PREDICTABLY UNPREDICTABLE

Volatility in Future Energy Supply and Price from Over-Dependence on Natural Gas

WashPIRG Foundation

Elizabeth Ridlington
Robert Pregulman

Fall 2003

ACKNOWLEDGMENTS

The WashPIRG Foundation gratefully acknowledges Danielle Dixon (NW Energy Coalition) and Jim Lazar (Micro-Design) for peer review. Mara Thermos provided valuable research help. Thanks also to Susan Rakov and Brad Heavner for editorial assistance.

This report was made possible by the generous support of the Energy Foundation.

The authors alone bear responsibility for any factual errors. The recommendations are those of the WashPIRG Foundation. The views expressed in this report are those of the authors and do not necessarily reflect the views of our funders.

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WashPIRG Foundation
3240 Eastlake Ave. E., #100
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Design by Jon Hofferman/Carissimi Publications

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"The oil and gas industry is in painful need of a wake-up call.

"Over the years, the industry's wonderful can-do attitude, coupled with an over-cautious mindset that prices will never rise, created an industry-wide blindness to the many energy problems looming over the horizon, and the train wreck about to occur in the energy markets. Too many problems were ignored for too long. It is a sad commentary to have to make, but I fear we are now in the early days of a severe energy crisis that will take at least a decade to fix."

– Matthew Simmons, consultant to the National Petroleum Council, December 2000

Executive Summary

In response to the energy crisis of 2000-2001, Washington state policy makers rushed to approve and encourage the construction of natural gas power plants. This dash to a "solution" could have dangerous effects on the state's long-term energy stability. By relying so heavily on one fuel source, the state risks setting itself up for another energy crisis in the near future. The outlook for natural gas is troubling, and Washington should be working to diversify its energy mix.

Demand for natural gas is skyrocketing.

- Natural gas consumption has grown by 40 percent nationwide since 1986, and is still growing: demand is expected to be 54 percent greater in 2025 than it was in 2001.

- In Washington, utilities' use of natural gas for electricity generation increased sevenfold from 1999 to 2001. In that time, utilities and industrial users added thirteen new natural gas power plants. Overall gas use is expected to increase by another two percent annually over the next few years, as seven additional plants come on line.

- Over 90 percent of new centralized energy production currently under development will come from natural gas, nearly doubling the percentage of Washington's electricity generated from natural gas from 13 percent to 24 percent. Only one percent of the state's electric power comes from clean, non-hydroelectric renewable resources–wind and solar.

The U.S. has very limited supplies of natural gas. More new wells have to be drilled each successive year just to produce the same amount of gas.

- If demand growth and import levels follow current trends, the predicted domestic supply of natural gas will be consumed by 2040.

- There are 2.5 times as many wells in the U.S. today as there were in 1973, but each well is producing only a third as much gas. This means many more wells need to be drilled to meet national production goals.

- Because the more accessible reserves have already been tapped, many of these wells will be deeper in the ground, deeper underwater, and deeper into ecologically sensitive areas.

Federal energy officials are knowingly instituting an energy policy that will lead to increased dependence on foreign fuel supplies. Policymakers are well aware that under our current pattern of energy use, increasing demand and insufficient predicted growth in domestic supply of natural gas will force us to become more dependent on foreign suppliers. The U.S. Department of Energy predicts that, based on current usage patterns, the U.S. will import 13 percent of its gas by 2025. Because of limits to the growth rate of production, this is likely to be a vast underestimation of our future reliance on foreign gas supplies. The Pacific Northwest already imports 80 percent of its gas from Canada.

Washington's increasing use of natural gas will lead to steadily rising electric-

ity prices mixed with periodic price spikes.

- Gas price volatility has increased since the early 1980s as the indus try has become more tied to short-term market signals. As the margin between growing demand and available supply narrows, these disruptions are sure to become more frequent and severe.

- Natural gas prices have soared to $6 per thousand cubic feet this year, twice the price of a year ago.

- Imported gas will not provide price relief. Because shipping gas overseas requires liquefying the gas at -256 degrees Fahrenheit, non-Canadian imported gas is very expensive.

Energy efficiency measures can reduce the state's need for electricity and its vulnerability to unstable electricity prices. Many efficiency gains are inexpensive. With renewed investment in efficiency, Washington could achieve savings equal to 12 percent of current electricity use by 2010 and 24 percent by 2020.

Renewable energy can provide electricity at low, stable prices. Renewable energy technology is ready for widespread use.

- Because renewable energy does not rely on fuel, its costs are predictable and stable. Once the plants are built, producers have to pay only regular operating and management costs to keep the power flowing.

- Both wind and solar energy costs have plummeted over the last twenty years and are predicted to continue declining.

- Washington has tremendous potential to produce renewable energy in-state, creating jobs and keeping energy dollars in the state economy.

Introduction: Washington's Energy Choice

In the winter of 2000, electricity prices in Washington rose dramatically. By 2001, the average residential user experienced a 20 percent increase in electricity prices. Industrial users saw electricity rates rise 50 percent.[2]

These price increases had two major causes: limited power supplies and soaring natural gas prices. Drought in the Northwest reduced reservoir levels and hydroelectric generating capacity. Typically, in such a situation Washington would import power from California. However, during the winter of 2000, California power plants that usually are able to send excess power to the Northwest during our cold months had little extra power. Some plants were shut down for maintenance during the winter because the summer's energy crunch in California had prevented routine maintenance.[3] Reduced supply contributed to higher prices for power across several western states.

Additionally, what excess power California's plants could provide was expensive. Approximately half of California's power is generated at natural gas-fired power plants. Beginning earlier in 2000, the price of natural gas rose dramatically. Demand for natural gas outstripped available supply–supply that was, in part, artificially reduced by the manipulations of large energy trading companies like Enron, Duke Energy, and El Paso Corporation. In Washington, prices rose three times higher than normal in the summer and fall of 2000.[4] By early December 2000, spot market prices for natural gas were 20 times higher than two years previously.[5] The price spikes in California were even more severe. Thus the electricity produced from California's natural gas power plants was correspondingly expensive.

To meet projected demand and forestall future electricity shortages, Washington policy-makers have recognized that the state needs to add electricity-generating capacity. However, nearly all of the recently added and planned capacity is fueled by natural gas, leaving us vulnerable to price and supply disruptions in the natural gas market.

Because natural gas is a limited resource, average prices will gradually rise as the supply diminishes. And as petroleum companies go deeper underground for less certain reserves and the nation relies more on international markets for gas, price volatility will become greater.

It would behoove policymakers to examine the alternatives. Washington has tremendous untapped potential for renewable energy. The technology to harness this potential is available and cost-effective. Despite high infrastructure costs, many projects are being developed right now.

Renewable energy's great economic strength is that it is not subject to periodic price spikes, because the fuel is free. Wind and sun are not subject to market fluctuations. Once renewable energy producers build their plants, they can count on a steady price for generating electricity throughout the lifetime of those plants.

A major reason that more renewable energy plants have not been constructed is that they have high up-front costs compared to traditional technologies. Much of the cost of natural gas plants lies in purchasing fuel over the years; in contrast, wind and solar facilities have no fuel costs but have greater initial construction costs. Without long-term purchasing contracts from utilities, investors are reluctant to support renewable energy projects. Natural gas-fired plants require less initial investment, and investors know that increases in fuel costs can be passed along to consumers.

Washington has a clear choice: steadily rising prices, mixed with price spikes, for power from a diminishing and non-replaceable resource, or slowly declining prices without spikes for power from clean renewable sources. In approving plants and encouraging technologies, policy makers should look beyond start-up costs and take the long view of Washington's energy future.

THE FUTURE OF NATURAL GAS AND ELECTRICITY GENERATION

As Washington's demand for electricity grows beyond its hydroelectric generating capacity, the state is increasingly reliant on new natural gas power plants for electricity. Natural gas offers clear environmental advantages over coal, oil, and nuclear power. It makes sense to develop some amount of gas-fired electricity production rather than building plants with greater public health consequences. But what's good in small doses can be disastrous on a larger scale.

By relying on natural gas for almost all of its new electricity production, Washington is setting itself up for another energy crisis. If the state invests only in natural gas-generated electricity, the shortcomings of this fossil fuel can greatly outweigh its benefits.

- The rest of the nation and much of the world is rushing to increase the use of gas at the same time that Washington is increasing its dependence.
- U.S. domestic reserves of natural gas are relatively small.
- Importing natural gas from overseas is expensive and unreliable.
- Gas prices will remain volatile as supplies fluctuate.
- All of the gas consumed in Washington is imported from outside the state. This means that if demand–and prices–rise in California or elsewhere, Washington will be exposed to those price fluctuations.

Photo: Sandy Ridlington

CURRENT WASHINGTON USE

Natural gas first became widely available in the Northwest in 1957 after the Northwest Pipeline was completed. Industry was the primary user of the gas, though in the 1980s home use became more common. In the 1990s, the use of natural gas for electricity generation and for home heating proliferated, such that by 2001, half of the homes in the state were heated with natural gas.[6] More significantly, the use of natural gas to generate electricity has been rising.

There are two ways to evaluate the importance of natural gas to Washington's electricity supply: measuring natural gas' share of electricity produced and its share of electricity consumed. Washington's electricity production is not the same as its consumption. Overall, Washington produces more electricity than it uses. However, the state also imports electricity from other western states to meet demand at peak times and because some power utilities own electricity-generating capacity outside of the state.

The fuel sources of electricity consumed are relatively similar to the fuel sources of

Table 1: 2001 Washington Electricity Production and Consumption[7]

Power Sources	Production (aMW)	% of In-State Production	Consumption (aMW)	% of In-State Consumption
Traditional				
Hydro	6,667	67%	5,312	60%
Natural gas	1,194	12%	1,366	15%
Coal	1,095	11%	1,553	17%
Nuclear	896	9%	455	5%
Solid Waste	119	1.2%	161	2%
Fuel oil	50	0.5%	54	0.6%
Waste gas	8	0.08%	9	0.1%
Clean, Renewable				
Wind	0.0299	0.0003%	3	0.03%
Geothermal	0	0%	18	0.2%
Solar	0	0%	0	0%
Total	**10,028**		**8,931**	

electricity produced, as seen in figures 1a and 1b. Note that natural gas is a larger portion of the electricity consumed than produced and that hydropower is a smaller portion. Thus in measuring Washington's reliance on natural gas, production numbers understate natural gas usage. However, figures about the sources of electricity consumed, while more accurate, are not readily available. This report thus uses production numbers as a proxy measure for Washington's current and rising dependence on natural gas for electricity.

Electricity production figures include more than just the power produced by utilities for sale to retail customers. The figures also cover electricity generated at industrial facilities for their own consumption and electricity produced using excess heat from manufacturing processes. Including all these sources of power best reveals Washington's total demand for natural gas-generated electricity.

Note on Units

The size of a power plant is expressed in terms of megawatts (MW). This unit indicates how much electricity a plant can generate at one time. Utilities also measure their ability to supply demand on the grid at any one time in terms of MW. A plant's capacity stated in megawatts is like the horsepower of a car engine–the maximum potential when operated at full speed.

Power plant output and electricity consumption are measured in terms of megawatt-hours (MWh) or average megawatts (aMW). These units indicate the total and average amount of electricity generated during a period of time. A 100 MW power plant operating for 100 hours at 90 percent capacity would produce 9,000 MWh, or 9 gigawatt-hours (GWh), of electricity. If the plant operated only these 100 hours over the course of the year, it would have an average output of 1 aMW.

Figure 1a. 2001 Washington Electricity Production

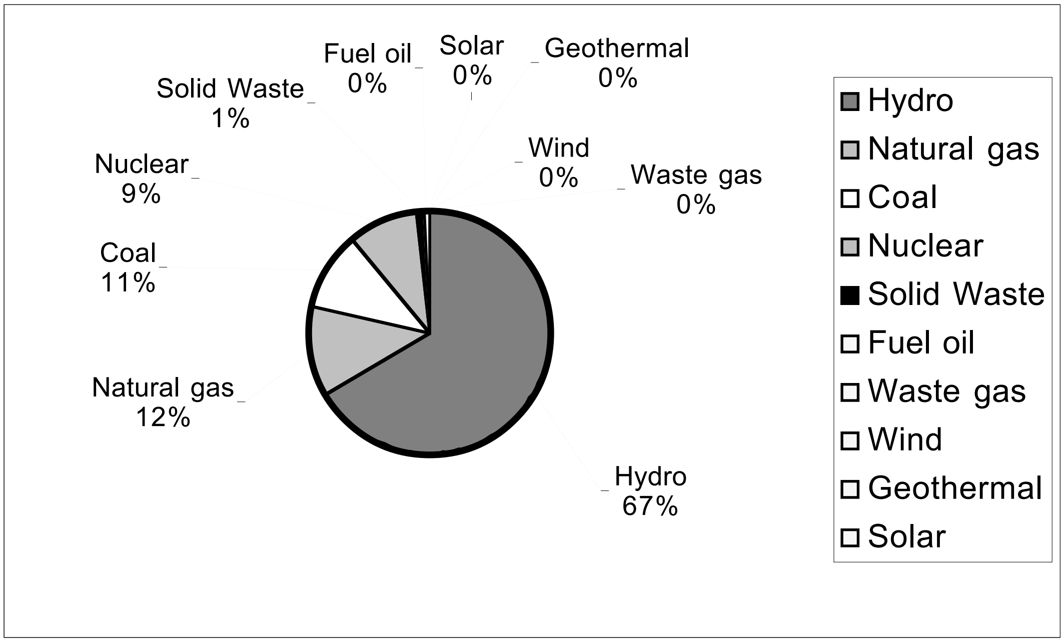
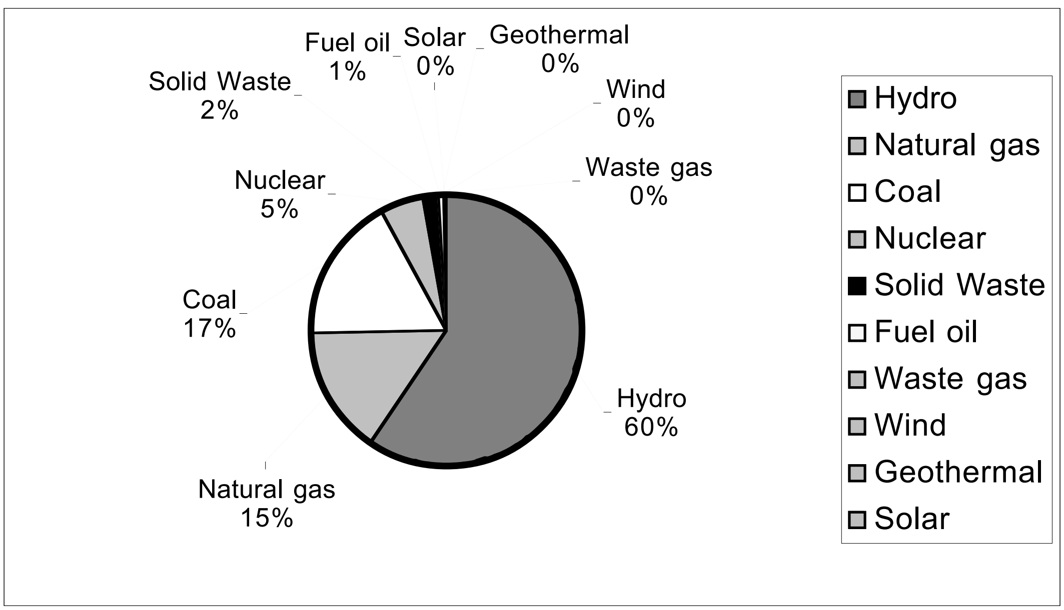


Figure 1b. 2001 Washington Electricity Consumption



"As you know, demand for natural gas is on the rise because most new electricity generation is gas fired, and projected increases in electricity demand over the next 20 years will significantly stretch our capacity to produce adequate supplies of natural gas both in the United States and around the globe."

— Remarks prepared for Secretary of Energy Spencer Abraham at the International Energy Agency Ministerial Working Dinner, April 2003[8]

GROWING DEMAND

Experts debate the question of how much natural gas remains in the Earth. Estimates vary based on the estimator's assumptions about how much the retrieval process can acceptably cost, among other things. But with respect to the choices we make about how we use this important resource, supply is of less importance, ultimately, than demand.

As long as demand is growing for a limited resource, the size of the resource matters much less than the rate of growth. A supply that would last 100 years at a constant demand level is used up in 47 years with only three percent annual growth. Triple the supply and it only adds 31 years. Ten times the original supply would only last another 40 years. Reducing demand annually by just one percent per year, on the other hand, will extend the supply to 1,673 years.

New Washington Plants

Washington once consumed electricity generated almost exclusively by hydropower. Today the state receives electricity from a mix of sources. Only since 2000 has the state collected detailed information about the sources of electricity consumed. That brief three-year history shows that natural gas provides a growing portion of Washington's electricity.[9]

Table 2. Electricity Consumption in Washington by Source[10]

Fuel Type	2000	2001	2002
Hydro	67.17%	59.66%	72.29%
Coal	16.07%	17.24%	12.93%
Cogeneration	5.37%	7.75%	0.00%
Natural Gas	5.29%	7.69%	8.48%
Nuclear	4.24%	5.17%	4.95%
Biomass	1.09%	1.22%	0.50%
Petroleum	0.40%	0.64%	0.03%
Waste	0.16%	0.31%	0.03%
Geothermal	0.14%	0.21%	0.00%
Landfill Gases	0.07%	0.09%	0.28%
Wind	0.00%	0.03%	0.21%
Solar	0.00%	0.00%	0.00%
Other	0.00%	0.00%	0.03%

Though the use of natural gas for electricity generation accounts for only 25 percent of Washington's natural gas consumption, that figure is rising rapidly. From 1999 to 2001, utilities' use of natural gas to produce electricity increased sevenfold.[11] Industrial users also increased their use of natural gas. In contrast, average demand for electricity increased only two percent per year in that period.[12]

The state's total demand for natural gas today is three times higher than it was in the early 1980s.[13] According to the Washington State Office of Trade and Economic Development, usage is expected to increase by two to four percent annually over the next few years.[14] This includes demand for electricity generation, industrial processes, and direct residential consumption.

Nearly all new centralized generation in the state is from natural gas: of power-generating capacity added since the beginning of 2000, 84 percent has been as natural gas plants. Of capacity added since June 2001, 97.7 percent has been natural gas.[15] Five new natural gas power plants–utility and industrial–with a combined capacity of 1,472 aMW have been approved since 2000 but not constructed (see Table 4). Two plants with a capacity of 691 aMW are under construction and will soon be in service (see Table 5). By the time these seven plants are completed, 24 percent of new centralized energy production will come from natural gas.

Only one percent of new production has come from clean non-hydro renewable resources–solar and wind. A small amount of clean renewable energy will also come online from dispersed photovoltaics, not included in this calculation of centralized production.

Table 3. Washington Natural Gas Power Plant Additions Since 2000 (Utility and Industrial Capacity)[16]

Name	Location	Capacity (MW)	Projected Output (aMW)	Date Online
Frederickson Power 1	Frederickson Industrial Area	249	224	2002
Big Hanaford	Big Hanaford Valley	248	223	2002
Fredonia 3 + 4	Mount Vernon	106	95	2001
BP Cherry Point GTs	Blaine	73	66	2001
Clark Public Utilities ICs	Vancouver	50	45	2001
Pasco	Pasco	43	39	2002
Equilon GTs	Anacortes	39	35	2000
Finley	Finley	27	24	2001
Boulder Park	Spokane	25	22	2002
Cowlitz Co. PUD ICs	Longview	22	20	2001
Tesoro (Perm ICs)	Anacortes	19	17	2002
Georgia-Pacific	Bellingham	11	10	2001
Kettle Falls GT	Kettle Falls	7	6	2002

Table 4. All Generation Capacity Approved Since January 1, 2000[17]

Resource	Operating New Capacity (aMW)	Capacity Under Construction (aMW)	Permitted New Capacity (aMW)	Total New Capacity (aMW)	% of New and Planned Production
Natural gas	825	223	1,472	2,521	91.6%
Fuel Oil	61	0	0	61	2.2%
Hydro	6	40	0	46	1.7%
Solid Waste	9	0	0	9	0.3%
Wind	75	18	21	115	4.2%
Solar	0.01	0.00	0.00	0.01	0.0005%
Total	977	281	1,494	2,752	

Table 5. Total Current and Approved Energy Capacity[18]

Fuel Source	Capacity in Service (aMW)	% of Current Capacity	Under Construction (aMW)	Permitted (aMW)	Total Current and Approved Capacity	% of Future Capacity
Hydro	12,547	72.5%	42	29	12,618	63.3%
Natural gas	2,311	13.3%	691	1,827	4,829	24.2%
Coal	1,168	6.7%			1,168	5.9%
Nuclear	851	4.9%			851	4.3%
Solid Waste	269	1.6%			269	1.3%
Fuel oil	79	0.5%			79	0.4%
Waste gas	14	0.1%			14	0.1%
Wind	75	0.4%	18	21	115	0.6%
Solar	0.01	0.0%			0	0.0001%

Figure 2a. Current Energy Production Mix

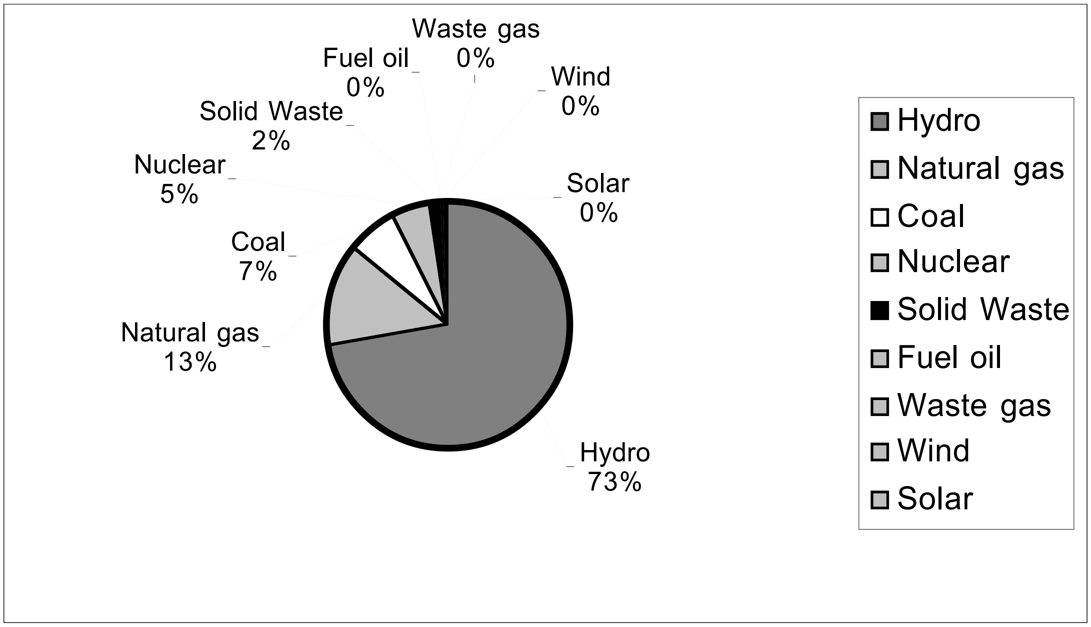
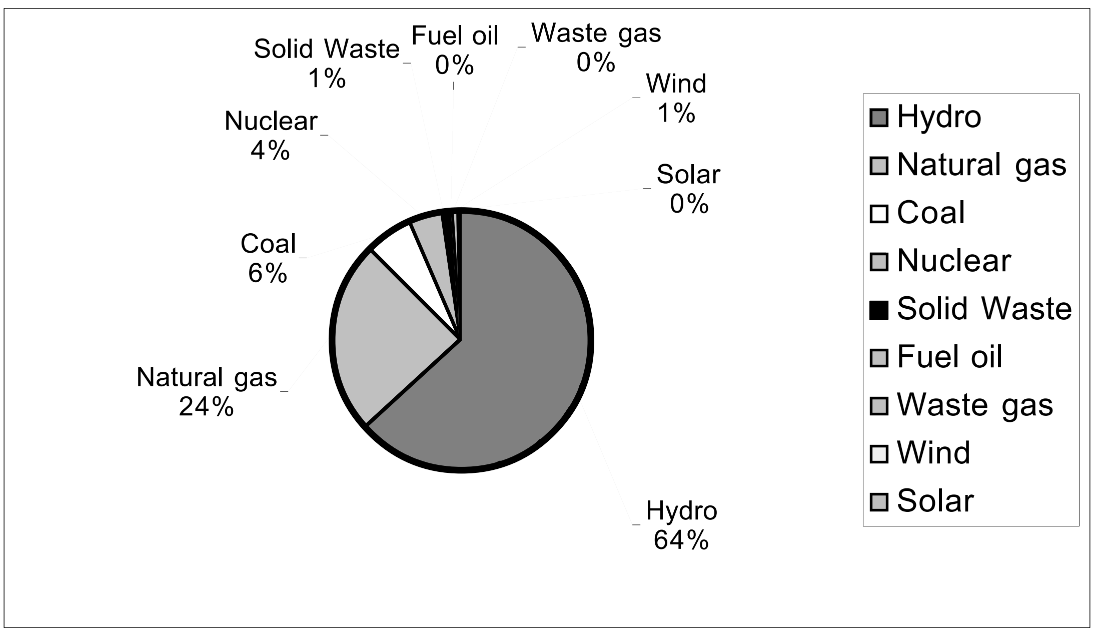


Figure 2b. Future Energy Production Mix



Increasing our reliance on natural gas as an energy source will increase the vulnerability of Washington's energy portfolio to changes in natural gas supply and price. The more dependent the energy system is on a fuel source, the more vulnerable the system is to any supply disruptions of that fuel source. As natural gas is a limited resource that must be extracted from uncertain reserves, such shortages–and accompanying price spikes–will invariably occur. Though 70 percent of the state's power capacity is hydroelectric, in periods of drought or high electricity demand such

A natural gas power plant. *Photo: Sandy Ridlington*

as the winter of 2000, a much greater portion of the state's electricity comes from natural gas sources.

Because of natural gas' supply volatility, natural gas power plants were originally designed to use fuel oil as a backup when gas supplies were tight. However, burning oil is extremely polluting and has therefore been restricted.

National Demand

Washington's increased reliance on natural gas for electricity production is part of a regional, national, and world-wide trend.

In the Northwest as a whole, 93 percent of power generating capacity built or approved between 2000 and early 2003 was natural gas-powered.[19]

Nationally, demand for natural gas has risen by 40 percent since 1986 and the Energy Information Administration projects that demand will rise another 54 percent by 2025.[20] Today, natural gas-fired plants comprise approximately 90 percent of new electricity generating capacity.[21] The Department of Energy (DOE) projects that total U.S. gas demand will increase by an average of 1.8 percent per year from 2000 to 2025. If this proves true, the nation will be using 50 percent more gas in 2025 than in 2001, with consumption rising from 22.6 trillion cubic feet (tcf) to 34.1 tcf per year.[22]

With a finite amount of domestic natural gas and limits to how fast it can be

"Policies encouraging [natural] gas use as a base load fuel for power generation should be rethought."

— Emil Attanasi, U.S. Geological Survey, August 2001[27]

Emissions from Natural Gas in Washington

One reason why the use of natural gas has been rising so rapidly is that it is a relatively clean-burning fossil fuel. Nonetheless, natural gas still produces greenhouse gases and hazardous air pollutants. Recently proposed combined-cycle gas plants in Washington emit approximately 830 pounds of carbon dioxide (CO2) per MWh of electricity produced.[28] Many of the newly added natural gas plants are of single-cycle design which is less efficient, and thus produce more CO2 per MWh. Using combined-cycle CO2 emission rates for the 917 MW (825 aMW) of natural gas-fired generating capacity that has been added since 2000 means that Washington's annual CO2 emissions have risen by three million tons, the equivalent of adding 450,000 cars to the road. Emissions of nitrogen oxide, a contributor to smog, have risen by 500,000 pounds per year, as if 17,500 cars had been added to the state's roads.[29]

tapped, it is doubtful that this demand can be met with domestic supplies. Demand will be difficult to curb once major power plants are built from coast to coast and energy companies will increasingly have to rely on expensive and unstable supplies of gas overseas.

Washington may have to pay a premium to secure supplies since none of the nation's gas is in the state. Washington receives all of its natural gas supply through three pipelines. The Duke Energy/Westcoast Pipeline from Canada enters the state near Sumas. The Pacific Gas Transmission line carries gas from Alberta into Eastern Washington.[23] Northwest Pipeline comes north from the Utah/Colorado Rocky Mountain gas basins. These pipelines serve Idaho, Oregon, and California also.[24]

In a 2001 report, the Washington Office of Trade and Economic Development warned that if all the plants under development at the time were constructed "there is no certainty that the natural gas pipeline infrastructure could accommodate all of these plants being built."[25]

In another report later in 2001, the Office of Trade and Economic Development further cautioned that "the Northwest will increasingly be subject to forces over which it has no control. Demand from new gas-fired plants in California and other western states will place pressure on the Northwest's natural gas infrastructure even if the region doesn't build a single new plant."[26]

LIMITED U.S. DOMESTIC SUPPLIES

The U.S. Geological Survey (USGS) and the U.S. Department of Energy predict that there are 1,049 tcf of natural gas reserves in the U.S.[30] Of that amount, only 167 tcf is known to exist. The rest consists of anticipated future discoveries and a factor to increase the size of known reserves to account for the possibility of underestimation and more thorough extraction at known reserve locations, using future technologies.[31]

None of this gas–proven or anticipated–is in Washington. Forty percent is in the Gulf Coast, 20 percent in the Rocky Mountains, and 11 percent in the Texas/Oklahoma/Kansas region.[32]

If demand for natural gas were to grow by 1.8 percent per year through 2025 (as predicted by the Department of Energy) and stay constant thereafter, and imports remain around 13 percent of demand, this amount of gas would only last through 2041.[33]

Table 6. U.S. Projected Natural Gas Supply (trillion cubic feet)

	Known Supply	Additional Supply	Total
Proved Reserves	167		
New Discoveries		527	
Reserve Growth		355	
Total Reserves	167	882	1,049

Proved Reserves

The amount of gas in proved reserves–known resources that can be recovered profitably with existing technology–is actually quite small. The 167 tcf of U.S. proved reserves represents a six-year supply at projected demand levels. Only 16 percent of estimated total domestic supplies are proved reserves.

Future Discoveries

There are many areas where preliminary geological data suggests gas deposits may exist but which have not been developed into producing fields. Until a production company goes in to extract the gas to bring it to market, surveyors are not certain if any gas is actually there. Approximately one in two production wells drilled finds developable gas.[34]

In 1996, the U.S. Geological Survey published the results of a comprehensive three-year survey of natural gas reserves on land and in state waters that are expected but not proved. In this analysis, they found 259 tcf of gas in conventional reserves.[35] In that same year, the U.S. Minerals Management Service published an assessment of gas reserves in federal waters indicating 268 tcf of conventionally recoverable gas.[36]

Discoveries of new gas fields have been rare. The largest gas fields were discovered between 1910 and 1956. Only eight percent of gas production in the early and mid-1990s was from newly discovered fields, while more than 90 percent was from extensions in old fields and adjustments to reserve estimates.[37] This trend continued in the late 1990s, with new discoveries five percent lower in 1999 than in 1998 and 31 percent lower than in 1997.[38] Hence, most of the major resource areas in this country have likely been identified, with the remaining question being exactly how big each of those fields are and how recoverable their contents are.

Reserve Growth

Estimates of the size of natural gas reserves have historically been considerably lower than the reserves have actually turned out to be. This phenomenon of underestimates, often known as "reserve growth," happens for three principle reasons: actual expansion in drilling reach through well extensions, improved recovery resulting from new technology, and recalculation of estimates based on continued surveying and experience. Because reserve growth has consistently occurred, it is now included in USGS assessments of total available supply based on historical averages.

Of the 1,074 tcf of natural gas that USGS estimates to exist in the U.S., 322 tcf (30 percent) is expected from reserve growth.

LIMITS TO PRODUCTION GROWTH

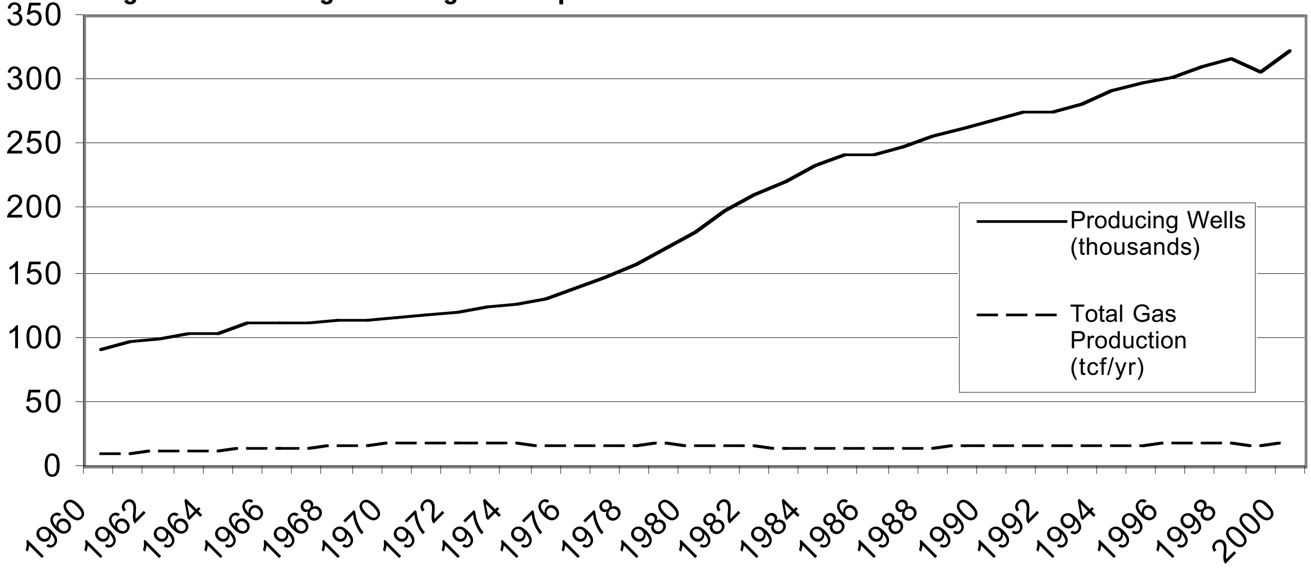
Several factors indicate that we will have to rely on overseas gas supplies even earlier and more extensively than the numbers above suggest. The actual number of cubic feet of natural gas supplies remaining is not the only crucial consideration when estimating available fuel. Declining production rates of natural gas wells, the time needed to develop gas fields, and accessibility are equally important.

Declining Production Rates

The productivity of gas wells peaked in 1973 and has steadily declined since then. The 124,000 wells in the U.S. in 1973 produced an average of 182 million cubic feet (MMcf) of natural gas. This productivity fell sharply in the following years, then continued on a gradual decline. From 1984 to 2000, the average annual gas production per well declined by 21 percent.[39] In 1999, the country had two and a half times as many wells as in 1973, but each well was producing less than a third as much gas–307,000 wells produced an average of 55 MMcf/yr each.[40]

The natural gas industry has evidence that the rate per well of natural gas production will continue to decline. William Wise, Chairman and CEO of the world's biggest natural gas company, El Paso Corporation, recently stated that gas production in North America is flat despite a recent surge in drilling. Receipts from his

Figure 3. Declining natural gas well production



company's expansive pipeline systems have stayed roughly constant despite more drilling. "Our field services are in all of the basins where all of the drilling in the United States is taking place and we are not seeing a production response. We're just kind of treading water, holding our own," Wise said. Decline rates–the speed with which production decreases from the peak output achieved at a new field–have increased from a 17 percent decline per year in 1970 to a nearly 50 percent decline per year now. "What not everybody realizes is the same thing is happening in Canada," Wise said. Decline rates there went from 20 percent per year in 1990 to 40 percent per year in 1998.[41]

Rate of Development

To meet the Department of Energy's projections of demand for natural gas in 2025, the gas industry would have to drill an unprecedented and possibly unfeasible number of wells.

If the productivity per well stays constant at the current rate of 55 MMcf/yr, 618,000 producing wells will be needed to produce 34 tcf of gas in 2025. This is more than twice the number of wells in operation in 1999. With the generous assumption that all current wells will still be producing gas in twenty years, the U.S. would need an additional 311,000 producing wells. Since only one out of two wells drilled actually produces gas, 622,000 wells would need to be drilled, an average of 28,000 per year. This is several thousand wells more than were drilled in 2002.[42]

However, since the productivity per well has declined continually since 1973, it would be more realistic to assume that the productivity rate will continue to decline. Between 1984 and 2000, productivity declined by 21 percent. If productivity declines another 20 percent over the next twenty years, 773,000 new wells will need to be drilled, an average of 42,000 per year. Since drilling will be significantly less than that in the next few years, drilling in the later years will likely need to be over 42,000 wells per year, an unprecedented amount. (See Table 7.)

If productivity rates decline further as petroleum companies go into deeper reaches to tap smaller gas reserves, even more drilling than that will be needed for the industry to meet its production goals.

Table 7. New Wells Needed to Meet Production Goals

	Constant Productivity Scenario	Declining Productivity Scenario
Projected Annual Gas Production (MMcf)	34,000,000	34,000,000
Average Annual Production per Well (MMcf)	55	44
Producing Wells Needed	618,182	772,727
Current Producing Wells	307,449	307,449
New Producing Wells Needed	310,733	465,278
Percentage of New Wells that Produce Gas	50%	50%
New Wells Needed	621,466	930,557
New Wells Needed per Year	28,248	42,298

In his address to the National Petroleum Council, oil and gas industry leader Matthew Simmons explained, "For the first time in our nation's history, we are out of the capacity to grow our use of petroleum products, out of capacity to increase natural gas supply, and out of electricity generating capacity during hot summer days or cold winter days in too many regions of the country.… It is time to begin preparing a national energy contingency plan for what to do if natural gas supplies cannot grow by any significant degree. It is time to begin preparing an escape route for our electricity markets if we fail to deliver the massive growth in natural gas supply needed to provide feedstock for the large backlog of natural gas-fired electricity plants being built."[43]

Accessibility

Many of the new gas wells needed in the future will be tapping reserves that are more difficult to reach than those that have already been excavated.

Gas producers have extracted much of the gas in the shallow waters of the Gulf of Mexico; they now need to build platforms in deeper waters. As Texas reserves close to the surface have been depleted, producers need to drill deeper wells.

With the largest reserves gone, it will take more work to extract the remaining gas from smaller fields. The Energy Information Administration acknowledges that the natural gas industry is undergoing a "natural progression of the discovery process from larger and more profitable fields to smaller, less economical ones."[45]

Accessibility challenges are clearly apparent in the Gulf of Mexico, where tapping the bulk of the remaining supply will involve drilling into depths never before reached. The difficulty of this undertaking is made evident by a federal subsidy specifically directed toward deepwater drilling, as well as the enormous investments oil companies are making in an attempt to develop technologies capable of the task.

The Outer Continental Shelf Deepwater Royalty Relief Act of 1995 allows the Secretary of the Interior to suspend the royalty payment obligations of companies leasing oil fields in the Outer Continental Shelf of the Gulf of Mexico when certain conditions are met. The Act directs the Secretary to follow an evaluation process to determine which fields "appear uneconomic with royalties but are potentially viable with royalty suspensions."[46]

Similarly, the multi-billion dollar Deepstar project demonstrates the immense challenge involved in excavating the bulk of the remaining oil and gas in the deep waters of the Gulf of Mexico. Deepstar is attempting to develop a dizzying array

"There has been considerable discussion within the industry that a lack of good gas drilling prospects might lead to future U.S. supply problems."

— Energy Information Administration, May 2003[44]

of highly sophisticated technology to overcome issues such as extremely high pressures and low temperatures that remain stubborn barriers to access.[47]

The ecological imperative to protect sensitive areas further limits access to reserves. Much of the gas in the Rocky Mountains lies below important wildlife habitat. Retrieving this gas would threaten delicate habitat. Protected lands in the Rocky Mountains containing gas deposits include Bridger-Teton National Forest, Book Cliffs-Desolation Canyon, Grand Staircase-Escalante, Lockhart Basin, Otero Mesa, Red Desert, Rocky Mountain Front, San Juan National Forest Roadless Area, Upper Green River Basin, Upper Missouri River Breaks National Monument, and Vermilion Basin.

Other potentially significant reserves are in coastal waters. Even conducting a survey of offshore gas reserves will disrupt the marine environment with seismic surveys and sediment sampling.[48]

Existing environmental safeguards would need to be removed before much of this land could be cleared for drilling. However, opposition from the public will make such rollbacks unlikely. Only 16 percent of Americans consider more drilling in the U.S. the best energy strategy, while 44 percent prefer developing alternative energy sources and 31 percent prefer more efficient use of energy.[49] Without public support for removing wilderness protections, many reserves in the Rocky Mountain region are likely to remain off limits.

NATURAL GAS IMPORTS

Since about 1986, U.S. production of natural gas has not been able to keep up with the nation's consumption, and the gap is predicted to continue to widen. Currently, the U.S. produces 85 percent of the natural gas it consumes. Imports provide the rest: 14 percent comes via pipelines from Canada

Figure 4. U.S. Natural Gas Consumption versus Production[52]

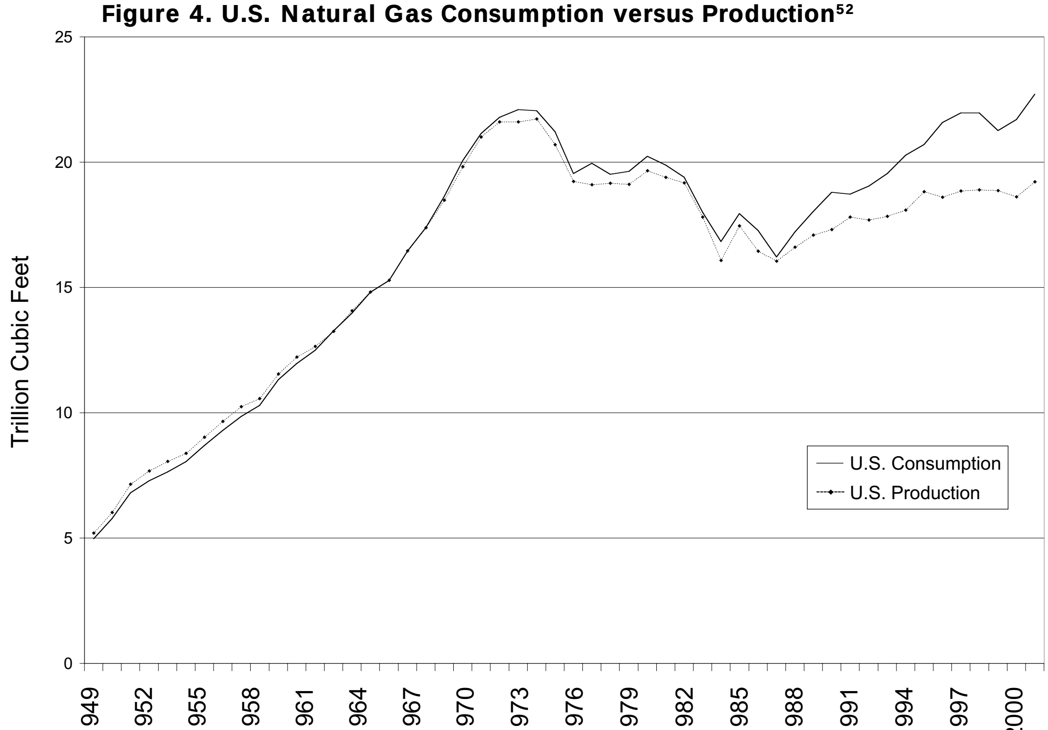
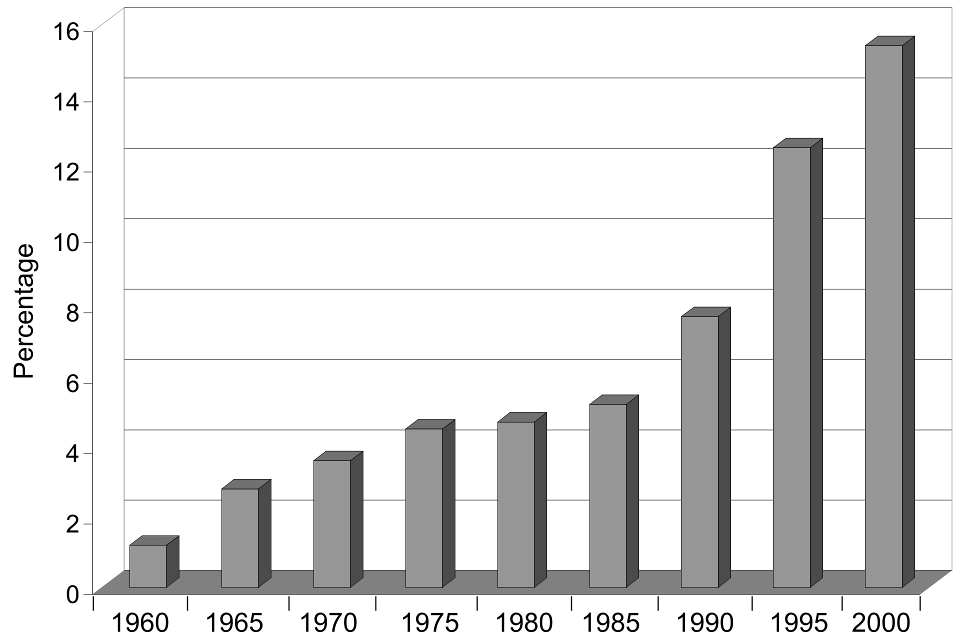


Figure 5. Net U.S. Natural Gas Imports as Share of Consumption[53]



and 1 percent arrives as liquefied natural gas.[50]

DOE estimates that domestic production in 2025 will be 26.7 tcf per year, or 77 percent of the 34.9 tcf projected demand.[51] As domestic reserves become further depleted, the shortfall will undoubtedly continue to worsen after 2025. Energy officials are therefore knowingly instituting an energy policy that increases dependence on foreign fuel supplies.

Because of the factors outlined above–limited supplies and limits to the growth rate of production–the gap between domestic supply and demand is likely to widen even faster than DOE projections. The nation's electricity supply would therefore be increasingly dependent on expensive and uncertain foreign supplies of gas.

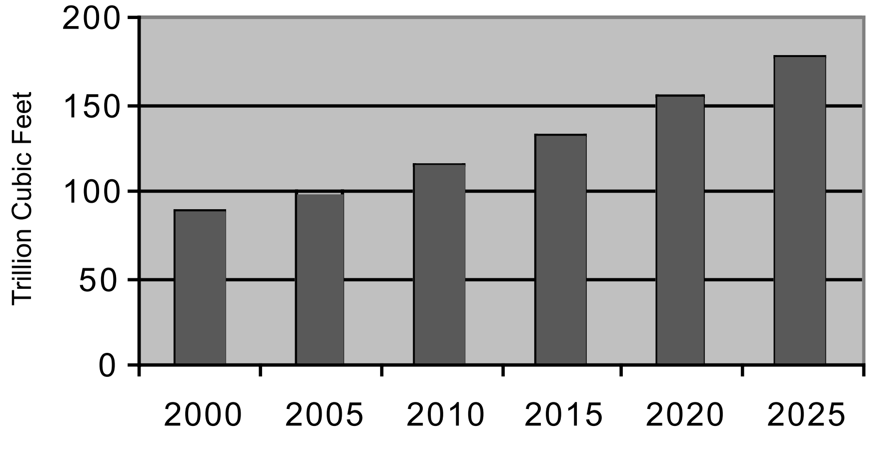
Liquefied Natural Gas

Gas imported from Canada can be shipped by pipeline, but pipelines are not an option for overseas gas shipments. To import natural gas from other continents, the gas must first be turned into a liquid by cooling it to -256 degrees Fahrenheit. It is then shipped overseas, turned back into a gas at receiving facilities, and sent by pipeline to its final destination. The process is prohibitively expensive for wide-scale use at today's prices.

Liquefied natural gas (LNG) currently constitutes less than one percent of U.S. supply. The high cost of importing LNG led oil companies to close two of the country's four LNG receiving facilities years ago.[54] But now companies are responding to expected increases in gas prices by re-opening those facilities and adding others.[55] Phillips Petroleum and El Paso Corporation have a $5 billion plan to ship LNG from Australia to a new West Coast receiving facility starting in 2005.[56]

Puget Sound Energy (PSE) has proposed constructing a LNG facility in Gig Harbor. Though PSE intends to use the facility for only ten days per year when existing pipeline capacity cannot fulfill natural gas demand in Gig Harbor, the LNG facility will consume 14 acres.[57]

Figure 6. Worldwide Natural Gas Consumption[60]



DOE estimates LNG imports will increase by 11 percent annually from 2001 to 2025.[58] Trinidad and Tobago, Qatar, Angola, Nigeria, Venezuela, and Indonesia are among the largest LNG exporters to the U.S. market. Relying on these countries, however, may have uncomfortable geopolitical effects.

Worldwide Demand

By the year 2025, the Energy Information Administration projects worldwide annual consumption of natural gas will reach 176 trillion cubic feet, roughly double the amount consumed in 2000.[59] There will therefore be extensive competition for natural gas supplies worldwide and imported gas will be increasingly expensive.

"Today's tight natural gas markets have been a long time in coming, and futures prices suggest that we are not apt to return to earlier periods of relative abundance and low prices anytime soon."

— Federal Reserve Board Chairman Alan Greenspan, testifying before the House Committee on Energy and Commerce, June 2003

PRICE PROJECTIONS

Rising Prices

Most energy experts agree that the average price of natural gas will gradually rise over the coming years and decades.

In the 1990s, national natural gas prices averaged $2.40 per million British thermal units (mmBtu).[61] In 2002, prices averaged $3 mmBtu–an increase of 25 percent in less than a decade.[62] The unflinchingly optimistic U.S. Energy Information Administration (EIA) predicts that gas prices will most likely rise just 1.8 percent but could rise by as much as 17 percent in total from now through 2025.[63] In the gas price section of its most recent *Annual Energy Outlook*, EIA states that "as gas resources are depleted, however, wellhead prices are expected to increase."[64]

Other experts concur that prices will continue to rise. Alan Greenspan, testifying before Congress, notes that even improved technology has "been unable to prevent the underlying long-term price of natural gas in the United States from rising."[65] Sempra Energy, a major supplier of natural gas, is confident that natural gas prices will remain well above the average of past years. As a result, the company is investing in two expensive LNG terminals.[66]

Increased imports from overseas will not alleviate the problem. Liquefying gas, shipping it, and regasifying it–one method suggested to ease the current shortfall in gas supplies–is an expensive process. Greater reliance on LNG for fueling power plants will raise electricity prices.

Volatility

Although forecasts of future natural gas prices vary, most forecasters agree that natural gas prices will be volatile.

The EIA expects the price to fluctuate, as explained in a 2001 report: "Like any commodity price, actual natural gas prices are likely to oscillate significantly around the trend line projected in the *Annual Energy Outlook 2001* as a result of business cycles in the industry, unusual seasonal temperature variations, or other special circumstances like pipeline ruptures–the kinds of events that have been experienced in the past 24 months."[67]

EIA explains that natural gas price volatility has increased since the early 1980s as the industry has become more tied to short-term market signals.[68]

Short-term price spikes have always been a regular feature of the natural gas market due to periodic supply disruptions.[69] As the margin between growing demand and available supply narrows, these disruptions will become more frequent and severe.

The Washington State Office of Trade and Economic Development warns that "it is increasingly apparent that wholesale electricity and natural gas prices are sub-

Figure 7. U.S. Natural Gas Prices[71]

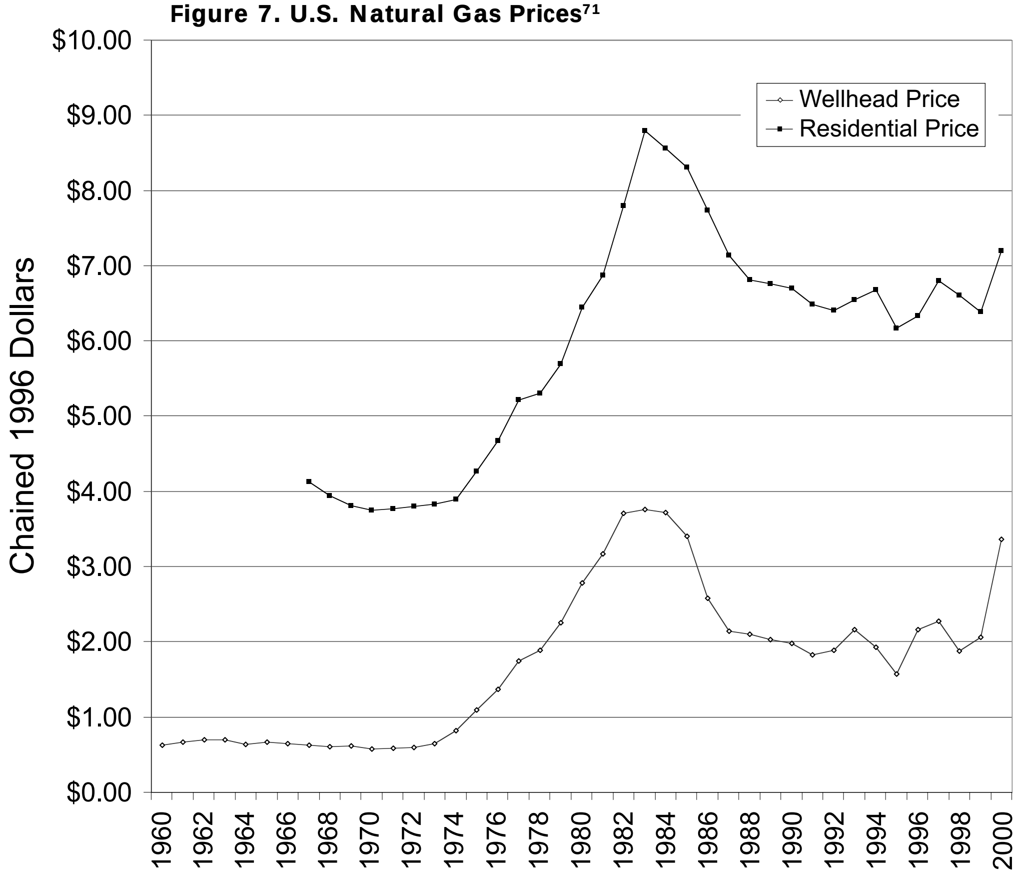
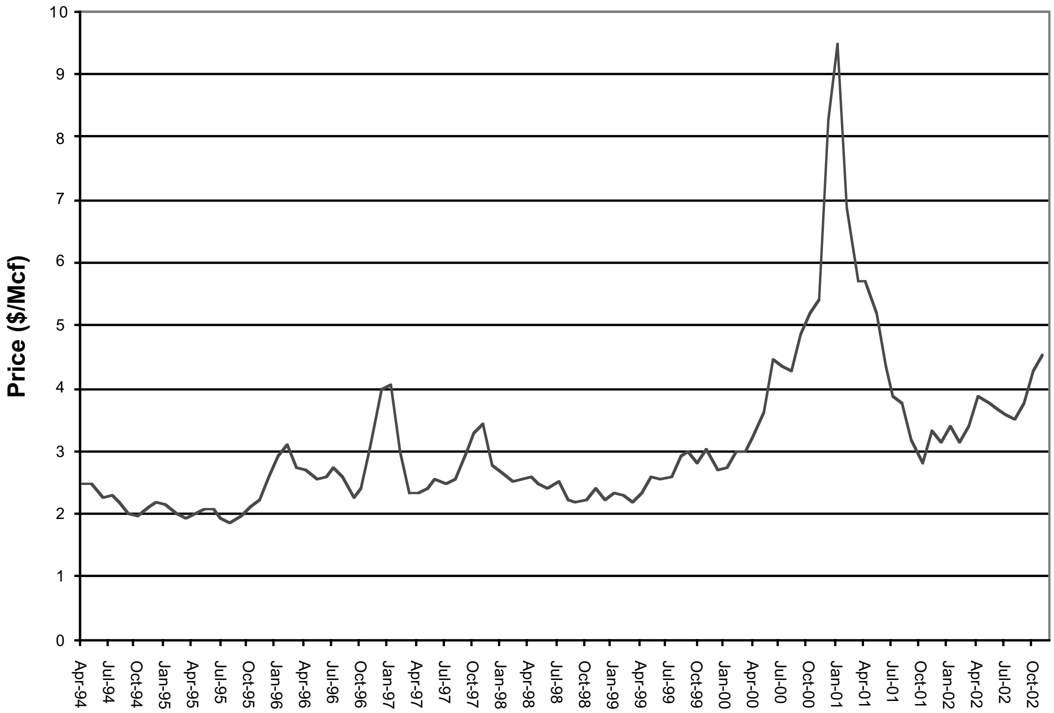


Figure 8. Price of Natural Gas Sold to Electric Utilities in the U.S.[76]



ject to extreme price volatility, and increasing convergence of the electricity and natural gas markets means that extreme events are likely to affect both markets simultaneously."[70]

Recent Price Spikes

Natural gas price spikes plagued the entire country in 2000-2001. Prices in Washington rose three times higher than normal in the summer and fall of 2000.[72] By early December 2000, spot market prices were 20 times higher than two years previously.[73]

Ultimately, natural gas prices were 60 to 70 percent higher in Washington in 2001 than in 1999.[74] For residential users, this translated to a 20 percent increase in electricity prices. Industrial users saw electricity rates rise 50 percent.[75]

The Washington State Office of Trade and Economic Development lists several main factors that led to natural gas price spikes in 2000 and 2001:

- Increased demand as more power is generated by natural gas and as hydroelectric power generation capacity has fallen with recent droughts.[77]

- Constrained supply capacity.[78]

- Rising oil prices: in many industrial processes, oil and natural gas can be substituted for one another. When the price of one rises, the other rises also.[79]

These factors are at work again today. Natural gas prices have soared to $6 per thousand cubic feet, twice the rate of a year ago.[80] EIA expects prices to remain "unseasonably high" through the rest of 2003, with "occasional sharp price increases."[81]

Each of these factors will continue and worsen in the near future.

- Demand for natural gas is currently experiencing its most rapid growth ever. As detailed above, energy companies will be greatly challenged to keep up with this growth rate.

- When newly approved gas plants are completed the state will deepen its reliance on natural gas. Clean, renewable energy sources–wind and solar–currently generate just one percent of Washington's energy.

- In California, the state's energy commission finds that a lack of excess pipeline capacity leads to "extraordinary volatility and price spikes." They predict that the gas industry will remedy the situation, but on a timeline that "can stretch into several years."[82] Washington is subject to the same pipeline capacity limitations as California, with the state's three pipelines already near capacity and much of the gas already committed to California users.[83]

Unsustainable Alternatives

While increasing dependence on natural gas is problematic for Washington, additional hydropower, coal, oil, or nuclear plants are simply not feasible options. The state has limited additional hydropower capacity and to build more dams would exacerbate impacts on fish. Coal and oil-fired power plants would severely worsen air pollution, and nuclear power is an intolerable risk and an economic failure.

HYDROPOWER

Hydropower produces 57 to 70 percent of Washington's electricity, the majority of which comes from large dams. Most major hydroelectric sites have already been developed in the state, so little future increase in hydropower capacity is anticipated.

Though these dams produce no air pollution, they have major negative environmental impacts: they have decimated salmon and steelhead populations and destroyed thousands of acres of habitat.

Each dam kills young fish as they migrate to the ocean. The fish are killed by turbine blades, get lost in overheated, sluggish reservoirs, or are eaten by predators who can easily capture stunned fish below the dams. Salmon and steelhead in the Columbia and Snake Rivers must pass as many as eight dams on their way to the ocean. The mortality rate rises for each dam and reservoir fish must navigate.

COAL AND OIL

Coal and oil are the largest contributors to energy-related health problems. Although coal plants make up only 56 percent of power plant boilers in the country, they are responsible for 93 percent of the industry's nitrogen oxide emissions, 96 percent of the industry's sulfur dioxide emissions, and 99 percent of the industry's mercury emissions.[84] Oil plants are also heavy polluters, emitting twice as much NOx and 80 times as much SO2 as gas plants.[85] These emissions are in turn the greatest contributors to smog, fine particulate matter, and atmospheric mercury deposition. This pollution results in children with asthma, youths with diminished attention capacity, adults with chronic bronchitis, and lethal respiratory complications.

Burning coal and oil is also a leading cause of climate change, probably the most dangerous effect of global energy production. Since the advent of fossil fuel technology, the atmospheric concentration of carbon dioxide, the most prevalent greenhouse gas, has doubled. Large scale and irreversible climate change could alter ocean currents, cause devastating droughts, floods, and violent storms, and spread tropical dis-

Columbia River Salmon — *Photo: Oregon Sea Grant* eases to temperate climates.[86] In the 1990s, extreme weather caused more than $642 million dollars in damage and emergency management spending in Washington, and $87 billion nationally.[87]

Washington has one electricity-generating coal plant, which is located in Centralia. It has a capacity of 1,460 MW, but is assumed to produce only 1,168 aMW. This single plant emits an estimated 12.4 million tons of carbon dioxide each year when operating at full capacity.[88]

NUCLEAR

Nuclear power puts lives at risk from potentially disastrous accidents and creates the most harmful substance known, for which there is no safe disposal process. For these reasons, construction of new nuclear power plants or extensions of the lives of old ones should not be considered.

Direct exposure to irradiated fuel from nuclear reactors delivers a lethal dose of radiation within seconds. According to DOE, 95 percent of the radioactive waste in this country (measured by radioactivity) is from commercial nuclear reactors. The storage of this waste poses a threat to water supplies throughout the nation. At the Hanford Nuclear Reservation, 67 of 177 underground tanks have leaked more than one million gallons of waste, contaminating groundwater and threatening the Columbia River.[89] Though this radioactive waste is the byproduct of weapons development rather than electricity generation, the hazard it presents is the same.

Presently there are more than 42,000 metric tons of spent fuel in temporary storage in the U.S., with that number increasing by five metric tons every day.[90] The potential risk to human health is staggering. The total radioactivity of spent fuel at this point is 30.6 billion curies; one curie generates a radiation field intensity at a distance of one foot of about 11 rem per hour; the exposure limit set by federal regulation for an individual is 5 rem per year.[91]

The risks of both catastrophic events and leakage of radioactive material into the environment pose great threats to public health. Even low-level radiation has been linked to cancer, genetic and chromosomal instabilities, developmental deficiencies in the fetus, hereditary disease, accelerated aging, and loss of immune response competence. The risk of accidents at reactors is also ever-present. Because many nuclear plants in the U.S. are decaying, the risk of accidents is greater now than it ever has been.

Nuclear power is also uneconomical. Nuclear power would not exist in this country today were it not for massive government subsidies. Taxpayer-financed federal research and development alone has totaled $66 billion.[92] On top of that, the nuclear industry receives a special taxpayer-backed insurance policy known as the Price-Anderson Act, taxpayer-funded cleanup of uranium enrichment sites, the costly privatization of the previously government-owned Uranium Enrichment Corporation, and unjustifiably high electricity rates from state regulators. Add to this the enormous bailouts in state deregulation plans that began a few years ago and will continue in the coming years. These "stranded costs" in just eleven key states may total more than $132 billion.[93]

Washington's direct experience with nuclear power has been financially painful. The Washington Public Power Supply System (WPPSS), now known as Energy Northwest, failed to complete construction of four nuclear plants in the early 1980s and defaulted on bonds it had used to fund the projects. As a result, electricity rates rose significantly to cover the losses. Approximately $6 billion of debt remains from this failure.[94]

REAL ALTERNATIVES

Washington has two options to avoid needing to construct natural gas-fired electricity generating plants and to reduce the state's exposure to volatile natural gas supply and prices. The first is to reduce the amount of energy that each person in the state consumes. The second option is to use renewable energy.

ENERGY EFFICIENCY

Despite a reasonable track record of improving energy efficiency in Washington, we have much room for further improvement. The state has not exhausted the "low-hanging fruit" of efficiency measures, and innovative new measures have become possible as technologies and systems advance. Reducing electricity consumption is less expensive than constructing new generating capacity and transmission lines to deliver additional power.

Washington was extremely successful in energy efficiency efforts in the early 1990s. Utilities invested $155 million in efficiency measures in 1993, which yielded energy savings of 100 aMW.[95] Annual utility investment in efficiency dropped to $37 million by 1999; savings dropped to 17.7 aMW.[96]

Washington's reduced spending does not mean that the state has already captured all cost-effective conservation measures. The potential for energy savings remains high. In an October 2002 study commissioned by the NW Energy Coalition, the Tellus Institute measured potential savings from cost-effective energy efficiency improvements and fuel switching in all sectors throughout the Northwest. The study determined that the region could achieve a 12 percent overall reduction in electricity use by 2010 and 24 percent by 2020.[97]

In the residential sector, the study found potential savings through more efficient

Table 8. Energy Efficiency Measures Identified in Tellus Study

Measure	% of Total Savings in 2020
Residential	
Furnace & Duct Service	0.9%
Furnace & Heat Pump Fans	2.3%
Super-Efficient Windows	0.6%
Weatherization	0.4%
Beyond Code Performance	0.2%
Manufactured Home Insulation	0.8%
Compact Fluorescent (CFL) Torchieres	0.7%
Indoor CFL Fixtures	1.5%
Outdoor CFL Fixtures	0.6%
CFL Bulbs	0.6%
Add-On Heat Pump Water Heaters	2.0%
Integral Heat Pump Water Heaters	5.3%
Electronics Standby-Mode Losses	3.5%
Residential Subtotal	19.5%
Commercial	
Systems Analysis for New Bldgs	1.5%
Systems Analysis for Existing Bldgs	0.4%
Fluorescent Lighting	2.3%
Advanced Lighting Measures	6.7%
Low-Cost Refrigeration	0.9%
High-Cost Refrigeration	0.5%
General O&M	1.3%
Internet Data Centers	1.3%
Clothes Washers	0.2%
Commercial Subtotal	15.0%
Industrial	
Premium Motors	2.4%
Motor Systems	6.7%
Aluminum Production Process	3.3%
Other Industry-Specific Processes	8.2%
General O&M	0.6%
High-Efficiency Transformers	0.1%
Industrial Subtotal	21.2%
Other	
LED Traffic Signals	0.2%
Irrigation	0.5%
Solar Direct Hot Water	1.2%
Condensing Gas Water Heaters	5.1%
Commercial Combined Heat & Power	20.9%
Industrial Combined Heat & Power	16.4%
Other Subtotal	44.3%

water heating, home heating, and other measures. In the commercial sector, most savings were in better heating, ventilation, and air conditioning systems and lighting. In the industrial sector, the study identified motor efficiency and improvements to the aluminum production process as the areas with highest potential energy savings. Further possible reductions were measured in street lighting and irrigation, and the study also explored improved efficiency in electricity production through combined heat and power systems.

Recent conservation efforts in Washington have yielded substantial savings. In 2001, when energy supplies were tight statewide, Seattle City Light set a goal of achieving a 10 percent reduction in electricity demand in a single year. Through a combination of public education, distribution of efficient light bulbs, and incentives for business customers, the utility surpassed its ambitious goal–reducing demand by 12 percent for the year. Thus the utility's Energy Management Services Division acquired 11.7 aMW in 2001 from strategies that use less energy to receive the same level of productivity. This is enough energy to power 11,000 Seattle homes for a year. These savings allowed Seattle City Light to avoid the purchase of $80 million of electricity on the regional market.[98]

Similarly, in California, energy conservation was a highly visible priority throughout the energy crisis of 2001. State efforts to promote energy savings paid off, with a total annual reduction of 6.7 percent in statewide generation in a single year. Monthly peak load reductions from the previous year reached a high of 14 percent in June 2002.[99]

Although the energy savings outlined in the Tellus Institute study represent real, cost-effective opportunities specifically identified by their survey, even a more conservative estimate of savings bears substantial results. If Washington reaches six percent cumulative savings by 2010 and 12 percent by 2020, the state will be reducing electricity demand by 734 aMW in 2010 and 1,703 aMW in 2020. (See Table 10.) 734 aMW is equal to 40 percent of the capacity of natural gas plants that have received permits but have not yet been constructed.

Each MWh of coal or natural gas-generated electricity that is not needed avoids production of 800 to 2,500 pounds of the greenhouse gas carbon dioxide.[100]

Table 9. Projected Energy Conservation (aMW)

Year	Projected Demand without Efficiency	% Savings from Efficiency	Total Efficiency Savings	Projected Demand with Efficiency
2003	11,000	0.8%	80	10,920
2004	11,200	1.5%	170	11,030
2005	11,400	2.3%	260	11,140
2006	11,500	3.0%	350	11,150
2007	11,700	3.8%	440	11,260
2008	11,900	4.5%	540	11,360
2009	12,000	5.3%	630	11,370
2010	12,200	6.0%	730	11,470
2011	12,400	6.6%	820	11,580
2012	12,600	7.2%	910	11,690
2013	12,800	7.8%	1,000	11,800
2014	13,000	8.4%	1,090	11,910
2015	13,200	9.0%	1,190	12,010
2016	13,400	9.6%	1,290	12,110
2017	13,600	10.2%	1,390	12,210
2018	13,800	10.8%	1,490	12,310
2019	14,000	11.4%	1,600	12,400
2020	14,200	12.0%	1,700	12,500

Efficiency Potential: Residential Hot Water Heating

The electricity consumed by heating water represents roughly one quarter of the electricity sold to residential customers in the Northwest.[101] The most common types of water heaters are electric or gas-fired and, though gas in particular can be inexpensive (especially when gas prices are low), neither, in its most commonly sold form, is very efficient.

Electric resistance water heaters draw power from the grid to warm a heating element inside an insulated hot water tank. These heaters are highly inefficient but can be improved to use 50 percent less electricity when paired with a heat pump. Heat pumps capture existing heat from their surroundings and use it to heat water with little additional energy expenditure.[102] Heat pumps can turn an electric water heater with only 42 percent efficiency into a heater with 112 percent efficiency–meaning that more energy (in the form of heat) is contained in the heated water than was contained in the electricity consumed by the water heater. Each kWh of power saved costs $0.027 to $0.048.

Gas-fired water heaters can operate more efficiently when the warm combustion gases that typically are released into the air are instead captured to further heat the water. This improves the efficiency of gas water heaters from their current 60 percent to 86 percent.[103]

A third type of water heater that is effective, even in relatively cloudy areas, is solar-powered. Flat panels mounted on an unshaded roof capture solar energy to heat water. The water is connected to a water heater tank. This set-up can provide up to 70 percent of the hot water needs for a family.[104] Because of the high initial cost of installing a solar system, each kWh of power saved costs $0.13.

RENEWABLE ENERGY PROSPECTS

In addition to pursuing conservation measures, Washington could reduce its reliance on natural gas by turning to renewable energy sources. Washington has substantial renewable energy potential. Renewable projects using wind and solar energy are already operating today throughout the state, proving the technology is ready to harness these resources economically.

Because renewable energy does not rely on fuel, its costs are predictable and stable. Once the plants are built, producers only have to pay regular operating and management costs to keep the power flowing. Many of these payments go to in-state workers and companies, whereas payments for natural gas go entirely to out-of-state interests.

In addition, both wind and solar energy costs have plummeted over the last twenty years and are predicted to continue declining. Geothermal energy costs, which currently range from slightly higher to lower than conventional fossil fuel power, have also declined historically and are predicted to remain roughly the same over the next ten years.

The single biggest impediment to developing renewable energy projects is that nearly all of the costs are incurred up-front, in the form of initial construction costs. In effect, renewable energy producers are financing 30 years worth of power all at once. In the absence of long-term contracts, building renewable energy plants involves more risk to investors due to uncertain future markets. Traditional power plants can be more attractive to investors because the technologies have been around longer, require less initial investment, and attract long-term purchase contracts from utilities; fuel costs are then incurred over time, and increases due to fuel cost changes can be passed on to consumers.

Due to the real and perceived risks associated with renewable power, lenders have offered less favorable financing terms and demanded a higher return on investment than for traditional energy sources.[105] For capital-intensive technologies like wind, the price of electricity depends greatly on the interest rate at which the owners pay off debt. A 1996 study by the Lawrence Berkeley National Laboratory found that contract prices for wind-generated electricity could decrease by 25 percent with financial terms typical of natural gas projects.[106]

High plant construction costs followed by almost free production makes renewable energy unique in the world of electricity generation. Fortunately, electricity is also somewhat unique in that it is a widely used commodity that has a long history of regulation to ensure stable supplies at fair prices. To promote renewables, the state can provide a guaranteed market for renewable energy without vast subsidies or regulation of specific investments. If renewable energy producers had a guaranteed price for much of the lifetime of their plants, the high construction costs would present less of a barrier and attract better financing terms. Given a foothold in the market, renewable energy technologies will then be able to gain a larger market share with less assistance.

Wind

Potential

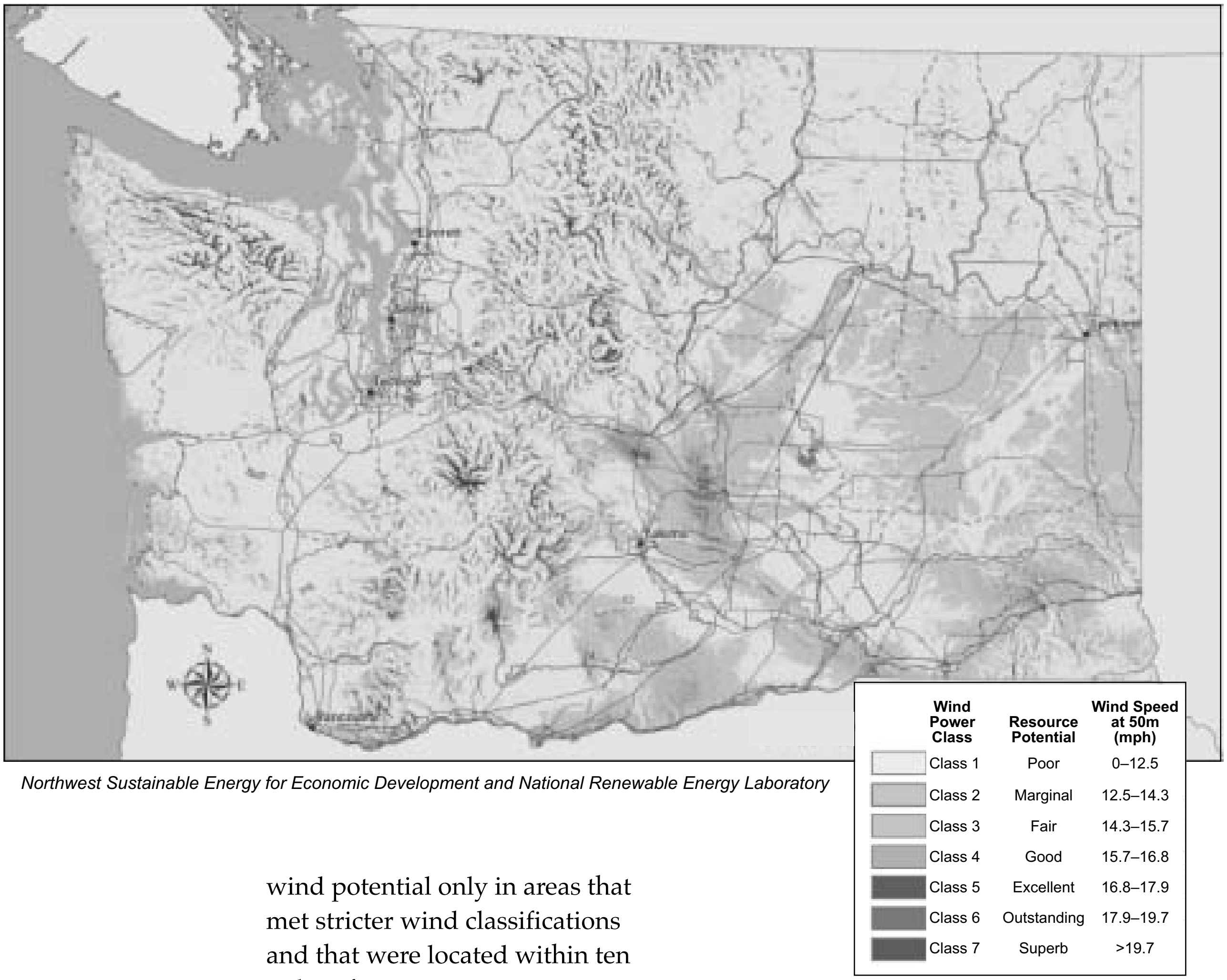
Washington has enormous wind potential by all estimates.

- The Pacific Northwest Laboratory (PNL) estimated in 1994 the state could generate 3,700 aMW of electricity from wind—more than one-third the total amount of electricity the state generated in 1998.[107]

- The National Renewable Energy Laboratory (NREL) made more conservative estimates, measuring

Photo: NREL

Figure 9. Washington State Wind Power Resources



Northwest Sustainable Energy for Economic Development and National Renewable Energy Laboratory

wind potential only in areas that met stricter wind classifications and that were located within ten miles of existing transmission lines. Under these criteria, NREL estimated Washington could generate 3,400 aMW of electricity from wind.[108]

- More recently, four research organizations published a survey of renewable resources in eleven Western states called the *Renewable Energy Atlas of the West*. This study found 7,000 aMW of wind potential in Washington. The study used higher resolution data to measure the potential for generation from taller and more advanced turbines than those used for the earlier analyses.[109]

- The Tellus Institute, in the recent report contracted by the Northwest Energy Coalition, identified 1,900 aMW of wind energy potential in Washington looking only at the windiest and most developable locations. Including medium-wind locations, many of which are cost-effectively developable, the study found 76,000 aMW of wind potential in four northwestern states.[110]

Economics

The cost of wind-generated electricity has declined by more than 80 percent from the early 1980s, when it averaged 38 ¢/kWh. The best sites nationally are now generating electricity for 3 ¢/kWh, not including the federal wind energy Production Tax Credit (PTC).[111] In Washington, the best wind power costs 4 ¢/kWh, before the PTC is applied.[112] (The PTC is a federal subsidy for wind production, paid at a rate per kWh.)

Currently, Washington has two major wind farms with a combined capacity of 228 MW and output of 76 aMW, but the technology is ready and the price is competitive to build more now. Eight additional wind projects with a combined capacity of 753 MW are currently in development and two others totaling 230 MW of capacity (78 aMW of output) are being considered.[113] When the Bonneville Power Administration sought 1,000 MW of new wind power for the Northwest, it was "blown away with 25 proposals that could provide 4,000 MW of wind capacity."[114]

It is reasonable to project that Washington wind developers could complete half the 835 MW of wind projects currently in development by 2004 over the next two years to reach a peak capacity of 600 MW (the conservative result of 228 MW current production plus 410 MW of new capacity) by the end of 2004, then add wind power capacity at the rate of 250 MW per year. In this scenario, by 2010 the state would have 2,100 MW of available power, equal to 700 aMW; by 2020 the average would be 1,700 aMW. With this amount of growth, Washington will have developed 89 percent of its total wind potential according to the most pessimistic resource estimate mentioned above and 24 percent of the total potential according to the most optimistic published estimate.

Figure 10. Projected Wind Power Growth[115]

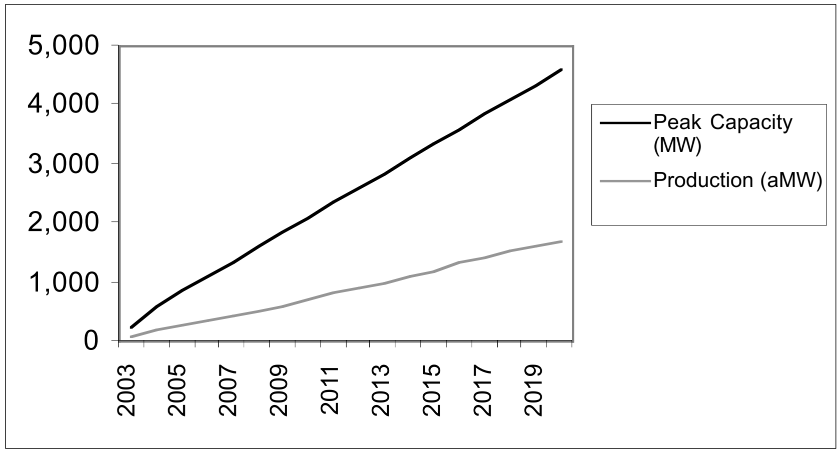


Table 10. Wind Projects in Washington[116]

Project	Peak Capacity (MW)	Average Output (aMW)	Status
Mariah	0.2	0	online
Nine Canyon	48	16	online
Stateline, phase I	180	60	online
Nine Canyon Expansion	15	5	under construction
Stateline, phase II	40	14	under construction
Klickitat Wind	15	5	permitted
Desert Claim	180	60	in permitting process
Kittitas Valley	181	60	in permitting process
Maiden Wind Project	150	50	in permitting process
Stateline, phase III	204	68	in permitting process
Zintel Canyon	50	17	in permitting process
Total online	228	76	
Total in development	835	279	
Total	1063	355	

The Columbia River at the eastern end of the Gorge. *Photo: Sandy Ridlington*

Profile: Nine Canyon Wind Project

Located just eight miles from Kennewick, the Nine Canyon Wind Project relies on the strong winds that gust up the Columbia Gorge to turn 37 wind turbines. Those turbines are each rated at 1.3 MW. Operating together, they have a maximum output of 48 MW.[117] The project began producing power in September 2002.[118]

The project is the largest publicly-owned wind power project in the country. Power from the facility is purchased by eight public utility districts: Okanogan County PUD, Grant County PUD, Chelan County PUD, Grays Harbor PUD, Benton County PUD, Douglas County PUD, Lewis County PUD, and Mason County PUD #3.[119] An estimated 10,000 to 15,000 homes can be powered by the energy from Nine Canyon.[120]

The project has provided economic benefit to two farm families. Though the project is owned and operated by Energy Northwest, it is located on two privately-owned dry land wheat farms.[121] Energy Northwest paid $500 for land on which to place each turbine, and annually pays $1,000 or 3.5 percent of gross revenues per turbine.[122] Of the 2,000 acres included in the two farms, only 50 acres have been removed from agricultural production to accommodate the wind turbines.[123]

The Nine Canyon Wind Project also confers environmental benefits. If the electricity produced by the wind turbines were instead generated at a coal-fired plant, an additional 55,000 tons of carbon dioxide (a greenhouse gas) and 5.3 tons of nitrogen oxides and sulfur dioxide (contributors to acid rain and smog) would be produced.[124]

Energy Northwest plans to expand the project by adding 12 more wind turbines. Identical to the original 37, they will have a capacity of 15.6 MW. This will bring the total generating capacity of the wind project to 63.7 MW.[125] The benefit from the additional 15.6 MW will serve an additional 680 homes.

Wind turbines at Nine Canyon *Photo: NREL*

Solar Photovoltaic

Potential

Although sunlight is not as intense in Washington as it is further south, solar panels still function at sufficient voltage in a cloudy climate. Despite the state's reputation, the amount of sunlight in Washington is within 25 percent of the national average.[128] Solar intensity measurements throughout the state indicate that Washington has a total PV generating potential of 4,800 aMW, 45 percent of 1999 statewide demand.[129]

Solar PV is especially complementary to Washington's hydropower system. Solar PV output peaks during the irrigation and air conditioning season in the eastern portion of the state. Utilizing solar PV on a wide scale would assist hydropower facilities in managing river operations to satisfy the competing demands of electricity, irrigation, and salmon habitat protection. As solar PV lowers demand for hydropower in the summer, the Columbia River system acts as a "battery bank" storing power (water) for the winter.

Solar Energy

There are two different types of technology for harnessing the sun's energy to generate electricity: solar thermal electric power plants and photovoltaics.

Solar thermal power plants use reflectors to concentrate sunlight on a receiver that uses the sun's heat to drive a turbine and generate electricity. Parabolic troughs, power towers, and dish/engines are the three technologies either in use or in development for solar thermal power plants, differing mainly in the shape and configuration of the reflectors.

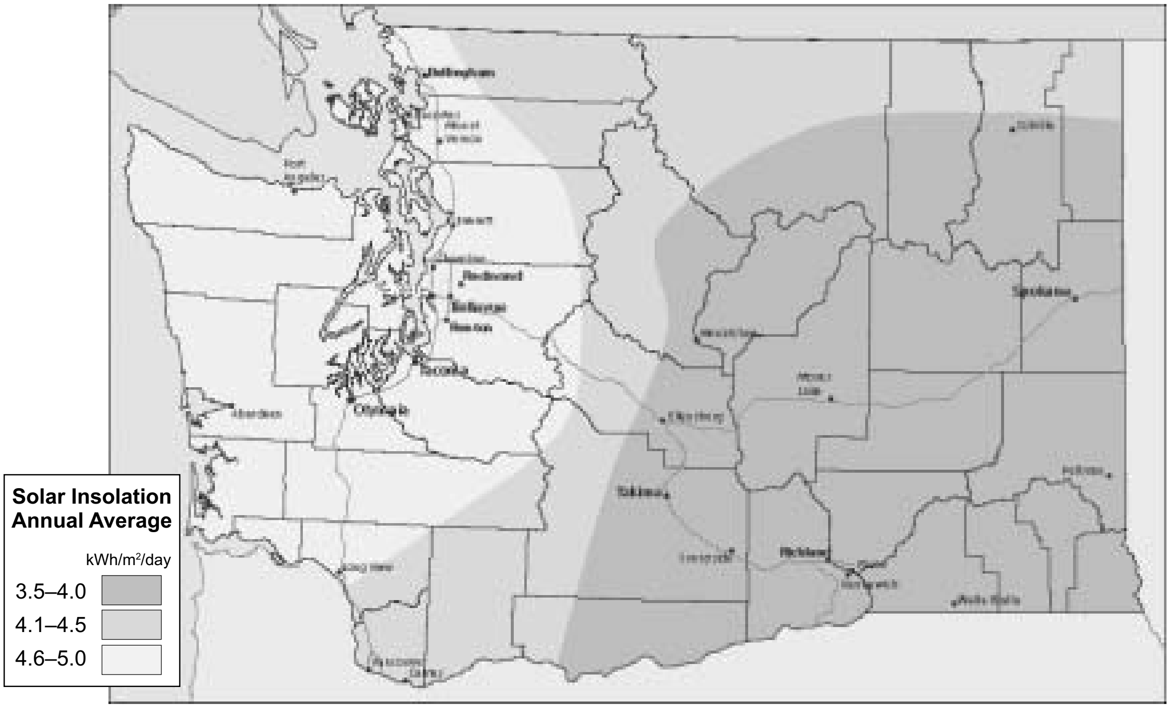
Photovoltaics are very different from any other method ever used to generate electricity. All other methods require at least a two-step conversion of energy from its natural state into mechanical power and then to electrical power. Photovoltaic (PV) panels convert sunlight directly into electricity without the use of a generator or any moving parts.

The basic building block of this technology is the photovoltaic cell, which is made of semiconductor materials. Cells can be connected together to form modules, and modules can be connected to form arrays. In this way, PV systems can match power output to power needs. A few PV cells will power a hand-held calculator or wristwatch, while interconnected arrays can provide electricity for a remote village.

PV systems can operate either remotely or in connection with the utility grid. Their reliability even in adverse environments has been proven over decades by their performance powering satellites, which have to operate long term with no maintenance. The Federal Emergency Management Agency now uses solar electricity systems for prevention, response, and recovery in emergency situations. It learned the value of PV for this purpose after Hurricane Andrew, when some Miami suburbs were without grid power for as much as two weeks. The PV systems that had previously been installed in that region survived and were able to help in the relief efforts.[126] With PV's long life, minimal operation and maintenance requirements, versatility (remote or grid-connected operation), reliability, and sustainable nature, the U.S. Department of Energy has concluded that, "it is easy to foresee PV's 21st century preeminence."[127]

Compared to a conventional fossil fuel plant, a solar plant requires more land to harness the diffuse energy from the sun. But when the full cycle of fuel-gathering through power generation (which includes mining and waste disposal) is compared, land requirements for solar plants are no more than those of conventional fossil fuel plants.

Figure 11. Washington State Solar Power Resources



Data source: National Renewable Energy Laboratory 2002

Washington has at least 123 kW of solar PV generating electricity right now, including the 39 kW White Bluffs Solar Station at Hanford that sells solar power to several Washington utilities.[130] The state is aiming to have 5,000 new solar systems in place by 2005 and 20,000 by 2010 to fulfill its part in the national Million Solar Roofs Program.[131] About half of the systems installed are expected to be PV systems. At an average size of 2 kW per PV system, this program will add 20 MW of PV capacity to the state by 2010.

The other 10,000 systems in place by 2010 will be solar thermal collectors for water heating. Collectively these solar thermal collectors will go a long way to conserve fossil fuels, mostly natural gas used for water heating.

The state has several operations by different utilities, municipalities, and groups striving to level the playing field between fossil fuels and solar power. For example, the Western SUN (Solar Utility Network) Cooperative negotiates and resells packaged solar electric systems to its members, allowing them to acquire and implement renewable energy technologies at the lowest possible cost through market aggregation. Western SUN members are electric cooperatives, public utility districts, and municipal utilities. The co-op provides educational resources, training, and marketing to its membership and their customers. Given this activity, the goals of the Million Solar Roofs program should be reasonably attainable.

Economics

PV can generate electricity for 19-25 ¢/kWh.[132] This is more economical than fossil fuel-generated electricity right now for some situations, such as remote applications in the U.S. and vast areas of the developing world that have no grid or power plant infrastructure in place. However, this is not competitive with the lowest rates from gas-fired power plants today in the grid-connected developed world. Only when the industry is further developed will the cost of PV be on a par with traditional technologies.

Economies of Scale

The current cost of PV modules is quoted at about $3.50-$3.75/watt wholesale and $6-$7/watt for an installed system.[133] This cost is a dramatic reduction from twenty years ago, when PV power cost $27 per watt.[134] The cost will continue to decline as PV manufacturers reach economies of scale. Since nearly all of the costs for PV-generated electricity lie in the equipment, the more that equipment can be manufactured on a mass scale, the cheaper the electricity becomes.

The relationship between increased volume and decreased price is called the experience curve. For PV, it is estimated to be 82 percent. That is, for every doubling of production volume, the price of PV declines by 18 percent.[135]

To compete on equal footing with traditional power sources in a short-term economic view, PV prices will need to be around $1/watt for an installed system.[136] According to this experience curve, that price will be reached once PV installations total 500,000 MW. In 1999, total installed PV capacity was 1,034 MW.[137] The PV industry clearly has a fair distance to go, but recent trends prove that the industry is steadily progressing toward its goal.

Market Growth

PV module shipments in the U.S. and worldwide have steadily increased over the past twenty years. Furthermore, the rate by which shipments have increased has also risen.

From 1989-1999, the worldwide PV growth rate averaged 18 percent. For the same time period, the U.S. growth rate was 21 percent. Recently the growth rate has been much higher. The average growth rate in 1997-1999 in the U.S. and worldwide was

Table 11. Experience Curve for PV Module Price

Doubling	Installed MW	Wholesale Price per Watt	Installed System Price per Watt
0	1,043	$3.50	$6.50
1	2,086	$2.87	$5.33
2	4,173	$2.35	$4.37
3	8,346	$1.93	$3.58
4	16,692	$1.58	$2.93
5	33,383	$1.30	$2.40
6	66,767	$1.06	$1.97
7	133,533	$0.87	$1.62
8	267,067	$0.72	$1.32
9	534,133	$0.39	$1.08
10	1,068,267	$0.39	$0.89

Figure 12. Annual PV Manufacturing Volume[140]

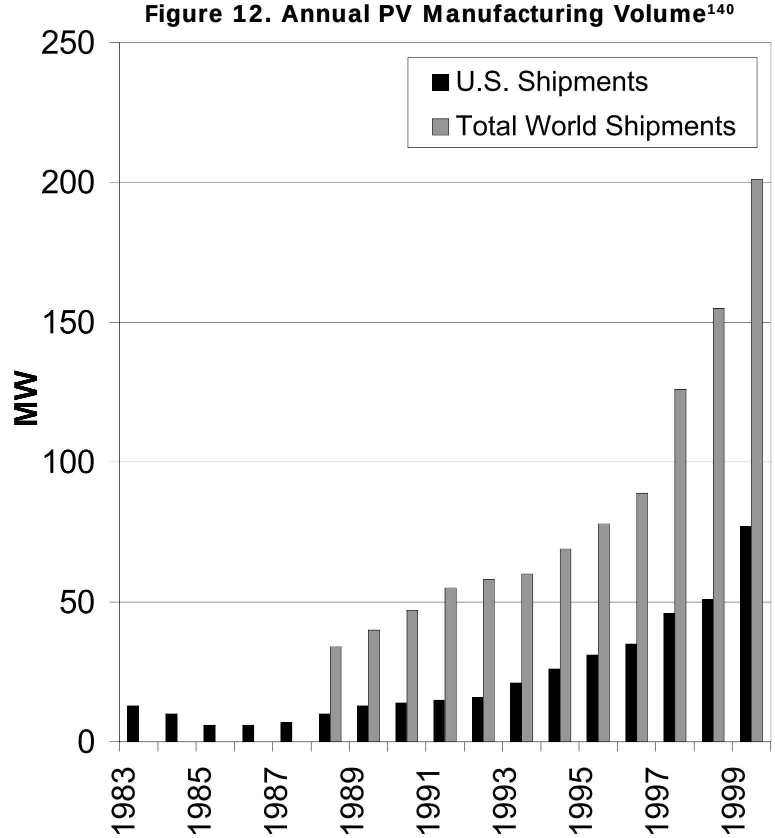
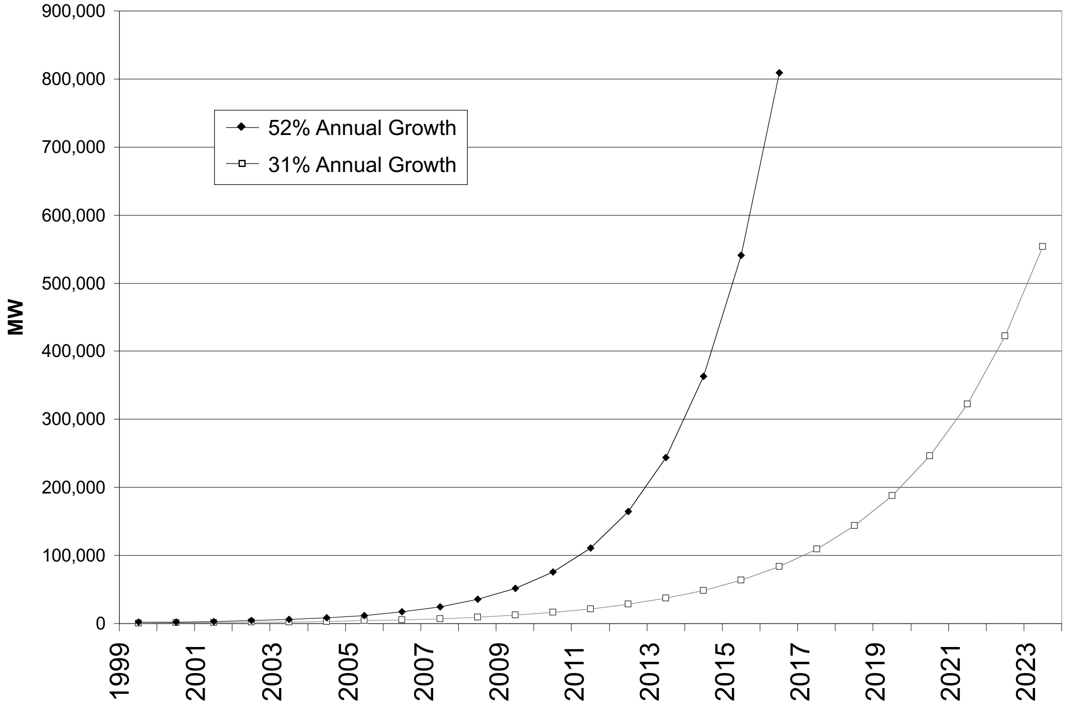


Figure 13. PV Market Growth Rates[141]



a healthy 31 percent.[138] In 2001, the U.S. growth rate was 55 percent, the highest ever.[139]

If the growth rate in PV manufacturing activity continues at the 52 percent level it reached in 1999, cumulative worldwide PV capacity will have reached 500,000 MW by 2016. If growth in manufacturing grows at only the 1997-1999 average rate of 31 percent, the industry will have reached this

Profile: Millennium Elementary School

The Millennium Elementary School in Kent is an excellent example of green building principles at work in an educational facility. Kent School District and a design team integrated a number of sustainable design elements into an otherwise normal school. The school opened in August 2000.

One of Millennium's more prominent features is the 180-square-foot rooftop-mounted solar array. The system currently consists of 24 photovoltaic panels capable of producing two kW of energy.[142] Also providing energy to the school is a 400 watt wind turbine.[143]

Though the amount of power generated by the PV and wind system is minimal, the projects are nonetheless important.[144] The systems are part of a test to demonstrate the long-term feasibility of solar and wind power for the school district.[145] According to Lori Moen, Resource Conservation Specialist for the Kent School District, the "proof of concept" experiments will answer the question whether the systems generate enough energy to make them cost effective. Ultimately the school district will balance the educational uses of sustainable systems with their ability to generate power.[146]

Other sustainable features in the Millennium school include geothermal heating, the collection of stormwater for irrigation, and waterless urinals.[147] The *Seattle Times* calls the Millennium school "the most environmentally friendly in the state."[148]

milestone in 2023. At this point, PV electricity will be cost-competitive.

Solar Thermal

Solar thermal units also have potential in Washington. These systems use reflectors that move to capture the maximum sunlight throughout the day. Western Washington does not receive enough sunlight to make a large-scale solar thermal system cost effective. In sunnier portions of the state, though, DOE's division for Energy Efficiency and Renewable Energy projects that a 200-acre system of solar collectors could generate 4.2 aMW per year. That is enough electricity to power nearly 4,000 homes.[149]

Geothermal

Washington has the potential for an estimated 300 MW of geothermal electricity-generating capacity.[150] The actual capacity may be higher because there is thought to be much potential that has not yet been tested. The best of these resources can be developed now at a cost lower than the cost of a natural gas power plant.[151] The last nationwide geothermal resource assessment was published in 1978. Since knowledge about geothermal resources has advanced dramatically in the past 20 years, there is need for reassessment of resources in the western U.S.

The entire state of Washington can access resources for ground-source heat pumps, although cost-effectiveness varies widely. Washington has been a leader in the field of ground-source heat pumps, installing the first systems in the 1950s. Case studies of installed systems in commercial buildings revealed long-term reliability, low operation and maintenance costs, and high customer satisfaction.[152] Heat pumps provide water and building heating in the winter months and air-conditioning in the summer months, directly reducing the use of fossil fuels and electricity.

Although some of Washington's geothermal electricity generation potential is developable within the next decade, geothermal is not included in this report's projections as all Washington geothermal projects are in the early planning stages.

Policy Recommendations

Washington has several policy options to realize the economic benefits that renewable energy and energy efficiency can provide. Based on the experience of other states, the most effective policies:

- ensure a lasting, stable market for renewables and energy efficiency upon which developers and investors can depend, and

- are guided by a cohesive state policy rather than varying policies adopted by different jurisdictions.

Washington state government has a responsibility to develop an energy policy that ensures reliable supplies at stable prices produced with tolerable impacts. The state should diversify its energy sources and begin now to develop a sustainable energy future.

NATURAL GAS

Deny Pending Proposals

Energy companies have built 985 MW in fossil fuel-based power plants in Washington in the past two years and are actively constructing 768 MW more. In addition, the state has granted initial approval to fossil fuel power plants with a combined capacity of 1,636 MW that are now under development. Nearly all of this capacity is fueled by natural gas.

This amount of natural gas power plant development has more than achieved its purpose of boosting in-state energy reliability. At this point, ironically, the state risks decreased reliability due to over-dependence on volatile fossil fuels.

Most recently proposed power projects have been for natural gas-fueled plants. The state should stop Washington's move toward greater dependence on natural gas and not grant approval to any more natural gas power plants. The wind projects currently being studied are more appropriate for the next stage of energy capacity development in Washington, and can meet the state's projected needs.

ENERGY CONSERVATION STANDARD

Washington should require all utilities doing business in the state to meet a percentage of future power needs with energy conservation. Opportunities for energy savings are abundant, and the utilities are well positioned to administer the development of many of those opportunities. As part of their responsibility to the public, utilities should be required to include energy conservation as part of their energy development plans.

Higher efficiency standards for new buildings can help to reduce energy consumption and can be promoted through better building codes. Tax incentives can also be given to consumers to encourage them to install efficient appliances in existing homes.

RENEWABLE ENERGY

Renewable Portfolio Standard

A minimum of 15 percent of electricity production from wind, solar, and non-hydro renewable sources by 2023 is reasonable and achievable. This would create economies of scale, spur innovation, and establish markets and technologies.

A "renewable portfolio standard" would create guidelines under which utilities would be required to purchase a minimum percentage of electricity from renewable sources. Creating a guaranteed market for renewable energy with a purchasing requirement will ensure that renewable energy developers do not overlook Washington. To ease the hurdle of high up-front costs and uncertain markets, the state can require utilities to enter into long-term contracts with renewable energy producers. Such agreements guarantee a set price for much of the lifetime of the plant, reduce the risk of investment, and make it possible to produce cheaper electricity.

There are about a dozen states that have some kind of minimum renewables requirements now, including California, Nevada, Arizona, New Mexico, Texas, Wisconsin, New Jersey, Connecticut, and Massachusetts.

Effective purchase requirements include a clear way to track utility compliance and a system of incentives and penalties to encourage utilities to follow through with procuring renewable energy.

Subsidies for Development and Production

New energy technologies need assistance in order to compete with mature technologies. Historically, no new energy technology has been commercialized without government financial help. If a new technology proves to indeed provide a valuable benefit to and gains acceptance from the public, assistance will gradually become unnecessary and can be terminated at that time.

Tax incentives such as a sales tax exemption for equipment used in wind farm construction or manufacturing can help make wind energy more economical. These incentives reduce the initial capital investment required to develop a wind farm and produce a lower levelized cost for wind-generated electricity. However, it should be noted that tax incentives work best in conjunction with standards rather than in isolation.

Subsidies for Consumers

As long as consumers are expected to shoulder the burden of the investment costs of solar panels and small wind systems, the government must provide financial incentives to install this equipment. Even though wind and solar power generation is cost-effective for consumers over the lifetime of the panels, the high initial investment precludes most consumers from taking advantage of good opportunities they may have. A well-funded buy-down program would result in considerable load reductions on the grid. Since many residential solar arrays produce more power than a household uses during peak demand times, this will reduce the need to build power plants throughout the state which only serve peak need.

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