing to meet growing demand with gas imported from the Arctic, via pipelines, and from overseas, via liquefied natural gas (LNG) tankers. However, our examination of this import strategy reveals that it will take many years and billions of dollars to implement. The Bush administration is also proposing to weaken environmental protections on public lands to encourage new drilling, which would yield only small amounts of new gas over the long run.

In the meantime — and quite likely in the long run — supply will remain tight and prices high. The continuing risk to the economy is as real as the economic downturn that accompanied the last two gas price spikes.

Environmentalists have long advocated greater efforts to expand energy efficiency and renewable resources to reduce air pollution and global warming. But it now appears that greatly reducing the amount of natural gas wasted in old, inefficient power plants and gas-guzzling buildings is an economic imperative, and expanding our use of renewable resources like solar, wind, biomass, and geothermal energy is a crucial strategy for stretching increasingly scarce and costly supplies of natural gas.

In this report, we propose several ways to achieve those goals. And because of the interdependence of the natural gas and electric power industries, our proposed policies would also go far toward reducing the chances of another power blackout.

V. John White
Executive Director,
CEERT

INTRODUCTION

Natural gas has become an increasingly important part of California's and the nation's energy supply. It is now the fuel of choice for generating electric power, as well as for space and water heating in new buildings. But after years of relatively low and stable natural gas prices, the last three years have seen two episodes of tight supplies and sharply higher prices. These two price spikes cost U.S. consumers more than $100 billion and contributed to the present economic slowdown.

Even more troubling, our analysis of the available data on North American natural gas production and consumption suggests that, despite the boost in drilling from higher gas prices, natural gas production is not increasing. It is not keeping up with demand. The amount of natural gas currently being stored for winter is behind historical levels, creating the possibility – depending on the weather – of another price spike and perhaps even supply shortages in the winter of 2003-04.

Over the longer term, possibility looks more like certainty. Experts now agree that traditional production sources of natural gas in the U.S. and Canada will not be able to keep up with the growth of demand that can be expected when the U.S. economy recovers from the current slowdown. While the Bush Administration and many industry leaders seek to relax environmental protections for public lands in order to encourage new drilling for gas, the evidence indicates that only marginal increases in domestic natural gas supplies would result from such misguided policies.

As a consequence, it is likely that California and the U.S. will become increasingly dependent on natural gas imported from the Arctic and from overseas. These options will require the construction of pipelines and liquefied natural gas (LNG) tankers and receiving facilities, which will take many years and billions of dollars to build. In the meantime, supplies will remain tight and prices volatile.

In light of the evidence of a growing crisis in natural gas supply and the likelihood of skyrocketing prices for consumers in both the short and long term, we need to take prudent and practical steps to avoid economic chaos and catastrophe. Most compelling are steps to reduce the amount of natural gas we waste and increase the amount of electricity we produce from other resources – in particular renewable resources such as solar, wind, biomass, and geothermal energy. Importing new supplies is expensive and uncertain; stretching the scarce and costly supplies we have is a national imperative.

THE CURRENT SITUATION

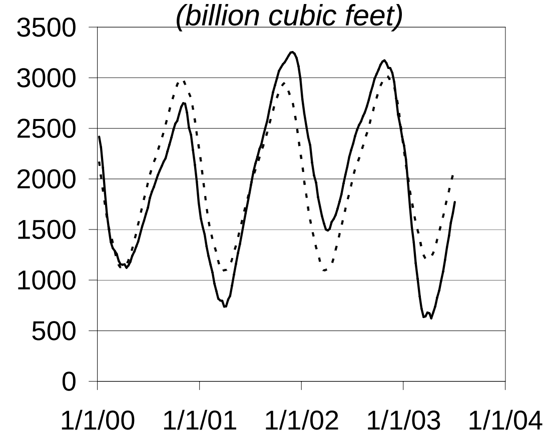
In May 2002, the Center for Energy Efficiency and Renewable Technologies issued a report entitled "Risky Diet: North America's Growing Appetite for Natural Gas."[1] At a time when most industry and government officials were predicting cheap and plentiful future supplies of natural gas, the CEERT report concluded that conventional North American sources of natural gas would not be adequate to meet expected future demand. To keep sufficient gas flowing, the report said, would require large investments to develop LNG import facilities, Arctic pipelines, deepwater wells, and other such unconventional sources of natural gas. In the meantime, the report predicted repeated price spikes like the near-tripling of wholesale gas prices that occurred in the winter of 2000-2001, and quite possibly actual shortages of gas.

After only one year of respite, that's exactly what happened. North American natural gas markets experienced another series of dramatic price increases in the winter of 2002-2003 brought on by low volumes of gas in storage and fears of shortages.

While storage was not fully depleted during the winter heating season and shortages did not occur, a record drawdown did take place. Natural gas in U.S. storage facilities plummeted from a near record high of 3.17 trillion cubic feet (tcf) at the beginning of last winter's heating season on October 25, 2002, to a near record low of 0.62 tcf on April 11, 2003. (See Figure 1.) And as the market watched the storage numbers fall, buyers bid up the price for the remaining supplies, as shown in Figure 2.

The average price paid to producers during the last three years of the 20th century was $2.16 per thousand cubic feet. The average price from January 2000 through May 2003 was $3.76 per thousand cubic feet, and during this time nearly 74 trillion cubic feet of natural gas was sold to U.S. consumers. Higher prices have thus added more than $100 billion to the cost of gas to U.S. consumers.[2]

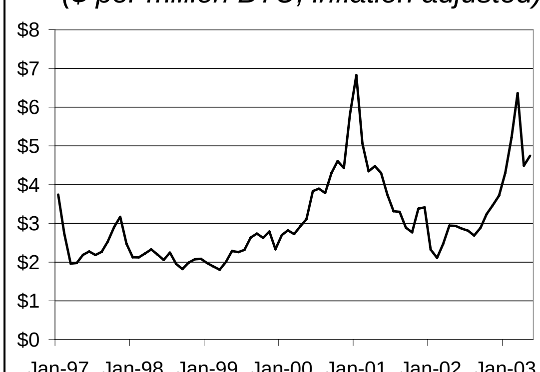
Figure 1
U.S. Storage – gas available for use
(billion cubic feet)



Solid line – reported storage
Dashed line – prior 5-year average for same week
Source – USEIA

The beginning of this summer's storage-rebuilding season did not assuage fears of shortages. As of July 4, storage remained below the lowest value for that date in the previous five years. And at the time of this writing, in the late summer of 2003, U.S. natural gas prices remain well above historical averages as buyers compete for gas that they can put into storage to meet the remainder of the summer's electricity-generating needs and the coming winter's heating demand.

Figure 2
U.S. Wellhead Prices
($ per million BTU, inflation adjusted)



Source – USEIA

The market is exceedingly tight, in part because the storage buildup this year started from a very low base. In fact, even if no shortage develops in the coming winter, if the current high prices fail to stimulate robust increases in production and/or decreases in demand, the storage situation next spring may be dire.[3] Some experts believe that as much as one trillion cubic feet (about 5 percent of last year's consumption) must be squeezed out of the market by high prices this year to avoid shortages next year.[4]

There are still some who see this return to crisis conditions as another temporary glitch in an otherwise healthy system. And unfortunately, it is impossible to know with certainty how much of the current market tightness is the result of temporary conditions – larger than normal demand this year or smaller than normal production. Official production and consumption data are published by the U.S. Energy Information Administration (USEIA) several months after the fact, so 2003 data are only just beginning to appear. Moreover, the reliability of USEIA consumption and production numbers is less than ideal. In June 2003, the agency revised years of consumption data upwards — by an amazing 10 percent for 2002.[5]

However, it is hardly plausible that the main culprit, as many in the media speculated last winter, is a spate of bad weather. For one thing, the new USEIA data show 2002 consumption increasing less than 1 percent over the prior year, no remarkable spike in demand. And weather was not, as it turns out, unusually cold. A National Weather Service indicator known as "gas home heating customer weighted heating degree days" provides an objective measurement that reflects the impact of cold weather on gas consumption.[6] And it shows that the nation's weather from November 2002 through February 2003, although it was 17 percent colder than the previous season, was actually very nearly average.[7,8,9]

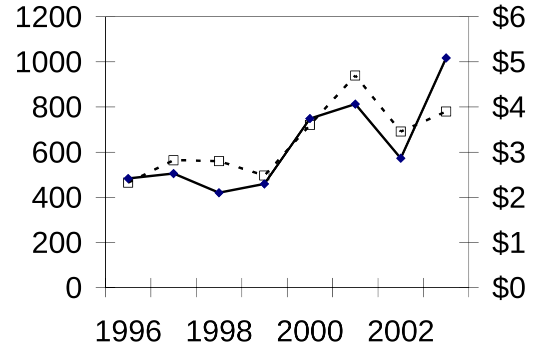
The current tightness of the natural gas market is almost certainly not an anomaly at all. It is primarily the result of the underlying condition of this sector of the economy, a condition that most observers finally agree is one of diminishing supply. Thus, the Bush administration, following much of the gas and oil industry, is calling for decreased regulation in order to increase drilling. Other investors are pressing for alternatives to conventional drilling – such as imports from the Arctic via new pipelines and from overseas in the form of LNG. Even Alan Greenspan, chairman of the Federal Reserve Bank, recently pronounced on the subject, saying that prices would not settle down until the United States stopped relying on its domestic sources and developed facilities for importing LNG on a large scale and joining the global market.[10]

CONVENTIONAL PRODUCTION

The evidence that cheap domestic sources of gas are disappearing is, indeed, compelling. Despite ample incentives for expanded investment in exploration and production, which the higher prices of the last few years have provided, North American production has increased by less than 2 percent since 1999. And virtually all of that increase came in Canada, where no further increases are expected. [See p.9.]

Drilling activity through 2002, as reported by the oilfield services company Baker Hughes[11], has actually responded to wellhead price signals remarkably closely — at least until the first months of 2003 — as shown in Figure 3. (The early 2003 figures show drilling lagging well behind price, a pattern that may mark a significant change or may disappear in the final average for the year.).

Figure 3
U.S. Drilling Activity and Wellhead Prices



Solid line – wellhead prices in 2002 dollars per million BTU (right scale)
Dashed line – drilling activity in average number of active rigs (left scale)
Source – USEIA, Baker Hughes

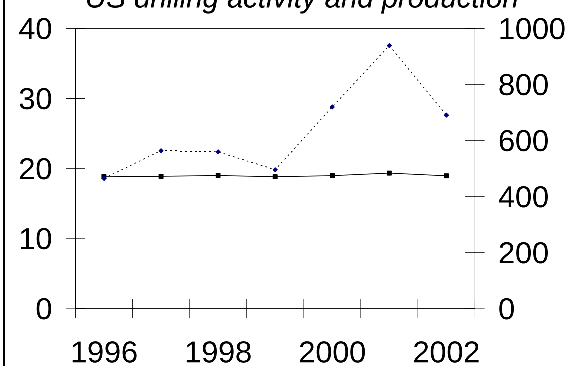
However, production has not been proportional to drilling activity, as Figure 4 shows. While high prices have indeed prompted more activity in the field, the additional wells drilled in response to high prices evidently produce little additional gas. The relatively low drilling numbers in early 2003 may even indicate that the industry is reluctant to keep investing in conventional drilling, because the benefits do not justify the costs. But whether or not drilling activity picks up during the remainder of 2003, the inability of the North American gas industry to increase production significantly despite the increased activity is an ominous sign.

As seen in Figure 4, maintaining production now requires considerably more drilling activity than it did in 1996. Moreover, average costs are higher and the average productive life of natural gas wells has been declining.[12,13] The industry consulting firm, Raymond James, is now finding much the same thing. As reported this summer in *BTU's Daily Gas Wire*,

> Raymond James states that the independents and the "mom & pops" are driving the [year's] drilling activity increases with little production increases to show for it. The independents have put an additional 250 rigs to work, a 30 percent increase, since the beginning of the year, and corresponding production results only show a 1.4 percent year-to-year growth or a 1.3 percent sequential growth. [14]

It remains to be seen how production this year will respond to current high

Figure 4
US drilling activity and production



Solid line – production in tcf/yr (left scale)
Dashed line – drilling activity in average number of active rigs (right scale)
Source = USEIA, Baker Hughes

prices. But judging from this recent history and the rate at which storage is being rebuilt, any increase in 2003 production is likely to be only marginal. In the long run, as Raymond James concludes, "the underlying problem of falling U.S. natural gas production is similar to the [problem of the] 1970s, when oil production was on the decline regardless of the number of rigs drilling."[15]

The industry continues to maintain that regulations that restrict exploration and drilling on some federal lands are responsible for the dismal production results of recent years. However, a recent report to Congress from the Department of Interior finds that 63 percent of all the gas believed to be available from federal lands is open to exploration and development under standard permits. Only 12 percent of the gas is totally unavailable, since the lands closed to development contain little gas potential. The remaining gas potential is available with only seasonal occupancy restrictions.[16]

An analysis performed by USEIA in 2000 examined the increase in production that might be achieved by increasing access to areas in the Rocky Mountains, a long-standing goal of the industry. The report indicates that removing virtually all restrictions on gas development in the Rockies would increase national annual production by a mere 200 bcf/yr, less than 1 percent, in ten years.[17] While the gas industry would like to use the current crisis to eliminate regulations that protect public property, even such a draconian measure would not increase gas production significantly.

THE OUTLOOK FOR NATURAL GAS

Future Prices

According to USEIA estimates, U.S. annual demand for natural gas -- 22 tcf last year -- will increase by 4.5 tcf[18] (20 percent) by 2010, while total annual North American demand will go up 6.2 tcf (23 percent) over the same period. Supplies are projected to remain overwhelmingly domestic, with only 1 tcf/yr imported as LNG.[19] At the same time, USEIA also expects average gas prices paid to producers in the lower 48 states to be considerably lower than they are now. Its projected wellhead price in 2010 is an amazingly low $3.19 per million BTUs (MMBTU),[20] a price sustained for only a few months out of the last several years. (See Figure 2.)

What's wrong with this picture?

The unrealistic price projections appear to be due to the use of outdated production costs and overly optimistic assumptions about capital investment. Industry and government agencies may agree that substantial economically recoverable reserves of natural gas remain in North America, including those already "proven," expected, and yet to be discovered.[21] But that hardly means that future gas prices can be predicted simply by estimating the cost of producing gas from these reserves. The staff of the California Energy Commission concluded from such a calculation that gas prices for the foreseeable future should be in the range of $3/MMBTU.[22] Presumably USEIA is relying on similar calculations. Yet prices were twice as high in the winter of 2000-2001 and again last winter.

The average wellhead price for all of 2001 was $4.06 per MMBTU (in inflation-adjusted 2002 dollars).

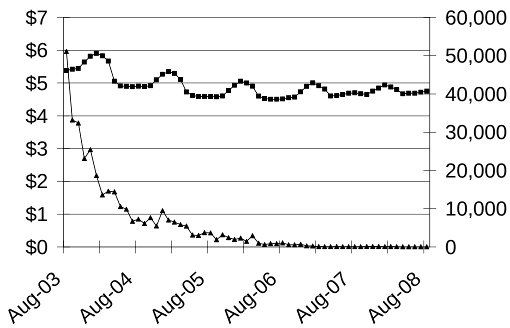
The theoretical cost of producing natural gas in the U.S. may be a lower limit below which prices cannot fall (unless production is to occur at a loss). However, it is unlikely to be the price at which supply and demand come into balance in a market in which supplies are short and most buyers have little choice about how much they must buy. Equilibrium theories are of little use in predicting actual prices in natural gas markets.

Another reference for estimating the future price of natural gas is more widely used in the industry, and that is the price in the futures market run by the New York Mercantile Exchange (NYMEX). Contracts for deliveries of gas in future months, known as "futures contracts," are traded daily. Prices for these contracts, as of July 8, 2003, are shown in Figure 5. As the graph shows, prices for these contracts generally decline somewhat for delivery dates farther out in time.

Some observers, including Mr. Greenspan, argue that futures prices show that "the market" expects gas prices to decline over time. This interpretation is an oversimplification, however, even if one subscribes to the theory that the market is an excellent predictor of the future. After all, the market failed to anticipate the two recent price spikes shown in Figure 2.

Moreover, there is little activity in the market for contracts more than a few months in the future, as shown by the "open interest" curve in Figure 5, a measure of trading activity. The trading volume for contracts only one year hence is a small fraction of the activity in the nearby month and thus less likely to reflect a market-wide consensus. In addition, a futures market condition known as "backwardation" distorts the price of futures contracts for distant months. This happens because traders holding these contracts in a volatile market incur risk and therefore require prices to be discounted.

Figure 5
NYMEX gas futures, 7/8/03



Upper line – price for gas to be delivered in future months ($/MMBTU, left scale)
Lower line – number of active futures contracts by delivery month (right scale)
Source – NYMEX

In fact, the likelihood that gas prices next year will be significantly different from futures contract prices is reflected in the market itself, if one looks at the price of *options* on contracts for future delivery.

Less persuasive than the USEIA's rosy price projections, however, are its expectations that production can meet growing demand at those low prices. Even with prices considerably higher than those projected by USEIA, U.S. production has been essentially flat and Canadian production has increased only marginally since 1996.

A more likely scenario is that prices will remain high, in the $5 - $10 range. Such prices will likely induce some increase in production, although recent experience indicates that a production increase as large as USEIA predicts would be difficult to sustain. Instead, both shortages and high prices would combine to reduce consumption. During the first decade of the new century, the point at which North American consumption and supply come into balance is likely to occur at considerably lower levels of consumption and higher prices than those projected by USEIA.

The worst case scenario (from the consumer's point of view) is one in which increasingly high prices are required simply to *maintain current* levels of production. This scenario is not far fetched; it closely resembles what has in fact occurred in the last six years.

Future demand

Still, absent aggressive steps to reduce it, the need for natural gas is going to grow. Natural gas is the fuel of choice for water and space heating in new construction. It is also a key feedstock for the fertilizer and petrochemical industries. As such, demand for gas can be expected to grow with the economy.

Beyond that, much of the increase in gas consumption predicted by government and industry officials is due to the rapid proliferation of new electricity-generating plants fueled by natural gas. The USEIA's recently revised data show that consumption of natural gas by U.S. electric generators has increased by 1.5 tcf/yr (38 percent) since 1997.[23] A further increase, of another 1.5 tcf/yr, is expected between now and 2010, accounting for a full third of the projected increase in total gas consumption.[24]

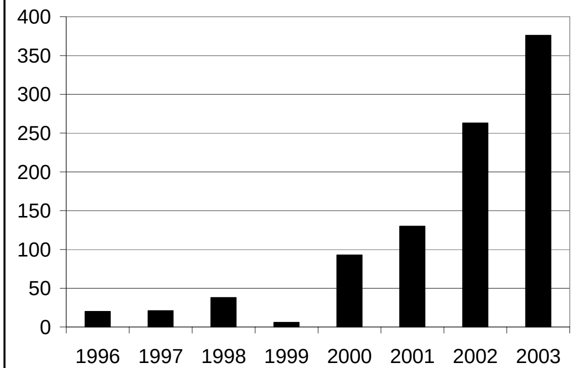
Fortunately, the gas combustion turbines and gas-fired "combined cycle" plants[25] being built today are significantly more energy efficient than older gas plants, many of which are still in use. A new, efficient combined cycle power plant can turn more than one-half the energy in its fuel into electricity, whereas some older plants operate at less than 30 percent efficiency. Nonetheless, because USEIA expects so much additional electricity to be required in the years ahead, it is predicting that the electricity sector's need for gas will rise significantly.

Increases in demand are also affecting the cycle of storage buildup and drawdown. The increasing use of air conditioners combined with the increasing reliance on natural gas by electricity generators has increased demand for gas in the summertime. Consequently, gas that would have been available for storage in the summer is now being burned. As of this writing, there is considerable worry in the industry that if summer 2003 is exceptionally warm, the buildup in gas storage will be insufficient to maintain supplies through the heating season next winter.

Another factor complicating the North American gas situation is the rapid increase in Mexico's demand for natural gas. Northern Mexico is connected to the grid of gas pipelines that extends through the U.S. and Canada and contributes to the overall supply and demand picture. Until recently, Mexico was a net exporter of gas to the North

American grid, but rapid economic development has resulted in Mexico becoming a significant net importer, as shown in Figure 6. Construction of a new pipeline to carry gas from Texas to Mexico began this spring. Estimates of future increases in Mexican gas demand have been as high as 14 percent annual growth,[26] which would double current demand of 4.5 tcf/yr by 2010. USEIA projects an average annual growth of Mexican demand at 6.1 percent through 2020.[27]

Figure 6
U.S. Gas Net Exports to Mexico (annual, bcf)



Note – 2003 estimated from Jan – Apr data
Source – USEIA

Accelerating investment in gas production is a high priority for the Mexican government. Efforts to attract foreign investment are being considered. In addition, the Mexican government recently issued permits for construction of three terminals in Baja California to receive shipments of LNG, and at least some of this gas will be shipped to the U.S. Nevertheless, most observers agree that Mexico will remain a net importer of North American gas for the rest of the decade.

Yet another force likely to drive demand upward is the aging of nuclear power plants in the U.S. and Canada. Last spring a spate of nuclear power plants were taken off line as a result of a variety of age-related problems. On April 7, 79 percent of the U.S. nuclear capacity was off-line. This put upward pressure on short-term gas prices.[28] The power these plants would have generated was replaced primarily by gas-fired generation, further increasing gas demand.

Although on-line performance by U.S. nuclear plants actually has been increasing somewhat in recent years, age-related metal fatigue in nuclear reactors is a growing concern. In the past, the U.S. Nuclear Regulatory Commission routinely granted extensions to nuclear plant operating licenses, but it remains to be seen how the plants' performance will be affected by increasing age in the future. The permanent retirement of even 10 percent of the nation's nuclear power — a plausible number — if replaced by gas-fired generation, would increase the annual North American demand for natural gas by about 500 billion cubic feet,[29] or 2 percent.

Future supplies of natural gas

Conventional sources

"Proven" reserves of natural gas in the U.S. have continued to expand more rapidly than production in recent years.[30] The difficulty of bringing additional supplies to market from these reserves, despite higher prices, indicates that the cost of developing them must be high indeed.

The outlook for Canadian production may be even bleaker. As reported in Toronto's *National Post* in June 2003,

> Gas production and drilling results in Western Canada have been so "dreadful" in recent months, almost no amount of drilling can overcome production declines in the next few years, according to a report by FirstEnergy Capital Corp.
>
> Martin King, commodities analyst for the energy investment specialist, said poor drilling and poor production results in the last months of 2002 and the beginning of 2003, despite a large industry push to find new reserves, mean the industry won't be able to halt accelerating decline rates.[31]

The newspaper also quotes Mr. King's projection that Western Canadian production will decrease by 200 billion cubic feet (bcf) this year, an amount equal to approximately 6 percent of U.S. gas imports from Canada. Another 90 bcf/yr may be taken out of production in order to maintain pressure in the Athabasca oil sands where bitumen is recovered.[32]

Based on recent performance and reports like King's, it is difficult to escape the conclusion that North America will have difficulty maintaining even present levels of production, and that to do so would require prices significantly above USEIA's low projections. Indeed, meeting increasing demand from conventional North American sources appears to be impossible.

Unconventional sources

The supply alternative to increased production from conventional North American resources, of course, is to get natural gas from somewhere else. One possibility is to build pipelines to the Arctic, and two such pipelines are under consideration. A second possibility is to bring natural gas to North America in tanker ships, and the industry is already taking existing tanker terminals out of mothballs and proposing new ones. There is now a consensus in government and industry that North America will need to build both LNG facilities and pipelines But each is problematic and extraordinarily expensive.

<u>Arctic gas pipelines</u>

Private investors are currently considering two major pipelines to bring natural gas from the Arctic to southern markets. The Canadian option would bring gas from the Mackenzie River Delta area in the Northwest Territories to a hub in Alberta. The proposed capacity of this pipeline is 440 bcf/yr, and the estimated cost around $2 billion ($US).[33] The proposed Alaskan pipeline to carry gas to Alberta from Prudhoe Bay and the North Slope is considerably longer and larger. Its cost is estimated at $20 billion for a project with a capacity of 1600 bcf/yr.[34] Development of the smaller Canadian pipeline is already underway. It may be operational before 2010. The oil and gas industry press considers the Alaskan pipeline to be at least a decade away from operation, but current high gas prices could provide sufficient incentives to accelerate both schedules.

These two projects, which together could supply approximately 10 percent of today's North American demand for natural gas, illustrate the difficulties of meeting future demand. According to USEIA, U.S. demand for natural gas is projected to grow by about 500 bcf each year. If so, the Canadian pipeline would satisfy merely one year's increase in demand[35] and the Alaskan pipeline three years' increase. Many more such projects would be required simply to keep up with increasing demand.

Moreover, each megaproject big enough to provide significant amounts of gas would require enormous additional capital investments – for the pipeline itself, for facilities to produce and process the gas, and for enlargements to the domestic distribution system. To handle the amount of gas in just the currently proposed Alaskan pipeline, transmission lines from Alberta to southern markets would need to be expanded at considerable cost.

At the current price of about $5/MMBTU, these pipelines would be quite profitable. The problem is that the financial community has to face the risk that prices will not stay high. If prices were to follow the low USEIA projections, for example, the Alaskan pipeline would most likely be uneconomical, as would LNG importation facilities, as discussed below. (Ironically, USEIA may be hurting the North American gas supply picture with its price projections to the extent that these projections are unrealistically low and discourage investment.)

Alaskan pipeline promoters want the U.S. government to guarantee that their investment will be profitable, and legislation to that effect is included in one of the energy bills now before Congress, a bill which is on the front burner ever since the August 14, 2003, blackout of New York, the Midwest and parts of Canada. However, Canada has threatened to bring action under NAFTA if the U.S. government provides any such subsidy to the Alaskan pipeline, since it would compete with the Canadian project.[36] Gas producers in the Gulf of Mexico, where production costs are high, are also opposed to federal subsidies for competing supplies.[37]

Intra-industry disagreement over public policy will likely drag out the already decade-long lead times of these megaprojects. And in the meantime, North America will have to continue to meet demand from present resources as best it can.

Liquefied natural gas (LNG)

The second option for significantly increasing North American natural gas supplies is to import gas from other continents. With all the political hype over U.S. dependence on foreign oil, one might expect similar concerns to be raised over the prospect of dependence on foreign natural gas. However, there is now a consensus in the industry and in government that the best way to meet North American gas demand is with large new infusions of imported LNG.[38,39]

Natural gas is a mixture of gases, primarily methane, with a density about half that of air. It is compressed and transported in gaseous form through pipelines, but for regions separated by large expanses of ocean, this means of transportation is impractical. The alternative is to cool the gas to temperatures sufficiently low for the gas to condense into its liquid phase. To liquefy methane, temperatures of minus 260 degrees Fahrenheit are required, low enough to be considered "cryogenic." The density of liquid methane is much higher than that of the gaseous phase. Gas that would fill a basketball can fit into a ping pong ball when it's condensed into a liquid. As a liquid, it is feasible to transport gas over long distances in specially designed ships with thermally insulated LNG containers. The liquid methane in these ships is actually boiling, that is, turning back into gas, and this gas is used as fuel for the ship.

However, the process of liquefying and shipping LNG is expensive, both in energy and capital. The energy to operate the refrigeration equipment that liquefies the gas at the sending terminal is obtained from the natural gas input to the system. Approximately 8 percent of the input gas is used in this process. Another 5 percent or so is used to fuel the transport ship, depending on the length of the voyage.[40] More energy is needed at the receiving terminal to turn the liquid back into gas. Altogether, 10 percent to 15 percent of the gas entering the LNG process in the source country is used to provide the energy required to put the gas into the North American pipeline system.

The capital requirements are also high. A recent study compared the costs of five modern LNG liquefaction plants constructed in recent years at sites in Oman, Nigeria, Qatar, and Trinidad and Tobago.[41] The average capital cost for the five plants was approximately $250 for each metric ton of annual LNG production. On this basis, the capital cost of LNG liquefaction facilities sufficient to supply one trillion cubic feet of gas per year (less than one-fourth the *increase* in demand that the USEIA expects in 2010) would be about $5 billion.[42]

A typical LNG tanker can hold 140,000 cubic meters of LNG (the equivalent of about 3.1 billion cubic feet of gas) and costs approximately $150 million to build.[43] How many ships are needed to meet a given demand depends on the length of the voyage and how quickly round trips can be made. To supply one tcf of natural gas each year to the U.S. from South America, for example, would require approximately 24 such ships,[44] at a total cost of $3.6 billion.

The third step in the LNG import process is to receive the cold liquid, boil it rapidly to regasify it, and put the gas into the North American gas transmission system. Needless to say, locating such facilities on shore can be controversial. Several current proposals for West Coast receiving terminals would place the facilities miles off shore with underwater pipelines connecting to the mainland. Based on the cost of one such proposal, receiving facilities sufficient to supply one tcf per year to North American markets would cost approximately $2 billion to build.[45]

Importing LNG is a high-cost proposition. The process of liquefying, shipping and regasifying natural gas would add $3.50 to $4.50 per MMBTU to its cost. In other words, a growing dependence on LNG ensures future natural gas prices will remain well above those seen in the 1990s.

Investment and Prices

But it's not just the costs of these investments that will determine future natural gas prices, and it's not just the profitability of an individual project that will determine whether the investments will be made — and will provide sufficient supply to meet demand.

The decisions that energy investors have to make are difficult ones. On the one hand, too little investment invites competitors to step in and reap potential profits. On the other hand, too much investment, if it increases supplies and drives prices down, may make any particular investment unprofitable.

And a company must consider more than simply the profitability of the individual project. The effect of price movements on its overall portfolio means that investment in new infrastructure that brings prices down, even if it is profitable, may reduce overall returns. By the same token, supply shortfalls, by driving prices up, may increase a company's profits.

Thus, the fact that a project would be profitable does not mean that it will be built. Still, to the extent that an investment decision does turn on project profitability, it turns on natural gas prices. And the price necessary to make investing attractive is, in a word, high.

Indeed, as capital requirements and lead times become larger, price signals must be louder than ever – high prices remaining high for extended times. This is especially true in today's risk-averse energy investment climate in the wake of the Enron debacle. Major energy companies such as El Paso, Williams, Calpine and others are struggling to improve balance sheets by shedding assets, and they are not in a position to increase debt loads associated with major new investments.

The volatile gas prices of the current market pose substantial risks for investors at every step in the LNG process. Producing countries, terminal operators and ship owners will all seek to minimize these risks by entering into long-term contractual arrangements. For example, last fall China signed a 25-year contract to receive LNG from Australia.[46] To ensure supplies of LNG, North American utilities and utility regulators may have to offer LNG suppliers expensive, long-term "take-or-pay" contracts, at great cost to consumers.

Furthermore, the global LNG trade is expanding rapidly as demand soars in industrializing countries such as China. When North America starts importing large amounts of LNG, it will be competing for supplies in the global marketplace. As a result, future North American natural gas prices must be high enough to attract those supplies.

Thus, the fact that the cost of delivering gas to North America in the form of LNG may be in the range of $3.50-$4.50 per MMBTU does not necessarily mean that this will be the market price of natural gas in the future. The U.S. will be competing for LNG supplies in the global marketplace, as it does for crude oil and petroleum products, where the price may exceed the cost of production. The market price of such commodities is determined by the cost of production only when there is a surplus of supply and producers compete for sales, a so-called "buyers market." Currently, North American buyers are competing for supplies, a "sellers market," and the price is bid up well above the cost of production. Adding LNG to the supply mix will not produce low market prices unless and until large surplus amounts of LNG are available.

The U.S. is in the midst of a historic transition from dependence on North American natural gas supplies to one of dependence on megaproject investments and global markets. The one certainty in this new environment is that the era of inexpensive natural gas in the United States is coming to a close.

PUBLIC POLICY OPTIONS TO REDUCE NATURAL GAS CONSUMPTION

In light of the evidence of a growing crisis in natural gas supply and the likelihood of skyrocketing prices for consumers in both the short and long term, American policy makers must start taking prudent and practical steps to avoid economic chaos and catastrophe. As we have seen, a single-minded focus on increasing supplies will not do. It will be many years, at best, before supplies might increase sufficiently to halt rising and volatile prices. It is thus incumbent on policy makers to focus efforts on reducing consumption.

Environmentalists have long advocated greater efforts to expand energy efficiency and renewable resources to reduce air pollution and global warming. But it now appears that greatly reducing the amount of natural gas wasted in old, inefficient power plants and gas-guzzling buildings is an economic imperative, and expanding our use of renewable resources such as solar, wind, biomass, and geothermal energy is a crucial strategy for stretching increasingly scarce and costly supplies of natural gas.

Since gas-fired power plants are now the marginal source of electricity in North America, every measure that reduces demand for electricity also reduces gas consumption. Every kilowatt-hour (kwh) saved eliminates the need for approximately 10 cubic feet of natural gas.[47]

Researchers have identified a host of cost-effective possibilities. A recent report commissioned by the Hewlett Foundation and the Energy Foundation found that cost-effective efficiency improvements could dramatically reduce electricity use. In California, annual reductions of 40 billion kilowatt-hours of electricity, 13 percent of the state's projected use, could be achieved cost effectively by 2011. Another 5 percent reduction is technically feasible, although at higher cost.[48]

Solar domestic water heating

Measures that directly reduce the need for gas in non-electrical applications are also available.[49] Using solar energy to replace some of the natural gas used for domestic water heating is one obvious step, and in California it has been priced out. The average single-family residence in California uses over 23,000 cubic feet of gas annually for water heating.[50] Simple passive systems can cut this requirement by as much as one-half. If included in a new house and financed in a mortgage, such a system would generate monetary savings to the residence from day one.

Over 100,000 new single-family houses are built every year in California. Changing the building codes to require solar water heating would save over one billion cubic feet of natural gas in the first year alone. In the first five years of such a program, savings of over 17 bcf would accrue. This is a program appropriate for other sunny regions as well. And the reduction in gas consumption would be further magnified if solar water heating were installed in existing houses, in addition to new ones, though the price of retro-fitting is much higher.

Electric power sector

Efforts to retire obsolete, inefficient gas-fired electricity generators are long overdue. According to Environmental Protection Agency data, the average gas-fired generator in the U.S. is only about 37 percent efficient, and many power plants have efficiencies less than 30 percent.[51] Accelerating the retirement of old, inefficient, polluting gas-fired generating plants could improve the average efficiency of the nation's fleet of power plants significantly. Lowering the average energy requirements of these plants from 9200 to 8400 BTU/kwh – an aggressive but feasible goal – would reduce gas demand in the electric sector by approximately 500 bcf per year, or more than 2 percent of today's total gas consumption.

Deployment of wind generators and other renewable-resource technologies also reduces the need for gas-fired electricity generation. For example, a wind turbine rated at one megawatt (MW) avoids the need for over 25 million cubic feet of gas every year.[52] According to the American Wind Energy Association, boosting U.S. wind capacity from today's 4,700 MW to 30,000 MW could be achieved within four years and reduce natural gas consumption by about 1 tcf/yr, about 4.5 percent of current consumption.[53]

These three strategies should become the core of public policies for dealing with the natural gas situation:

1. Reduce gas consumption by improving the efficiency with which electricity and natural gas are used.
2. Accelerate the retirement of inefficient gas fired electric generators.
3. Accelerate the deployment of wind power and other renewable resources.

These strategies are highly cost effective and can be implemented quickly, given proper political leadership. And in addition to saving money by saving gas, the reductions in demand would put downward pressure on gas prices, compounding the savings.

Retiring old, inefficient, polluting power plants

The Energy Policy Act of 1992 held the promise of increased competition at the wholesale level among electric power generators. Because power plants using new technology make so much more efficient use of fuel, the hope was that the promised competition would force the old, inefficient plants out of the market. That has happened in some regions, such as Texas and New England. However, in other regions, notably the South, powerful multi-state utilities have managed to protect their inefficient plants from competitors. Because these utilities also control access to the transmission lines in the region, they have been able to keep out competing generators simply by refusing to let them use the wires.[54]

The Federal Energy Regulatory Commission (FERC) is the entity charged with implementing federal electricity laws. FERC ruled in Order 888 in 1996 that transmission owners may not use their control of the wires to discriminate against competing generators; rather, they must provide “open access” to all on equal terms. This order had limited success, and FERC has since proposed to go one step farther by requiring transmission owners to relinquish control to regional grid operators as part of a new “standard market design.” But success is still not guaranteed. Controversy over open access and the competition it would facilitate is at the heart of the energy policy debate that has stalled energy bills in Congress for several years.

No doubt some utilities will attempt to use this summer’s power blackout as an excuse to retain old barriers and raise new ones against competing, more efficient suppliers of electric power. While the causes of the blackout are still not fully understood, it would be a serious mistake to let what appears to have been a grid management problem hinder the modernization of the nation’s gas-fired power plants.

The politicians’ past unwillingness to demand better behavior from transmission line owners certainly exacerbated the natural gas problem, and on that ground alone, it must not be allowed to continue. It is not a stretch to say that the continued operation of gas-guzzling power plants threatens the national economy and even national security. Moreover, since these old plants emit large amounts of air pollution and are put into service during the hottest and smoggiest days, their impact on public health is a serious concern. If market forces don’t shut them, they should be closed by regulatory fiat.

Inefficient gas-fired generating plants have also been kept alive in areas where they might be used for back-up purposes. Old power plants in San Francisco and San Diego, for example, continue to operate for this reason. During the so-called California “electricity crisis” in 2000-2001, the oldest, dirtiest and least efficient plants were put into service. They managed to keep the lights on most of the time but at the expense of a colossal waste of natural gas. It should be federal policy to ensure reliability by retiring or upgrading *all* inefficient gas-fired generators as quickly as possible.

Reducing use of electricity and gas

Modern technology has improved the efficiency with which electric- and gas-powered machines do their work. A modern household refrigerator, for example, uses about one third as much electricity as a new model did just ten years ago. New state and federal standards are responsible for improving the efficiency of much electric equipment now available in the market, but additional improvements are quite feasible. Making home air conditioners more efficient is especially important, since generating electricity for air conditioners requires large amounts of natural gas and puts additional strain on the power grid.

Reducing electric demand during the summer months would also reduce the likelihood of blackouts such as occurred on August 14. John Hanger, former Pennsylvania Public Utilities Commissioner and one of the more knowledgeable experts on the electricity grid, points out:

> Air conditioning creates peak summer demands. Air conditioning is the usage that stresses the grid most. Pennsylvania and the nation should adopt stringent air conditioning energy efficiency standards as well as increased appliance efficiency standards. The Bush administration should realize that their refusal to tighten efficiency standards will lead to more – and more frequent – blackouts, and it should reverse this bad policy.[55]

However, even with improved standards, much of the older equipment will remain in use for many years in the absence of public policies to accelerate its retirement.

One such program has been offered on a small scale in California for many years, operated by the Appliance Recycling Centers of America and managed by Southern California Edison Company. Consumers are offered a cash incentive to turn in an older, working refrigerator which is then dismantled and recycled. The cost of the program is covered by a surcharge on utility bills (essentially a tax). Thus, the public is buying old, inefficient refrigerators in order to get them off the electricity grid. If such a program were expanded nationwide to prematurely retire one million of the nation's oldest refrigerators — about 1 percent of all its refrigerators — savings on the order of 100 billion cubic feet of gas could accrue.[56] The cost of the program would be significantly less than the value of the gas that would otherwise be burned.

Such projects, by reducing electricity consumption, would also eliminate the need for and cost of additional power plants, gas pipelines, electric lines, and so on; would avoid the associated pollution, and would lower the price of natural gas for all.

What is needed is an aggressive public program of incentives to bring all gas- and electricity-using equipment up to modern standards in the shortest possible time.

Unfortunately, energy-inefficient buildings pose a more difficult problem. Retrofitting older houses or commercial buildings with energy-saving insulation and windows is an expensive chore. Moreover, building stock turns over very slowly, and inefficient structures remain in use for decades.

To begin to address this problem, states should make sure that no additional inefficient structures are built. Adoption of aggressively energy-efficient building codes for new construction is long overdue in most states.[57] California's is a model, though even it does not do as much as it could. Building an energy- efficient structure is much less expensive than retrofitting an old one to bring it up to modern standards. All cost-effective energy efficiency measures should be required of all new buildings.

There is much that can be done cost-effectively to reduce energy consumption in older buildings, too. But little of it happens because substandard housing is so often home to low-income citizens who cannot afford the needed improvements.

The current natural gas situation demonstrates, however, that substandard housing is not merely an issue that affects low-income families. More than ever before, it's now possible to see that the profligate use of natural gas resources hits all pocketbooks. Every extra dollar per MMBTU in the price of natural gas costs American consumers $22 billion per year. Reducing gas consumption anywhere puts downward pressure on prices, providing financial benefits to all. As a matter of fiscal prudence as well as social justice, an aggressive public program to improve the energy efficiency of older houses and structures should be undertaken.

Expanding reliance on renewable energy

As mentioned above, accelerating the development of renewable energy resources for electricity generation would displace large amounts of natural gas. Renewable energy development is capital intensive, but lack of capital is not the major obstacle. Perhaps the most serious problem is the present utility culture, whose mission is to build and operate fossil-fuel-burning plants. Energy resources provided by Mother Nature, over which engineers have little control, are looked upon with suspicion. Only a small fraction of renewable-energy power plants are owned and operated by utilities.

Unregulated companies are more than willing to provide these resources, but utilities throw up roadblocks. They deny access to transmission or offer it only at exorbitant rates. They forecast unrealistically cheap natural gas prices, which make renewable energy appear "uneconomic." They follow outdated rules for assuring reliability, which unnecessarily limit their use of variable resources such as wind power.

No doubt a new generation of engineers will be required to change the utility culture. But policy makers and utility regulators should not wait that long. The first step is to admit that the era of cheap gas is over and require that realistic projections of future gas prices be used for planning purposes. One effective mechanism for ensuring realistic price projections would be to simply require that a utility building a gas-fired power plant accept the risk that its fuel-price projections might be low. If utilities, rather than ratepayers, had had to absorb the cost of the last two gas-price spikes, they surely would be using more realistic projections now.

FERC has labored mightily in recent years to prevent utilities from limiting access to their transmission lines in order to protect utility-owned generating plants from competition. Whether it will succeed or not is uncertain. Politically powerful utilities will always make it difficult for appointed FERC commissioners to pass and enforce rules sufficient to end anti-competitive practices. A more effective approach might be legislation prohibiting ownership of transmission facilities by companies also in the generation business.

Also promising, in the Senate version of the federal energy bill now under consideration in Congress is a provision that would require utilities to include a certain percentage of renewable resources in their energy mix, the so-called “renewable portfolio standard.” Several states have already adopted this approach.

Opponents of such government mandates prefer to rely on “free market” forces to determine the industry’s energy mix. The problem with this approach is that the electricity market is anything but “free.” It is dominated by entrenched utilities determined to use their economic and political power to protect their interests. And consumers in this market have little or no choice about how much or what products they must buy.

If electric generation is to remain a de facto utility monopoly, then federal mandates for renewable development are essential. If generation is to become a competitive business, the current owners must not be permitted to control access to the grid. As Americans unfortunately have found out, allowing the current muddle to continue is costing the nation tens of billions of dollars per year.

CONCLUSION

The era of cheap natural gas is over. North America will remain vulnerable unless and until coherent national policies are adopted that address both the supply and demand sides of the problem. But cost-effective measures are waiting to be deployed when politicians develop the will to do so.

ACKNOWLEDGEMENT

The author would like to thank Rhea Wilson for her patient and thoughtful editing of this report. Translating technical material into language that is understandable to a larger audience is a difficult task, but Rhea has done an excellent job.

Thanks also to the staff at CEERT and the colleagues who read and commented on various drafts of the report. Responsibility for the accuracy of the material contained herein remains with the author, of course.

[1] The first "Risky Diet" report is available on the CEERT web site at www.ceert.org.
[2] Prices are "wellhead" prices paid to U.S. producers as reported by USEIA and are not weighted by volume or adjusted for inflation. Sales volumes, also from USEIA, do not include fuel used in production or gas transmission.
[3] The USEIA storage report for June showed a record increase for the month, so perhaps the current prices have indeed increased production and/or reduced demand significantly. However, the impact of weather during the period also may have played a role.
[4] "Anadarko Exec: Up to 7 bcf/d of demand destruction needed to balance market," reported in NGI's Daily Gas Price Index, May 8, 2003.
[5] On June 12, 2003, USEIA released its April 2003 Monthly Natural Gas Report with revised consumption data dating back to 1997. Previously, gas consumption by non-utility electric generators was included in the industrial sector but all electric generation now is lumped together. However, how 2.2 trillion cubic feet of consumption could have been overlooked is not explained except to say that new sources of data are being used. Although we shall use USEIA data in this report, the reader should be wary of placing too much credence in its accuracy.
[6] U.S. National Weather Service Climate Prediction Center, www.cpc.ncep.noaa.gov.
[7] Data reported by USEIA, Natural Gas Monthly April 2003.
[8] See also a lengthy discussion of last winter's heating demand by Andrew Weissman in "Days of Shock and Awe About to Hit the Natural Gas and Power Markets Part 1", Energy Pulse, available at www.energypulse.net.
[9] The National Weather Service has recently made some corrections to its heating and cooling degree data. Whether the numbers currently given by USEIA will be changed in the future is unknown at this time.
[10] Carl Hulse, "Natural Gas Outlook Worries Greenspan," New York Times, June 10, 2003.
[11] Baker Hughes rig counts are available at. http://www.bakerhughes.com/investor/rig/index.htm.
[12] "Natural Gas Markets", USEIA.
[13] See the 2002 "Risky Diet" report, page 6.
[14] BTU's Daily Gas Wire, Aug. 11, 2003
[15] Ibid.
[16] As reported by the Houston Business Journal, January 27, 2003.
[17] USEIA Report #; SR/OIAF/2000-04, available at www.eia.doe.gov/oiaf/servicerpt/depletion/index.html.
[18] USEIA AOE 2003, table A13. Whether this number will be revised upward in light of the additional 2.2 tcf of annual consumption "found" in USEIA Natural Gas Monthly Report April 2003 remains to be seen.
[19] USEIA Annual Energy Outlook 2003, Table A13.
[20] USEIA Annual Energy Outlook 2003, Table A14. USEIA reports price projections in 2001 dollars per thousand cubic feet. For consistency with market prices in million British Thermal Units (MMBTU) we assume one cubic foot of gas provides 1030 BTU.
[21] See, for example, USGS Assessment 2000.
[22] "Natural Gas Supply and Infrastructure Assessment", California Energy Commission staff paper, December 2002.
[23] USEIA Monthly Natural Gas Report April 2003, Table 3, "Natural Gas Consumption in the United States, 1997-2003."
[24] USEIA Annual Energy Outlook, Table A13.
[25] A combined cycle plant uses the hot exhaust from a combustion turbine to generate steam and additional electricity.
[26] Williams, "Mexico seen relying on imports for gas supply needs", Oil & Gas Journal, November 11,2002.
[27] USEIA International Energy Outlook 2003, Table A5. Not all this demand is supplied through the North American grid, and the influence on US and Canadian markets is unclear.
[28] Williams, "Nuclear outages bolster gas price outlook", Oil & Gas Journal, May 19, 2003.
[29] Based on 2001 nuclear generation of 769 billion kilowatt-hours as reported by USEIA, AEO 2003, Table A8. For the purposes of this calculation it is assumed that the gas-fired replacement facility requires 7000 BTU to generate one kilowatt-hour of electricity.
[30] USEIA, "US Crude Oil, Natural Gas, and Natural Gas Liquids Reserves 2001 Annual Report, Chapter 4.

[31] "Natural gas in dangerous decline, says analyst", National Post, Ontario, Canada, June 11, 2003.
[32] "Alberta may shut 2% of gas output to conserve oil sands pressure", Oil & Gas Journal Online, June 17, 2003
[33] "Mackenzie gas producers award pipeline contract", Alaska Journal of Commerce, web posting May 24, 2002.
[34] Canadian frontier gas supplies a decade away, experts say", Oil & Gas Journal Online, April 21, 2003.
[35] If projections of declining production in Western Canada are correct, the Mackenzie Delta pipeline may not even be able to maintain current levels of supply, much less increase them.
[36] "Family Feuds", OGJ Online, May 17, 2002.
[37] "Proposed Alaskan natural gas project questioned", Alexander's Gas & Oil Connections, November 27, 2002.
[38] See, for example, "LNG imports to be key source of future US gas supplies", Fletcher, Oil & Gas Journal, February 24, 2003.
[39] Testimony of Federal Reserve Board Chairman Alan Greenspan before the Committee on energy and Commerce of the US House of Representatives, June 10, 2003.
[40] A detailed description can be found in "B.B. InterCapital's Plan to Convert Natural Gas in South America to Regassified Natural Gas in the United States", B.B. InterCapital, LLC of Boston, MA, January 12, 2003.
[41] "Benchmarking study compares LNG plant costs", Yost and DiNapoli, Oil & Gas Journal, April 14, 2003.
[42] Calculation based on one metric ton of LNG yielding 50,000 cubic feet of gas.
[43] "Oman LNG receives bids for Train III LNG carriers", Oil & Gas Journal Online, March 27, 2003.
[44] See B.B. InterCapital, Chart 1.
[45] Media accounts of the Marathon proposal for Baja California cite costs of $550 million to supply 750 MMcf/d.
[46] Australian Ministers for Foreign Affairs and Trade, press release October 22, 2002. Available at http://www.foreignminister.gov.au/releases/2002/fa151a_02.html.
[47] Estimate based on heat rates of 10,000 BTU/kwh and 1,000 BTU/cuft.
[48] Rufo and Coito, "California's Secret Energy Supplies: The Potential for Energy Efficiency", Xenergy, Ind., September 23, 2002, available at http://www.ef.org/energyseries_secret.cfm.
[49] See www.aceee.org/energy/natlgas.htm.
[50] Wong, Leber and Sugar, " Analysis of Various Water Heating Systems", California Energy Commission, May, 1996. The average house heating water with natural gas uses 235 therms of gas for this purpose, or 23,000 cubic feet. Houses heating water with electricity require even more gas to generate the electricity used.
[51] Data for 2000 from E-GRID database, USEPA.
[52] Estimate based on a wind capacity factor of 35% and avoided gas generation having a heat rate of 8,500 BTU/kwh.
[53] "Wind Energy Can Relieve Natural Gas Shortage", available at www.awea.org.
[54] For a thorough discussion of the problem and the energy savings that could be obtained from the retirement of inefficient plants, see J. Jolly Hayden, "Why are $$$ being flushed down the toilet… when there's a way we can all win!", New Power Executive, April 4, 2003.
[55] Hanger, John, "5 Wrong Answers and 5 Smart Solutions to Reduce Blackouts", available at www.pennfuture.org.
[56] According to Southern California Edison, estimated savings are nearly 2000 kilowatt-hours per year per refrigerator. The program is believed to hasten the end life of the unit's working by an average of six years and costs about $200 per unit. The average gas fired generator uses about 10 cubic feet of gas per kilowatt-hour. The estimate assumes that growing electricity demand will be met by gas.
[57] Information on these codes is available from the California Energy Commission web site at www.energy.ca.gov.