STANFORD INSTITUTE FOR ECONOMIC POLICY RESEARCH
SIEPR

Policy Brief

Stanford Institute for Economic Policy Research

Liquefied Natural Gas (LNG) Is Essential to California's Energy Future

Frank A. Wolak

Since January 2000, wholesale natural gas prices in California have averaged more than double the average price over the five-year period January 1995 to December 1999. Before January 2000, California supplied roughly one-third of its electricity and nearly all of its space heating needs from natural gas. Since then California has constructed more than 10,000 MW of new electricity generation capacity—a roughly 20 percent increase in its installed generation capacity—and virtually all of these generation units are natural gas-fired, thereby increasing the demand for natural gas in California. At the same time, domestic supply is limited; at current rates of consumption in the United States and Canada, the estimated natural gas reserves in North America are expected to run out in fewer than 15 years.

Fortunately, the rest of the world has enormous natural gas reserves. North America is estimated to have only approximately 5 percent of the world's reserves. Moreover, different from the case of oil, where estimated reserves have decreased over the past five years, estimated natural gas reserves have increased as more gas fields have been discovered and technological advances have increased the efficiency of natural gas production. Furthermore, these reserves are far less concentrated in the Middle East than are oil reserves.

December 2004

Benefits from Natural Gas

There has been an increase in the number of ways that natural gas can be consumed and the efficiency with which it can be used. For example, natural gas-powered taxis and buses have found widespread use, particularly in areas facing significant pollution problems. Natural gas can be burned using combined-cycle gas turbine (CCGT) technology instead of conventional steam turbine (ST) technology to produce electricity. Steam turbines typically burn coal, or any other fossil fuel, in a boiler to produce steam that is subsequently used to spin a turbine that generates electricity. CCGT generation technology burns natural gas to spin a gas turbine. CCGT technology takes the exhaust heat from the gas turbine and uses it to produce steam that then powers another turbine to produce electricity. The CCGT technology allows a British Thermal Unit (BTU) of energy from natural gas to produce approximately 40 percent more megawatt-hours than the same BTU of coal or oil consumed in a state-of-the-art steam turbine generating facility.

The ability to produce significantly more useful energy per BTU of input fuel consumed implies much less carbon dioxide (CO_2) emissions. The estimated CO_2 emissions reductions vary considerably, depending on how intensively natural gas is used to produce useful energy and what is assumed about the alternative fossil fuels consumed if natural gas is not available. However, all of these scenarios demonstrate significant CO_2 emissions reductions from an increased share of natural gas in the fossil energy mix.

Burning natural gas produces significantly fewer particulates, which have been shown to contribute to heart and lung disease, than burning oil or coal. Burning natural gas also produces significantly less nitrogen oxides (NO_X) and sulfur dioxide (SO_2) per BTU consumed. For example, burning 1 BTU of natural gas releases approximately one-tenth of the NOx produced from burning a BTU of coal and approximately one-third of the NO_X produced from burning a BTU of oil. NO_X emissions are a major cause of smog. The environmental benefits in terms of SO_2 emissions are even more impressive. Burning 1 BTU of oil releases more than 1,000 times the SO_2 that results from burning 1 BTU of natural gas. Depending on the sulfur content of the coal, the amount of SO_2 released from burning a BTU of coal is many times higher than the amount released from burning 1 BTU of oil. SO_2 emissions are a major contributing factor to acid rain.

Barriers to the Use of Natural Gas

The major barrier for California and the rest of the United States to realizing the energy efficiency and environmental benefits of increased use of natural gas is the inability to access the enormous natural gas reserves outside of North America. Natural gas requires a sophisticated pipeline network to transport it from where the gas is produced to where it is consumed. The natural gas pipeline network must be maintained within certain pressure tolerances and other technical specifications in order to deliver natural gas in a reliable manner. California’s location at the endpoint of the Gulf Coast and Desert Southwest, Pacific Northwest and Canada, and Northern Rocky Mountains natural gas pipelines further increases the difficulty in maintaining a reliable natural gas supply for the state.

The most economic way to transport natural gas over long distances that cannot be served by a pipeline is in liquid form. This requires specialized facilities to cool the natural gas to minus 260 degrees Fahrenheit to a clear liquid that occupies approximately one six-hundredth of the volume it did as a gas. This liquefied natural gas (LNG) is then put into specialized tanker ships that allow it to be transported all over the world. Because the natural gas is transported in a liquid form, specialized facilities are needed to receive the LNG and convert it back to natural gas. These facilities must allow the tankers to dock and unload their LNG cargo and convert it to natural gas for injection into the natural gas transmission network. Currently there are no LNG receiving facilities on the Pacific Coast of North America. There are a small number of LNG facilities operating on the Atlantic Coast and one on the Gulf Coast of the United States.

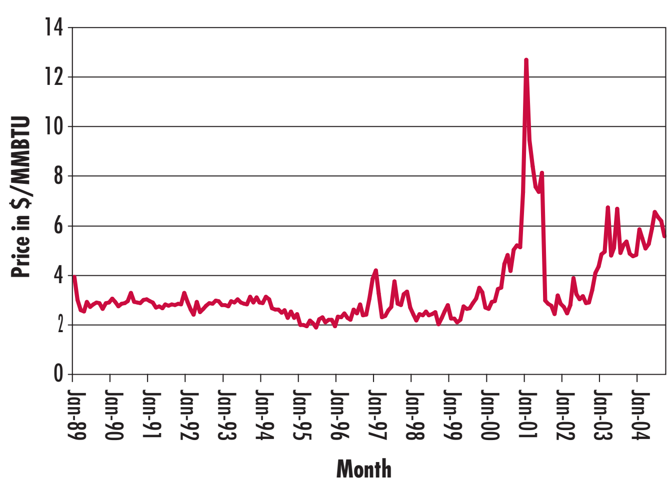
LNG Is Economic at Post-January 2000 Prices

The breakeven price of natural gas at which an LNG receiving facility pays for itself is estimated to be between \$3.00 to \$4.00 per million BTU (MMBTU), depending on the costs of natural gas liquefaction, transportation and regasification. All of these operations are very capital intensive, and as a result of economies of scale in production and technical change in the production process, the average total cost associated with each of these steps has declined considerably. For example, the average cost of an Australian liquefaction plant built in 1985 is approximately double the average cost of a recently completed plant in Sakhalin Island in Russia. The average price of LNG tanker ships has fallen by close to 50 percent over the past 10 years. The average cost for regasification facilities also has declined as the scale of facilities built has increased.

Figure 1 plots the monthly average price of wholesale natural gas deliveries in California. This figure demonstrates that even at a breakeven price of \$4.00/MMBTU, an LNG facility on the Pacific Coast would have been extremely profitable from January 2000 onward. The efficient scale of current regasification facilities would deliver approximately 800,000 MMBTU per day, which is slightly more than 10 percent of California's daily demand for natural gas. At this level of daily production, post-January 2000 natural gas prices imply a substantial volume in profits to the owner of this facility throughout much of this time period at wholesale prices given in Figure 1.

Although it is unclear if natural gas prices higher than \$5.50/MMBTU (their level at the end of the sample period in Figure 1) will continue into the future, it is difficult to imagine prices ever getting below the breakeven price for an LNG facility on the Pacific Coast. The enormous growth in world oil and natural gas demand driven in large part by the rapid economic growth of China and India make it very unlikely that California natural gas prices ever will fall below this

Figure 1
California Natural Gas City Gate Prices in Dollars per Million BTU (MMBTU) (January 1989 to September 2004)



Source: United States Department of Energy, Energy Information Administration level. Unless there is some huge unanticipated increase in North American natural gas reserves, prices in North America should continue to be at or above the breakeven price for a Pacific Coast LNG facility into the distant future.

Environmental Dividend of Developing the World LNG Market

There is another reason for California and the United States to foster the development of the world LNG market. In most cases, natural gas is a by-product of oil production. The oil-producing region's natural gas pipeline infrastructure, storage facilities and liquefaction facilities are often inadequate to make use of all of this natural gas, so it is simply "flared off" without producing any useful work.

To give an idea of the scale of this problem, in 1999 it is estimated that worldwide slightly more than the annual natural gas demand of California was flared off. While it is impossible to tell precisely how much of this could have been avoided with a more well-developed world market for LNG, the following comparison of North America and the rest of the world suggests that significant savings are possible. In 1999, less than 1 percent of North American production was flared off, compared to close to 5 percent of rest-of-the-world production.

A well-developed world market for LNG would cause more producers to find it profitable to construct natural gas storage, pipeline and liquefaction facilities to sell this natural gas in the world market. A significantly smaller fraction of the natural gas burned worldwide would contribute CO_2 and the other harmful emissions without producing any useful energy. This environmental dividend will be realized only if more producing regions find it profitable to transport, store and liquefy natural gas as opposed to burn it at the point of extraction.

Safety Issues Associated with LNG Transportation and Regasification Terminals

A major objection raised with siting LNG regasification terminals in California and other parts of the United States is that they involve risk. For instance, the fact that LNG is extremely cold creates dangers for both humans and materials not treated to withstand extreme cold. The most important concern, however, is that an LNG cloud can ignite if there is present the appropriate mixture of natural gas and air and an ignition source. For this reason, LNG regasification facilities are required to have a significant amount of land around the facilities to serve as a buffer zone against the potential harm to surrounding areas should such an event occur.

Although these safety risks should not be underemphasized, it is important to note that regasification facilities have been in operation in European and Asian countries for a number of years. For example, Spain, Portugal, France, Belgium, Italy, Greece and Turkey all have regasification capacity. Japan, South Korea and Taiwan rely on LNG for virtually all of their natural gas needs. These countries have managed to address these safety concerns satisfactorily. California and the United States should learn from their experience.

A final environmental benefit associated with greater world LNG trade is the fact that, different from oil, there is relatively little harm associated with an LNG tanker spill. The LNG simply evaporates on contact with the warmer ocean water and turns to gas. Consequently, the additional benefit of increased LNG trade is that it has the potential to reduce the risk of oil spills to the extent the increased LNG trade reduces the number of oil tankers operating.

What Is Needed to Move Forward

California policymakers should streamline the process for siting LNG facilities in California similar to what occurred during the period June 2000 to June 2001 with respect to siting power plants in California. Following the first oil price run-up in the early 1970s, the California legislature passed the LNG Terminal Act of 1977 to streamline the siting process. The 1977 act was subsequently repealed, which has left the state with no clear siting process for more than 10 years. There are a number of outstanding legal issues that new legislation would have to solve. Most of them revolve around the role of federal versus state regulators in the siting process.

In this regard, there is a recent technological innovation in regasifcation technology that may exclude many state agencies from participating in the siting process. It is possible to construct offshore LNG regasification facilities far enough from shore for the location to be classified as in federal government waters. A recent proposal envisioned building a facility 20 miles offshore from the city of Port Hueneme in Southern California. There would be an underwater pipeline from this facility to the Southern California natural gas transmission and distribution network.

Locating the facility offshore significantly increases the construction cost relative to an on-shore facility—in the range of 50 to 100 percent. However, this off-shore location does address the major safety concerns mentioned above and does limit the interference that LNG tanker activity would have with the coastline activities of human and marine life.

As should be clear, from the natural gas prices in Figure 1, the cost to California of delaying action on this issue is very high, both in terms of natural gas costs to consumers and environmental harm from burning fossil fuels that could be reduced by having a larger share of the state's energy needs met from natural gas. Natural gas can be the transitional fossil fuel to a more environmentally friendly energy future, but this seems unlikely to occur without investing now in a significant LNG regasification infrastructure on the Pacific Coast of the United States.

About the Author

Frank A. Wolak received his Ph.D. and S.M. from Harvard University. He is a Professor of Economics at Stanford University, and the Chairman of the Market Surveillance Committee of the California Independent System Operator (ISO), an independent market monitoring entity for state's electricity supply industry. He has been a visiting scholar at University of California Energy Institute (UCEI), is a Research Associate of the National Bureau of Economic Research (NBER), and a Senior Fellow at SIEPR. Wolak's fields of specialization are industrial organization and econometric theory. His recent work studies methods for introducing competition into formerly regulated infrastructure industries—telecommunications, electricity, water delivery and postal delivery services—and on assessing the impacts of these competition policies on consumer and producer welfare.

The Stanford Institute for Economic Policy Research (SIEPR) conducts research on important economic policy issues facing the United States and other countries. SIEPR's goal is to inform policy makers and to influence their decisions with long-term policy solutions.

With this goal in mind SIEPR policy briefs are meant to inform and summarize important research by SIEPR faculty. Selecting a different economic topic each month, SIEPR will bring you up-to-date information and analysis on the issues involved.

SIEPR Policy Briefs reflect the views of the author. SIEPR is a non-partisan institute and does not take a stand on any issue.

For additional copies, please see SIEPR website at: http://SIEPR.stanford.edu

SIEPR Policy Briefs
are underwritten by a generous grant from the Taube Family Foundation.

STANFORD INSTITUTE FOR ECONOMIC POLICY RESEARCH
SIEPR

SIEPR *Policy Brief*

A publication of the
Stanford Institute for Economic Policy Research
Stanford University
579 Serra Mall at Galvez Street
Stanford, CA 94305
MC 6015