Prepared for
NorthernStar Natural Gas
June 20, 2007

Liquefied Natural Gas and the Pacific Northwest:

Clean, affordable energy as the engine for economic growth.

An economic impact analysis for the states of Oregon, Washington and Idaho

Dr. Philip J. Romero
Professor, Lundquist College of Business, University of Oregon
and Principal, Forward Observer

FORWARD OBSERVER

Executive summary

The Pacific Northwest is economically dependent on the energy from natural gas for nearly one-fourth of its total energy. The gap between growing demand and constrained supply has led to rising prices, especially in the past few years. Since natural gas is fundamental to the production process of many industries, these price increases have reduced industrial output and employment. Furthermore, as the Northwest transitions to a "green" energy future, it will continue to rely upon natural gas to achieve its clean energy goals. This report examines the impact a liquefied natural gas (LNG) import terminal located in the Pacific Northwest would have on the region's economy. The results are dramatic. An LNG terminal would support an increase in regional employment of between 5,100 and 20,300 jobs and support an increase in household income of between $51 and $214 million.

These are important conclusions because without LNG, the Northwest's gas supply outlook is constrained by geography and market forces. The West Coast is the area of the Continental U.S. most distant from the main North American natural gas deposits of South Texas and the Gulf of Mexico meaning that transportation costs are significant. In addition, new pipelines such as the Rockies Express, are under construction which will carry more Rocky Mountain gas (a major source of gas for the Northwest) to higher-priced East Coast markets. This will put upward price pressure on the cost of gas in the western states.

Increasing the amount of natural gas delivered to the Northwest would protect the regional economy from the effects of a lessening gas supply and high prices. In addition, it would stimulate the economy, particularly in several high value-add exporting industries which typically pay wages well above the regional average. The most cost-effective way to increase the region's gas supply is to create the necessary infrastructure to import natural gas shipped by sea from foreign countries—where it exists in abundance. To maintain a stable supply of natural gas, the Northwest—and the nation—needs one or more West Coast terminals to receive liquefied natural gas.

The world has ample supplies of natural gas, which can be cost-effectively transported by sea as LNG. Once chilled to minus 260 degrees Fahrenheit, natural gas condenses to a liquid (note that this is achieved by temperature and not by pressurization) taking up 1/600th of its volume as a gas. Receiving terminals convert the LNG back into a gas, a process known as re-gasification. It is then transported through the natural gas pipeline system to industrial and residential consumers.

There are five such terminals in operation in the U.S. today, but none on the West Coast. There are also several proposals to build terminals that would serve the Pacific Northwest market.

This study was undertaken to determine the economic impact of one new LNG terminal serving the gas markets of Oregon, Washington and Idaho. It is worth noting that it is common to include British Columbia within a description of Northwest gas

markets. Accordingly, gas demand data was adjusted downward to reflect consumption in these three states prior to estimating economic benefits.

If constructed, a single terminal capable of delivering up to 1 billion cubic feet of gas per day (Bcf/day) would increase the Pacific Northwest's available gas supply between 10.3% and 51.5%, depending on the capacity utilization of the terminal. Such an increase in supplies could reduce gas prices by between 6.7% and 33.7%.

In our analysis we emphasize a scenario in which the terminal's capacity is utilized at rates similar to today's industry norms. In that circumstance, regional gas supplies in 2012 (the year that the Bradwood Landing terminal is scheduled to be fully operational) would be increased by 20.6%, creating conditions that would allow natural gas prices to fall by an estimated 13.1%.

To the extent that high natural gas prices contribute to the region's escalating electricity prices (because the region relies on natural gas for one-fifth of its electricity production), those prices become an issue of interstate competitiveness. Much of the Northwest's industrial base was built on a longstanding cost advantage in electricity, due to the region's abundant hydropower. Reduced or even more stable natural gas prices would help the Northwest remain competitive with other states and nations.

In a regional economy of nearly $500 billion in GDP with more than 5 million workers, the numbers provided in this report may sound small, but they amount to several weeks of economic growth, every year for as long as an LNG terminal operates. As a recent Stanford University report notes, "the cost… of delaying action on this issue is very high." A terminal to receive LNG is in the Northwest's economic interest, and as this analysis indicates, would provide many significant benefits.

With a stable supply of natural gas, Northwest industries such as pulp and paper mills, food processors, aerospace firms, microchip fabricators, and other manufactures, would have a secure energy future enabling them to compete and grow. Likewise, Northwest households would have higher disposable income (which would create a positive ripple effect through the regional economy) because they would have to spend less of their incomes on energy.

For this study, the economic benefits of increased natural gas supplies were estimated using two different methods: (a) a "top down" macroeconomic method that used national estimates of the economy's elasticity to oil price changes; and (b) a "bottom up" method that estimated the increase in disposable incomes from the price reductions that would be caused by increased supplies. The two different methods produced similar results, giving added credence to our estimates.

The top-down estimate suggested that a 10% reduction in natural gas prices would increase regional gross domestic product in 2012 between $222 million and $826 million. Regional employment would increase by 5,100 to 20,300 jobs. Households' income would grow by $54 million to $214 million.

The table below reports our bottom-up estimates, which are somewhat larger.

Output, income, and employment effects of alternative increases in regional natural gas supplies
(bottom-up estimates)

	Terminal Capacity Utilization (1 Bcf/day throughput)			
	20%	**40%**	60%	80%
Direct savings	$353.4	**$706.7**	$1,060.1	$1,413.4
Output multiplier *(total GDP per $ of added direct spending)*		**1.4707**		
Change in Regional GDP *($ millions)*	$519.7	**$1,039.5**	$1,559.2	$2,079.0
Reduction in gas prices		**-13.1% ($1.14 per MMcf)**		
Change in GDP *(%)*	0.11%	**0.23%**	0.34%	0.45%
Overall jobs multiplier *(jobs per million $ direct spending)*		**14.36**		
Change in regional employment *(# of jobs)*	5,100	**10,100**	15,200	20,300
Income multiplier *(household income per million $ direct spending)*		**0.43**		
Change in household income *($ millions)*	$152.0	**$303.9**	$455.9	$607.8
Income gain per family of four	$54	**$107**	$161	$214

Table 1 - Output, income and employment effects

The "bottom up" approach, summarized in Table ES-1, produced similar, but slightly larger, results compared to the "top down" approach: A 20.6.% increase in gas supplies from an LNG terminal operating at a 40% capacity utilization rate would produce a 13.1% reduction in natural gas prices. This would provide $706.7 million in savings to regional gas consumers, leading (with indirect effects included) to an increase in regional gross domestic product (GDP) of $1.039 billion.

Other scenarios at lower or higher utilization rates show the increase in 2012 regional GDP ranging from $520 million to $2.079 billion. Regional employment would increase by 10,100 jobs—roughly equivalent to a few weeks of growth for the entire economy. Other scenarios put the range of added jobs from 5,100 to 20,300. Households' income would grow by $304 million, or roughly $107 per family of four. Again, other scenarios show the range of household income added between $152 million and $608 million, or $54 to $214 per family of four.

As noted before, the top-down and the bottom-up estimates yielded similar results. They are also consistent with—but more conservative than—other, national-scale studies of the economic effects of higher natural gas prices.

We have attempted to be as conservative as possible in producing our estimates of a project's economic benefits. Below is a list of the main ways that our assumptions either inflated, or (more often) deflated the estimated economic impact.

Biases that inflated impacts

- Multiplier approach ignores adjustments that naturally occur after an economic change (such as price reductions due to increased supply).

Biases that deflated impacts

- Relatively low terminal capacity utilization assumed in our base case.
- Relatively high price elasticity of demand, which lowers magnitude of price reduction.
- Recognition that lower prices will cause increased consumption of gas, thereby reducing the savings available for other consumption or investment.
- Use of household multiplier, lower than any industry.

We believe that taken together our deflating biases exceed our inflating biases, making our analysis quite conservative. This is consistent when our findings are compared to those in national studies.

Introduction

To most people, natural gas is nothing more than the invisible vapor that fuels their cook-top, furnace, and water heater. But, it is also a vital feedstock to industries that employ more than one of every 50 Northwest workers. In addition, it fuels nearly one-fifth of all electricity generated in the region, and virtually all of the growth in electric generation throughout the U.S. In contrast to oil, whose long-term availability remains uncertain, there is no question that world natural gas supplies are ample for decades to come. There is also no question that natural gas is the cleanest-burning fossil fuel, and will be the fuel of choice until other energy sources, such as renewables, are produced on a scale sufficient to allow them to be competitive in the marketplace.

We in the Northwest produce very little natural gas, yet we rely on it for more of our total energy needs than from electricity, as shown in Figure 1. The Northwest is becoming more reliant on gas and so is the world as a whole. By 2020[1] the world will use more gas than oil (on a BTU basis) and gas will meet one-quarter of the world's energy needs by 2025[2]—as already is the case here in the Northwest.

Because the Northwest produces little gas, it must rely on natural gas imports from other U.S. regions, from Canada, and from overseas. In the past, when demand for gas was lower than today, the Northwest's geographic position between two producing regions (the U.S. Rocky Mountains and Western Canada) was an advantage. Today, however, growth in demand and a slackening of supply has put our region in competition with others, including eastern U.S. markets that have traditionally paid more for gas. The gap between growing demand and constrained supply has led to escalating prices. This is especially salient because much of our region's industrial economy was built on low energy prices. Since natural gas is fundamental to the production process of many industries, these price increases have reduced output and employment.

Figure 1. Energy consumption by type (electricity vs. natural gas)
Source: Northwest Gas Association

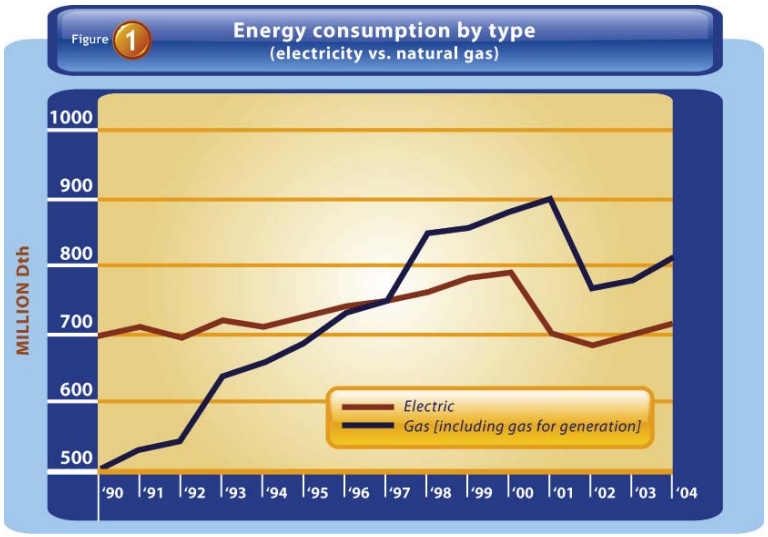


Figure 1 - Energy consumption by type

Increasing the amount of natural gas delivered to the Northwest would thus stimulate the economy, particularly in several high value-add industries that typically pay wages well above the regional average. Because traditional sources at the sending end of pipelines are either already committed or face declines in production, the most cost-effective way to increase gas supply is to create the necessary infrastructure to import natural gas by sea. It can be shipped from foreign countries, where it exists in abundance. As several observers have suggested, the West Coast—and the nation—needs one or more terminals to receive liquefied natural gas.

This report examines the regional economic impact of an LNG terminal in the Northwest. Its focus is on the effects of the wider economy of lower gas prices made possible by increased supply. The report's sponsor, NorthernStar Natural Gas, is in the latter stages of the permitting process for an LNG terminal called Bradwood Landing, on former industrial land on the Columbia River upstream of Astoria, Oregon. This report is not an evaluation of the engineering or environmental merits of this specific project, but rather an estimate of the economic benefits that can be expected if an LNG terminal of its approximate capacity is built somewhere in the Northwest. Therefore, these findings apply to some degree regardless of which of the several terminals currently proposed should come to fruition.

This report has five main parts. *The role of natural gas in the Northwest economy* (second) chapter provides background on the economic importance of natural gas to the Northwest's economy. The third chapter, *The Northwest's energy portfolio*, outlines the portfolio of Northwest energy sources and the constraints on their transmission and distribution that lead to excess demand relative to supply, and consequently, inflated prices. It also describes the increasing role that LNG must play in meeting the Northwest's energy needs. The fourth chapter, *Economic implications*, identifies the industrial and consumer demand destroyed by higher energy prices that divert spending away from other goods and services. It includes the report's core finding: estimates of the benefits that could accrue to the economy if an LNG terminal was built, expressed in terms of economic output (gross domestic product), jobs, and household income. The final chapter, *Conclusions*, reiterates the paper's main findings and their policy implications.

The role of natural gas in the Northwest economy[3]

Most consumers use natural gas to cook, or to heat their homes. Beyond these everyday residential uses, natural gas has two other important applications.

(a) *Electricity generation*: About one-fifth of the region's electricity is generated at gas-fired facilities, from traditional large plants to very small generators that power individual homes or commercial buildings. As shown in Figure 2, nearly one-fourth of natural gas delivered to the Northwest is employed in electricity generation. Nationally, gas consumption for electricity generation has been growing faster than overall demand for gas (2.7% vs. 1.7% per year), largely because 94% of new plants constructed between 2001 and 2003 were gas-fired. Overall, natural gas accounts for 23% of total U.S. energy use (the same proportion as in the Northwest), which will continue to grow as more gas-fired plants come on-line and nuclear plants are shut down due to age.[4]

Figure 2. Natural gas demand in the Northwest by sector 2005
Source: Northwest Gas Association, 2006

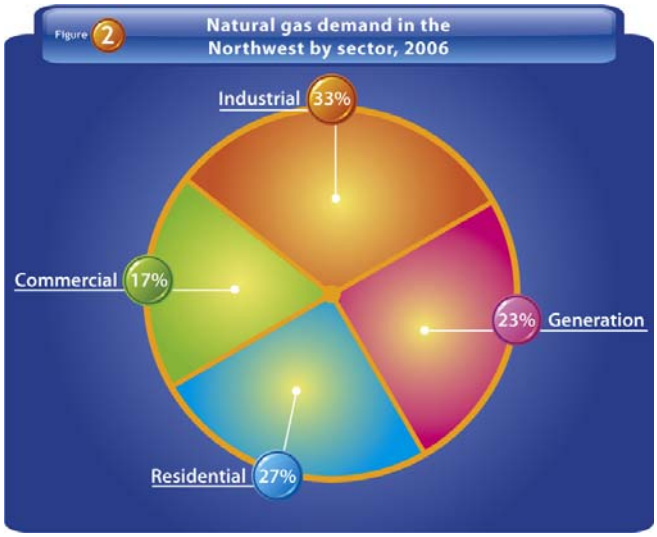


Figure 2 - Natural gas demand in the Northwest

(b) *Industrial uses*: The U.S manufacturing sector uses 25% of total generated electricity while the Northwest manufacturing sector uses 33% of region's generated electricity. In addition, natural gas is a primary feedstock for several chemical industries (chemicals, plastics, and fertilizers), or is the heat source of choice in processes that require high temperatures (glass).[5] These industries employ 1.5% of the U.S. workforce, and a higher fraction of the Northwest's.[6] Combining the direct use of natural gas in production and the indirect use in electricity needed for manufacturing, the industrial sector consumes 34% of all natural gas in the U.S, and a larger share within the Northwest. The specific

effects of increased gas imports on natural gas-intensive industries are briefly discussed in the *Economic Implications* chapter.

Why natural gas prices are high

Since natural gas can often be a substitute for oil, and frequently is a byproduct of oil production, gas prices (in terms of dollars per million cubic feet) closely track oil prices (in dollars per barrel), as shown in Figure 3. Weak natural gas production, high demand and rising oil prices are the main drivers of high natural gas prices. Because some large volume customers, primarily industrial consumers and electricity generators, have the ability to switch between natural gas and petroleum products, natural gas will correlate closely with crude oil. However, with increased environmental concerns, more and more large-scale users require substantial price differential before switching to the high emission petroleum products. As a result, this will cause natural gas and crude oil price decoupling. Weather related events such as lack of rainfall in hydroelectric generation regions, hurricane impacts on Gulf of Mexico production and pipeline capacity limitations will create price spikes any given year.

Figure 3. The relationship between the price of crude oil and natural gas
Source: Energy Information Agency[7]

Figure 3 - The relationship between the price of crude oil and natural gas

Beginning in the winter of 2000-01, which was colder and drier than normal, cold weather drove up heating demand, and dry weather reduced the availability of hydropower, increasing the demand for gas-fired electricity. U.S. gas prices that had remained in the range of $1.40 to $2.40 per million British thermal units (MMBTU) for 95% percent of the 1990s spiked to over $6.00 per MMBTU in late 2000.[8]

Futures markets suggest that prices will remain near or above $7.00 per MMBtu for the foreseeable future.[9] In fact, as of June 11, 2007, the NYMEX future prices for January 2012 (the first full year of Bradwood Landing's operation) settled recently at $8.66 per MMBTU.

Figure 4. NYMEX Henry Hub Natural Gas Price Forecast
Source: NYMEX June 7, 2007

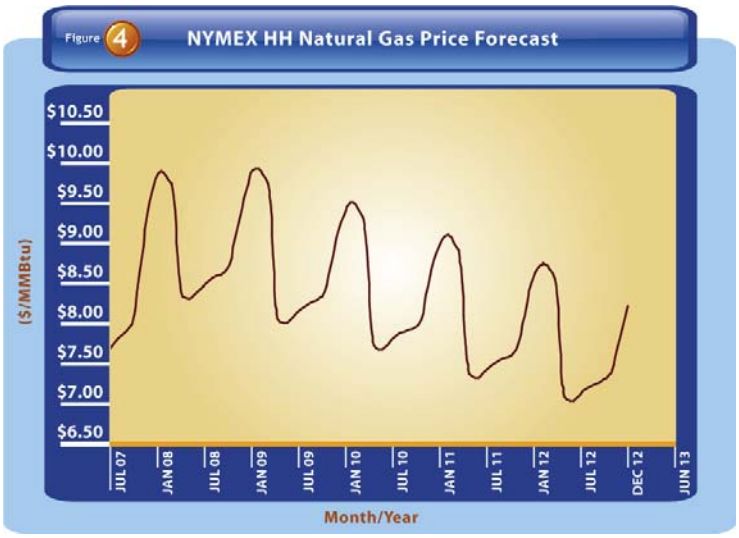


Figure 4 - NYMEX Henry Hub Natural Gas Price Forecast

The consequences of inaction

Natural gas supplies to the Northwest are below the level of demand. This disparity will only increase without more imports. Continued shortages will lead to one or all of the following results:

(1) The free market will drive natural gas prices up. This will "destroy Demand," as economic consulting firm Global Insight has put it.[10] Spending by businesses and consumers that would otherwise have gone to non-energy purposes—for example, investment in productivity-enhancing technologies—will instead be spent for the same amount of fuel at higher prices. Less spending on other things means less aggregate economic activity.

(2) Since natural gas is used so pervasively in the economy, a wide range of businesses will face higher costs, and defray them by raising their prices. Inflation, which is already above the upper level of the Federal Reserve's target range, will accelerate. This could force the Federal Reserve to raise interest rates further, slowing economic activity. However, it is unlikely that the slowdown would be of sufficient magnitude to bring on a recession.[11]

(3) These two effects can be summarized in one word: stagflation—reduced economic activity simultaneous with higher inflation. Which of the two effects will be stronger is difficult to determine (and is greatly dependent on the Federal Reserve's actions). However, since the world market for energy redirects fuel to where it can command the highest price, higher Northwest energy prices may attract more gas (assuming it can be transmitted through an already stressed infrastructure), which will partly mitigate the regional price increase. More likely, it will export some of that inflation to other customers in the global market.

The Northwest's energy portfolio

As shown in Figure 5, about one-fourth of the U.S. energy use is fueled by natural gas. The proportion in the Northwest is virtually identical, as noted earlier.

Figure 5. Fuel sources for U.S. energy use, circa 2000.
Source: National Petroleum Council, 2003

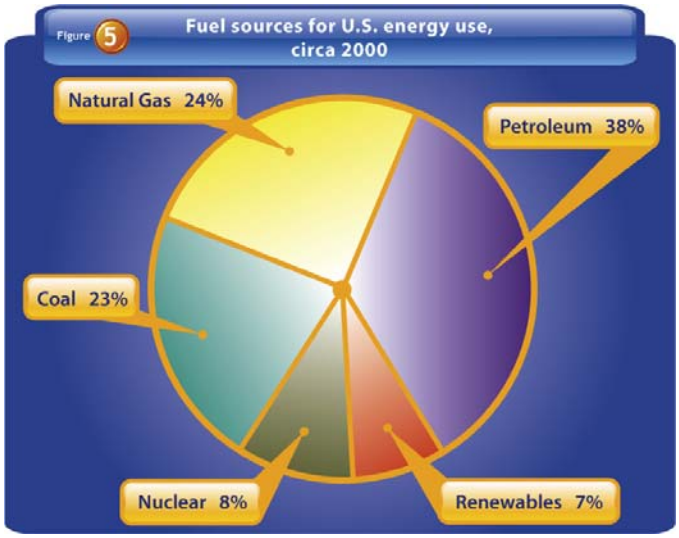


Figure 5 - Fuel sources for U.S. energy use, circa 2000

Northwest energy demand

Natural gas' share of total Northwest energy use first exceeded electricity's in 1998 and has been growing rapidly since, as shown in Figure 6.

Figure 6. Pacific Northwest energy consumption
Source: Northwest Gas Association, including British Columbia

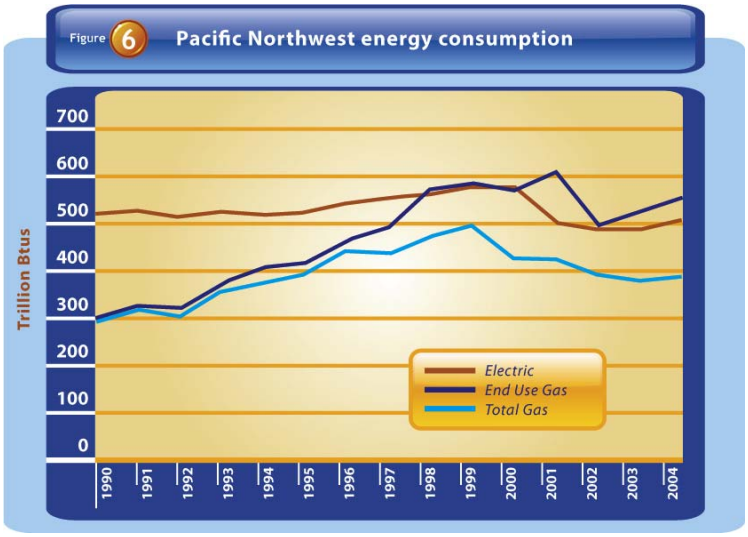


Figure 6 - Pacific Northwest energy consumption

Because natural gas is the fossil fuel of choice because if its low emissions, it will power the majority of growth in electricity production over the next two decades, as shown in Figure 7.

Figure 7. U.S. electricity generating capacity by fuel type 1995 to 2025
Source: National Petroleum Council[12]

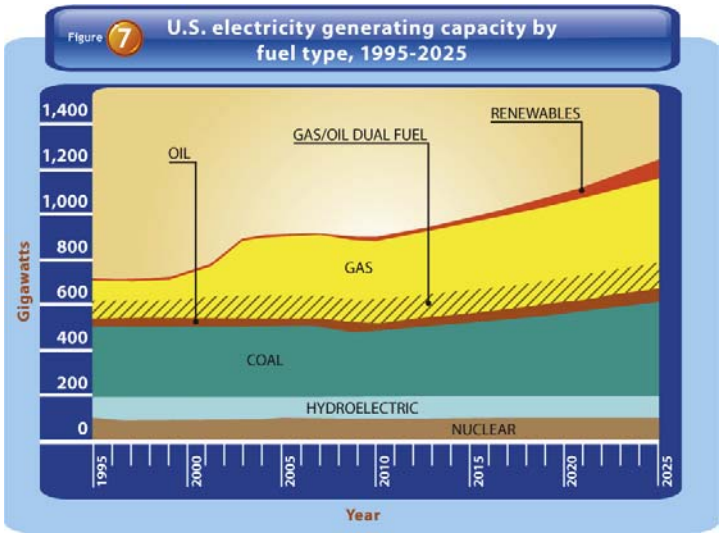


Figure 7 – U.S. electricity generating capacity by fuel type 1995 to 2025

In the Northwest, historically industry (i.e., manufacturing companies) has been the largest consumer of natural gas, as shown in Figure 8. When gas consumed to generate power for industry is included, industry's share very likely exceeded 50% of total gas use in the Northwest as recently as 2005.

Figure 8. Distribution of Northwest demand for natural gas 1999 and 2005
Source: Northwest Gas Association, including British Columbia

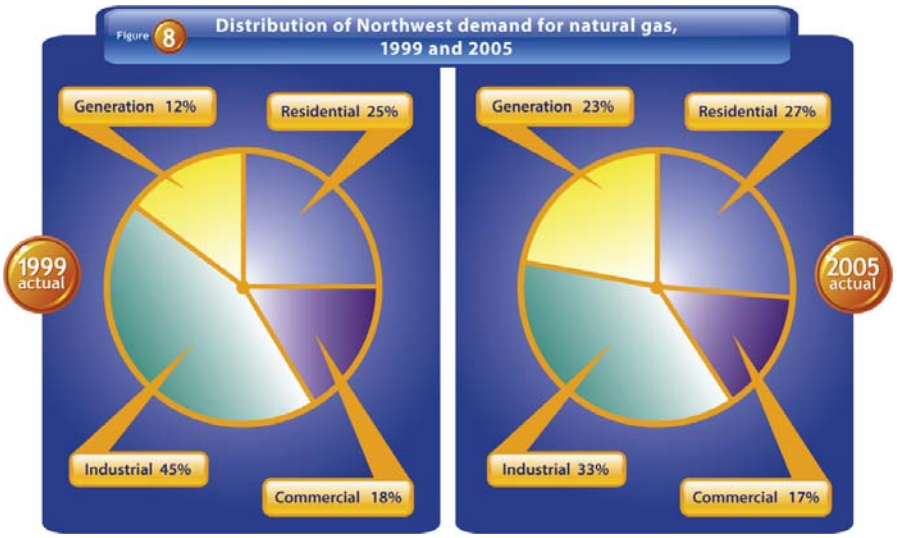


Figure 8 – Distribution of Northwest demand for natural gas 1999 and 2005

However, as manufacturing has declined as a share of the Northwest's economy (in parallel with, but more precipitously than, the longstanding national trend), electricity generation and to a lesser degree residences have taken up the slack. Essentially all hydro power opportunities have already been exploited, and air pollution regulations have obliged utilities to shift to cleaner fuels for electricity generation. As a result, virtually all generation plants constructed in the past decade have been natural gas-fired. Nationwide, most new homes are being heated by natural gas, as shown in Table 2, so its share of residential energy use has risen. Natural gas' share of home heating has risen by more than two percentage points for the nation as a whole, but by slightly less in the West because the region was already the second-highest in gas intensity.

Share of U.S. homes heated by natural gas, 1997 and 2001
Source: American Gas Association, 2002[13]

Region	2001	1997
U.S. total	54.8%	52.7%
Northeast	52.4%	46.0%
Midwest	76.8%	75.0%
South	39.5%	38.0%
West	59.5%	58.0%

Table 2 - Homes heated by natural gas

Although new homes tend to be more energy-efficient per square foot than older homes, they also tend to be much larger. Despite considerable emphasis on conservation in building codes, EIA predicts that the Northwest residential demand for gas will rise by 3% by 2010.

Northwest natural gas supplies

The primary sources of the Northwest's gas are fields in Western Canada, which sends about 1 billion cubic feet per day, and the U.S. Rockies, which sends about 100 million cubic feet.[14] Unfortunately, U.S. domestic gas production has been declining at double-digit rates for almost two decades, as shown in Figure 9.

Figure 9. Rate of decline in natural gas production in the U.S. lower 48 states
Source: National Petroleum Council, 2003[15]

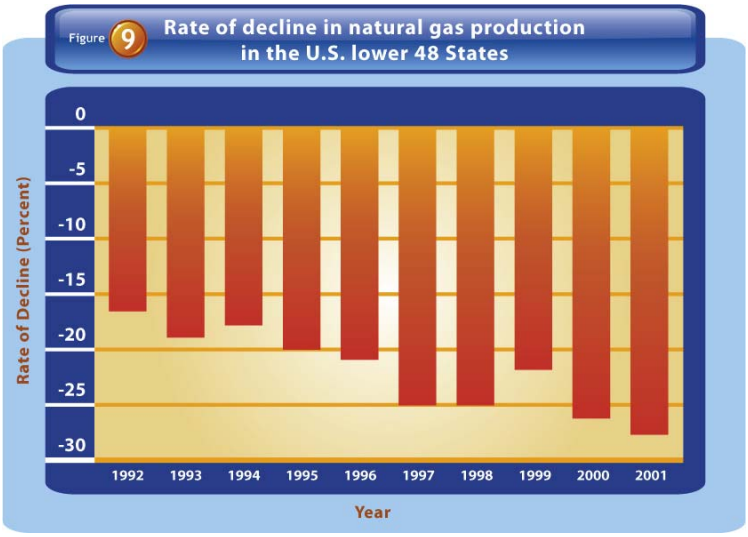


Figure 9 - Rate of decline in natural gas production in the U.S. lower 48 states

Canadian production and therefore exports are forecast to begin declining shortly, as shown in Figure 10, with their peak production year in approximately 2007.

Figure 10. Canadian natural gas production and demand 1990 to 2020
Source: Natural Resources Canada

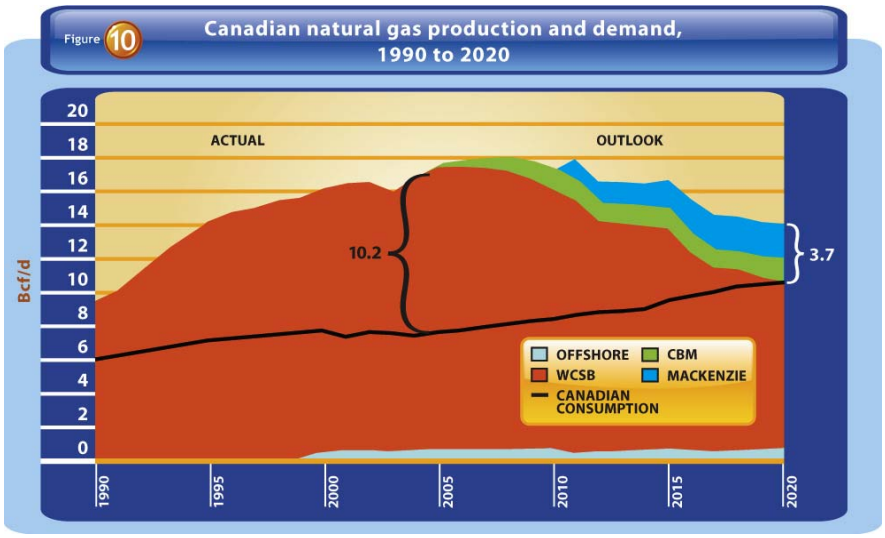


Figure 10 - Canadian natural gas production and demand 1990 to 2020

Due to high oil prices, crude bitumen production from Canada's tar sands has become economical. Bitumen is a semi-solid form of crude oil that is mixed with silica sand, clay material and water. Vast oil deposits lie under Alberta's Athabasca Oil Sands in Northern Alberta. The natural gas required to excavate the bitumen is enormous and Natural Resources Canada predicts demand to increase 2 Bcf/d by 2020.

These forecasts reflect expectations that some fields which otherwise would be considered fully depleted may yield more gas through the use of unconventional techniques, such as the injection of nitrogen to force more gas to the surface. Similar approaches have been used in oil fields for years. Nevertheless, as Figures 11 and 12 show, for the Lower 48 and Canada respectively, such techniques are not expected to do more than, at best, roughly maintain—not expand—current levels of production. Likewise, Mexican production of oil has begun to decline, and Mexican gas may not be far behind.[16]

Figure 11. Lower 48 natural gas production by resource category
Source: National Petroleum Council

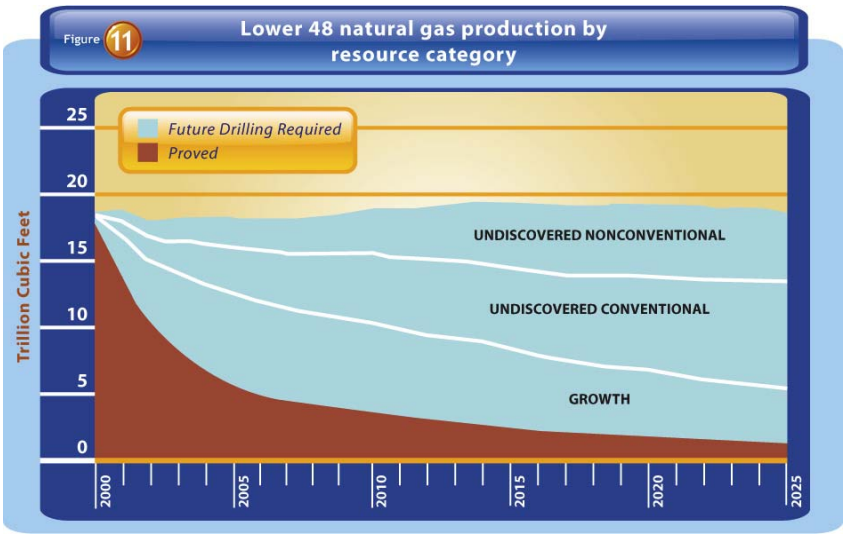


Figure 11 - Lower 48 natural gas production by resource category

Figure 12. Canadian natural gas production by extraction technology type
Source: National Petroleum Council

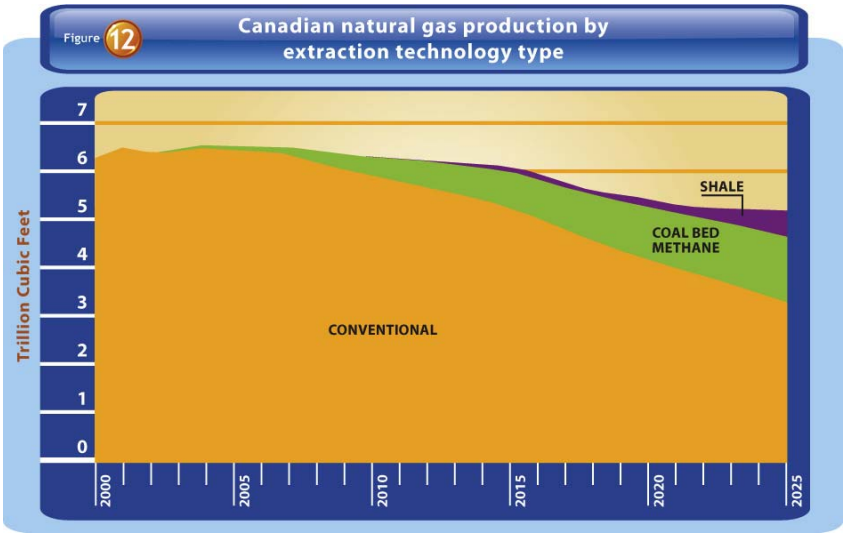


Figure 12 - Canadian natural gas production by extraction technology type

Responses to the shortfall between supply and demand

The net effect of these trends will be a shortage of natural gas. The market will allocate that shortage through higher prices.

Economic consulting firm Global Insight has said higher energy prices (especially for imported energy) "destroy demand"[17]. That is, disposable income must be spent on energy that would otherwise have been spent on consumption or on investment. Firms in the industries denied this spending are forced to cut back on their own spending, investment, and hiring. The effects ripple through the economy, cumulating to reduce aggregate economic activity and employment.

Conceivably, it could be even worse than this. Affected firms which see their energy costs rise may raise their own prices to compensate. Their customers may in turn raise their prices also (if their customers are individuals, they will demand higher wages). Cumulatively these price increases can accelerate inflation, at a time when the Consumer Price Index is already rising faster than the Federal Reserve is believed to consider acceptable.

Either way—inflation, stagnation, or both—the result will be the same: reduced economic activity. It may come naturally, or the Federal Reserve may engineer it to prevent rising inflation. The analysis in Chapter III, *Economic Implications*, will emphasize the effects on aggregate economic activity, employment, and income, making the assumption that the Federal Reserve will err on the side of vigilance, and slow the economy down by an additional decrement to avoid increased inflation, as it has for almost 30 years under three chairmen.

A supply response: LNG

What can be done? Conservation—a demand-side strategy—can close some of the gap between supply and demand. However, the EIA's forecast shown above assumes considerable conservation steps, including those brought on by escalating prices. Further conservation would require raising prices still higher—such as through an energy consumption tax, which would only aggravate the economic problem, at least temporarily.

The alternative is to augment supply. Natural gas is in plentiful supply overseas. But transporting it requires a different approach: it must be liquefied (not pressurized) to be carried on ships. Shipping terminals to receive liquefied natural gas (LNG) exist on the East and Gulf Coasts, but none have ever been built on the U.S. West Coast.

The need for increased imports: liquefied natural gas (LNG)

The Northwest produces very little natural gas, so nearly all of the natural gas consumed is imported from Canada's Western Canadian Sedimentary Basin (WCSB) and the Rockies. Because the West Coast is the area of the continental U.S. most distant from the majority of all other natural gas basins, transportation costs are higher. With the construction of the Rockies Express Pipeline, which will move 1.8 Bcf/d of Rockies gas eastward, the decrease of WCSB production and the increase of gas consumption in Canada to produce crude oil from the tar sands,

Lacking this supply, the West has less ability to smooth seasonal swings in prices through the use of stored reserves (inventories). According to the Energy Information Administration (EIA), 82% of the nation's storage capacity for LNG is in the East (where three of the five existing LNG terminals are located; the other two are in the Gulf of Mexico), and only 14% in EIA's 13-state Western region (essentially all states west of Texas)[18]. Imported LNG provides 45% of the East's net gas imports, but essentially none of the West's.[19]

How liquefied natural gas (LNG) works

Within a contiguous land mass (e.g., within North America), natural gas is normally transmitted via pipelines. However, when it is shipped across oceans, it is chilled to minus 260 degrees Fahrenheit (but not pressurized), where it condenses to a liquid state. As a liquid, natural gas takes up 1/600th the volume it does as a gas, allowing it to be economically transported via ship in large amounts. Figure 15 shows some of the locations where natural gas is presently liquefied, and the sources of U.S. LNG imports.

Figure 13a. Sources of liquefied natural gas and U.S. imports of LNG
Source: National Petroleum Council

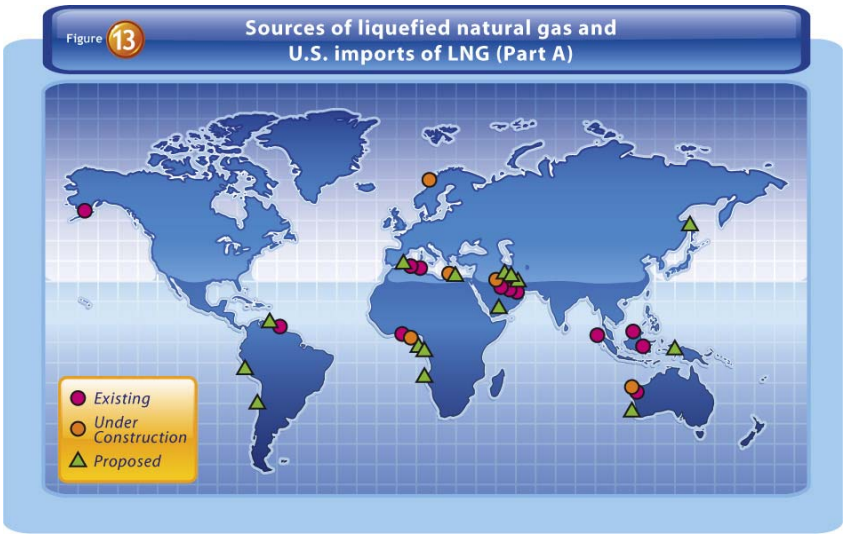
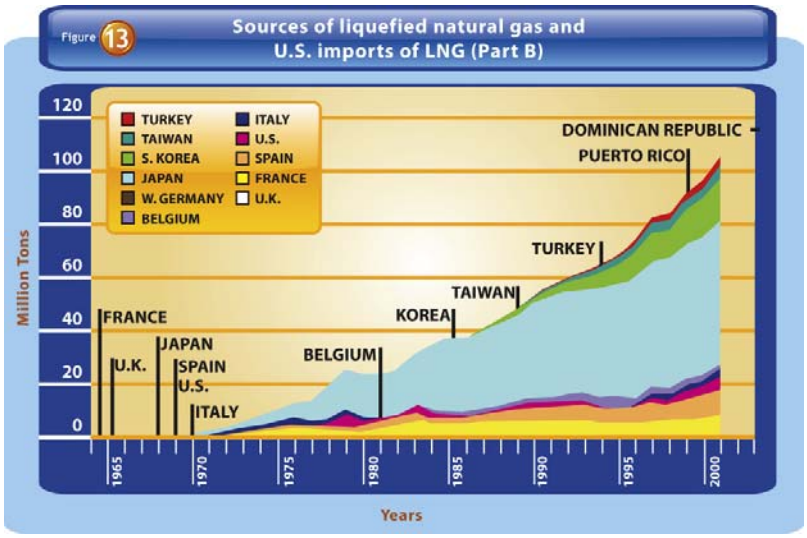


Figure 13 - Sources of liquefied natural gas and U.S. imports of LNG

Figure 13b. Sources of liquefied natural gas and U.S. imports of LNG
Source: National Petroleum Council



While LNG is relatively unknown to the U.S. general public, some countries have been relying on it as a major energy source for decades. Japan and Korea, for example, rely heavily on LNG for their energy needs. In the 48 years that LNG has been transported by ship not a single incident has occurred that injured a member of the public. A report by Stanford University's Institute for Economic Policy Research (SIEPR) points out, "Although safety risks should not be underemphasized, it is important to note that re-gasification facilities have been in operation in European and Asian countries for a number of years… these countries have managed to address safety concerns satisfactorily."[20] *Important caveat: The authors of the present report are not safety experts. We are only reporting the views of experienced observers of LNG.*

Figure 14. Projected U.S. natural gas supply and demand balance
Source: EIA via Northwest Gas Association [21]

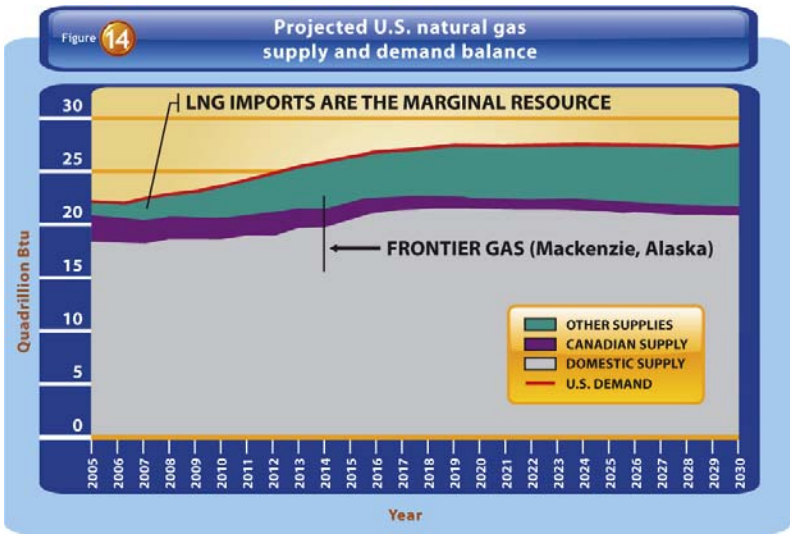


Figure 14 - Projected U.S. natural gas supply and demand balance

EIA's forecast (shown above in Figure 14) anticipate that all growth in natural gas demand will be met either by sources in Alaska or by overseas sources brought to the U.S. lower 48 states. There are proposals to construct a natural gas pipeline from Alaska and the MacKenzie Delta southward; however, environmental concerns and increased capital cost have placed the project in doubt. Regardless, the vast majority of the new gas will be transported by ship as LNG. Figure 15, from the National Petroleum Council shows these sources in greater detail.

Figure 15. Sources of natural gas consumed in U.S.
Source: National Petroleum Council

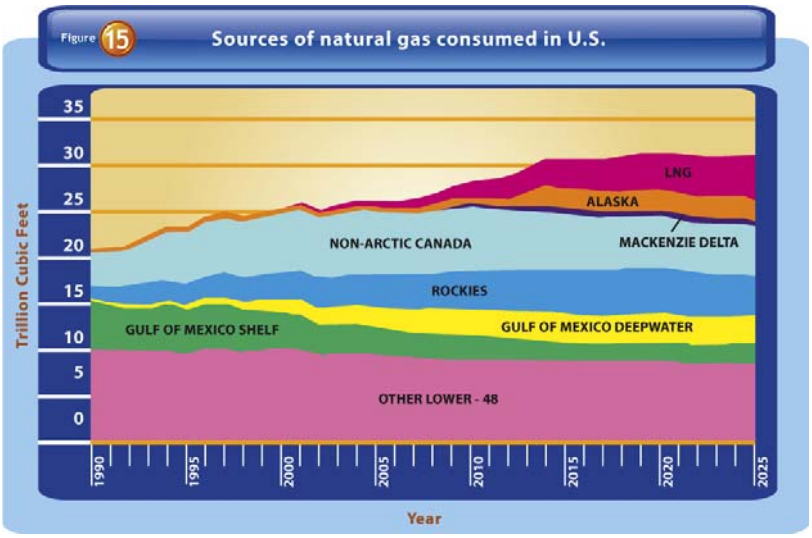


Figure 15 - Sources of natural gas consumed in U.S.

What about renewable energy?

Natural gas is the cleanest burning fossil fuel, and its combustion in a furnace or turbine is far cleaner than flaring it off as an unwanted byproduct of oil production. There is great interest worldwide in increasing the use of renewable energy sources such as solar, wind, biomass, and geothermal to even further reduce the environmental impacts of creating energy. Concerns have been raised that the importation of LNG will simply displace and delay the implementation of these prospective sources, generally termed "renewables" because they do not consume fossil fuels.

Renewables hold great promise for a cleaner energy future, and while governments and the capital markets are investing aggressively in their development to bring them on-line, it will be decades before they can efficiently supplant all fossil fuels – including gas. In addition, gas is likely to be with us a very long time as a heating fuel.

According to energy experts, natural gas is likely to be the energy source of choice for the next few decades, until renewables are developed to a scale and efficiency that they can replace it. In the recent past or for the immediate future, renewables have

been and will be a minor addition to the Northwest's electricity generation capacity, as shown in Figure 16, and they will have no impact on heating fuel. Most new generation facilities have been natural gas-fired and will continue to be so for the next few decades.

Figure 16. Additions to Northwest electricity generation capacity
Source: Northwest Power and Conservation Council

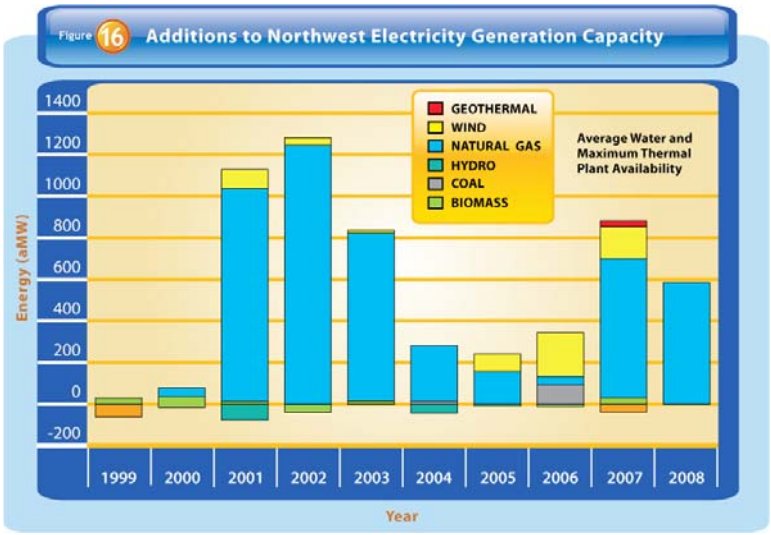


Figure 16 - Additions to Northwest electricity generation capacity

A comment about forecasts

This report relies heavily on forecasts of energy supply and demand to 2012, from the Energy Information Administration, the Northwest Gas Association, the Northwest Power and Conservation Council, the National Petroleum Council, and others. All forecasts are subject to change, have varying degrees of accuracy and in the case of natural gas, the main reasons are threefold. First, because energy is such a pervasively consumed commodity, many unpredictable elements of the world economy can affect energy demand and supply. Second, price changes will change both supply and demand. For example, an unexpected price increase will reduce demand and increase supply, albeit with long lags in both cases. Finally, new technologies will both increase effective supplies and reduce demand.

Although it is extremely unlikely that sales of natural gas in 2012 will be exactly as projected, fundamental analysis is necessary in order to estimate the effects of supply increases on natural gas prices in that year. Today's estimates of the base price of gas in 2012 may be incorrect, but we believe that our estimates of the price change caused by added supplies are reasonable, even conservative.

Economic benefits of a natural gas price reduction resulting from increased supplies

We estimated the economic impact of the establishment of an LNG terminal in the Northwest by two methods:

(1) A top-down method based on a hypothetical 10% reduction in natural gas prices, with its estimated economic effects based on national macroeconomic studies of the relationship between fossil fuel prices and macroeconomic variables; and

(2) A bottom-up approach that estimated the reduction in gas prices from a terminal, and its regional economic effects via regional input-output multipliers.

This chapter outlines both methods, which produced fairly consistent and quite conservative results.

Top-down, macroeconomic estimates

Consider for a moment a thought experiment: Given natural gas' ubiquitous and growing role in the economy, what would the economic benefit be if prices were reduced by making additional supply available? In the first section of this chapter, we will make the arbitrary assumption that price decreases by 10%. As will be seen in the next section, this is an arbitrary but conservative guess at the plausible decline that can be expected if LNG was added to the region's energy supply.

Table 3 shows two alternative estimates from other studies of the elasticity of the economy (gross domestic product, the sum of all goods and services produced) with respect to natural gas prices. This elasticity captures the change in overall economic output per one percent change in gas prices. Each of these sources' estimates was based on the equivalent elasticity of the national economy with respect to oil prices.

Natural gas price elasticity of U.S. economic output (GDP)
(% change in GDP per 1% change in natural gas price)

Source of estimate	Low Estimate	High Estimate
American Chemical Council, March 2003	0.467	
Federal Reserve Bank Dallas, Sept/Oct 2003	0.5	1.8
Midpoint of above estimates	**0.483**	**1.8**

Table 3 - Natural gas price elasticity

This means that, for example, a 10% reduction in natural gas prices will increase the Northwest's gross state product (GSP), which was $458.8 billion in 2005, by between 0.0483% and 0.18%, or between $222 million and $826 million.

These impacts are large for two main reasons. First, as economic forecasting firm Global Insight has put it, high natural gas prices "destroy [aggregate] demand,"[22]because gas is used so pervasively. When gas prices increase, corporate earnings and household disposable income decline and are unavailable for reinvestment or domestic consumption. We need look no farther than the sales of discount retailers, which cater to lower-income buyers. They have been reduced for about the past year due to higher gasoline prices, which hit lower income households harder because fuel is a larger share of their incomes.

These projected impacts are also large because any added resources being spent on higher natural gas prices are not simply transferred from one Northwest regional economic actor to another: virtually all purchases leave the region to pay for imports. Lower prices reverse these effects, creating more retained earnings or disposable income that can be spent on regional goods and services.

Such considerable changes in economic output will likewise affect employment and household income as well, as the added spending ripples through the economy. Based on the "top down" elasticities in Table 3, Table 4 estimates these additional effects for an assumed 10% reduction in natural gas prices. Northwest employment would increase by 5,100 to 20,300 jobs—roughly equivalent to a few weeks of growth for the region's entire economy[23]. Household income would grow by between $96 million and $355 million, or roughly $54 to $214 per family of four.

Northwest output, income, and employment effects of a hypothetical 10% change in natural gas prices
(Macroeconomic, top-down estimates)

	Low estimate	High estimate
Increase in direct spending *($ millions)*	**$222**	**$826**
Output multiplier *(total increase in GDP per $ of direct spending)*	**1.4707**	
Change in Northwest GDP *($ millions)*	**$326.5**	**$1,214.8**
Change in GDP *(%)*	**0.24%**	**0.9%**
Jobs multiplier *(jobs per million $ direct spending)*	**14.36**[26]	
Change in Northwest employment *(number of jobs*[27]*)*	**5,100**	**20,300**
Income multiplier *(income per million $ direct spending)*	**0.43**	
Change in household income *($ millions)*	**$95.5**	**$355.2**
Income gain per family of four *($/year)*	**$54**	**$214**

Note: GDP= Gross Domestic Product, the sum of all goods and services produced in the region. This parametric estimate is deliberately conservative. The "overall" multipliers used here are for the household sector, and are almost certainly lower than the relevant multipliers for this scenario. The industries that would be most affected by natural gas price changes have high value added per worker, and therefore higher multipliers than households.

Table 4 - Northwest output, income and employment effects

Lower gas prices would have similar national economic benefits. A simplistic translation of the above estimates to national numbers would suggest that a 10% reduction in natural gas prices would increase U.S. GDP by $3.0 to $11.2 billion This is broadly consistent with the American Chemical Council's 2003 estimate that a 100% increase in gas prices would depress the economy by about $200 billion. Since the Northwest uses just under 3% of the nation's gas (and has a GDP of about 3.5% of the nation's), it is reasonable to expect the region's share of national effects of gas price changes to be of similar proportion. 3% of $3 to 11.2 billion would be $90 million to $336 million, lower than the crude estimates in Table 4.

However, David Henry and Kemble Stokes of the U.S. Department of Commerce found a substantially larger effect: a 20% price increase would depress GDP by roughly $250 billion[24], with half of that effect persisting over the long run. (1.75%--3% share of the nation x a 10/20% price change—would be $1.875 billion.) Consequently, we consider our results—both the crude top-down estimates above and the superior bottom-up estimates shown—below to be quite conservative.

All of the estimates reported in this document may be modestly inflated, for two reasons. First, multipliers inherently assume no changes in the structure of economic

relationships after the price change, when in fact consumers and producers will adapt to moderate the effects of the change (e.g., by switching to substitutes if prices rose, or using their price savings to consume or invest elsewhere if prices dropped). Second, additional gas supplies to the West Coast will benefit the Western states—at the end of the line in the current North American gas distribution system—the most, and the rest of the country much less (e.g., it may reduce only the spread between Western and U.S. natural gas prices). On the other hand, as Table 4's explanatory note notes, the jobs and income multipliers are certainly too low and make these estimates quite conservative. These two countervailing biases should approach balance.

Bottom-up estimates

Seven Northwest LNG terminals are currently under consideration by regulatory authorities, including five in Oregon or Washington. These terminals would have the capacity to throughput between 300 and 1,700 million cubic feet of gas per day[25]. Bradwood Landing's capacity is designed for 1,000 million cubic feet per day, or 63.8% of the Northwest's 2005 average daily use.[26] However, it is unlikely that the terminal would be used to full capacity 100% of the time. If it were, the augmentation of natural gas supplies might be excessive, driving prices down below the level where liquefaction and transoceanic shipping would no longer be profitable. NorthernStar Natural Gas believes that Bradwood Landing would be 40% utilized (the industry norm) upon completion in late 2011, with capacity utilization increasing thereafter.

Because of the unavoidable uncertainty about the actual capacity utilization of a new LNG terminal, we will consider four scenarios: 20%, 40%, 60%, and 80% capacity utilization. The 40% scenario reflects NorthernStar's belief about their terminal's initial utilization. The 60% and 80% scenarios reflect possible utilization increases over time. The 20% scenario is a pessimistic excursion. Table 5 shows the proportion of the Northwest's natural gas needs that could be supplied under these different scenarios.

Share of the Northwest region's 2012 gas needs that could be supplied by an LNG terminal (alternative terminal capacity utilization scenarios)
Source: Author's calculations. Capacity utilization expectations from NorthernStar Natural Gas; regional demand from NGA, extrapolated by the authors to 2012

Scenario (capacity utilization rate)			
20%	40%	60%	80%
10.3%	20.6%%	30.9%	41.2%

Table 5 - Northwest gas needs in 2012 that could be supplied by LNG

Demand elasticity of natural gas

As natural gas prices change, the demand by various users will change. The most commonly used method to measure this consumer behavior is called the *price elasticity of demand*, which measures the percentage change in demand caused by a one percent change in price. It is calculated as follows:

$$\text{Demand Elasticity} = \frac{\%\ \text{Change (Quantity)}}{\%\ \text{Change (Price)}}$$

Most consumer goods tend to range in elasticity between 0.5 and 1.5. Goods with elasticities between 0 and 1 are generally referred to as inelastic; in other words, demand is not very sensitive to price changes. Goods with elasticities greater than 1 are generally referred to as elastic, meaning that demand is quite sensitive to price changes. Goods with elasticities equal to 1 are referred to as unitary, meaning that price and demand are correlated on a one-to-one basis.

Forward Observer analyzed national data from the Energy Information Agency to determine the expected elasticity of demand for natural gas. Forward Observer ran simple bivariate regressions for the national forecasts from 2004 through 2030 for three sectors of users – residential, commercial and industrial. All models as a whole proved to be statistically significant at the 95% confidence interval and explained between 26% and 42% of the variation in price and quantity, which is impressive for a simple model. Table 6 summarizes the results of the analysis. Each regression's correlation coefficient (R-squared) indicates the share of variation in demand explained by the elasticity; while the probability that the detected pattern is the result of random variation is captured by the F-statistic.

Table 6
Forward Observer's demand elasticity estimates for natural gas
Correlation coefficients and significance estimates

Sector	Correlation coefficient (R-Squared)	Significance coefficient (F-statistic)
Residential	0.42	<0.05
Commercial	0.34	<0.05
Industrial	0.26	<0.05

Table 6 - Correlation coefficients and significance estimates

The Y-intercept and the coefficient variables for each of the three models proved significant at the 95% confidence interval levels. Our three regression models are summarized below:

(1) Residential Price = 3.99 – 0.96 x Residential Quantity

(2) Commercial Price = 2.77 – 0.41 x Commercial Quantity

(3) Industrial Price = 3.24 – 0.67 x Industrial Quantity

The estimated elasticity coefficients ranged from 0.41 for the Commercial sector to 0.96 for the Residential sector, with the Industrial sector about midway between the two at 0.67. In other words, a one percent change in price for residential natural gas would yield a 0.96 percent change in the residential quantity demanded. A one percent change in the price of natural gas to the commercial sector would yield a 0.41 percent in the quantity demanded by the commercial sector. In the industrial sector a one percent change in price for the industrial sector would yield a 0.67 percent change in the demand for natural gas.

How does this compare to others' elasticity estimates? Table 7 and Table 8 below exhibit our results from a survey of studies regarding the short-run and long-run demand elasticity of natural gas, respectively. The differences in elasticities are driven by data sources, methodology and the geographic as well as the end-user market which is being assessed.

Elasticity of demand will also change between the short-run and long-run due to consumers increased abilities to make behavioral changes over time. For example, if gas prices rise, in the short run, consumers have few alternatives; while in the long run, they can insulate their homes, or purchase a more energy-efficient residence. Because of the nature of the EIA data, the Forward Observer derived elasticity estimates above are most directly compared to the long-run estimates summarized in Table 8.

Table 7. Natural gas short-run elasticity of demand - Survey of literature

Elasticity	Sector (Region, if applicable)	Source
0.10	Residential	Mackinac Center for Public Policy
0.12	Residential (US National)	RAND
0.15	Residential-commercial (British Columbia and Ontario)	Berndt and Watkins (1977) reprinted by the Gale Group and the International Association for Energy Economics.
0.17	Industrial	The Federal Energy Administration reprinted in the Gale Group and the International Association for Energy Economics.
0.18	Residential (Mountain)	RAND
0.18	Residential (Pacific Coast)	RAND
0.60	Industrial	Beierlin, et. al. reprinted by the Gale Group and the International Association for Energy Economics.

Table 7 - Natural gas short run demand elasticity

NOTES: In RAND's study, Pacific Coast Region is composed of Washington, Oregon and California. Mountain Regions is composed of Montana, Idaho, Wyoming, Nevada, Utah, Colorado, Arizona and New Mexico.

As shown in Table 7 above, short-run natural gas elasticity of demand is estimated to range between 0.10 and 0.60. Residential and Residential-Commercial elasticity estimates remained relatively consistent with values between 0.10 and 0.18. There is a greater variance in the industrial sector with estimates ranging between 0.17 and 0.60.

Table 8
Natural Gas long-run elasticity of demand
Survey of Literature, with interpolated Forward Observer regression results

Elasticity	Sector (Region, if applicable)	Source
0.36	Residential (US National)	RAND
0.41	**Commercial (US National)**	**Forward Observer regression**
0.44	Residential (Mountain)	RAND
0.50	Residential	Mackinac Center for Public Policy
0.63	Residential (Pacific Coast)	RAND
0.63	Residential-commercial	Balestra and Nerlove (1966) reprinted by the Gale Group and the International Association for Energy Economics.
0.69	Residential-commercial (British Columbia and Ontario)	Berndt and Watkins (1977) reprinted by the Gale Group and the International Association for Energy Economics.
0.67	**Industrial (US National)**	**Forward Observer regression**
0.72 – 0.96	Residential-commercial (Canada)	Fuss, et. al. (1977) reprinted in the Gale Group and the International Association for Energy Economics.
0.96	**Residential (US National)**	**Forward Observer regression**
1.3	Industrial	The Gale Group and the International Association for Energy Economics.
2.36	Industrial	Anderson (1971) reprinted by the Gale Group and the International Association for Energy Economics.
2.39	Industrial	Beierlin, et. al. reprinted by the Gale Group and the International Association for Energy Economics.

Table 8 - Natural gas long run demand elasticity
NOTES: In RAND's study, Pacific Coast Region is composed of Washington, Oregon and California. The Mountain Region is composed of Montana, Idaho, Wyoming, Nevada, Utah, Colorado, Arizona and New Mexico.

The long-run price elasticity of demand for the Residential/Residential Commercial sectors ranges between 0.36 and 0.96, with a median value of 0.63 and a midpoint value of 0.66. Once again, the industrial sector has larger variation, ranging

from 0.67 to 2.39 with a median value of 2.36 and a midpoint value of 1.83. Not surprisingly, industrial users are more price sensitive than residential or commercial users, since natural gas purchases tend to be a larger share of industrial purchases. This will be especially true if industry's purchases of natural gas-fueled electricity generation are taken into account. Forward Observer's regression-derived elasticity demands tend to be on the conservative side of the spectrum for both the Commercial and Industrial sectors. In fact, our estimate is roughly half that of the next highest estimate derived by the Gale Group.

Our regression estimate for Residential elasticity is on the high end of the surveyed elasticities. This may result in part because in the literature residential estimates are often combined with those for commercial users. But if our residential and commercial elasticity estimates were combined, weighted by residential and commercial natural gas use in the Pacific Northwest, it would generate a composite elasticity estimate of 0.75, which is slightly above the median value from the literature.

Table 9 summarizes the low, high and median demand elasticity estimates for natural gas by end-user and by time frame. The variations between the high and low demand elasticity estimates are relatively small when the three sectors are segmented. Moreover, there is very little difference between the median and midpoint values. In addition, the weighted average short-run and long-run elasticity is also included.

Table 9
Natural gas elasticity of demand summary
Survey of literature

	Low	High	Median	Midpoint
Short-run residential/commercial	0.10	0.18	0.15	0.14
Short-run industrial	0.17	0.60	0.39	0.39
Short-run weighted average	0.14	0.40	0.27	0.27
Long-run residential/commercial	0.36	0.96	0.63	0.66
Long-run industrial	0.67	2.39	2.36	1.83
Long-run Northwest weighted average	0.52	1.70	**1.53**	1.27

Table 9 - Summary of natural gas demand elasticity

NOTES: Weighted average was calculated using data provided by the Northwest Gas Association for 2010-11. Residential use is estimated to be 30%; Commercial use is estimated be 18%; Industrial use is estimated be 29% and power generation is expected to be 23%. For the latter, the industrial elasticity was used as a substitute since no study specifically estimated power generation.

As a whole short-run elasticities are generally lower than long-run elasticities. This is expected because in the short-run users will not be able to cut back on consumption or easily substitute natural gas burning equipment for equipment that uses alternative fuels. However, in the long-run, consumers can make changes to their equipment to more energy-efficient processes when the price of natural gas increases. This lock in effect may partially explain why residential/commercial elasticities are generally lower than that of industry as residential and commercial users have fewer

alternative fuel sources than industrial users. The elasticity shown in bold, 1.53, is the one used in the following economic analysis, because it is the best summary of the set of possible elasticities, and the most conservative (i.e., it generates the smallest effect on prices). This elasticity suggests that the "average" Northwest customer—combing all three sectors in their Northwest proportions—is moderately price sensitive.

Effect of a change in quantity supplied on prices

Since (from the equation that opened the last section):

Elasticity = % Change (Quantity) / % Change (Price)

It follows that:

% Change (Price) = % Change (Quantity) / Elasticity

As noted in a prior section, an LNG terminal could increase natural gas supplies in the Northwest by between 10.3% and 41.2%, depending on the terminal's capacity utilization. The industry norm of a 40% utilization rate yielded a 20.6% increase in the Northwest's supplies. Dividing 20.6% quantity by an elasticity of 1.53 yields a 13.1% reduction in prices—a bit more than the hypothetical 10% assumed in earlier sections.

Direct effects of price reductions as a result of added supply

But a 13.1% reduction from what price? We collected several natural gas price forecasts for 2012, summarized in Table 10.

Table 10. Alternative natural gas price forecasts ($ per MMBTU) for 2012

Alternative natural gas price forecasts ($ per MMBTU) for 2012

Forecast Source	Price	Source
AGF	$9.00	NWIGU, 2006
NYMEX Futures for Jan. 2012	**8.71**	***WSJ*, June 7, 2007**
EIA (NWGA)	8.11	EIA w/NWGA weights
EIA	7.71	EIA, *Annual Energy Outlook 2007*, Supplemental Table 108
NPC	6.20	NPC 2003
EEA May 2004	5.00	ACEEE, Jan. 2006

Table 10 - Alternative natural gas price forecasts

We discard the NPC and EEA forecasts because both were made prior to the post-Katrina price spike. The EIA (NGA) forecast is our weighted average of EIA's 2007

national forecast of sectoral prices based on sector weights from the Northwest Gas Association. We will use the forecast shown in bold ("Futures", $8.71), which is the price paid on the New York Mercantile Exchange (NYMEX) for Jan. 2012 natural gas deliveries on June 6, 2007, as reported in the next day's *Wall Street Journal.* We consider this "forecast" superior because it is based on actual market behavior, not analysts' predictions, and because futures markets have an enviable record of predicting commodity prices. In addition, it is close to the EIA forecast (weighted for the Northwest's sectoral consumption), which is considered the most objective. Therefore, for this report we believe that an LNG terminal will reduce natural gas prices by 13.1% of $8.71 per million BTUs, or by $1.14. Since each million BTUs is equivalent to about 1,000 cubic feet, this implies that natural gas users will save about $1,140 per million cubic feet.

The Northwest Gas Association projects U.S. Pacific Northwest regional demand (omitting British Columbia) for gas in 2010-11 (the last year of their most recent forecast) at 676,468,000 decatherms (a measure that is equivalent to roughly one million BTUs or one thousand cubic feet.) We extrapolated this demand to 2012 at NGA's projected annual rate of demand growth of 2.1%, leading to a 2012 demand of 709,021,000 decatherms, or about 709 billion (709,000 million) cubic feet. A simple static analysis therefore would suggest that Northwest users will enjoy direct savings from LNG of [709,000 x $1,140] = $883.4 million. This is higher than the high estimate in Table 3 of the direct effects of a hypothetical 10% price reduction, $826 million.

But the static analysis overestimates the magnitude of the benefits of increases in supply and consequent lower prices. Because consumers are price sensitive, lower prices will lead them to purchase <u>more</u> natural gas, just as higher prices would reduce their purchases. Our elasticity of 1.53 implies that consumers will buy [13.1% x 1.53] = 20.0% more gas. So a more accurate estimate of consumers' savings is [1 -.20 = 80.0%] of the $883.4 million static savings estimate provided in the prior paragraph, or $706.7 million. This is within the range shown for a hypothetical 10% price reduction shown in Table 4. Table 11 summarizes the direct economic effects of lower gas prices due to an LNG terminal.

Table 11. Direct savings from increased gas supplies from LNG

Direct savings from increased gas supplies from LNG	
Baseline Regional Natural Gas Consumption in 2012:	709,021 million cubic feet
Baseline 2012 Regional Price:	$8.71 per million BTUs/ or $8,710 per million cubic feet
Increase in Regional Natural Gas Supplies: *(40% terminal capacity utilization)*	20.6%
Price Elasticity:	1.53
Price Reduction due to Supply Increase:	13.1%
Price Reduction ($ per million cubic feet)	$1,140
Regional gas expenditure Reductions (Static):	$883.4 million
Regional Gas Expenditure Reductions: *(Reflecting consumers' behavioral response to lower prices)*	$706.7 million

Table 11 - Direct savings from increased gas supplies from LNG

Because the capacity utilization of a terminal is uncertain, Table 12 shows the direct economic effects for utilization rates from 20% to 80%. Our main scenario, in which the new terminal is used to 40% of its capacity like industry norms, is shown in bold.

Table 12. Direct economic effects at alternative terminal capacity utilization rates

20%	**40%**	60%	80%
$353.4 million	**$706.7 million**	$1,060.1 million	$1,413.4 million

Table 12 - Economic effects at alternative terminal capacity utilization

Indirect and induced effects

Regional economics uses input-output models to capture the indirect and induced effects of a change in direct spending. As noted earlier, when consumers are able to spend less on natural gas, they will divert that spending to investments or other consumption. The suppliers of those goods or services receive their income, and pay it out to their own suppliers (e.g., their employees), who do the same to theirs, etc. Over time, each dollar of original spending ripples through the economy several times. The cumulative effect of all the ripples is referred to as a *multiplier*. For example, one dollar of added output (gross domestic product) may ripple through the regional economy two more times, yielding a multiplier of 3.0. Multipliers are expressed as the *total* cumulative economic activity generated from a dollar of added spending. In this example, one dollar would generate two more dollars of activity, leading to a multiplier of 3.0.

Multipliers vary depending on which industry is receiving or losing the original spending. Generally the magnitude of multipliers correlates with the industry's value added per worker (i.e., each industry's labor productivity). We assume the most conservative possible multiplier, that of the household sector. Thus our estimates of total economic activity are probably understated. Table 13 shows our final results. In contrast to the earlier, hypothetical, "top-down" estimates, these are market-based, "bottom-up" estimates. The scenario shown in bold is the one we wish to highlight.

Table 13
Output, income, and employment effects of alternative increases in regional natural gas supplies
(Market-based, bottom-up estimates)

Output, income, and employment effects of alternative increases in regional natural gas supplies
(Market-based, bottom-up estimates)

	Terminal Capacity Utilization			
	20%	**40%**	60%	80%
Direct savings	$353.4	**$706.7**	$1,060.1	$1,413.4
Output multiplier *(total GDP per $ of added direct spending)*		**1.4707**		
Change in Regional GDP *($ millions)*	$519.7	**$1,039.5**	$1,559.2	$2,079.0
Reduction in gas prices		**-13.1% ($1.14 per MMcf)**		
Change in GDP *(%)*	0.11%	**0.23%**	0.34%	0.45%
Overall jobs multiplier *(jobs per million $ direct spending)*		**14.36**		
Change in regional employment *(# of jobs)*	5,100	**10,100**	15,200	20,300
Income multiplier *(household income per million $ direct spending)*		**0.43**		
Change in household income *($ millions)*	$152.0	**$303.9**	$455.9	$607.8
Income gain per family of four	$54	**$107**	$161	$214

Table 13 - Output, income, and employment effects of alternative increases in regional natural gas supplies

A brief comment on multiplier-based economic analysis

The analysis in this report uses multipliers from the U.S. Department of Commerce's Regional Input-Output (RIMS II) model of the U.S. economy. Implicitly it makes a reasonable, but over-simplifying assumption: *That a change to a major sector of the Northwest economy can occur without affecting the structure of the other sectors of the economy.* In other words, "all other things" are presumed to remain "equal." Any workers furloughed from gas-intensive industries due to higher prices are presumed to remain unemployed, at least as far as the region is concerned (i.e., they remain unemployed or relocate to another jurisdiction). In reality, some of such surplus human capital is likely to be reemployed, perhaps in the Northwest, perhaps elsewhere. So an "other things equal" analysis such as this probably modestly overestimates the long-run effects of natural gas price changes either increases or decreases.

Regardless of this caveat, the economic impact of lower gas prices will still be very significant, because it would fall most directly on some of the region's most productive industries. Very few of the workers who otherwise lose their jobs due to higher natural gas prices would be reemployed in occupations as well-compensated as those they might be obliged to give up if LNG is not imported (see also the discussion of highly affected gas-intensive industries below).

Comparison to Other Studies

The above result—a 0.23% increase in gross state product, and employment gains that are the equivalent of about 0.1% of regional jobs—is quite consistent with the findings of a national study conducted by the Economics and Statistics Administration of the U.S. Dept. of Commerce, which found GDP and employment losses from higher natural gas prices of between 0.1 and 0.2%[27]. The ESA's work was based on actual price trends and employment changes between 1999 and 2004. Likewise, Henry and Stokes found that 2008 losses from higher natural gas prices in Oregon and Washington would be 7,500 jobs or 0.15% of regional employment—higher than our own estimate, which also includes Idaho.[28] Their conclusion is the mirror image of ours (because they were examining the effect of higher, not lower, gas prices): A slowdown in economic growth, but not enough to throw the economy into recession.

Our estimates are also substantially more conservative than those of a separate study by the Interstate Natural gas Association of America (INGAA) Foundation, which found that a delay of three years in the creation of adequate natural gas infrastructure (including LNG terminals) would cost the Oregon economy $11.1 billion and Washington $9.7 billion, for a total of $20.8 billion. By contrast, our estimates never go beyond $2 billion, including Idaho. Similarly, our estimates of price effects are a small fraction of INGAA's. They estimate that such a delay would add $3.04 per million BTUs to gas prices, while we believe that price reduction from adding infrastructure will be about $1.14[29].

Summary of Biases that Inflate or Deflate Our Estimates

Below is a list of the main ways in which our assumptions either inflated, or (more often) deflated the estimated economic impact.

Biases that inflated impacts

- Multiplier approach ignores adjustments that naturally occur after an economic change (such as price reductions due to increased supply).

Biases that deflated impacts

- Relatively low terminal capacity utilization assumed in our base case.
- Relatively high price elasticity of demand, which lowers magnitude of price reduction.
- Recognition that lower prices will cause increased consumption of gas, thereby reducing the savings available for other consumption or investment.
- Use of household multiplier, lower than any industry.

We believe that taken together our deflating biases exceed our inflating biases, making our analysis quite conservative. This is confirmed when our findings are compared to those in national studies.

Highly affected industries

While many industries use natural gas to fuel their production processes, some are more gas-intensive than others. In some cases the gas use is direct, to produce high temperatures; in other cases gas fuels processes powered by electricity. Table 14 shows the industries for which natural gas costs are more than 5% of their cost structures.

Table 14. Gas-intensive industries in the U.S.
Source: ESA, *Impact of Rising Natural Gas Prices*, 2005[30]

Gas-intensive industries in the U.S.
Source: ESA, Impact of Rising Natural Gas Prices, 2005[34]

NAICS code	Industry	Natural Gas costs as % of shipment value	Change in Industry Employment
325311	Nitrogenous Fertilizer	45.30%	3.0%
331311	Alumina refining	13.50%	0.6%
325181	Alkalies & chlorine	12.40%	NA
227121	Brick & structural clay	9.50%	0.8%
327121	Flat glass	8.40%	0.8%
325182	Carbon black	8.30%	NA
327420	Gypsum products	7.00%	NA
327213	Glass containers	5.90%	0.4%
325199	Other basic organic chemicals	5.30%	NA

Table 14 - Gas-intensive industries in the U.S.

Several of these industries are disproportionately located in the Pacific Northwest. Each will see substantial benefits from lower gas prices—as will their customers. Our projections of the percentage increases in industry employment are based on Henry and Stokes[31].

The declines in many of these industries will have pervasive economic impacts. For example, the Brick and Structural Clay and Gypsum industries affect construction, and therefore home prices; while the Fertilizer industry affects food prices. At a time of rising inflation, disinflation in these industries will have a salutary effect on the overall price level. The absence of imports would have the opposite effect. Henry and Stokes found that recent (1997-2004) higher prices had cost the fertilizer industry between 3.3% and 4.4% of employment, for example.[32]

Local effects on tourism and property values

Regardless of the macroeconomic benefits, some local residents are concerned about local effects, such as on property values and whether an LNG terminal will reduce the area's attractiveness to visitors.

To illuminate this issue, we examined the record of a LNG terminal in the East: Cove Point, Maryland opened in 2003. Cove Point is a few hours from a major city, in an attractive rural location on the shores of the Chesapeake Bay; not unlike the setting for Bradwood Landing.

We compiled statistics on trends in tourism and property values in the Cove Point area (Calvert County, Maryland), for the years since it went into operation in 2003. We compared the records of the county to those of the state as a whole, inferring that any differences in trends would be due to the terminal, at least in part. Table 15 compares both tourism trends and property value trends.

Table 15. Trends in tourism in Calvert County, MD (Cove Point LNG terminal) vs. Maryland Statewide, 2003-06

Sources: Calvert County Office of Economic Development; Maryland Department of Assessment and Taxation

Visitor Spending		Property Assessed Value	
County	Statewide	County	Statewide
12.2%	5.7%	15.4%	16.2%

Table 15 - Trends in tourism in Calvert County, MD (Cove Point LNG terminal) vs. Maryland Statewide, 2003-06

Note: Cove Point opened in the summer of 2003.

In the year before Cove Point opened (2002), visitor spending grew at 6.2%, whereas after the terminal opened, growth was almost twice as rapid. While it would be a stretch to suggest that the opening of Cove Point *increased* either tourism or property values, there is little indication that the terminal that has depressed them.

Conclusions

By accident of geography, the U.S. West Coast is far from many existing domestic sources of natural gas, yet the Pacific Northwest is dependent on this source for the largest share of its energy. Increasing worldwide demand for natural gas is driving up prices, which the futures markets expect will continue. These price increases create a significant drag on both the state and national economy; as Global Insight puts it, they "destroy demand."

Fortunately, a solution is readily at hand. The world has plentiful supplies of natural gas, which can be transported across oceans readily in liquefied form (LNG). All that is missing is a terminal that can receive the LNG, convert it back into gas, and transport it through pipelines to customers. A number of such terminals are proposed for the Pacific Coast of North America, including seven in the Northwest. Any of them would increase available gas supplies by a considerable percentage.

If a terminal were built that augmented gas supplies by 20%, a fairly conservative assumption, analysis of historical price data indicates that a price decline at least in the low double digits would occur. Two different estimation methods (a macroeconomic approach based on analogous effects of oil price changes and a more direct analysis of changes in natural gas consumption) produced similar results. Since the two different methods (top-down and bottom-up) produce similar, although not identical results, readers can have confidence in their rough accuracy. Our results also are consistent with, but lower than, national-level studies.

In addition, to the degree that high natural gas prices contribute to the West's above-average electricity prices, they become an issue of interstate competitiveness. The Northwest has traditionally enjoyed a major competitive advantage from low electricity prices due to its abundant hydropower. In fact, for many industries, especially heavy manufacturing, it is the Northwest's <u>only</u> competitive advantage. Natural gas price reductions from increased supplies would reduce the incentive to migrate away, and produce additional economic benefits not included here.

In a regional economy of almost $500 billion with more than 5 million workers, the numbers provided in this report may sound small, but they amount to about one month of economic growth, every year for as long as an LNG terminal operates. As a Stanford University report notes, "the cost…of delaying action on this issue is very high."[33] A terminal to receive LNG is in the region's economic interest, and overdue.

About the Author

Dr. Philip J. Romero is a Professor of Business Administration (economics and strategy) and Dean Emeritus at the University of Oregon business school. In the 1990s, and again in 2005, he served as chief economist to the governor of California. He also is a member of the Oregon Governor's Council of Economic Advisers. Through the Forward Observer policy consulting firm as well as in government, he has estimated the economic impact of a very wide range of public policy proposals, and designed regulatory apparatus for the health insurance, electric utility, and telecommunications industries. He gratefully acknowledges the invaluable assistance of Andrew Chang. The views expressed in this report do not necessarily reflect those of the client, Forward Observer, or the University of Oregon.

About Forward Observer

FORWARD OBSERVER is a research and consulting firm that advises global companies on policy development and strategy at state and national levels.

Forward Observer provides policy analysis and strategy on state and national issues, as well as supporting issues research for media relations, public affairs and statewide initiative campaigns. The firm includes a network of policy consultants with subject-matter expertise in a wide range of fields.

Our principals are skilled in developing policy positions for candidates, elected officials and private industry clients; defending these initiatives in the public arena; and seeing ideas through to implementation.

More information is available on our website: www.fwdobserver.com.

About Bradwood Landing LLC

Bradwood Landing believes that natural gas continues to be the best energy source for the Pacific Northwest. The company will deliver new sources of natural gas to this region creating new jobs and millions of dollars in local investment in surrounding communities. When completed, Bradwood Landing will provide an estimated 65 jobs averaging $60,000 a year and spend more than $30 million annually throughout the region to operate and maintain the facility. The facility will also increase Clatsop County's property tax base by more than $7 million annually, creating a valuable source of income for improvements in essential services and education throughout the region. The company's financial commitment includes unprecedented levels of investment in the local environment. Beyond our deep financial commitments, Bradwood Landing is driven by our promise to make life better wherever we live and work. We want more than a presence our communities; we want to create a positive and lasting legacy that generates

community pride. For more information about Bradwood Landing LLC, please visit: www.bradwoodlanding.com

About NorthernStar Natural Gas Inc.

At NorthernStar Natural Gas, we create innovative solutions that bring clean, safe, affordable natural gas to meet America's energy needs. Led by a dynamic executive team with deep industry experience, NorthernStar Natural Gas is a US owned and operated company that is currently developing liquefied natural gas terminals across the country. We combine our business aspirations with a bold commitment to improve the communities where we live and work by generating new jobs and economic opportunities, supporting better education for our children and leaving a lasting legacy of environmental excellence in all that we undertake. NorthernStar Natural Gas is the Nation's Clean, Safe Energy Solution™. For more information about NorthernStar Natural Gas Inc., please visit: http://www.northernstar-ng.com

Bibliography

Al-Sahlawli, Mohammed A., *The Demand for Natural Gas: A Survey of Price and Income Elasticities*, The Energy Journal, International Association for Energy Economics, New York, 1989.

American Gas Association, *Gas Facts 2001*, 2002

Anderson, Patrick L., Richard McLellan, Joseph P. Overton and Gary Wolfram, *The Universal Tuition Tax Credit: A Proposal to Advance Parental Choice in Education: How Educational Freedom Will Help Michigan Students, Schools and Taxpayers*, Mackinac Center for Public Policy, c. 1997.

Bellemare, Bob, and Neenan, Bernie, "Do Electric Costs Drive the Economy?", *Utilitypoint International Issue Alert*, March 26, 2007

Bernstein, Mark A., and James Griffin, *Regional Differences in the Price-Elasticity of Demand for Energy*, RAND Corporations – Infrastructure, Safety and Environment, Santa Monica, c. 2005.

Bureau of Labor Statistics, *Employment and Output by Industry, 1992, 2002, and Projected 2012*

The Demand for Natural Gas: A Survey of Price and Income Elasticities, the Gale Group and International Association for Energy Economics, 1989, 2007.

Di Giovanna, Mark, *Presentation to the Western Interstate Energy Board - CREPC Meeting: Western Natural Gas Assessment Workshop*, California Energy Commission – Natural Gas and Special Projects Office, April 19, 2005.

Economics and Statistics Administration (ESA), U.S. Dept. of Commerce, *Impacts of Natural Gas Prices on U.S. Economy and Industries*, , June 29, 2005

Energy Information Administration, *Annual Energy Outlook*, Washington, DC, c. 2007.

Energy Information Administration, *International Energy Outlook 2007*

Energy Information Administration, U.S. Department of Energy, *Natural Gas Annual 2005*.

Energy Information Administration, "Pending Natural Gas Infrastructure Projects", 2005

Energy Information Administration, *U.S. LNG Markets and Uses: June 2004 Update*

Federal Energy Regulatory Commission's "Potential North American LNG Terminals", 2005

Federal Reserve Bank of San Francisco, *FRBSF Economic Letter, 2001-04*, Feb. 9, 2001.

Gaul, Damien, *U.S. Natural Gas Imports and Exports: Issues and Trends 2005*, Energy Information Administration, U.S. Dept. of Energy, February 2007.

Gaul, Damien, "Short-Term Energy Outlook Supplement: U.S. LNG Imports-The Next Wave", Energy Information Administration, January 2007

Global Insight, *The Impact of Natural Gas Prices on the California Economy: Final Report*, Feb. 2006

Henry, David K., and Stokes, H. Kemble, *Macroeconomic and Industrial Effects of Higher Natural Gas Prices*, Economics and Statistics Administration, U.S. Department of Commerce, December 2006

INGAA Foundation, *Discussion of Effects of Long-Term Gas Commodity and Transportation Contracts on the Development of North American Natural Gas Infrastructure*, 2005

John, Pratap, "Natural gas 'will fill 25% of world energy mix by 2025', *Gulf Times* (Persian Gulf), March 6, 2007

Kirschner, Dan, Executive Director, Northwest Gas Association, presentation, "NW Gas Outlook", May 2, 2007

"LNG Can't RIP", *Sacramento Bee* (editorial), April 16, 2007

Millard, Peter, "Mexico Pemex Hopes Chicontepec Zone Can Stop Oil Output Fall", Dow Jones Newswires, May 18, 2007

Morlan, Terry, "The Electricity Outlook and the Role of Natural Gas" (presentation), Northwest Power and Conservation Council, May 2, 2007

National Petroleum Council, *Balancing Natural Gas Policy: fueling the Demands of a Growing Economy*, 2003

"NGSA Market Outlook" *DownstreamToday.Com*, May 24, 2007

Northern Star Natural Gas, "Bradwood Landing and the Columbia River: What you should know about LNG and its transport" (presentation), March 2007

Northwest Gas Association (NWGA), presentation to Oregon Public Utility Commission 2006 Natural Gas Outlook Meeting, July 20, 2006

NWGA, *Natural Gas*, undated

NWGA, *Natural Gas Demand in the Pacific Northwest*, 2006

NWGA, *Natural Gas Supply in the Pacific Northwest*, 2006

NWGA, *Natural Gas Prices in the Northwest*, 2006

NWGA, *Northwest Gas Outlook Update 2006*

Oregon Public Utility Commission 2006 Natural Gas Outlook meeting, July 20, 2006

"Report: Demand to outstrip supply in the Northwest", *Platt's Gas Daily*, July 11, 2006

Prindle, William; Elliott, R. Neal; and Shipley, Anna Monis, , *Impacts of Energy Efficiency and Renewable Energy on Natural Gas Markets in the Pacific West*, American Council for an Energy-Efficient Economy (ACEEE), January 2006

Saefong, Myra P., and Lesova, Polya,"Natural Gas, Crude Futures Rise", *Wall Street Journal*, May 14, 2007, *MarketWatch*

"A Snag in the Pipeline", *Economist*, April 14, 2007

Snow, Nick. "EIA forecasts another wave of growth in US LNG imports", *Oil and Gas Journal*, January 15, 2007

U.S. Census Bureau, *Statistical Abstract of the United States*, 2007

U.S. Department of Commerce, Bureau of Economic Analysis, *Regional Input-Output Multiplier System (RIMS II)*, 2004 version

Value and Growth in the liquified gas market, PriceWaterhouse Coopers, undated

Villar, Jose, and Joutz, Frederick, *The Relationship Between Crude Oil and Natural Gas Prices*, Department of Energy, Energy Information Administration (EIA), Oct. 2006

Ward, Leah Beth, "Basin draws hunters of natural gas", *Yakima Herald*, May 27, 2007

Wilson, Ian, "Gas terminals moving forward", *Calgary Sun*, June 6, 2006

Wolak, Frank, *Liquefied Natural Gas and California's Energy Future*, Stanford Institute for Economic Policy Research, Dec. 2004.

Xinhua News Agency, "World demand for natural gas to exceed oil by 2020: report", October 29, 2006

Endnotes

[1] Xinhua News Agency, "World demand for natural gas to exceed oil by 2020: report", October 29, 2006

[2] John, Pratap, "Natural gas 'will fill 25% of world energy mix by 2025'", *Gulf Times* (Persian Gulf), March 6, 2007

[3] For the purpose of this report, the Pacific Northwest is defined as the states or Washington, Oregon, and Idaho, with a combined 2005 population of 11.4 million and gross state product of $458.8 billion. Figures from *Statistical Abstract of the United States* for 2005, U.S. Census Bureau, http://www.census.gov/compendia/statab/tables/07s0617.xls. Northwest imports are shown in National Petroleum Council, *Balancing Natural Gas Policy: Fueling the Demands of a Growing Economy*, 2003. (Hereafter, "NPC".) The NPC is an advisory committee to the Secretary of Energy, which has been in existence since 1946.

[4] Energy Information Administration, U.S. Dept. Of Energy, *Annual Energy Outlook 2007*, Feb. 2007. http://www.eia.doe.gov/oiaf/aeo/forecast.html#ng.

[5] Norman, Donald, *Liquefied Natural Gas and the Future of Manufacturing*, September 2004.

[6] Author's calculations from 2002 data (most recent available) in the Bureau of Labor Statistics' *Employment and Output by Industry, 1992, 2002, and projected 2012*. This employment computation is almost certainly an underestimate, since it includes only NAIC industries 325 (chemical manufacturing), 326 (plastics and rubber products manufacturing), and 3272 (glass and glass product manufacturing).

[7] Villar, Jose, and Joutz, Frederick, *The Relationship Between Crude Oil and Natural Gas Prices*, Department of Energy, Energy Information Administration (EIA), Oct. 2006.

[8] Federal Reserve Bank of San Francisco, *FRBSF Economic Letter, 2001-04*, Feb. 9, 2001.

[9] WACOG projection reported in Oregon Public Utility Commission 2006 Natural Gas Outlook meeting, July 20, 2006. Also Myra P. Saefong & Polya Lesova,"Natural Gas, Crude Futures Rise", *MarketWatch* in *Wall Street Journal*, May 14, 2007 (reporting on , NYMEX futures prices, 2007-10). .

[10] Global Insight, *The Impact of Natural Gas Prices on the California Economy: Final Report*, Feb. 2006, which endorses an earlier California study conducted by one of the authors of this report.

[11] National-level estimates of the effects of past price increases can be found in *Impacts of Natural Gas Prices on U.S. Economy and Industries*, Economic and Statistics Administration (ESA), U.S. Dept. of Commerce, June 29, 2005; and Henry, David, and Stokes, Kemble, *Macroeconomic and Industrial Effects of Higher Natural Gas Prices*, ESA, Dec. 2006, (hereafter, "ESA"). Their conclusion is similar to ours: A slowdown in economic growth, but not enough to throw the economy into recession.

[12] NPC, *op. cit.*

[13] American Gas Association, *Gas Facts 2001*, 2002.

[14] From a map presented by Dan Kirschner, Executive Director, Northwest Gas Association, in presentation, "NW Gas Outlook", May 2, 2007. Regional average daily demand from source in fn 36.

[15] NPC, op. cit.

[16] Millard, Peter, "Mexico Pemex Hopes Chicontepec Zone Can Stop Oil Output Fall", Dow Jones Newswires, May 18, 2007

[17] Global Insight, *op cit.*

[18] Department of Energy, Energy Information Administration, *U.S. LNG Markets and Uses: June 2004 Update*, www.eia.doe.gov

[19] DOE EIA, *U.S. Natural Gas Imports and Exports: Issues and Trends 2005*, www.eia.doe.gov, *op. cit*.

20 Wolak, *Liquefied Natural Gas and California's Energy Future*, Stanford Institute for Economic Policy Research, Dec. 2004

[21] Northwest Gas Association, *op. cit*, based on EIA forecasts.

[22] Global Insight, *op. cit*

[23] Regional base 2005 employment of 5.05 million, and average growth of 120-150,000 per year, from the U.S. Census Bureau, *Statistical Abstract of the United States*.

[24] David K. Henry and H. Kemble Stokes, *Macroeconomic and Industrial Effects of Higher Natural Gas Prices*, Economics and Statistics Administration, U.S. Department of Commerce, December 2006. This report expands on the *ESA's Impacts of Rising Natural Gas Prices on the U.S. Economy and Its Industries*, June 29, 2005.

[25] From the Department of Energy's Energy Information Administration, "Pending Natural Gas Infrastructure Projects", www.eia.doe.gov., as well as the Federal Energy Regulatory Commission's "Potential North American LNG Terminals". http://www.ferc.gov/industries/lng/indus-act/terminals/horizon-lng.pdf; and "Existing and Proposed North American LNG Terminals", http://www.ferc.gov/industries/lng/indus-act/terminals/exist-prop-lng.pdf. Similar information is also available in NWGA, *op. cit*.

[26] Total consumption in Idaho, Oregon, and Washington in 2005 totaled 571,900 million cubic feet, according to the Energy Information Administration's *Natural Gas Annual 2005*, Table 15, http://www.eia.doe.gov/pub/oil_gas/natural_gas/data_publications/natural_gas_annual/current/pdf/table_015.pdf. Bradwood Landing's 1,000 million cubic feet per day throughput if fully employed (i.e., 100% capacity utilization) would supply 63.8% of the Northwest's annual consumption at 2005 rates. Consumption is rising by 2-3% per year, mainly due to residential demand.

[27] ESA, *op. cit.*

[28] Henry and Stokes, *op. cit.*

[29] INGAA Foundation, *Discussion of Effects of Long-Term Gas Commodity and Transportation Contracts on the Development of North American Natural Gas Infrastructure*, 2005

[30] ESA, *op. cit.*

[31] Henry and Stokes, *op. cit.* It was not possible to produce independent estimates because the federal government does not publish state-level industry data at the level of details (six-digit NAICs) required.

[32] Henry and Stokes, *op. cit.*

[33] Wolak, *op. cit.*