Texas Public Policy Foundation

Texas Energy and the Energy of Texas



The Master Resource in the Most Dynamic Economy

Prepared for the Texas Public Policy Foundation
by Steven F. Hayward, Ph.D. & Kenneth P. Green, Ph.D.
American Enterprise Institute

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Summary: "If It Ain't Broke, Don't Fix It"

There are few current conditions in America to which this old folk axiom applies better than the Texas economy. The Texas economy is (or ought to be) the envy of the nation. The Texas economy has been notably outperforming the nation's economy for at least a decade. Texas' relative share of total national economic output has grown by a full percent over the last decade, and it has been racing ahead of the nation's largest state, California, as shown in the table below. Although Texas has shared the nation's economic pain during the current Great Recession, its economy continues to outperform the nation, with unemployment about 2 percent lower than the national average. Over half of the nation's total net new private sector jobs between August 2009 and August 2010 were generated in Texas.

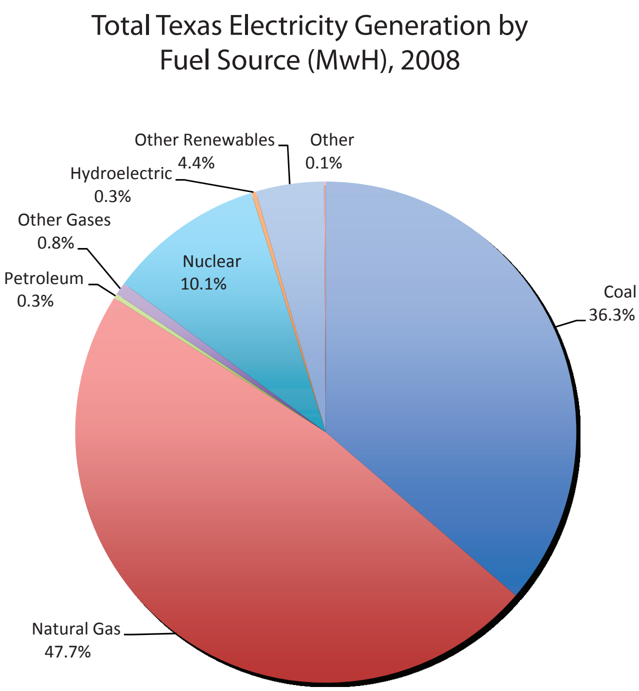
Two main macroeconomic factors explain this success:

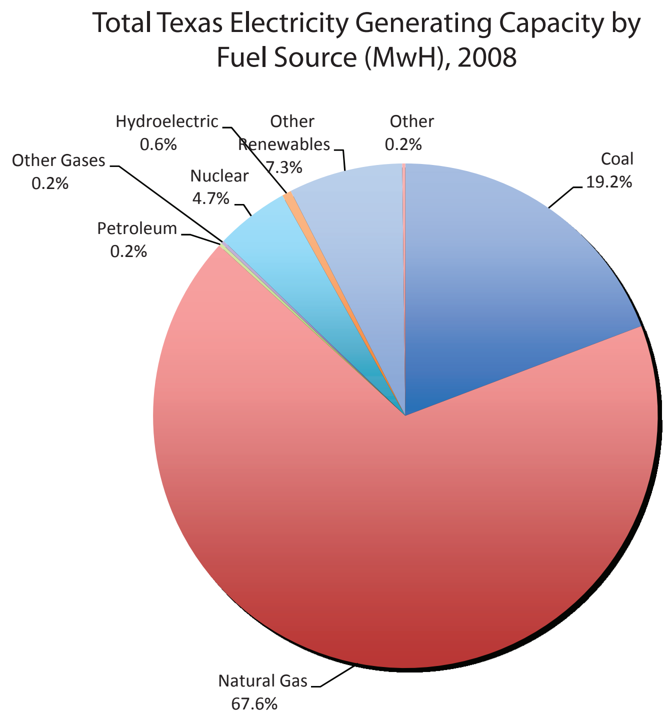
- The first—sensible low taxes and moderate regulatory policy—are well known, and explain the dynamic entrepreneurial culture of the state. Texas has succeeded in avoiding the mistakes of Washington, D.C. and other states that have hampered economic growth with high taxes and cumbersome regulations. Few people in Texas are proposing to abandon this winning formula.
- The second factor is less fully appreciated: the role of energy in the Texas economy. *Texas is the largest energy producing and consuming state in America; energy use is a central factor in the state's prosperity*. Understanding the details of this story is the focus of this study. Any proposal that may threaten to disrupt this side of Texas' winning formula should be carefully avoided.
    - Just as the Midwest is regarded as the "breadbasket of America," Texas should be regarded as the "energy breadbasket of America."
    - Texas accounts for more than half of the nation's total domestic production of oil and natural gas. The long history of oil and gas in Texas is well-known, but that is far from the end of the story.
    - Texas is also the leading *coal*-consuming state in the nation, using nearly twice as much coal to generate electricity as the second-place state (Indiana). Texas is also the eighth largest coal-mining state.
    - While much of Texas' oil and gas production is for export to other states, its coal production and consumption is the mainstay of its electricity production.

Economic Growth Comparisons, 1999-2009

	U.S.	California	Texas
Population Growth	10.0%	10.3%	20.5%
Growth in Nominal GDP	52.4%	56.3%	70.4%
Growth in Personal Income	53.9%	53.0%	76.0%
Growth in Per Capita Income	39.9%	38.7%	46.0%
Total Employment Growth	7.6%	5.6%	19.5%
Growth in Small Business Employment	38.5%	28.2%	48.2%

Source: U.S. Bureau of Economic Analysis





Source: EIA

- Although Texas, like many other states, has more gas-fired electric generation capacity, it relies on its coal-fired power capacity for a larger share of its 24/7 baseload electricity needs. Texas, like most states, uses natural gas as a "swing" producer for peak periods of power demand because it is a higher cost source than coal. This contrast is evident in the above figures.

- Coal is the cheapest source of Texas electricity after nuclear power (but nuclear power only supplies 10 percent of electricity in Texas—see above); suppressing coal-fired electricity will entail higher energy prices for Texas consumers.

- The Texas energy picture is changing rapidly and presenting new challenges for policymakers—chiefly the challenge of doing no harm to the sector.

  - Texas natural gas production has soared with the development of new drilling technologies and the opening of "unconventional" gas fields in the state. New supply is putting downward pressure on natural gas prices—a blessing for consumers but a market risk for gas producers, who fear falling prices may render gas production less profitable.

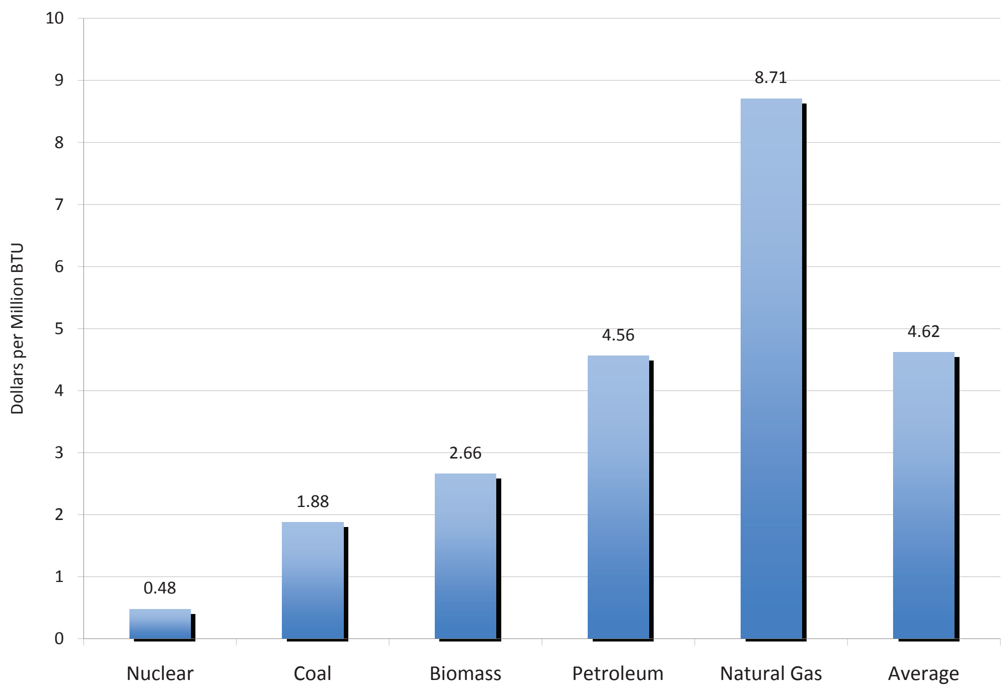
  - Market mandates on picking one fuel source are akin to sawing off one of the legs of the three-legged stool (oil-gas-coal) that comprises the Texas energy portfolio. This balanced portfolio has been critical to Texas' success.

- Texas' position as the highest energy consuming state in the nation needs to be better understood, not presumptively criticized. Energy consumption is controversial today: environmentalists especially mark out high energy consumption as a sign of inefficiency or profligacy.

  - Texas is in fact *America's largest industrial state*, with a high concentration of energy-intense manufacturing industries, especially petrochemical refining. Texas uses more energy for industry than the next top three states combined (California, Louisiana, and Ohio). Nearly half of Texas' total energy use is in its industrial sector. This is *one-third higher* than the national average. Higher energy prices will reduce the competitiveness and profitability of Texas' manufacturing sector.

  - The affordability of energy is a key component in the economic competitiveness of the state. The states that have attempted to intervene in energy markets are saddled with the nation's highest energy prices.

Texas Electricity Cost by Fuel Source, 2008



Source: EIA

- Texas' strong position as a fossil fuel energy producing state is an asset rather than a liability, as it is better shielded from price and supply shocks.

- The Texas energy sector faces several key uncertainties from both federal regulatory initiatives and potential state regulation.

- Energy markets are volatile; price swings from national and global changes in supply and demand for different energy sources can have significant effects on the economy.

Conclusions

- The best energy strategy is to develop *energy resilience* through a diversified energy portfolio that emphasizes abundance, affordability, and reliability.

- The best policy for achieving energy resilience is an open, adaptable marketplace for competing energy supplies and technologies, rather than mandates and patchwork subsidies that introduce artificial distortions and constraints in energy markets. The goal of policy should be to make the entire "energy pie" bigger, not to try to force favored parts of the energy pie to grow or shrink. Existing mandates should be reviewed for possible elimination.

- To adapt another popular slogan, the best advice for Texas policymakers can fit on a bumper sticker: "Don't Mess with Texas Energy." Texas should not do to the energy sector what it would not do to any other sector of its economy.

The best energy strategy is to develop energy resilience through a diversified energy portfolio that emphasizes abundance, affordability, and reliability.

Introduction: "Energy 101" Why Energy Literacy Is Necessary

Energy is rightly called "the master resource" because it makes possible nearly all forms of human activity and advancement, and drives the economy. We tend to take it for granted precisely because of its abundance, convenience, affordability, and reliability. Consumers whose primary interaction with energy is turning on a light switch or filling up an automobile fuel tank take its abundance, reliability, and affordability too much for granted. In fact, mass-scale energy is relatively recent aspect of human existence—really just the last 200 years, although energy has a long and important history. And it requires a sophisticated supply chain that cannot be replaced or supplanted on wishful thinking or through blunt force government mandates.

Energy Literacy: Basic Measurements and Their Meaning

Energy is not a unitary phenomenon; in other words, energy comes in many different forms and has many different purposes. It is common to lump the majority of our energy consumption under the banner of "fossil fuels" (oil, coal, and natural gas) versus "renewable" energy, but this is misleading.

The most basic distinctions to keep in mind are that energy is consumed in the form of combustion for transportation, in the form of electricity, and in the form of a feedstock for industrial production (such a natural gas and oil for plastics, chemicals, and pharmaceuticals). About two-thirds of total American energy is consumed in the form of electricity, and one-third for transportation, which depends overwhelmingly on liquid fuels refined overwhelmingly from oil. Very little oil is used to produce electricity (only about 1 percent nationally), which is why expanding wind and solar power, or swapping natural gas for coal-fired electricity, do nothing to reduce America's dependence on imported oil.

Most people have a good grasp of one aspect of energy use—gasoline. Because we regularly buy gasoline at the pump, we have a good idea of the utility of gasoline (that is, the miles per gallon) as well as its price. The basic unit of energy analysis is the BTU—the "British Thermal Unit." A BTU of energy, unlike a gallon of gasoline, is an utterly meaningless number to anyone except an energy engineer. It might as well be a Qautloo from *Star Trek* or measuring speed in furlongs per fortnight. But energy analysis requires a common unit of measurement, and if we did not use the BTU, we would use a similarly opaque composite unit. (In fact, the alternative unit of energy measurement is the Joule, an even more unwieldy unit that measures energy in terms of force necessary to move 1 kilogram a distance of one meter.)

A BTU is the amount of energy required to heat a pound of water by 1 degree Fahrenheit. What does this mean in practical terms? Consider a common cup of tea, which is about 8 ounces of water. It requires 75 BTUs to heat a cup of water from average room temperature to boiling. In the standard microwave oven, it requires about 22 watts of electricity to boil a cup of water; in other words, about as much electricity as a 75 watt lightbulb uses in 18 minutes.

To put this in perspective, Texas consumed 11.5 "quads" of BTUs (or quadrillion BTUs) in 2008. (More on how this energy use breaks down in the next section.) This is enough energy to boil over 9.6 trillion gallons of water, or about 14,600 Olympic size swimming pools.

One gallon of gasoline contains 124,238 BTUs of energy—enough to boil 1,656 cups of tea. To put this in alternative terms, a sedan that gets 20 miles per gallon of gasoline requires 6,212 BTUs to travel one mile, or the equivalent energy of 83 cups of tea.

This comparison helps explain why gasoline is such a useful fuel, and why attempts to replace it are so difficult. Gasoline has 1000 times as much energy as the same weight of flashlight batteries, and 100 times as much energy as an equal weight of lithium-ion batteries such as are found in today's computers and cell phones. This disparity between conventional fossil fuels and other energy sources explains why fossil fuels dominate the world's energy marketplace and will continue to do so for decades to come.

The key concept that emerges here is *energy density*—that is, the energy content of various sources. A lump of coal, a cubic foot of natural gas, a gallon of oil (and an ounce of uranium fuel for that matter) contain more energy by orders of magnitude over diffuse "renewable" sources such as wind, solar, and biofuels. According to Prof. Nate Lewis of CalTech, all of the batteries ever made in history would only power the world for about 10 minutes.

It is hard to overstate the role of energy as the "master resource" or cornerstone of the entire modern economy. Without affordable, abundant energy, most commercial industry would become uneconomic or cease altogether. Consider that a gallon of gasoline, which is produced from oil extracted from the ground, transported to be refined, and transported again for consumer use, is delivered for a price less than bottled water. This does not happen spontaneously. Yet it is precisely the high energy density and sophisticated organization of conventional fossil fuel sources, largely unseen by most consumers and unappreciated by policymakers, that have lulled us into complacency or superficial thinking that our energy marketplace can be rearranged through government diktat.

We have forgotten the lessons of the 1970s, where many aspects of the "energy crisis" of that time was the result of outmoded or ill-considered state and federal regulation of the energy marketplace. The de-regulation of energy from the 1970s, starting with oil, gas, pipelines, and railroads to enable more interstate transport and competition, and going through electricity de-regulation in the 1990s, played a large role in the economic growth of the nation during the last generation.

The following sections of this report will explore some of the details of energy production and use in Texas, a state that is unique among the states in both respects. It is hard to overstate the centrality of the place of energy in the Texas economy and therefore impossible to exaggerate the importance of policymakers proceeding with considerate wisdom in making new decisions affecting the sector.

(For a more extended analysis and additional background on energy literacy, see Appendix A.)

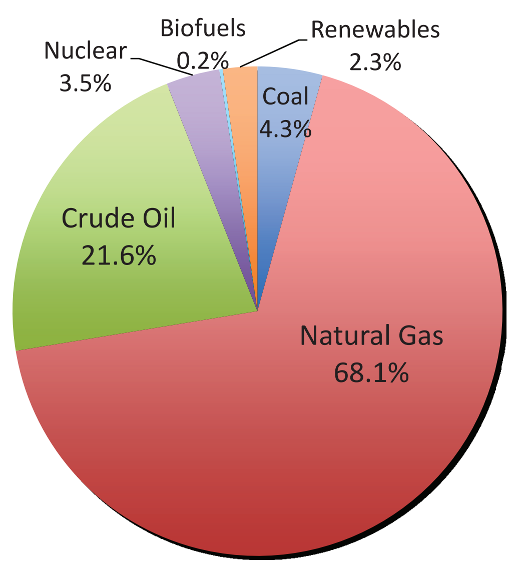
Energy Production in Texas

Texas is the leading energy producing state in the nation. This has a major macroeconomic benefit to Texas that non-energy producing states do not have. The primary benefit is that energy-producing states are less likely to suffer economic damage from energy price shocks. The logic is relatively straightforward for this dynamic: when world prices for oil go up, revenues for energy producing states go up with it. And to the extent that residents of energy producing states hold energy stocks, their investment and retirement portfolios improve. Mark Wiedenmier of Claremont McKenna College and the National Bureau of Economic Research explored the relationship between consumption and gross state product for all 50 states from 1963 to 2007, and concluded:

> The results show that an increase in oil prices reduces economic activity in non-energy states, but not in states where energy production constitutes more than 5 percent of gross state product. Oil shocks increase unemployment and reduce the number of jobs in non-energy-producing states, but they do not have a significant impact on unemployment or employment in energy-producing states. In some cases, an increase in oil prices actually reduces unemployment and creates jobs in states with a significant energy sector. Overall, the analysis shows that increasing domestic fossil-fuel production could potentially reduce unemployment, create jobs, and help jump-start the U.S. economy out of the Great Recession.[1]

Oil and gas extraction in Texas account for 52 percent of the nation's total GDP in that sector. Oil and gas extraction account for 8.2 percent of Texas' total economic output, compared to 1.3 percent for the nation as a whole, and 0.7 percent in California. As shown in **Figure 1**, natural gas—not oil—accounts for the largest share of energy resources produced in Texas: 68 percent on a BTU basis. Much of this gas production is for export to other states, however.

Figure 1: Total Energy Production in Texas, 2008



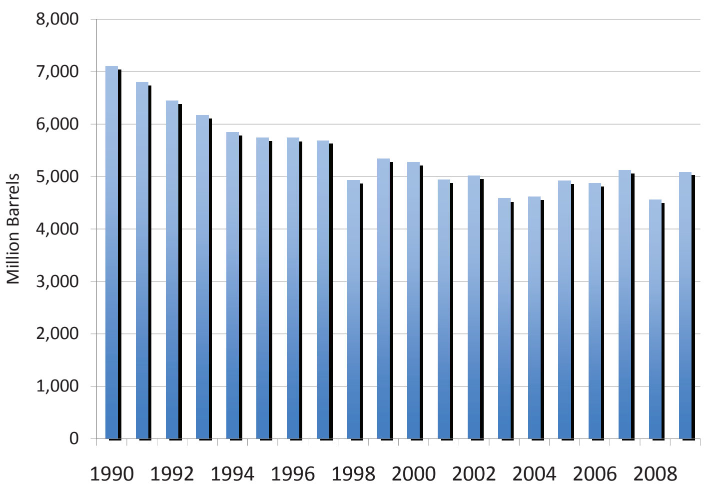
Source: EIA

Oil

- Texas accounts for over one-fifth of total domestic oil production: 403 million barrels in 2009, out of total domestic production of 1.95 billion barrels.

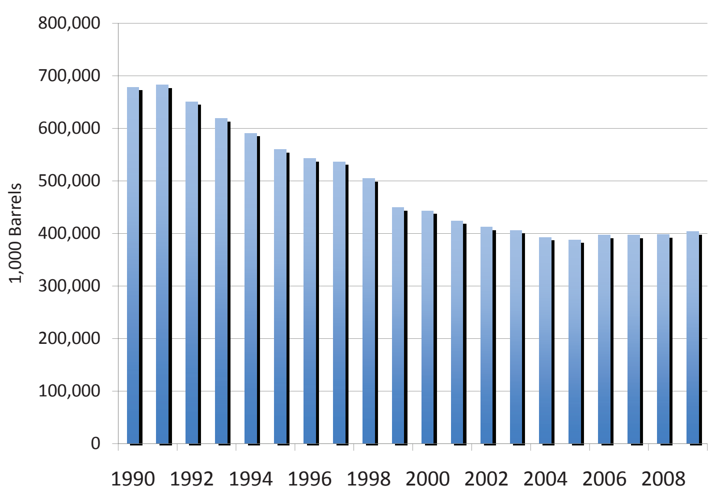
- In an era when the nation's domestic oil reserves and production have been falling, oil reserves and production in Texas have reversed their long-term decline and have been increasing in recent years. In 2009, Texas had the largest proved oil reserves increase, 529 million barrels (11 percent), nearly all in the Permian Basin. The largest total oil discoveries in the nation in 2009 occurred in Texas, with 433 million barrels.[2] (Figures 2 & 3)

Figure 2: Texas Proved Oil Reserves, 1990-2009



Source: EIA

Figure 3: Texas On Land Oil Production, 1990-2009



Source: EIA

- Another fourth of America's domestic oil production comes from offshore platforms in the Gulf of Mexico (569 million barrels in 2009). Most of this oil is brought onshore through Louisiana, but Texas has a significant share.

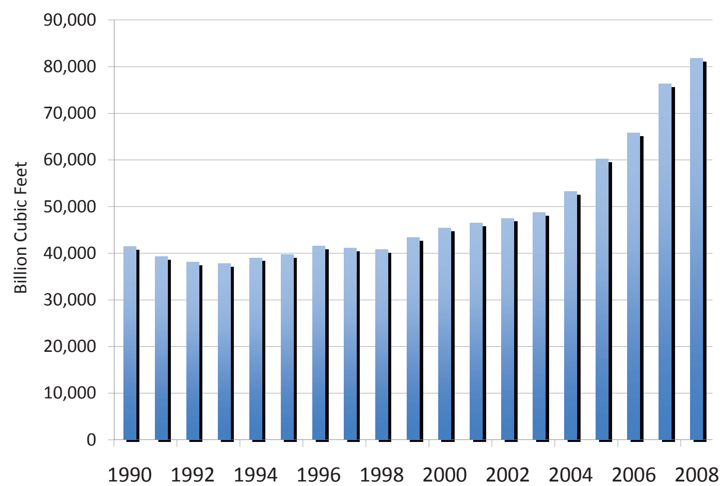
- About one-quarter of the nation's imported oil arrives through Texas ports. Six of the 11 Gulf of Mexico oil import terminals are located in Texas.

- Texas' 27 petroleum refineries account for 27 percent of the nation's total oil refining capacity (4.7 million barrels a day out of total U.S. capacity of 17.5 million barrels a day).

Natural Gas

- Natural gas production in Texas, and new reserves of natural gas, are growing rapidly. Proven natural gas reserves in Texas increased 80 percent from 2000 to 2008, with new fields in 2009 and 2010 probably bringing the increase in total reserves over 100 percent. (Figure 4) According to the Department of Energy, Texas showed the largest increase in reserve volume of any state in the nation over the last two years.

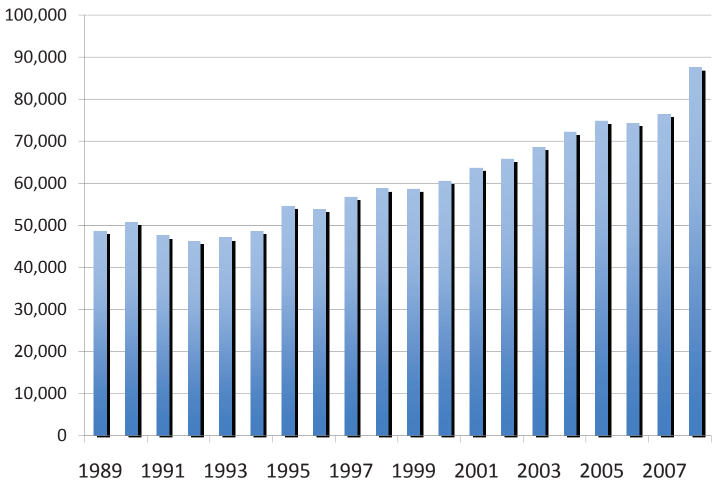
Figure 4: Texas Natural Gas Proved Reserves, 1990-2008



Source: EIA

- Texas accounted for 18.3 percent of the nation's total producing natural gas wells in 2008 (the last year of complete data). These wells produce about 30 percent of the nation's total natural gas. Between 2000 and 2008, Texas added 26,979 new producing natural gas wells, 19.7 percent of the nation's total new producing wells during this period. Over the last 20 years, the number of producing natural gas wells has increased 80 percent. (Figure 5)

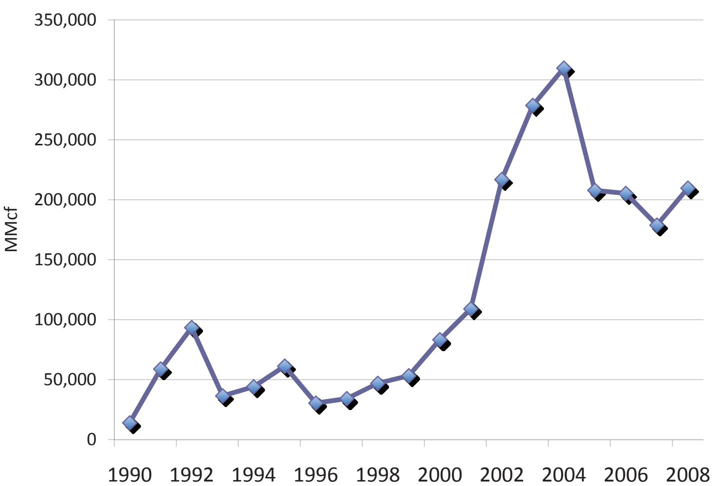
Figure 5: Texas Natural Gas and Gas Condensate Wells, 1989-2008



Source: EIA

- The amount of natural gas Texas exports to other U.S. states has doubled since the year 2000. Since 1990, exports of natural gas from Texas have increased 1,400 percent (the result of deregulation of the national market). (Figure 6)

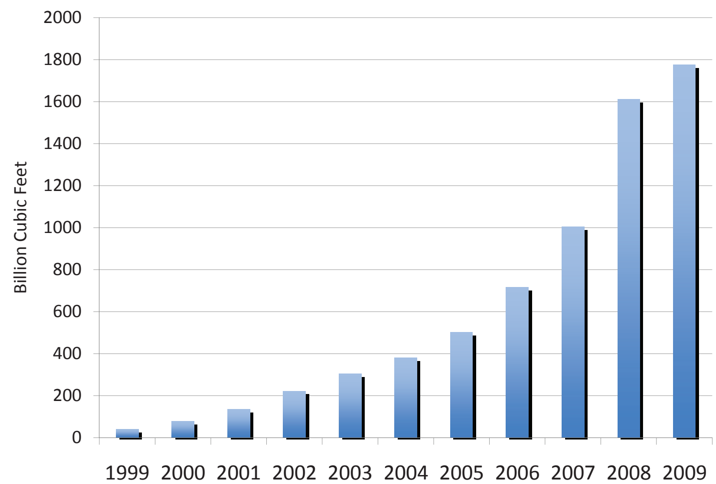
Figure 6: Texas Natural Gas Exports, 1990-2008 (Million Cubic Feet)



Source: EIA

The increase in reserves and production of both oil and natural gas owe much to technological progress in directional drilling and other enhanced recovery methods. There are four major Texas fields that new drilling technology have unlocked or revitalized: the Barnett Shale, the Eagle Ford field, the Haynesville-Bossier field that straddles the Texas-Louisiana border, and the Permian field in west Texas. **Figure 7** displays the 4,229 percent increase in gas production from the Barnett Shale from 2004 through 2009.[3] Even as production has increased, total Barnett Shale gas reserves continue to grow, by more than 4 trillion cubic feet in 2009; the Haynesville-Bossier field increased reserves by a staggering 9.4 trillion cubic feet while increasing its production twelve-fold.[4] The Barnett and Haynesville-Bossier fields represented almost half of the nation's total net increase in natural gas reserves in 2009.

Figure 7: Natural Gas Production from Barnett Shale Field, 2004-2009

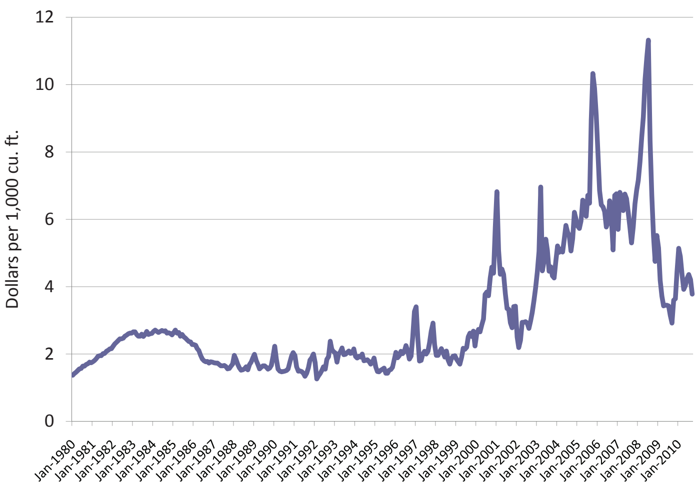


Source:Texas Railroad Commission

The Eagle Ford field increased its oil production more than fourfold in just the first 10 months of 2010, from 304,000 barrels in all of 2009 to 1,629,055 barrels from January through October of 2010.[5]

There are several implications of the rapidly changed natural gas story. Over the last two decades the price of natural gas has been highly volatile, as shown in **Figure 8**. The wellhead price—the most basic commodity price for gas—has swung wildly over the last decade, from a low of $2 per 1,000 cubic feet to more than $10 per 1,000 cubic feet.[6] The volatility of natural gas prices made gas less attractive than coal for electric utilities, and for chemical manufacturers who use natural gas as a raw material feedstock. Indeed, Dow Chemical cancelled plans to build a large chemical plant in Galveston on account of high natural gas prices several years ago, choosing the Persian Gulf state of Qatar instead because of reliable low-cost natural gas supplies. The rapid rise of unconventional gas supply in shale and coal-bed methane fields promises to reduce, though it may not eliminate, the price volatility of natural gas for the next several decades.

Figure 8: U.S. Natural Gas Wellhead Price ($/1,000 Cubic Feet), 1980-2010



Source: EIA

Coal: Three Surprising Facts

Coal is presently a "politically incorrect" fossil fuel. Environmentalists have named it public enemy number one, and some, such as NASA's James Hansen, employ extreme hyperbole, such as comparing freight rail coal shipments to Auschwitz "death trains." It is hard to credit this kind of extremism, but plainly necessary. Let us walk through some facts.

Texas is not typically regarded as a coal state. The mention of coal typically summons the image of West Virginia or Kentucky. In fact, Wyoming is the leading coal-producing state; in 2009, Wyoming produced 40 percent more coal than West Virginia, Pennsylvania, and Kentucky combined (431 million tons for Wyoming vs. 302 million tons for West Virginia, Kentucky, and Pennsylvania). This is the first surprising fact about coal.

The second surprising fact is that Texas deserves to be considered the nation's leading coal state because of the other end of the scale—*consumption* of coal (though it should not be overlooked that Texas is the eighth largest coal-*producing* state in the nation as well). Although Texas generates more electricity from natural gas than coal (discussed further in the next section), because of the size of the Texas economy and its energy intensity, Texas uses more coal than any other state—nearly twice as much as Indiana or Ohio or other states typically regarded as coal-dependent. (**Table 1** displays the top five coal-consuming states.) In fact, Texas accounted for almost 10 percent of total coal consumption in the U.S. in 2009.

Table 1: Coal Consumption for Electric Power, 2009 (Million Short Tons)

Texas	95,407
Indiana	54,626
Illinois	54,074
Ohio	50,633
Pennsylvania	47,580

Source: EIA

Texas produces about one-third of its coal (35 million tons from 12 surface mines in 2009), and imports the other two-thirds by rail mostly from Wyoming. It should be noted that surface-mined lignite coal is much cheaper than coal from underground mines; the average cost of Texas coal in 2009 was \$16.67 per ton, compared to the national average price from all sources of \$33.15 a ton.[7] (West Virginia coal averaged \$63 a ton. Some of the price difference is explained by the variety of coal types: bituminous coal is more expensive than lignite coal—the predominant coal type mined in Texas—because it has a higher energy content by weight. But even correcting for the different heat content of the varieties of coal, Texas-mined coal is still the cheapest source of energy in the state.)

The third surprising fact about coal in Texas is its very low rate of conventional air pollution emissions. Precisely because Texas is the leading coal-using state, Texas has been at the leading edge of incorporating pollution abatement technology (chiefly different types of "scrubbers") and using low-sulfur coal in its coal-fired power plants. Sulfur dioxide (SO_2) emissions and nitrogen oxide (NOx) emissions rates are among the lowest in the nation, and have been falling steadily, as shown in **Figures 9 and 10**.[7] **Figure 11** displays SO_2 emissions from coal-fired power plants. Af-

Figure 9: SO_2 Emissions Rate (Lbs/MWh), 2008

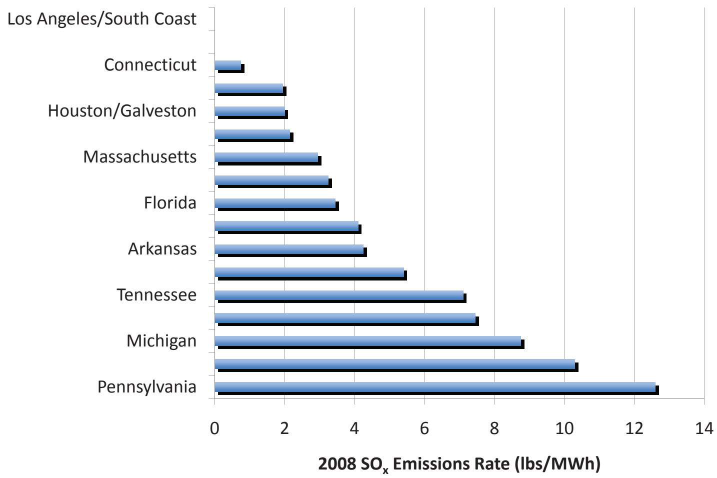
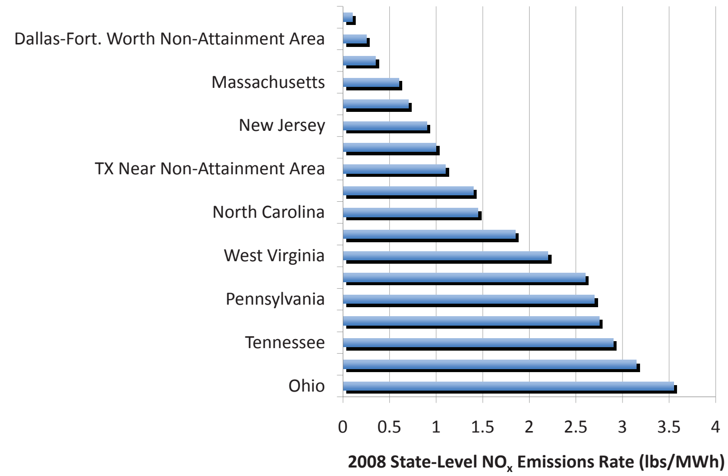


Figure 10: NOx Emissions Rate (Lbs/MWh), 2008

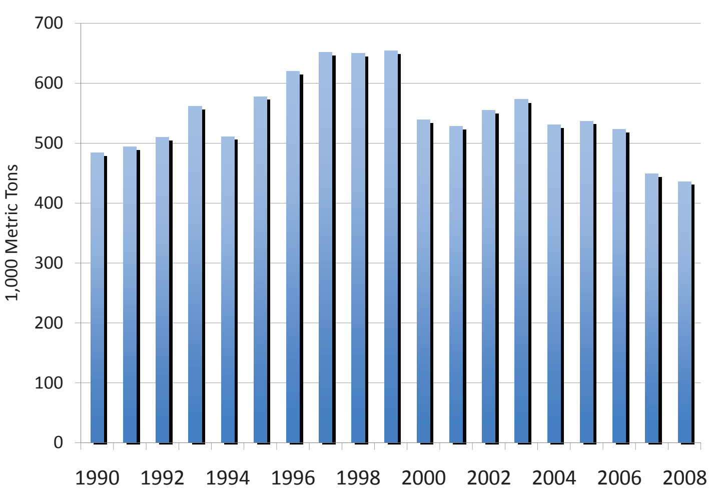


Source: Credit Suisse estimates, Energy Velocity

ter rising steadily in the 1990s, SO_2 emissions have fallen 33 percent since their peak in 1999, and NOx emissions, shown in **Figure 12**, have fallen 76 percent since 1990.

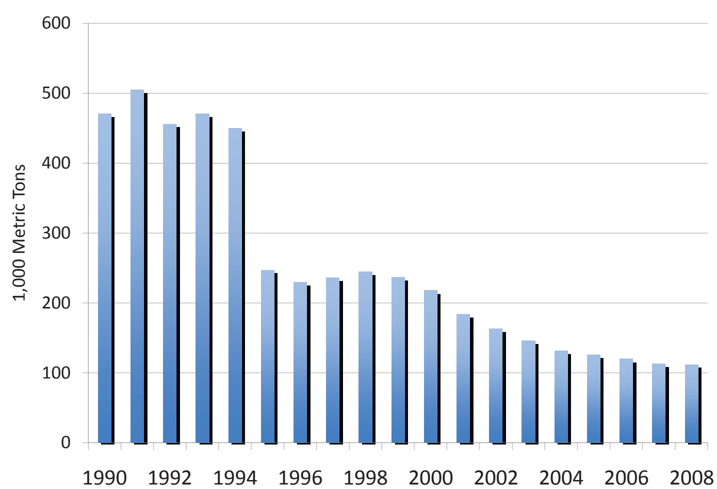
These data lead to several observations about the place of coal on the Texas energy portfolio. Natural gas is typically referred to as a "clean" fuel, but this comparison needs to be qualified properly. Natural gas produces lower emissions than coal in two principal categories: sulfur dioxide and carbon dioxide. However, air quality in Texas metropolitan areas is steadily improving, though several areas remain in non-attainment for the very strict ozone standard—the most stubborn of the major air pollutants. Texas is in full compliance with the Clean Air Act's sulfur dioxide standard, meaning that reductions in coal-fired power will produce little clean air benefits for Texans. Although natural gas fired electricity generates a lower level of nitrogen oxide emissions than coal, there are only modest NOx reductions—if any—to be achieved by switching from coal to natural gas. **Figure 13** displays NOx emissions trends from coal and gas-fired power plants, showing that NOx emissions from natural gas track emissions from coal-fired power closely since coal power plants adopted NOx controls in the mid-1990s. (For more information in air pollution levels in Texas metropolitan areas, see Appendix C.

Figure 11: SO_2 Emissions From Texas Coal-Fired Power Plants, 1990-2008



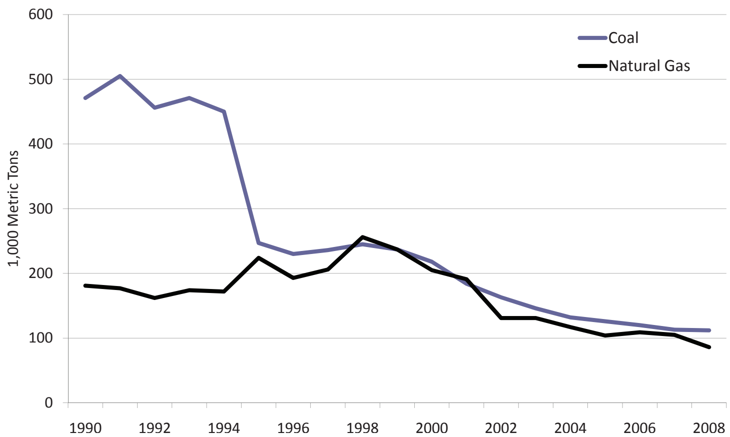
Source: EIA

Figure 12: NOx Emissions from Texas Coal-Fired Power Plants, 1990-2008



Source: EIA

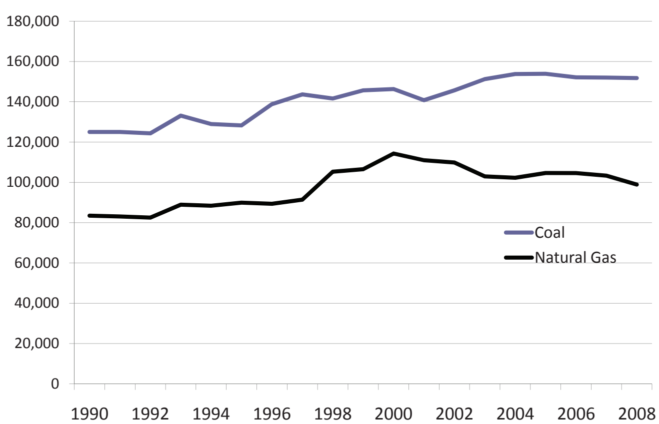
Figure 13: Nitrogen Oxide Emissions from Texas Coal and Gas-Fired Power Plants



Source: EIA/Texas Power Pollution Trends.xls

Natural gas does have lower carbon dioxide emissions than coal-fired electricity, but natural gas CO_2 emissions are still substantial, as seen in **Figure 14.** (Keep in mind that natural gas and coal provide nearly the same amount of Texas' electricity, as will be explored in the next section.) A complete swap of natural gas for coal would reduce CO_2 emissions by about 15 percent—not enough to affect any projections of greenhouse gas levels.

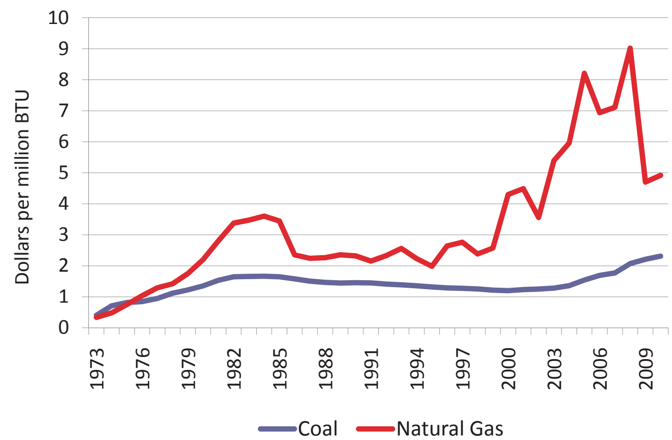
Figure 14: Carbon Dioxide Emissions from Texas Coal and Gas-Fired Power Plants



Source: EIA/Texas Power Pollution Trends.xls

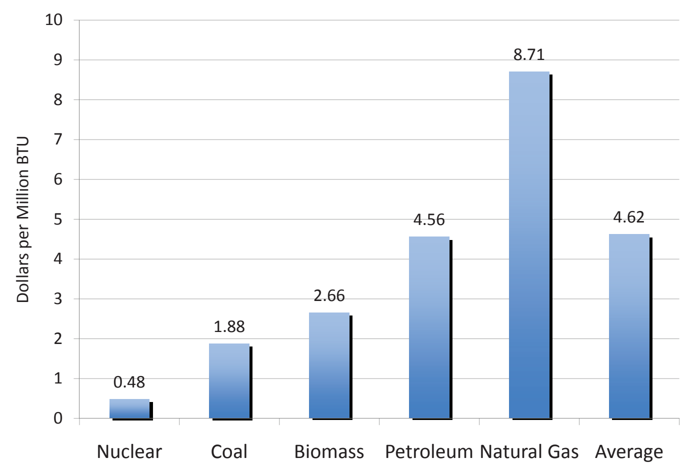
The second key point is that the price of coal is considerably lower than natural gas, and much less volatile than natural gas. **Figure 15** displays national trends in coal and natural gas prices, and **Figure 16** shows that coal is the second-cheapest overall source of energy in Texas. This figure explains why natural gas is used as a "peak" period electricity provider and why coal is relied upon as the mainstay for day-to-day baseload electricity needs.

Figure 15: Coal and Natural Gas Prices, 1973-2010



Source: EIA

Figure 16: Texas Electricity Cost by Fuel Source, 2008



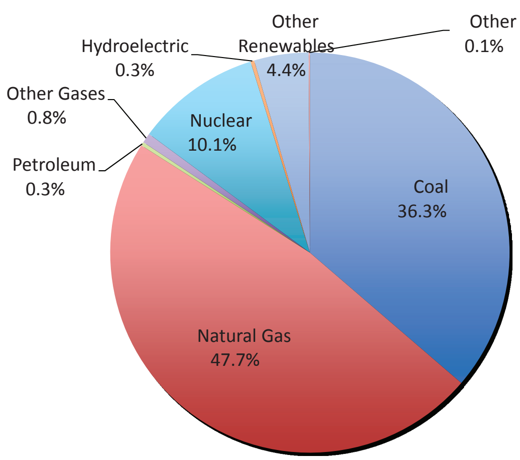
Source: EIA

Electricity Generation

The foregoing analysis of the different energy sources produced and consumed in Texas sets up consideration of policy choices in the all-important electric sector. Eighty-three percent of electricity in Texas is generated by coal or natural gas, with nuclear providing another 11.7 percent. Wind power generated only 4.4 percent of total electricity in 2008. Despite all of the attention (and generous subsides) for wind energy, its share of total electricity generation in Texas is not likely to grow large enough to displace a significant share of gas or coal-fired electricity.

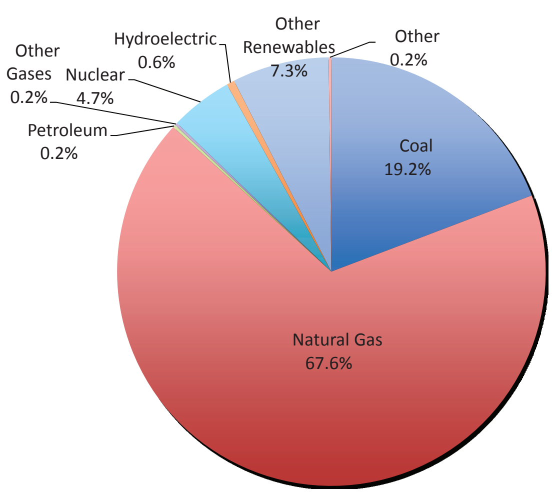
As of 2008 (the last year of complete data), Texas generated 47.7 percent of its electricity from natural gas, and 36.3 percent from coal, as shown in **Figure 17**. But the share of total generating *capacity* of natural gas is three times *higher* than coal (67.6 percent to 19.2 percent), as shown in **Figure 18**. Coal's higher share of total electricity generation in 2008 represents the higher utilization rates of coal-fired plants because of its lower fuel costs. In other words, Texas relies more on coal-fired power plants to provide its base-load electricity needs and brings gas-fired plants online on a more intermittent basis, i.e., during peak load periods, especially during summer months. This is typical of the natural gas portfolio across the nation.

Figure 17: Total Texas Electricity Generation by Fuel Source (MwH), 2008



Source: EIA

Figure 18: Total Texas Electricity Generating Capacity by Fuel Source MwH), 2008



Source: EIA

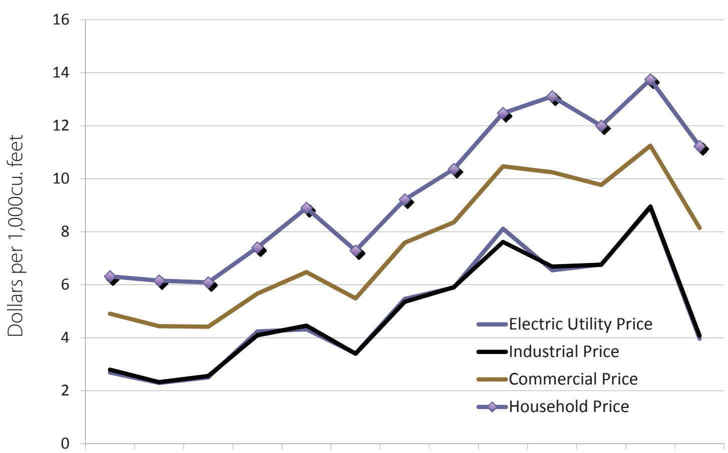
Eighty-three percent of electricity in Texas is generated by coal or natural gas, with nuclear providing another 11.7 percent. Wind power generated only 4.4 percent of total electricity in 2008.

The possible lower volatility of natural gas prices going forward may aid the development of more natural gas-fired electricity, even without government mandates. If natural gas in an uncoerced marketplace continues to experience falling prices, it may be able to compete head-to-head with coal on cost. However, some natural gas interests are not waiting to see whether gas can compete with coal in an open market, but are seeking mandates and regulatory measures to tilt the energy playing field in their direction. Colorado recently enacted legislation (HB 1365) providing financial incentives for utilities to switch from coal to natural gas, a measure Colorado's outgoing Governor Bill Ritter called a "template" for the nation.[9]

The Colorado Oil and Gas Association was remarkably candid in a document produced for its members that described its main objective to "increase the use of natural gas and renewables in power generation and transportation to *stabilize natural gas prices at a fair value*, enhance our national security, clean up the air, and protect human health—potentially increasing demand by 4 to 7 trillion cubic feet per year." (Emphasis added.) The italicized portion of the last sentence is transparent: "fair value" to gas producers clearly means "a higher price than we're likely to get in a open, competitive marketplace." Every other claim in this brief also fails to apply to Texas. Switching electricity production from coal to natural gas does nothing to change America's dependence on foreign oil. As the previous section explained, there are only modest air quality and health benefits to be achieved by fuel-switching.

Suppressing coal in favor of natural gas through regulation of mandates will increase energy costs, directly and indirectly. Directly, natural gas-fired electricity will push up utility rates; indirectly, it is likely to increase the cost of natural gas for household use. Utilities and industrial users of natural gas typically enjoy the lowest prices because they are able to enter into long-term contracts with gas suppliers, can hedge against price volatility, and can modulate their use when gas prices and supplies fluctuate. Households that rely on natural gas for heating and cooking cannot modulate their use, and are more vulnerable to price volatility. As **Figure 19** shows, the household natural gas price is usually about twice the utility or industrial price.

Figure 19: Texas Natural Gas Prices by Sector, 1997-2009



Source: EIA

It should also be observed that in calling natural gas a "bridge fuel," environmentalists who now advocate for gas will eventually turn on gas in the same way they are presently opposing coal, and for the same reason: climate change orthodoxy demands it. The explicit target of climate legislation such as the Waxman-Markey cap and trade bill that passed the House in the last Congress set as its goal an 80 percent reduction in greenhouse gas emissions by the year 2050. Few analysts have done the math on what this target means in terms of reducing fossil fuel use. In short, it means returning the United States to a level of fossil fuel use last seen around the year 1910. Achieving such a target will require not only the complete abandonment of all coal-fired electricity in the United States, but will entail about a 50 to 60 percent *reduction* in natural gas use from present levels.[10]

In this regard, environmentalist support for natural gas as a "bridge fuel" takes on a different aspect. Natural gas interests are likely to find that in the fullness of time they will become the next target of environmentalist opposition. The "bridge" of natural gas will turn out to be a drawbridge, which environmental opposition will seek to draw up and close off, strangling or stranding many investments. Natural gas interests should reconsider their current alliance of convenience with "pro-gas" environmentalists.

New Generation Capacity

The case for fuel-switching mandates or preferences further weakens when recent history and current cost comparisons are examined. **Table 2** displays new electricity generation capacity additions in Texas since 1995 by source, showing that new natural gas facilities account for just under 75 percent of all new generating capacity added in Texas since 1995, even though coal-fired electricity is still cheaper than natural gas on a total cost basis.[11] One reason for the predominance of new gas-fired power is that Texas already has a mandate that half of all new generating capacity be provided by gas. Although gas-fired plants are cheaper to build than coal plants, coal still maintains an overall cost advantage because it is so much cheaper than gas. According to the latest Department of Energy cost data (August 2010), the cost of fuel for coal-fired electricity in Texas was $1.81 per million BTU, while the cost of natural gas was $4.48 per million BTU—two-and-a-half times as much.

Table 2: New Electricity Generation Facilities in Texas, 1995-2009

	Number of Units	New Capacity (MW)	Percent of New Capacity
Coal	7	2,413	5.0%
Natural Gas	90	36,400	74.7%
Wind	140	9,652	19.8%
Biomass	3	40	0.1%
Nuclear*	1	200	0.4%

**Note: Upgraded capacity at existing nuclear facility*
Source: Texas Public Utilities Commission

Ascertaining the "levelized" cost (that is, the total capital costs and lifetime operating costs) of different forms of power generation is difficult to do, and there is a wide range of credible estimates available. **Table 3** displays two estimates, both based on similar raw data and analysis. The first column displays the Energy Information Administration's cost estimates for new electricity generation sources coming online in 2016, while the second column displays the

2005 estimated costs from a recent analysis by MIT's Joint Program on the Science and Policy of Global Change.[12] The EIA analysis suggests that new advanced gas fired power plants may be cheaper than new coal, while the MIT analysis finds coal still to be the cheapest form of power.

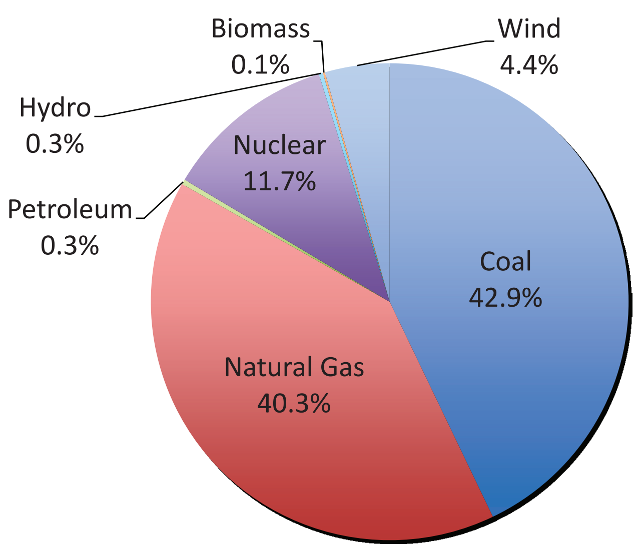
Table 3: Estimated Levelized Cost of New Generation Sources, Cents/KwH

Plant Type	EIA, 2016 Proj.	MIT 2005 Est.
Coal	10.0	5.4
Advanced Gas	7.9	5.6
Nuclear	11.9	8.8
Coal w/CCS	12.9	9.2
Gas w/CCS	11.3	8.5
Wind	14.9	6.0
Solar PV	39.6	19.3
Biomass	11.1	8.5

Source: EIA & MIT Joint Program on the Science and Policy of Global Change

In light of the trends in fuel prices, there is no reason for natural gas interests to be pushing for fuel-switching mandates to force conversion from coal to natural gas like Colorado. In addition to the fact that natural gas can compete on a level playing field with other fuel sources, coal-fired power plants in Texas have some of the lowest emissions of nitrogen oxides and sulfur dioxide in the nation—the result of aggressive adoption of state-of-the-art pollution abatement technologies and the use of low-sulfur Power River Basin coal. This means there are comparatively few conventional air pollution reductions to be achieved from fuel switching. (See Appendix C for data on air pollution trends in Texas metropolitan areas.)

Figure 20: Texas Natural Gas Prices by Sector, 1997-2009



Source: EIA

Energy Consumption in Texas: A Profile and Useful Comparisons

As the United States continues to suffer economic stagnation in the current "Great Recession," Texas stands out as a startling exception. Texas has not been immune from the current economic downturn; its unemployment rate doubled from a pre-crash low of 4 percent in April 2008 to a peak of 8.5 percent in June of 2010. However, throughout the entire recession the Texas unemployment rate has been below the national rate by as much as a full 2 percent, and the number of jobs in Texas has rebounded to pre-recession levels, while number of jobs nationally is still more than 6.4 million below the pre-recession level.

The chief reason for the strong performance of the Texas economy is its suite of pro-growth policies. Since the trough of the national recession in 2009, Texas has been leading the nation in private sector job growth. Over half of the nation's total net new private sector jobs between August 2009 and August 2010 were generated in Texas. In-migration to the state—Americans moving to Texas from other states—continues at a brisk pace, a key sign of vibrancy.[13] The Texas economy has been notably outperforming the nation's economy for at least a decade. Texas' share of total national economic output has grown by a full percent over the last decade. As **Table 4** displays, the rate of state GDP growth, personal income growth, per capita income growth, and total employment growth in Texas over the last decade has been one-quarter to one-third higher than the nation or California. Most importantly, the growth rate in small business employment—that is, growth of entrepreneurial enterprises that are responsible for most new job growth—is notably higher than the national average, and almost twice as high as California. Texas enjoys a dynamic entrepreneurial culture. If the Texas story was occurring in a northeastern state, the national media would be proclaiming daily about an "economic miracle."

Table 4: Economic Growth Comparisons, 1999-2009

	U.S.	California	Texas
Population Growth	10.0%	10.3%	20.5%
Growth in Nominal GDP	52.4%	56.3%	70.4%
Growth in Personal Income	53.9%	53.0%	76.0%
Growth in Per Capita Income	39.9%	38.7%	46.0%
Total Employment Growth	7.6%	5.6%	19.5%
Growth in Small Business Employment	38.5%	28.2%	48.2%

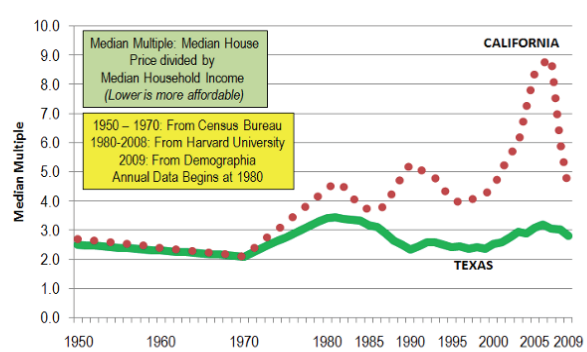
Source: U.S. Bureau of Economic Analysis

The comparison with California is significant for several reasons, starting with the fact that Texas is the second most populous state after California, and thus more comparable than a smaller state (such as North Dakota or South Carolina) whose demographic and economic profiles are narrower. California long enjoyed the reputation as the most economically dynamic state in the nation and was the principal home, in recent decades, of the high technology revolution and aerospace design and manufacturing before that. In the aftermath of the bursting of the dot-com and real estate bubbles, California finds itself in its worst economic condition since the Great Depression. The point is, the economic fortunes of a state can reverse quickly and deeply. Middle-aged Texans remember the collapse of the oil economy in the mid-1980s, and the secondary economic shock of the real estate and saving and loan sector collapse in the early 1990s. Texas should not take its relative prosperity for granted, or assume that its comparative advantages and enviable past performance will continue into the indefinite future. California has made this mistake repeatedly, and is paying a high price for its hubris now.

The recent performance of Texas is part of a long-term story with several important parts:

- **Lower tax burden:** The total tax burden in Texas is 2.1 percent lower than in California (10.5 percent versus 8.4 percent).
- **Legal reform:** Texas has enacted legislation restraining egregious abuses of the tort liability system.
- **Respect for private property rights:** Among other important effects of robust protection for property rights, housing costs in Texas are moderate because regulation of development has not imposed the kind of excessive cost on the housing sector. The 2009 median home price in Texas was $145,900, compared to $172,500 for the U.S. as a whole, and over $250,000 in California. Moreover, because Texas is more development-friendly, it avoided the worst excesses of the housing bubble. Between 2000 and the height of the real estate bubble in 2006, the U.S. median home price rose 54.5 percent, with California seeing a median price increase of 130 percent. The median home price increase in Texas was only 31 percent. More probative is the relationship between median home prices and median incomes. Urban policy analyst Wendell Cox vividly traced out this relationship in **Figure 21**.[14] (It should be added that property rights play a prominent role in the Texas energy story, as most oil and gas resources are produced from privately-owned land, and therefore not subject to bureaucratic or other political interference, unlike Alaska and other states where resources on publicly-owned land are tangled in endless red tape and litigation—when it is allowed to be exploited at all. Unknown to most Americans, for example, is the fact that Alaskan oil production is falling rapidly, by more than 65 percent since its peak in the late 1980s, chiefly because new fields are not being developed as older ones decline.)

Figure 21: California and Texas Housing Dynamics Compared, 1950-2009 Median Multiple



Not surprisingly, the home mortgage foreclosure rate, with all of the economic and social ruin it brings in its wake, is notably lower in Texas than the nation as a whole. As of the end of the first quarter of 2010 (the most recent quarter with publicly available figures), the foreclosure rate in Texas was 2.08 percent, compared with 4.63 percent nationwide, 5.15 percent in California (7th highest rate in the nation), and 13.79 percent in Florida (the state with the highest rate).

These aspects of the Texas story are well known and have been the subject of extensive commentary and analysis in recent years.[15] One aspect has been less noted and analyzed, and is the subject of this report:

- *Texas is the largest energy consuming state in America; energy use is a central factor in the state's prosperity.*

The facts surrounding energy use in Texas are poorly understood. High energy consumption has become controversial and subject to efforts to extend political controls over the energy marketplace, especially amidst the environmental fixation with fossil fuels and climate change. A common superficial theme is that high energy consumption is inefficient or wasteful, costly, counterproductive, and highly polluting. For many environmentalists, energy is like adult beverages—to be used in only modest quantities. As the state famous for 10-gallon hats and large ranches, Texas' high energy consumption is taken as *ipso facto* proof.

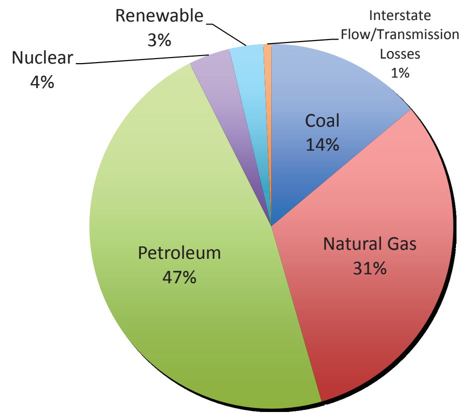
Both of these views are mistaken.

Some basic facts:

- In 2008 (the most recent year for which complete national statistics are available from the U.S. Energy Information Administration), Texas consumed 11.5 "quads" (quadrillion BTUs—British Thermal Units) of energy, about the same as Florida, New York, and Illinois combined.

- Petroleum products are the largest source of energy consumed in Texas, accounting for 47 percent of total energy use. (Figure 22) Most petroleum energy is used for transportation and chemical refining. Natural gas is the second leading energy source in Texas, accounting for 31 percent of total energy consumption.

Figure 22: Total Energy Consumption in Texas, 2008 by Source



Source: EIA

Texas and California Compared

Texas uses 38 percent more energy than California even though California's population is 49 percent larger than Texas, and its economic output is 65 percent larger than Texas. **Table 5** displays the energy intensity of Texas relative to California and the United States as a whole. Texas uses 39 percent more energy than the U.S. average per dollar of economic output, and 121 percent more than California. On the surface these numbers seem to support the common view that California is more "energy efficient" than Texas. This perception dissolves upon further analysis.

Table 5: BTU Per Dollar of Nominal GDP, 2008

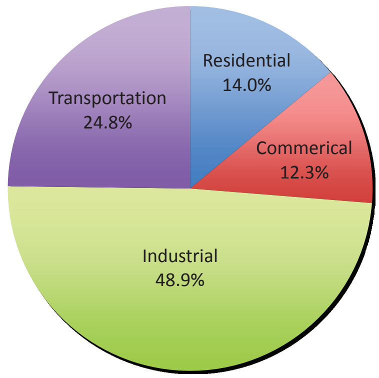
	BTUs/$ GDP	Rank
United States	6,928.5	--
California	4,362.0	47
Texas	9,658.5	15

Source: BEA & EIA

The most important reason for high energy use in Texas is that Texas has the most energy-intensive industrial sector in the United States. *Nearly half of Texas' total energy use is in its industrial sector.* Texas uses more energy for industry than the next top three states combined (California, Louisiana, and Ohio).

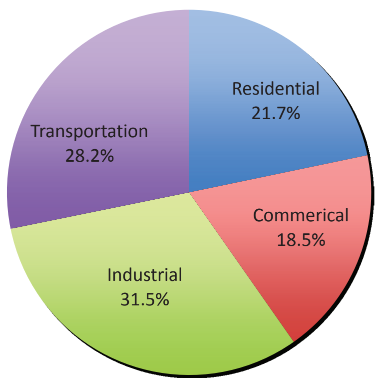
Figures 23 and 24 display the shares of energy consumption by each major sector of the economy (residential, commercial, industrial and transportation) for the year 2008 (the last year for which individual state data is available),

Figure 23: Texas Energy Consumption by Sector, 2008



Source: EIA

Figure 24: United States Energy Consumption by Sector, 2008



Source: EIA

and make vividly clear the larger industrial share of energy use in Texas (48.9%) over the national average (31.5%).

Table 6 displays total energy use by the manufacturing sector and economic output (in constant 2005 dollars) for each of the top four states and all 50 states. Although the popular image is that the upper Midwest is the industrial heartland of America, *Texas is in fact America's largest industrial state*, with two and half times more manufacturing output than Michigan; its output is larger than Michigan and Ohio combined. Texas' manufacturing and energy extraction activity account for almost 15 percent of total industrial activity in the U.S. when measured in dollar terms, compared to only 12.2 percent for California.

The most common misconception is that California's relatively lower energy intensity is the result of deliberate energy policies that encourage conservation and efficiency. In fact, California's lower relative energy intensity is explained mostly by its industrial mix and benign climate. California's manufacturing sector consists of low energy intense industries such as computer and electronic products manufacturing, while Texas has a disproportionate concentration of high energy intense industries such as chemicals and petroleum refining. (According to Energy Information Administration data, the chemical industry accounts for 18.4 percent of total electricity consumption in the U.S.) **Table 7** displays leading manufacturing sectors in California, Texas, and the United States as a whole, showing the very different relative proportions of manufacturing activity and energy use coefficients (thousand BTUs per dollar of output). (Table 6 uses 2006 figures, as this is the most recent year of data available from the Department of Energy's Manufacturing Energy Consumption Survey.) One quarter of California's total manufacturing activity is in computers and related electronics manufacturing, which has the lowest energy use coefficient of all manufacturing sectors (1,600 BTUs per dollar of output), even lower than apparel manufacturing (1,740 BTUs per dollar of output). In addition to chemicals and petroleum products, Texas has several other manufacturing sectors (such as machinery) that are also highly energy intense. (For a complete breakdown of the manufacturing sector in Texas, see Appendix A.)

Table 6: Industrial Sector Energy Consumption, 2008

	Trillion BTUs	Manufacturing Output (Million $)	1,000 BTU/$ Output
Texas	5,651.6	152,713	37.0
Louisiana	2,204.0	41,190	53.5
California	1,954.8	220,559	8.9
Ohio	1,341.0	82,065	16.3
United States	31,356.3	1,669,640	18.8

Source: BEA & EIA
Note: Table 6 displays manufacturing output only, and does not include energy extraction.

Another important difference between California and Texas is climate, which directly affects the level of energy consumption for heating and, especially, cooling with summertime air conditioning. The National Oceanic and Atmospheric Administration (NOAA) calculates a measure for state-by-state climatic differences, known as "degree-heating days" and "degree-cooling days." One "degree-heating" or "degree cooling day" is a deviation of a single degree above 65 degrees Fahrenheit (in the case of a "cooling day").

Table 7: Manufacturing Sector Energy Intensity, 2006

Manufacturing Sector	Energy Coefficient*	Share of Texas Manufacturing	Share of CA Manufacturing	Share of U.S. Manufacturing
Computers/ Electronics	1.60	17.6%	24.2%	12.1%
Chemicals	20.11	21.0%	9.7%	12.6%
Petroleum Products	26.13	17.8%	16.9%	8.5%

Source: Department of Energy and BEA
** Note: Energy Coefficient= 1,000 BTUs per dollar of output*

In other words, a day with an average temperature of 67 degrees would count as two degree cooling days for the region. NOAA adjusts degree-heating and degree-cooling days to correct for population concentrations (in other words, so that Death Valley or west Texas summer temperatures do not skew the data). As shown in **Table 8**, Texas and California have about the same number of degree-heating days, but Texas has almost two-and-a-half times more degree-cooling days, meaning there will be much higher electricity consumption for air conditioning in the summer in Texas.

Table 8: Degree-Heating and Degree-Cooling Days in California and Texas, 2009

	Degree-Heating Days	Degree-Cooling Days
California	2,674	1,043
Texas	2,426	2,808

Source: NOAA

The performance and profitability of Texas manufacturing would not be possible without affordable electricity. **Table 9** displays average 2009-2010 electricity costs for each major sector for Texas, California, and the United States. While Texas electricity prices are close to the national average, they are significantly lower than California: 42.6 percent lower overall, but 63.8 percent lower for industrial customers. Many Texas industries could not compete with California's electricity price structure.

Table 9: Electricity Costs, 2009-2010 (Cents/kWh)

	Residential	Commercial	Industrial	Total
Texas	11.95	9.44	6.58	9.7
California	15.3	13.97	10.78	13.83
U.S. Average	11.53	10.22	6.81	9.91
CA Premium	28.0%	48.0%	63.8%	42.6%

Source: EIA

Tables 3 through 9 illustrate some of the leading examples of the salient differences that explain the divergent energy profiles of California and Texas. A 2008 study by Anant Sudarshan and James Sweeney of Stanford University concluded that only 23.5 percent of the difference between California and the U.S. average energy consumption could be attributed to deliberate public policy.[16] The bulk of the difference is explained by structural and climatic factors such as those displayed here.

Key Uncertainties Affecting the Texas Energy Outlook

While the energy outlook for Texas is quite positive, there are several uncertainties regarding whether or not Texas will be allowed to fully develop its energy potential.

These uncertainties pertain mostly, though not entirely, to EPA's recent regulatory onslaught, which involves rulemaking that could have vast impacts on energy production and consumption in Texas.

As *The Wall Street Journal* pointed out in November 2010, "Since Mr. Obama took office, the agency has proposed or finalized 29 major regulations and 172 major policy rules. This surge already outpaces the Clinton Administration's entire first term—when the EPA had just been handed broad new powers under the 1990 revamp of air pollution laws.[17] The results of just one of these rules, revisions to the National Ambient Air Quality Standard (NAAQS) for sulfur dioxide, could impose an 18 month moratorium on building new, or expanding existing energy projects.

In addition, Texas has been fighting with the EPA over its rejection of Texas' approach to permitting new and expanding facilities. As the *Washington Examiner* reports, "Texas is now challenging EPA's invalidation of the Texas Flexible

Permitting Program in federal court. EPA's action jeopardizes the planned construction of a new $6.5 billion Motiva refinery in Port Arthur and Total's planned $3 billion refinery expansion. Thousands of new highly skilled and well-paying jobs are at risk. And it's not just Texas that suffers. EPA's heavy-handed response to a dispute over permit rules strikes at the heart of the state's industrial base, one of the vital engines of the U.S. economy."[18] The EPA responded one day before Christmas with the decree that it would take over Texas' permit processing for greenhouse gas regulations, clearly seeking to make an example of the state. (Several other states have said they are not ready for the bureaucratic burden the new GHG regulations will impose, but only Texas is receiving the hardball treatment from the EPA.)

Some of the created or proposed rules in EPA's regulatory onslaught include:

- The institution of federal Greenhouse Gas regulation under the Clean Air Act.
- Revising six of the National Ambient Air Quality Standards.
- Implementing Clean Water Act section 316(b) cooling water requirements.
- Implementing a raft of new standards and control technology rules for hazardous air pollutants.
- Proposed energy mandates (RPS, etc.) on either the state or federal level.
- Setting greenhouse gas emission standards and tightening fuel economy standards for light-duty vehicles.
- Rules aimed at reducing interstate transport of particulate matter and ozone.
- Emission controls for new Marine Diesel engines.
- Setting national emission standards for hazardous air pollutants for chemical manufacturing area sources.

Senator James Inhofe has raised special concerns about the proposed revision to the National Ambient Air Quality Standard for ozone. Inhofe warns that tightening the standard could lead to more than 600 new "non-attainment" designations across the country.[19] Inhofe points out that a non-attainment designation leads to industrial closures, job losses, and economic underperformance. Quite a few of those new non-attainment areas would be in Texas.

Kate Galbraith summarizes some of the other ways that the EPA is seeking to control the Texas energy industry:

> "The EPA is looking into other issues crucial to Texas' energy industries. For the first time, the agency proposes to regulate waste from coal-ash. In April, the agency proposed rules that would cut emissions of lead and mercury from boilers—which burn natural gas or other types of fuel to create steam, which in turn creates electricity—and some solid waste incinerators. Yet another issue critical to Texas is hydraulic fracturing, the practice of shooting water and chemicals below ground at high pressure to extract natural gas. The EPA is conducting hearings around the country on whether the practice, commonly called "fracking," impacts water supplies. On July 8, the debate will come to Fort Worth, near where the method is employed heavily in the gas-rich Barnett Shale. Currently, fracking in Texas is regulated by the Texas Commission on Environmental Quality and the Texas Railroad Commission, which oversees the oil and gas industry. But the EPA is studying the issue in the wake of Congressional interest in potentially ending an exemption from federal oversight of fracking in the Safe Drinking Water Act."[20]

Finally, in the wake of the BP Gulf oil spill, the Administration has developed a raft of new safety rules that oil and gas producers must comply with. And Interior Department Secretary Ken Salazar has said he wants to increase the permit-review period from its current 30 day processing limit to a deadline of 90 days, creating an expectation on ever-increasing delays and regulatory barriers to new energy exploration and production in the U.S. All of this has led to a dramatic slow down in permits issued to allow energy production. As reporter Star Spencer points out, "The ban on new drilling ended May 30 for shallow wells, but for waters greater than 500 feet it was extended for six months. It was officially lifted October 12, but still there have been no new well permits issued for deep waters since April. What happened next was painstakingly slow well approvals as the BOEM, then still called the U.S. Minerals Management Service, began to more finely scrutinize drilling applications, according to a new set of rules that critics claimed were inconsistent. Just two shallow-water new well permits were issued in each of June, July, and August. Four were handed down in September, including a deepwater water injection well, and five for shallow-waters-only in October. In November, seven new well permits were granted, including one in deep water for another water injection well. So far, just one new shallow-water permit has been issued in

December. That's 23 new permits in six months—nearly 43 percent or less than half the pre-Macondo flow in 50 percent more time. That's nowhere near the tempo industry would like, but it's a definitive upbeat. On the other hand, on a monthly basis it's sizeably less than the steady drumbeat of double-digit permit volumes that marched out of regulators' offices earlier in the year."[21]

Governor Rick Perry is fighting the EPA on its efforts to impose new greenhouse gas regulations and on its rejection of Texas' approach to air pollution control, but the outcome of such fights is highly uncertain.[22] EPA's track record of successfully expanding their oversight of energy production, chemical production, and industrial activity suggest that Texas will endure significant losses if EPA has its way.

Conclusions

Energy is an enormously complicated subject susceptible to multiple levels of analysis, and even more levels of confusion and misrepresentation. Some key points that emerge from the preceding analysis bear reiterating:

- The affordability of energy is a key component in the economic competitiveness of Texas. States that have attempted to intervene in energy markets are saddled with the nation's highest energy prices, and find key industries (i.e., aviation and auto manufacturing in California) are no longer competitive.

- Energy markets are volatile; price swings from national and global changes in supply and demand for different energy sources can have significant effects on the economy. Policies that constrict the energy market—or tilt it to favored energy sources—will reduce the resiliency of the energy sector and risk higher prices for consumers and industry.

- Texas' strong position as a fossil fuel energy producing state is an asset rather than a liability, as it is better shielded from price and supply shocks.

- The Texas energy sector faces several key uncertainties from both federal regulatory initiatives and potential state regulation. Uncertainty is the enemy of future planning for capital investment.

It is remarkable that so many people have forgotten the lessons of the 1970s, where much of the disruptions, scarcities, and price volatility of the "energy crisis" was the result of obsolete or ill-considered federal and state regulation. Leaders of both parties, on both the state and federal level, began de-regulating markets—first for oil and natural gas, later for transportation infrastructure such as pipelines and railroads, and finally with electricity—that enabled the U.S. to end that period of energy volatility. To paraphrase the old cliché, those who forget the lessons of policy history are doomed to repeat them.

- The best energy strategy is to enhance *energy resilience* through a diversified energy portfolio that emphasizes abundance, affordability, and reliability.

- The best policy for achieving energy resilience is an open, adaptable marketplace for competing energy supplies and technologies, rather than mandates and patchwork subsidies that introduce artificial distortions and constraints in energy markets. The goal of policy should be to make the entire "energy pie" bigger, not to try to force favored parts of the energy pie to grow or shrink. Existing mandates (such as "renewable portfolio standard") should be reviewed for possible elimination.

- To adapt another popular slogan, the best advice for Texas policymakers can fit on a bumper sticker: "Don't Mess with Texas Energy." Texas should not do to the energy sector what it would not do to any other sector of its economy. Tilting the marketplace almost always leads to bad outcomes; in the energy sector, adopting policies favoring some sources over others will reduce the reliability and resilience of the energy market. ✯

Appendix A: Energy 101

The key concepts necessary to understanding energy are: abundance, affordability, the "density" of energy sources, basic measurements of energy, and the tradeoffs between different sources of energy supply.

Energy Abundance

Understanding energy begins with an understanding of the relationship that humans have had with energy since we first harnessed fire millions of years ago. Since that time, energy has become omnipresent in human life, and we consume energy with virtually everything we do. Everything we eat, buy, or use, and every service we consume is produced with energy, distributed with energy, maintained with still more energy, and increasingly consumes energy with every use. Without abundant flows of energy, our society winds down and stops. Consider some of the ways we consume energy:

- Our food is grown with energy intensive fertilizers, harvested by energy consuming equipment, prepared, packaged, shipped, and cooked with still more energy.
- Our water is pumped, purified, and distributed using energy. In large buildings, our air is moved around by powered fans, filtered, humidified, de-humidified, heated, and cooled with air conditioning and heaters that consume major amounts of energy.
- The light we read by at work and at home is the product of energy use. The lumens which pour out of our (soon to be banned) incandescent light bulbs are mostly transformed fossil fuels, with some nuclear power and hydroelectric power thrown in the mix.
- The materials used to make our clothing are grown using energy, processed, dyed, cut, woven, sewn, packaged, shipped, and so on, all using energy. When we wash, dry, or dry-clean them, we use still more energy.
- The same is true for the places we live in, the furniture we sit on, the transportation we use, the gadgets we own, and basically, everything in our lives. Very little of what we do is untouched by energy.

The second thing to understand is that such energy use is not discretionary. To the contrary, energy use has shaped our evolution, and we are, as a species, both shaped by and dependent on energy. Of all the species out there, humans are the only one that can't live in most of our "natural" environment without using large amounts of energy.

The harnessing of fire, some two to six million years ago, changed our very biology. Additional calories liberated from cooked food led to increased brain size, a more streamlined digestive system, smaller dentition, less facial (and other) musculature, and less hairiness. Exposure to longer periods of light, some believe, changed our circadian rhythms. It also provided more time for socializing, a central place for the gathering of tribe members, and, one anthropologist suggests, was what anchored women to the kitchen. In the earliest days of fire control, primitive humans nurtured fire they found in nature and preserved it rather than starting it, so women, tending children, were the ones tending the fire by day, and cooking the food brought in by the male hunters throughout the day and evening.

Extending the day enabled greater productivity of primitive tools and allowed the hardening of those tools. Fire protected us from predators, let us preserve our food (by drying and smoking), and expanded the range of places we could inhabit, letting us spread out, and increasing the resilience of the human population.

We are not so much distinguished by our intelligence as by our control of energy. No human tribe, however remote, has ever been found unable to control fire. By contrast, no animal species, however bright, has ever been found that can control the use of fire in their natural environment. We are not addicted to energy. We are biologically adapted to enhanced living through the use of energy. There's a big difference. We are not so much *homo sapiens*, as we are *homo igniferens*, man who kindles fire and who kindles it in great abundance.

The Need for Affordability

Because energy is so integral to our lives, affordability matters. The higher the cost of our energy, the higher the cost of the things we do, the way we travel, the things we buy, and the more it costs us to maintain them and use those things.

Research conducted at the American Enterprise Institute shows that half the energy people consume (and half the money they spend on energy consumption altogether) is embedded in the things they buy and the services they use.[23] When we buy a cup of coffee, we may not have realized that we're paying for the long energy chain that produced it, but we are.

So, last night's pizza from Dominos? A share of that price was the energy used to grow all the different ingredients, make the pizza, package the pizza, and keep the pizza warm as it's delivered.

The e-mail notification on your Blackberry? The result of countless pulses of energy, from the sender's beaming it to a cell tower, from it being relayed to other cell towers (or run through regular phone cables), to being beamed to you from yet another cell tower that could be a quarter-mile away. And of course, you plug it in every night to charge it. One astonishing fact of our portable hand-held devices is that they have the energy footprint of a refrigerator when all of these factors are considered. In fact, the

Internet and wireless technology now account for as much as 8 percent of total electricity use in the U.S.

The bottom line is that raising the costs of energy raises the cost of virtually everything, and that has consequences. As economists will tell you, all things being equal, raising the cost of goods and services leads people to consume less of them. Less consumption means less production, which means less economic exchange, less productivity, and less employment. And raising energy costs unilaterally—as some would do to address climate change—raises the cost of exports, making you less competitive on world markets.

And it's not just about Americans: much of the world lives in dreadful energy poverty and has to rely on terribly unhealthy, environmentally destructive sources of energy like charcoal, dung, or wood. Lacking fertilizer, agriculture is woefully underproductive. Women toil to draw and carry polluted water from distant streams, and lacking the energy to purify it, pay a dreadful price in sickness and premature death. Energy poor people cannot preserve and make best use of their food, increasing famine.

Affordability Matters

There's no such thing as a free lunch, and trade-offs are inescapable.

Right now, the U.S. gets the vast majority of its energy (about 85%) from fossil fuels-coal, oil, and natural gas, a situation that disturbs many environmentalists, politicians, and other special interest groups. Some people call for us to "end our addiction to foreign oil," or to oil altogether. Some want more subsidies for wind or solar. Environmentalists would ban coal in a heartbeat. Republicans have a love affair with nuclear power and can't seem to get enough. President Obama seems fixated on battery-electric cars. Everybody has their favorite proposals for remedying some perceived energy woe.

So, can the U.S. "get off of petroleum?" Can we stop using coal for electricity? Can we grow our own transportation fuels? Can we be "energy independent"? Can we build more nukes?

We can, to varied (and highly limited) extents. But all of these choices come with serious economic and environmental tradeoffs and will take a long time: energy systems evolve on a time scale of decades, not years. Trying to rush it is just likely to break the bank and result in an abortive transition, as is happening in Spain and elsewhere in Europe, where excessive haste led to unsustainable subsidies for renewable energy.

Wind power, for example, will require many hundreds of thousands of windmills, requiring a vast network of service roads and power lines if it is to seriously displace coal or natural gas in electricity generation. And the wind is fickle: it doesn't always blow when we need power, so it requires completely redundant backup power. It's also hard on the environment. Besides killing birds and bats, offshore wind is suspected of harming sea mammals because of the sonic vibrations induced in the water. Other studies have shown that windmills actually cause warming of the local environment, which could affect local ecosystems, and furthermore, because the backup power has to "cycle" up and down to compensate for the fickle winds, wind power often generates more greenhouse gases than would be the case with natural gas by itself. And, as the rare earth elements needed to make the magnets are mainly in China, which has cornered the market, and because of China's lower labor rates, most windmills will be made overseas, shipped here on diesel ships, and sent to their location with diesel trucks and trains. Wind power is more expensive than other types, even without counting the necessary redundancy, and its output isn't dependable. A recent study from Scotland found that windmills, even in their windiest places, only produced about 17 percent of their supposed capacity and rarely, if ever, generated power when power demand is high.

Solar power has many of the same issues. First, people generally don't live out in the hottest places, so the power has to be transmitted long distances, often through populated areas or wilderness areas. In addition, desert ecosystems are quite fragile and are populated by many endangered species. This is one reason why so much of California's deserts have been set off limits for development or even recreational use. Gathering in lots of sunlight means gobbling up lots of space. Solar thermal power stations also require a lot of water to generate steam for turbines. As, by definition, water isn't found in great abundance in deserts, add in piping water, and releasing humidity into the desert into the equation. Solar power is also the most expensive form of power we can generate, and of course, it only generates power half the time, whereas a natural gas or coal power plant can run at high outputs 24 hours a day. Solar photovoltaic cells, it has been found, are also dangerous for the water-seeking insects that are at the base of desert food chains. Apparently, insects interpret the reflections from the solar arrays as water, and they hover over it until they die. Rooftop solar arrays also have a downside for homeowners. As Ed Begley points out in his book *Living Like Ed*, homeowners have to go on rooftops and clean solar panels three or four times a year, or they lose efficiency.

Biofuels have turned out to be an economic and ecologic disaster. Corn-ethanol is not only uneconomic, producing it causes air pollution, water pollution, wildlife contamination, huge coastal oceanic dead zones, soil erosion, excessive water withdrawals, and more. It also raises the cost of food and was partially responsible for the surge in food prices a few years back that had Mexicans near rioting over the cost of corn tortillas. It may count as the biggest energy boondoggle of all time, and the government keeps making it worse by increasing the amount of ethanol blended into the nation's gasoline supply.[24] Thankfully, Texas has a very small participation in the corn ethanol boondoggle.

Geothermal? Small scale works in some areas, but who wants to see a geothermal plant in Yellowstone? Hydropower is great, but we're demolishing dams to reduce harm to fish populations, and we've already dammed the major potential sources in North America.

More domestic energy production? We have plenty of resources (contra to the "running out of energy" myth), but they're not without risk. Look at the spill in the Gulf of Mexico and the coal mining disaster in West Virginia. And while hydraulic fracturing for natural gas looks to be safe, it's never been done on the kind of scale we're exploring now.

Nuclear power? It's not clear that it's economic, given how entangled it is with government for the fuel cycle and waste disposal. The industry is reluctant to expand in the absence of large government loan guarantees, which is not a promising requirement for a mass-scale energy technology.

Cellulosic ethanol? It's a technology that's been 10 years away for 40 years now, and it's still that far away. And it would consume massive land areas even if it were real. Algae fuels? There's real promise there, but again, it's far from ready for prime time, and when it does eventually happen, it'll almost certainly require genetically modified algae, which will raise alarms with environmental fundamentalists. Compact fluorescent bulbs? They contain mercury, put out poor quality light, are more expensive, and aren't living up to their reputation for long lives.

Well, can't we just be more efficient? Maybe, but most economists don't believe in the idea that people are terribly wasteful with their money. When you dig into proposed "efficiency" measures, you find that usually there's a good reason why someone has chosen not to insulate their house perfectly, or use fluorescent lights, or drive a compact car, or use a clothes dryer rather than hang their clothes out to dry. If people saw free money on the table, they'll generally put it in their pocket unless something stopped them. The idea that huge inefficiencies are laying around is fallacious. If you try to subsidize energy efficiency, you not only are robbing apartment-living Peter for home-owning Paul, you risk a range of unintended consequences. So, we subsidized energy-efficient refrigerators, and people kept the old one out in the garage. Consequence? More energy use. We subsidized electric cars with stimulus money but didn't rule out golf carts, so a bunch of people got free golf-carts at your expense. We forced cars to be made more fuel efficient, and people drove more miles.

So, it's not a question of whether we *can* do the things that the politicians and environmental groups talk about with regard to energy, the answer is "sure we can," at least to a limited extent. But there is no such thing as a free lunch, and trade-offs matter. These are the kind of questions to ask when energy discussions come up.

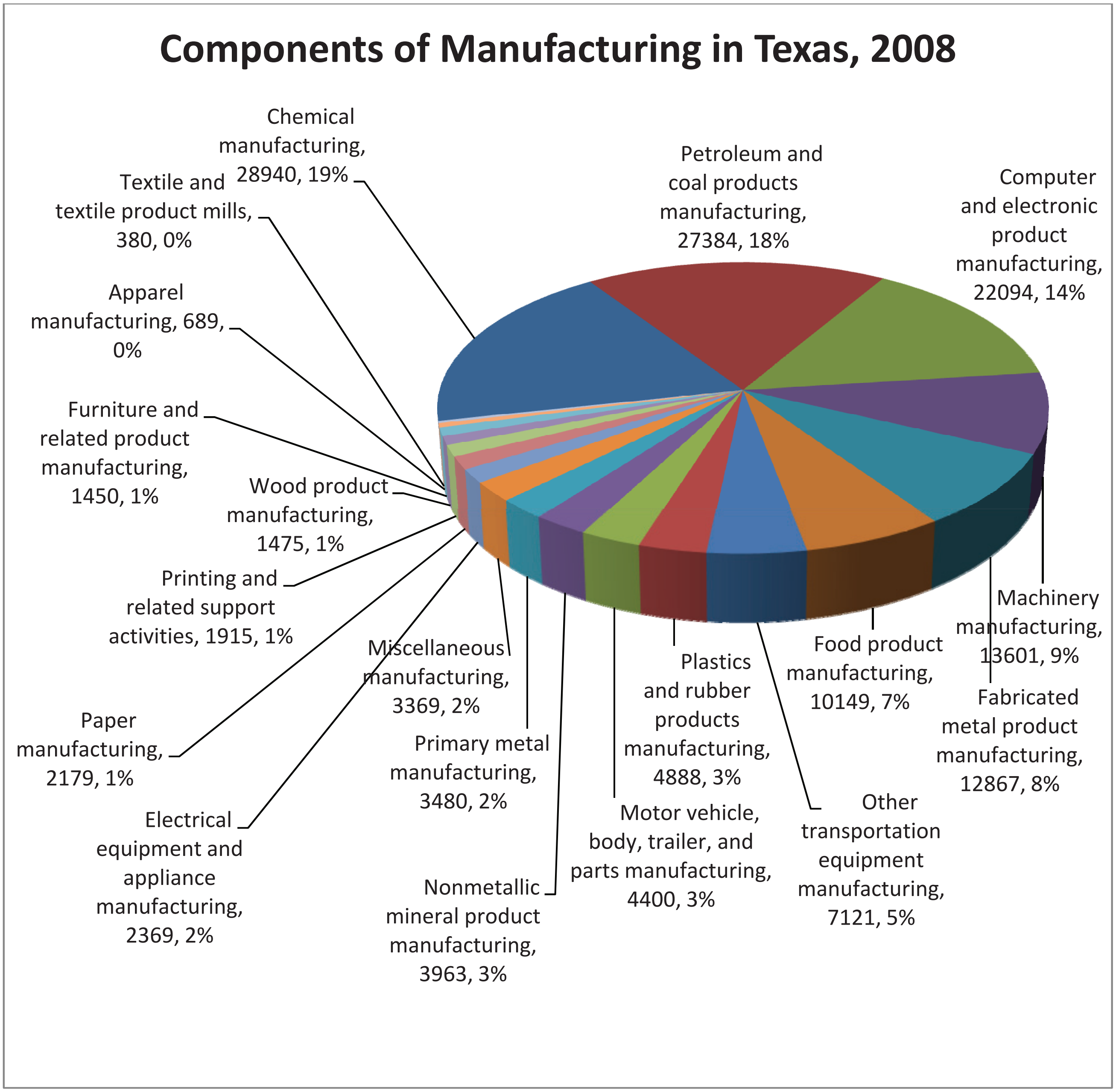
- How much rainforest would we see cut down to grow biodiesel, to avoid buying oil from Hugo Chavez, who will simply sell it to someone else?
- How much of America's wilderness would we see put under the plow for poplar plantations or for more corn for ethanol?
- How many tens of thousands of miles of service roads and power lines would we see across the landscape to deploy the hundreds of thousands of windmills that would be needed to significantly displace coal or natural gas use?
- How many new artificial lakes would we see dug to create "storage" for wind energy? How many millions of tons of toxic cadmium would we mine for back-up batteries, and where would we dispose of them?
- How much more nuclear waste do we want to produce and truck across the country to a repository, if we ever get one?
- And how much more will we pay, how many jobs will we see lost, for these energy transformations?

These are not simply economic questions; they are value questions that governments are particularly ill-suited to answering. How can the federal government know how the next generation will value any of these changes? How will they know how the present generation will value these changes? The answer is, they can't know that. This is the "knowledge problem" that always has, and always will, confound those who think they can plan the economy.

It would be great if there was someone smart enough to say, "here's how to perfectly balance everyone's economic, environmental, and esthetic desires," but there has never been, and never will be, such a wise man. That's why, the best energy solutions are those that tap the best knowledge engines we have, which are markets. To do that, we need the government to really change direction: to get rid of subsidies, open up markets, stop picking winners and losers, let consumers express their preferences, and accept the consequences of those actions.

Energy discussions must start with a realization that abundant, affordable energy is not discretionary, it is mandatory. How we get that energy is always open for discussion, but a realistic discussion includes an honest appraisal of costs, trade-offs, and the potential for unintended consequences.

Appendix B: Manufacturing Activity in Texas



Appendix C: Air Pollution Trends in Texas

Several Texas metropolitan areas continue to be "non-attainment" areas under the strict standards of the Clean Air Act, especially for ozone, the most difficult of the conventional air pollutants. However, both emissions and ambient levels of air pollution are consistently declining in Texas and will continue to do so for the next two decades *without a single new regulation*. This is chiefly because turnover of the vehicle fleet from older vehicles to new, very-low emitting vehicles along with already-programmed emissions reduction benchmarks for utilities and the industrial sector assure substantial emissions reductions over the next 20 years. For example, emissions from the car and truck fleet are currently falling by about 8 percent a year, simply from fleet turnover.[25]

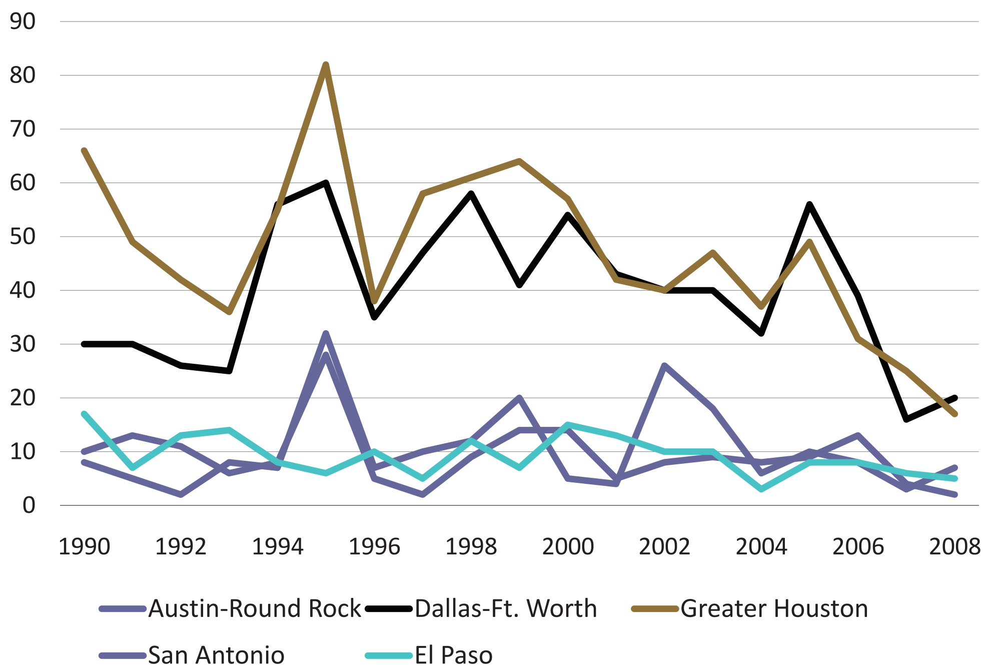
Moreover, every Texas metropolitan area has experienced significant declines in SO_2 levels and is compliant with the SO_2 standard. In Houston, SO_2 levels are down 58 percent since 1990; El Paso, down 81 percent; Corpus Christi, down 40 percent. Ozone trends have shown less consistent improvement. Houston's average ozone level has declined 34 percent since 1990, while average ozone levels in Dallas and Austin have declined only about 10 percent since 1990.

Overall annual ambient trends tend to understate the magnitude of air quality improvements, however. Another way of noting the progress in air quality is the trends in the number of days a metropolitan area exceeds a 100 score on the EPA's Air Quality Index (AQI), which is a composite of all major air pollutants. A score of 100 is the tripwire for people who have sensitive respiratory conditions.

Figure C shows the trends in the number of days Texas metropolitan areas have exceeded the AQI 100 threshold since 1990. As Figure C shows, 1995 was the peak year for scores over 100; since 1995, the number of days over a 100 score has declined between 78 percent (San Antonio) and 92 percent (Austin). (El Paso declined only 16 percent, but had a very low number of above-100 days to begin with.)

Figure C: Days Above 100 on the Air Quality Index, 1990-2008

GDP by Industry (millions of current dollars)



Source: EPA

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About the Authors

Steven F. Hayward is the F.K Weyerhaeuser Fellow in Law and Economics at the American Enterprise Institute in Washington, D.C. and Senior Fellow at the Pacific Research Institute for Public Policy in San Francisco. He holds a Ph.D. in American Studies and an M.A. in Government from Claremont Graduate School, and has been a visiting professor at Georgetown University and Ashland University. He widely publishes on a variety of topics, including energy, environmentalism, law, economics, and public policy for publications including *National Review, Reason, The Weekly Standard, The American Spectator, The Public Interest,* the *Claremont Review of Books*, and *Policy Review*. His newspaper articles have appeared in the *New York Times, Washington Post, The Wall Street Journal, San Francisco Chronicle, Chicago Tribune,* and dozens of other daily newspapers.

He is the author of a two-volume narrative history of Ronald Reagan and his effect on American political life, *The Age of Reagan: The Fall of the Old Liberal Order, 1964-1980*, and *The Age of Reagan: The Conservative Counter-Revolution, 1980-1989* (CrownForum books). *National Review* has called the first volume "grand and fascinating history," comparing it favorably to Macaulay's *History of England*. William Niskanen, chairman of Reagan's Council of Economic Advisers, called volume two "simply the *best* history of the Reagan presidency," while former Secretary of Education Bill Bennett said "this is the book we have been waiting for." His other books include *Churchill on Leadership* and *Greatness: Reagan, Churchill, and the Making of Modern Statesmen.*

Kenneth P. Green holds a doctorate in environmental science and engineering and a M.S. in molecular genetics. He has studied public policy involving risk, regulation, and the environment for more than 16 years at public policy research institutions across North America. He is the author of numerous policy studies, magazine articles, newspaper columns, encyclopedia and book chapters, and even wrote a textbook for middle-school students entitled *Global Warming: Understanding the Debate*. Green has testified before regulatory and legislative bodies at both state and federal levels, and speaks frequently to the public and in the media. He has twice served as an expert reviewer for the United Nation's Intergovernmental Panel on Climate Change.

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