May 6, 2008

Ladies and Gentlemen:

Reliable and affordable energy is critical to our state's ability to maintain strong economic growth. Texas has long been a leader in the energy industry and today has nearly one-quarter of the nation's oil reserves and about one-third of natural gas reserves. Texas also leads the nation with more than a quarter of all U.S. refining capacity. The energy industry plays a leading role in the Texas economy, employing nearly 375,000 people who earned more than $35 billion in total wages in 2006.

Fossil fuels — oil, gas and coal — continue to meet most energy needs for Texas, the U.S. and the world. Nearly all our vehicles remain powered by oil products, and about 87 percent of Texas' electricity is generated from the fossil fuels — coal and natural gas, with nuclear energy providing about 10 percent.

The use of renewable resources is on the rise, and Texas leads the nation in renewable energy potential. Texas has the resources and technical expertise to take advantage of increased use of a wide variety of renewable energy sources, including solar, wind, geothermal, biofuels and hydrogen.

The Energy Report, available at www.window.state.tx.us/specialrpt/energy/, is intended to serve as a reference tool for anyone seeking to understand the current Texas energy environment as they consider the potential impact of new policies. Texas remains at the forefront of the nation's energy industry. As such, the direction Texas takes in energy policy will help mark the path for the nation. Texas — and the rest of the world, for that matter — almost certainly will meet future energy demands using a wide variety of resources, and our state is well positioned to benefit from the increasing diversification of the nation's energy portfolio.

The Energy Report Executive Summary includes an overview of the energy industry in Texas, brief reviews of 17 fuel sources, an overview of energy uses and a summary of government financial subsidies for energy.

We recognize that energy prices are volatile and have increased significantly in recent months. Our report uses the most recent data available, which allows us to compare prices, production and consumption across different fuel sources. We have provided extensive source references so readers can check for updated data, while using this report as the basis for a basic understanding of the Texas energy landscape.

Sincerely,

Susan Combs

WWW.WINDOW.STATE.TX.US • P.O. BOX 13528 • AUSTIN, TX 78711-3528 • 512-463-4000 • TOLL FREE: 1-800-531-5441 • FAX: 512-463-4965

The Energy Report – Executive Summary

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The Energy Report
Executive Summary

Introduction

In 1908, America was embarking on an exciting new course of technological development. The year saw several important energy-related advances. Howard R. Hughes, Sr. filed basic patents for the Sharp-Hughes rock bit, which revolutionized oil well drilling; the Hanford Irrigation and Power Company opened the first hydroelectric plant to be built on the Columbia River; and Henry Ford began production of the Model T, generally regarded as the car that "put America on wheels."

Now, 100 years later, the ripple effect of those advances has continued, contributing to today's explosive evolution of technology. Developments that were the stuff of science fiction — global air travel, computers, electronic media and climate-controlled habitats — are now commonplace. And all of these modern conveniences have one basic requirement: energy.

As in the early 20th Century, we may be entering an era of technological change that will transform the way we produce and consume energy. The advances of a century ago helped make Texas, with its ample fossil fuel resources, the center of the world's energy industry. And today's Texas, with extensive energy resources and unmatched technical expertise, is well positioned to once again reap the benefits of technological advancement.

Reliable and affordable energy is a cornerstone of modern life. We use energy, mostly in the form of gasoline derived from crude oil, to power the vehicles that ferry us to work and play. Electricity from coal, natural gas, nuclear or wind power provides us with light, powered appliances, heating and cooling. And some sources of energy are used as a feedstock to make other products, an industry in which Texas is a world leader. Our standard of living, then, depends upon readily available sources of energy.

Energy use historically has been tied to population and economic growth. Texas' population is expected to continue increasing for decades to come, and our economic growth will depend on the availability of energy.

Texas — like most of the world — has relied largely on fossil fuels such as oil, gas and coal to meet its energy needs. But the energy landscape is changing. Rapid economic growth in developing economies results in an increasing demand for existing sources of energy, raising prices for these resources. Rising prices, the finite nature of fossil fuel supplies and the expectation that government action may soon limit the use of some fossil fuels, have combined to spur an interest in alternative sources of energy, including renewable and nuclear energy.

Fortunately, Texas has both the natural and human resources to create a broader energy portfolio. We have an abundance of alternative fuel sources, including the winds of the Panhandle, West Texas and the Gulf Coast; the sunshine of West Texas; the forests of East Texas; uranium in South Texas that can be mined and enriched for use in nuclear reactors; and the land and climate needed to grow crops for the next generation of ethanol and other biofuels.

Texas also has the human capital needed to tap those physical resources. Thanks to its history as a leading energy producer, Texas is blessed with an abundance of technical, legal, financial and research expertise that can be deployed to meet the challenges of providing energy for its growing population and economy.

Texas is uniquely positioned to lead the way in developing new technologies that will allow us to use fossil fuels in a more efficient, environmentally friendly manner; to make the technological advances necessary to make better use of our abundant renewable resources; and to reduce the demand for energy through greater efficiency.

Texas' population is expected to continue increasing for decades to come, and our economic growth will depend on the availability of energy.

Texas has the opportunity to influence the expanding public debate over energy use and production. Our state — and our choices — can set a new direction for the nation.

This report is intended to provide policymakers with a basic overview of the varied energy resources available to Texas. It can be used as a tool in considering energy policy. It also is a resource for anyone seeking a better understanding of the Texas energy landscape.

Texas will have to rely on an array of resources to meet its energy demand. There is no single solution to meeting our energy needs.

About *The Energy Report*

Comptroller staff conducted exhaustive research on the existing and potential resources Texas can employ to meet its energy demands. We talked to scores of individuals in the energy sector; visited mines, power plants, research centers and control rooms; and studied hundreds of research reports.

One thing we heard repeatedly is that there is no single solution to meeting energy demand. And almost everyone seems to agree that Texas will have to rely on an array of resources to meet its energy needs. This new energy portfolio will include renewable resources, nuclear power and traditional fossil fuels linked with new technologies to reduce their environmental impact.

It is important to remember, however, that there are *always* tradeoffs to be considered in energy policy. The fuels we have relied on for decades, despite recent increases in the cost of oil and gas, will continue to be the dominant means to meet specific energy needs. Our current energy infrastructure is designed to take advantage of them. Any policies that discourage their use, directly or indirectly, will likely entail costs to taxpayers and consumers.

This report is intended to be a resource for policymakers as they consider such tradeoffs. It provides an overview of a variety of energy sources that Texas can use to meet its future energy demands, with a fact-based assessment of each. Our report frames the critical issues and presents the objective information Texans will need to make informed choices about one of the most important issues facing the state.

The report contains four major sections. First is an overview outlining the current mix of energy resources and their uses. This is followed by a series of chapters describing in greater detail a variety of fuel sources and their potential to meet Texas' energy demands along with a discussion of efficiency. The third section describes Texas' uses of energy and important issues related to those uses. The final section contains estimates of federal, state and local subsidies for each fuel source in 2006, the first such analysis ever developed specifically for Texas.

This executive summary of *The Energy Report* provides a condensed version of the full report, summarizing key information and data. It also contains summary tables listing important characteristics of each fuel source and three tables capturing critical information for each fuel source that can be used for direct heat, transportation or electricity generation. The complete version of *The Energy Report*, which contains substantially more detail than the Executive Summary, can be found at www.window.state.tx.us/specialrpt/energy/.

Overview

For much of the twentieth century, Texas' economy was driven by the oil and gas industry. At the height of the oil boom of the early 1980s, the industry accounted for more than a quarter of the gross state product and of state government revenues.

Though the state's economy has diversified over the last 25 years, and the share of our economy accounted for by oil and gas has declined, the industry has seen a recent resurgence due to rising oil and gas prices. It remains a major component of the Texas economy and a significant contributor to the state's fiscal coffers.

Diversifying our Energy Portfolio

Texas, like most of the world, still relies on fossil fuels to meet most of its energy needs. Over the last century, resources such as oil, gas and coal were relatively abundant and inexpensive. And all of these fossil fuels benefit from an energy infrastructure — refineries, pipelines, tank farms, electricity plants — developed over decades to make use of them.

But times — and our economies — are changing. Texas and the U.S. have become increasingly reliant on foreign imports to meet our petroleum needs. In 2006, 60 percent of the oil used in the U.S. came from foreign sources.[1]

Furthermore, burning fossil fuels can have an environmental impact. Our government established policies decades ago that have ameliorated some of the air and water quality problems associated with the use of fossil fuels. A growing environmental concern today, however, relates to unregulated "greenhouse gas" emissions. Congress is debating plans that would limit such emissions, especially of carbon dioxide. Indeed, major financiers in the U.S. are working now to set up markets to trade carbon emission permits in the event that new laws are enacted.

The possibility of such policies, combined with rising oil and gas prices, has prompted a resurgence of investment in alternative energy sources, as well as the development of new technologies to reduce the negative consequences of fossil fuels. Wind and solar power, biofuels and other renewable resources are increasingly important. And recently revised federal regulations, combined with rising energy prices, have helped to renew interest in nuclear power.

Production

For decades, Texas has led the states in energy production and remains the nation's largest producer and refiner of oil and gas. Texas has abundant reserves of lignite coal, which can be used to generate electricity, as well as uranium deposits that can be used as fuel in generating nuclear power. Finally, Texas has an abundance of many types of renewable fuels and leads the nation in installed wind energy capacity.

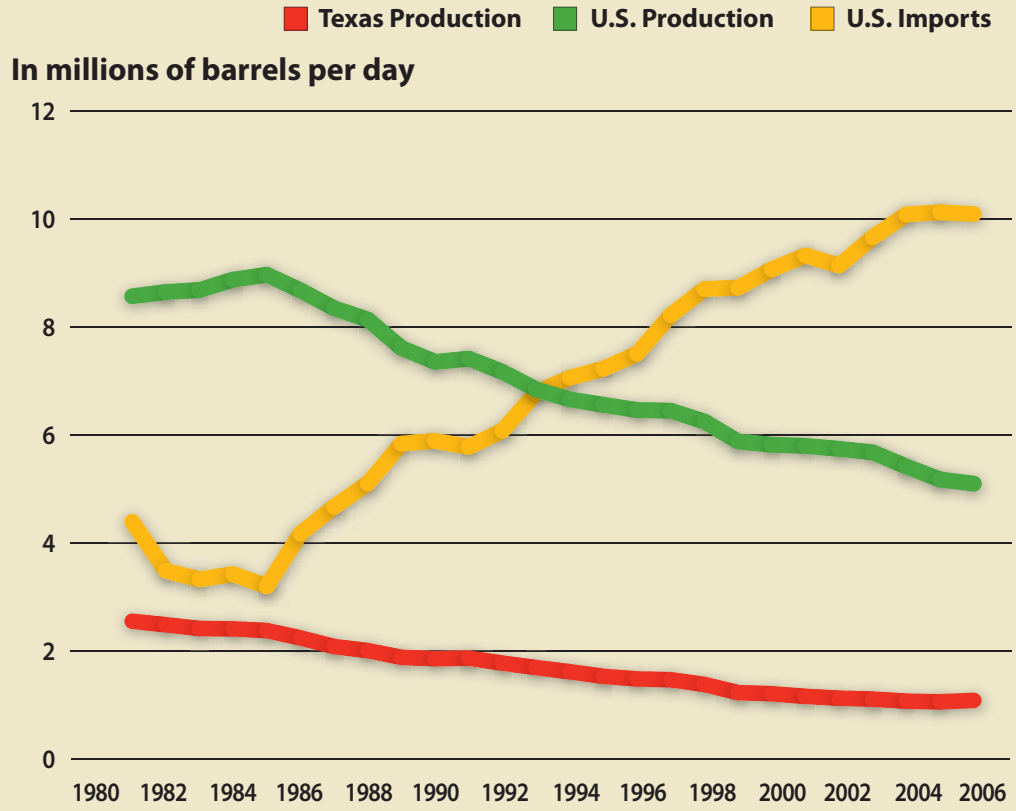
Texas, like most of the world, still relies on fossil fuels to meet most of its energy needs.

Texas energy production is still dominated by nonrenewable sources. Texas remains the nation's largest producer of oil and gas (excluding federal offshore areas), accounting for 21.3 percent and 27.8 percent of total U.S. production in 2006, respectively.[2] Texas has the largest share of the nation's fossil fuel reserves, with nearly a quarter of all U.S. oil reserves and nearly 30 percent of the country's natural gas. And the state is the national leader in refining capacity, with 23 refineries capable of refining 4.7 million barrels of oil per day, more than a quarter of all U.S. refining capacity.[3]

Nevertheless, Texas oil and gas production has matured. U.S. and Texas crude oil production both have declined steadily since their peak in the early 1970s, leaving the nation increasingly reliant on imports of oil (**Exhibit 1**). Texas' natural gas production has remained relatively constant over the past two decades (**Exhibit 2**). Recent, dramatic increases in oil and gas prices have spurred exploration and drilling activity in Texas, particularly for natural gas. Natural gas production rose by 4.5 percent in 2006, yet crude oil production continues to decline.[4]

EXHIBIT 1

U.S. and Texas Crude Oil Production and U.S. Imports



Source: U.S. Energy Information Administration.

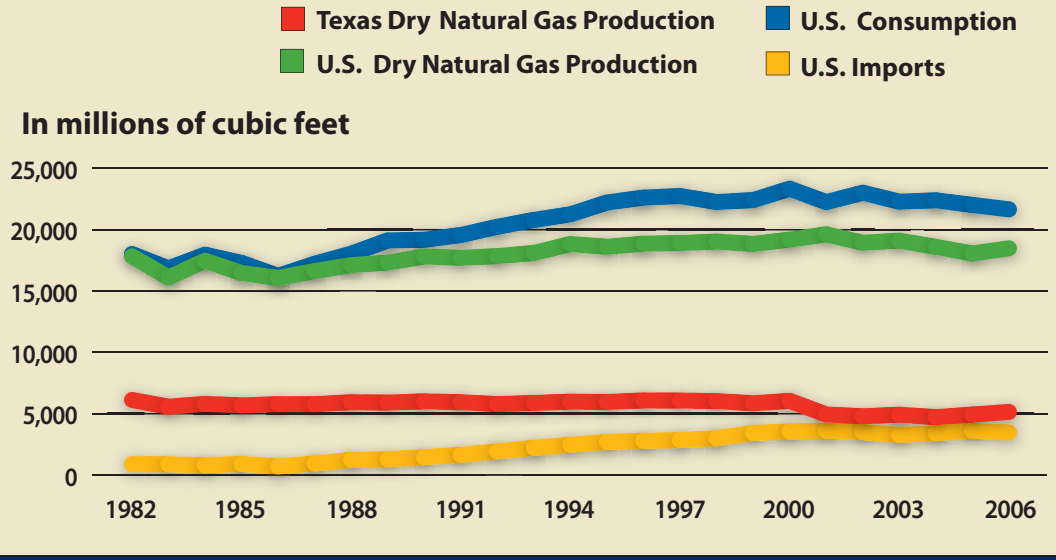
The nation's use of renewable energy sources, however — including conventional hydroelectricity, wood waste, ethanol, geothermal, solar and wind — has grown steadily, from 5.52 quadrillion British thermal units (Btu) in 2001 to 6.79 quadrillion Btu (or "quads") in 2006.[5] (The Btu is a measure of a fuel's heat content, useful for making comparisons among fuels.)

Texas leads the nation in renewable energy potential with a large amount of wind generation capacity and a high level of solar radiation capable of supporting large-scale solar power generation.[6] Though Texas gets only about 3 percent of its electricity from wind power, it now has the most wind generation capacity in the country, at 27 percent of the national total.[7] Texas' current wind energy production alone is enough to power about 1 million homes in the state.[8] The intermittent nature of wind energy, however, means that it cannot be relied upon as a primary source of electricity and must be supplemented by more reliable sources, such as coal, natural gas or nuclear power plants.

Texas also is the nation's largest producer of biodiesel transportation fuel, capable of making more than 100 million gallons of transportation fuel each year, with another 87 million gallons of capacity under construction. In 2007, Texas made about 73 million gallons of biodiesel.[9]

EXHIBIT 2

U.S. and Texas Natural Gas Production and U.S. Consumption and Imports



Sources: U.S. Energy Information Administration.

Much of Texas' energy consumption is attributable to industries that make products used across the U.S. and around the world.

CONSUMPTION

Texas' energy use is tied to its large population, hot climate and extensive industrial sector. Compared to the U.S., Texas has a high concentration of energy-intensive industries, such as aluminum and glass manufacturing, the forest products industry, petroleum refining and petrochemical production.[10] In other words, much of Texas' energy consumption is attributable to industries that make products used across the U.S. and around the world.

Texas thus leads the nation in total energy consumption, accounting for nearly 11.5 percent of all U.S. energy use. Texas leads the states in its use of oil, natural gas, coal and electricity, consuming over 11.5 quads of energy in 2005 (the most recent data available). California was second with more than 8 quads.[11]

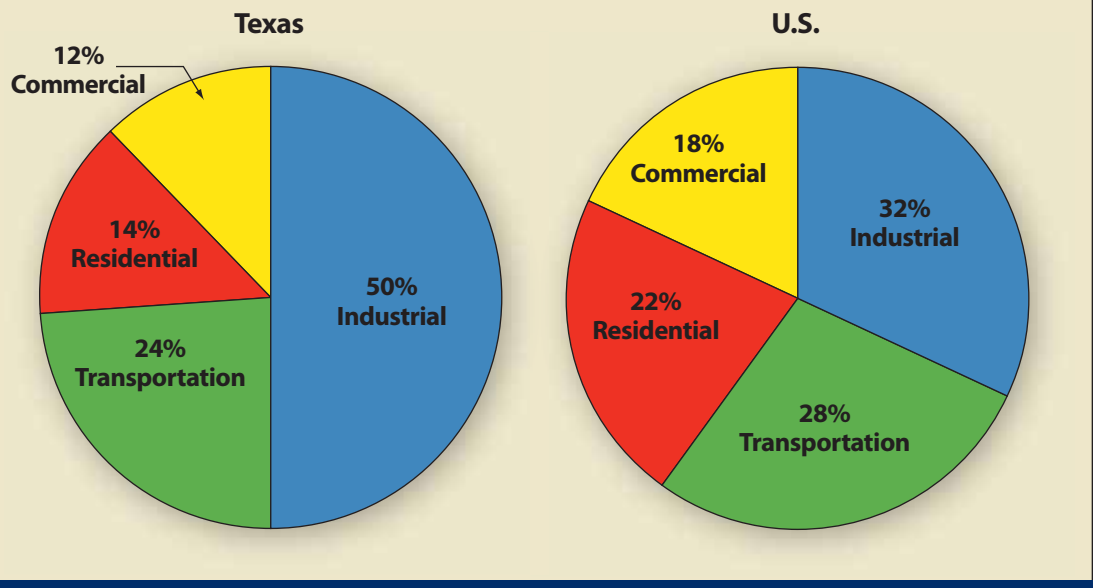
Analyses of energy consumption commonly consider four end-use sectors — residential, commercial, industrial and transportation. The industrial sector consumes the majority of energy in Texas (50 percent). For the U.S. as a whole, by contrast, the industrial sector consumes just 32 percent (**Exhibit 3**).

Exhibit 4 examines Texas' energy consumption by sector since 1960. Total energy consumption has risen by an average of 2.2 percent annually since 1960. Residential and commercial consumption both increased gradually, while the demand for transportation fuel rose more rapidly, a trend reflecting a growing population and expanding economy. Industrial consumption is much more variable than the other sectors, as it is more sensitive to higher energy prices and economic slowdowns. Industrial consumption fell by 13.3 percent from 2003 to 2005, due to higher energy prices and greater investments in efficiency, paralleling efficiency gains prompted by higher energy prices in the early 1980s.

Energy use per person in Texas also has decreased in recent years to its lowest level since 1965. Texas total per capita consumption exceeds the U.S. average,

EXHIBIT 3

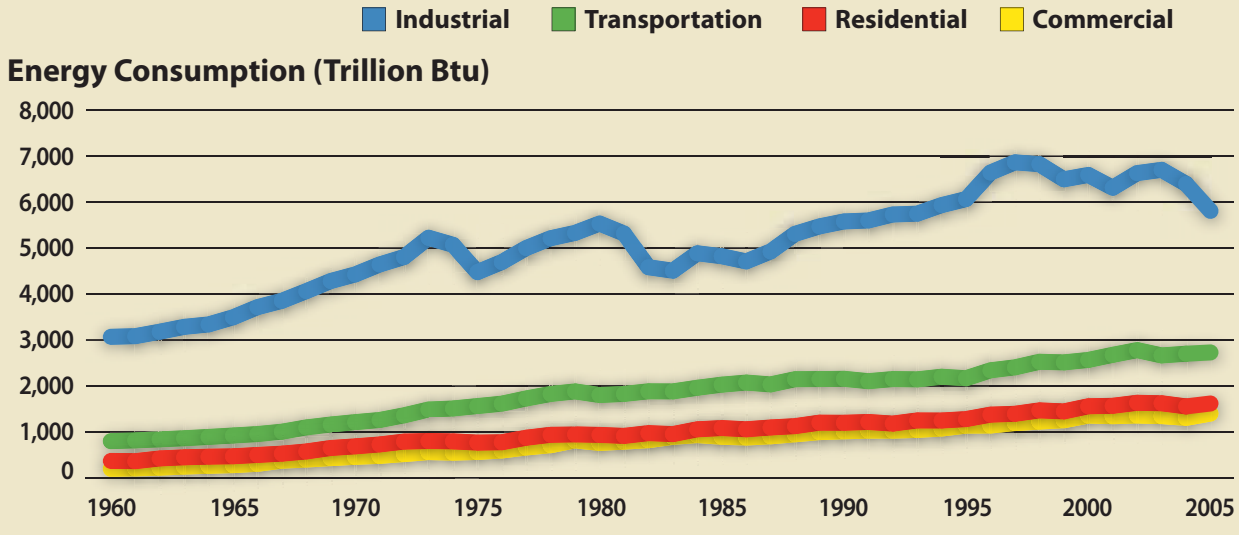
Energy Consumption by Sector, Texas vs. U.S., 2005



Source: U.S. Energy Information Administration.

EXHIBIT 4

Texas Annual Consumption by Sector



Source: U.S. Energy Information Administration.

mostly due to Texas' large industrial sector (**Exhibit 5**). Combined residential and commercial per capita consumption in Texas (excluding industrial and transportation use) was slightly lower than the U.S. average in 2005. In addition, per capita industrial usage in Texas has dropped steadily in recent years to its lowest level since 1960, the first year for which data are available. Per capita transportation use also has declined in recent years.

Furthermore, the overall energy "intensity" of the Texas economy — or its energy use per dollar of gross state product (GSP) — fell by nearly 68 percent between 1970 and 2005 (**Exhibit 6**).[12] Decreasing energy intensity is an indication of greater energy efficiency and structural changes in the economy, such as growth in less energy-intensive service industries. Pricing also has an effect, as energy intensity declines more during periods of high energy prices. While Texas and the U.S. are increasingly reliant on imported fuel, our economy is less dependent on energy in general, as **Exhibit 6** demonstrates.[13]

Spending

Given Texas' large population and many energy-intensive industries, it is no surprise that Texas businesses and consumers spend more money on energy than those in any other state. And with the cost of energy on the rise, total spending on energy has increased in recent years. Adjusted for inflation, Texas' energy expenditures in 2005 were at an all-time high. In 2005, Texans spent $114 billion on energy, accounting for nearly 11 percent of all U.S. energy expenditures. This measure nearly doubled the inflation-adjusted $61 billion spent in 1998, a period of much lower energy prices.[14]

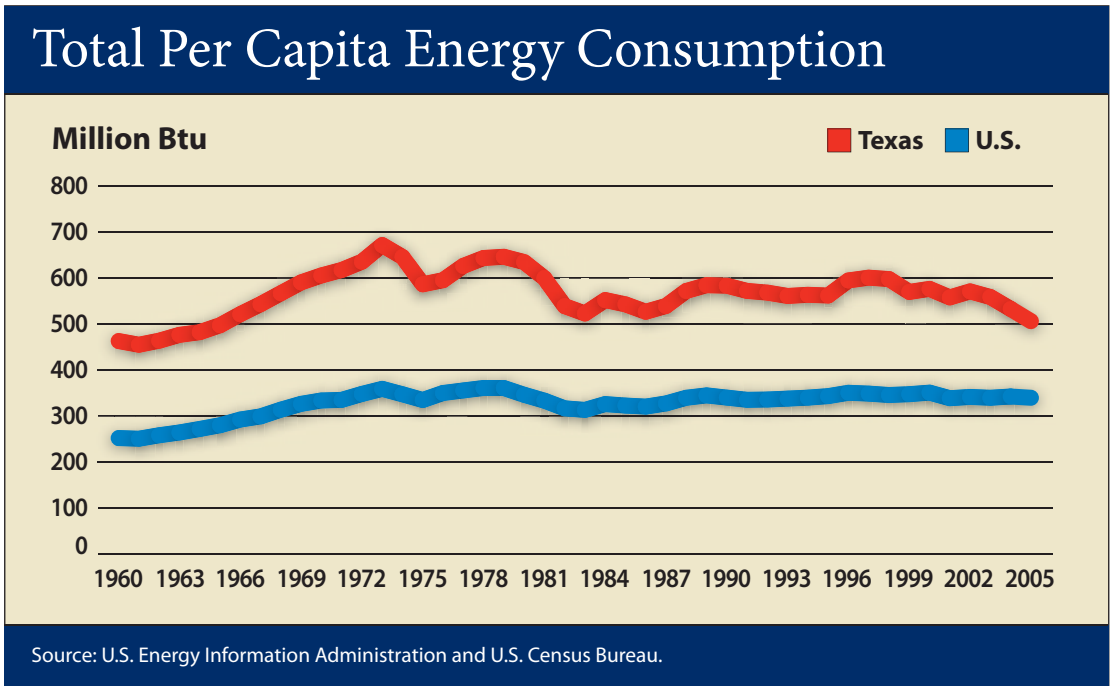
Per capita energy expenditures in Texas rose by 51 percent between 2002 and 2005, tracking the increase in energy prices. This rise roughly paralleled that for the U.S. as a whole, but Texas per capita energy expenditures were 42 percent higher than the national average in 2005 (**Exhibit 7**).

The share of GSP devoted to Texas' energy expenditures, however, declined steadily for most of the past 20 years, despite recent increases. In 2005, Texas' expenditures represented 11.6 percent of GSP, down from a peak of 17.5 percent in 1981. The U.S. expenditure share was 8.4 percent in 2005 (**Exhibit 8**).

Though complete data are not yet available, it is clear that energy spending has continued to increase since 2005. Oil prices have set new

Decreasing energy intensity is an indication of greater energy efficiency and structural changes in the economy.

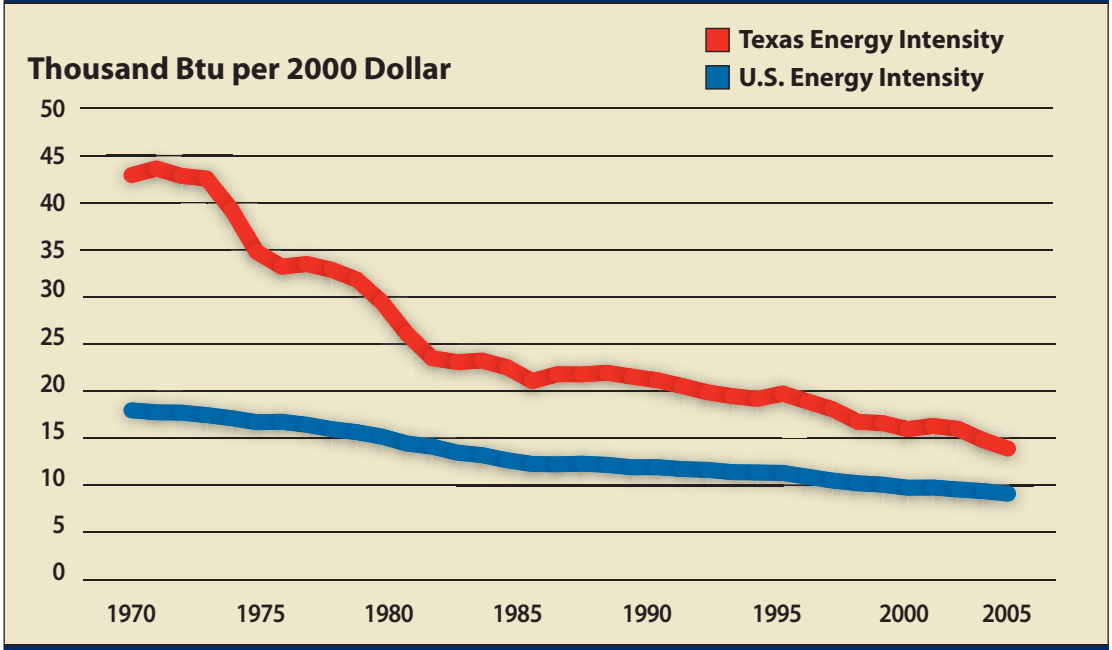
EXHIBIT 5



Source: U.S. Energy Information Administration and U.S. Census Bureau.

EXHIBIT 6

Energy Use Per Real Dollar of Gross Domestic Product

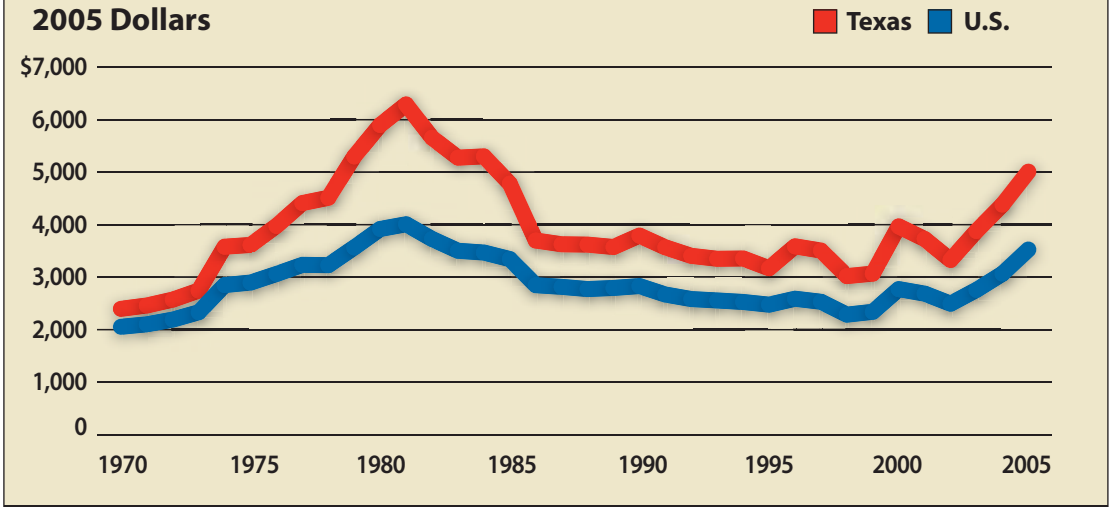


Sources: U.S. Energy Information Administration and U.S. Bureau of Economic Analysis.

While Texas and the U.S. are increasingly reliant on imported fuel, our economy is less dependent on energy in general.

EXHIBIT 7

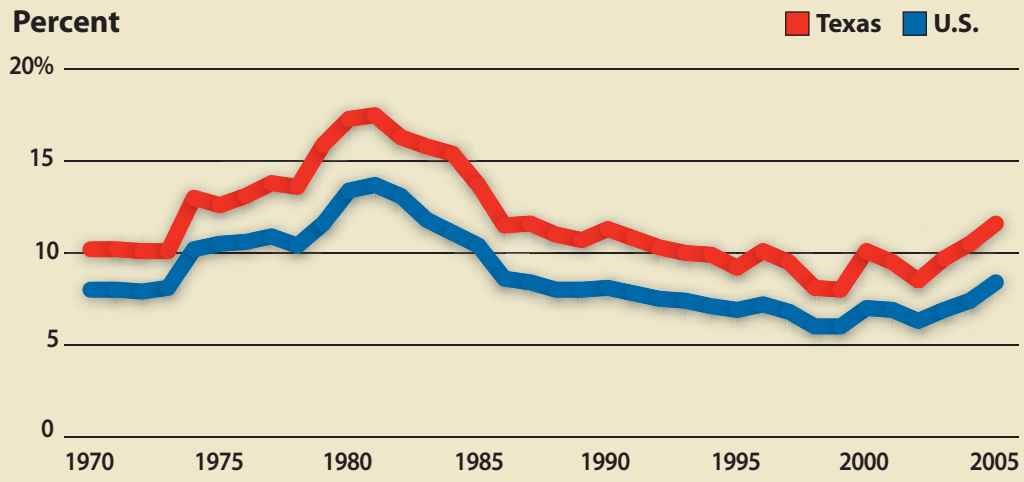
Real Per Capita Energy Expenditures



Source: U.S. Energy Information Administration.

EXHIBIT 8

Energy Expenditures as Share of Gross Product, U.S. and Texas



Source: U.S. Energy Information Administration and U.S. Bureau of Economic Analysis.

records, easily surpassing $110 a barrel. Prices for other fuels have been rising as well. It is likely that energy spending per capita and as a share of GSP have continued their recent climbs.

Economic Impact

In 2006, the Texas energy industry employed nearly 375,000 people who earned more than $35 billion in total wages. Energy-related industries include oil and gas extraction, coal and nuclear mining, utilities, petroleum refineries, petrochemical manufacturing and other energy-related manufacturing.

Not surprisingly, the oil and gas industry accounts for the largest share by far of this economic activity. In 2006, the oil and gas industry contributed 14.9 percent of Texas' GSP, compared to its lowest point of 7.4 percent in 1999. The oil and gas industry employed more than 312,000 Texans, or 3.1 percent of the state's nonfarm jobs. These recent gains are due in large part to rising oil and gas prices.

Texas has abundant deposits of lignite coal and some bituminous coal deposits. Coal production contributed 2,241 mining jobs and $168 million in wages in Texas in 2006.[15]

The state's two nuclear reactors — Luminant's Comanche Peak near Glen Rose and the South Texas Project (STP) in Matagorda County — employ a combined 2,150 persons, not including contractors. Total payroll for the two plants is about $196 million annually.[16]

The renewable energy sector is modest in size but is growing rapidly. Aggregate state employment and economic data currently are unavailable for this portion of the energy industry. It is, however, expanding in Texas, particularly in wind energy generation and biofuels production.

Environmental Impact

Energy production and consumption affect our environment in ways including air and water quality, land use and climate change. Government action to limit the negative effects of energy use can affect its cost by making various fuels more expensive.

In 2006, the Texas energy industry employed nearly 375,000 people who earned more than $35 billion in total wages.

In March 2008, the Environmental Protection Agency tightened federal restrictions on pollutants that contribute ozone, a primary component of smog which can cause respiratory and other ailments. Failure to comply with federal air quality regulations could lead to sanctions, including the loss of federal highway dollars.[17]

Much of the current debate concerning energy and the environment focuses on greenhouse gas emissions, which most climate scientists believe contribute to global climate change. A bill recently introduced in the U.S. Senate would establish caps on greenhouse gas emissions. If federal law requires limits on emissions of greenhouse gases such as carbon dioxide, it will inevitably shape the decisions made by Texas businesses, investors and policymakers as they develop the state's energy infrastructure. And since Texas is the nation's leading energy consumer, any caps on carbon emissions could have a significant economic impact on the state.

Efficiency and Conservation

The following pages discuss various fuels that might help to meet Texas' growing energy needs in the coming decades. Efficiency also has a potential role in meeting those needs by reducing energy use and offsetting the need to build new generating or production capacity. In general, investments in increased energy efficiency produce subtle and diffuse benefits, spread out among millions of consumers. Nonetheless, those results are quantifiable and justify the consideration of greater efficiency in energy policy development.

In light of a rapidly growing demand for power, higher energy prices and increased awareness of environmental and energy availability concerns, the concept of doing more with less offers an approach that many say is both feasible and affordable. Many government agencies, nonprofit organizations, utilities and their regulators, manufacturers, lawmakers and consumers across the country and internationally are undertaking energy efficiency measures and research.

In fact, efficiency gains have already made a strong impact on Texas' energy use. As previously noted, per capita energy use in Texas has declined in recent years as prices have climbed (see, for example, **Exhibits 4** and **5**). Furthermore, our energy "intensity," a measure of the amount of energy required to produce each dollar of economic output, has been in steady decline for more than thirty years (**Exhibit 6**). These are indications that Texas has already benefited substantially from efficiency improvements, a trend that is likely to continue.

Efficiency improvements can affect every type of energy use, although they vary widely in complexity and energy savings. Considerations such as costs and benefits, length of the "payback" period for investments and technological questions must be weighed carefully, but energy efficiency can provide Texas with the opportunity to reduce future energy demand.

Fuel Sources

The energy we use every day comes in many different forms from many different sources, but they can be categorized as two basic types: nonrenewable (those that cannot be replenished in a short length of time) and renewable (those that can be replenished in a short period of time).

Nonrenewable Fuels

Oil, natural gas, coal and uranium — the most common fuels in the world today — are considered to be nonrenewable, due to the eons it took to create them and mankind's inability to synthesize similar fuels readily. All but uranium are called "fossil fuels" because of their genesis in decaying plant and animal matter. Together, oil, natural gas, coal and nuclear energy account for about 87 percent of the world's energy supply, a share that has changed little over recent decades.[18]

Oil and natural gas built modern Texas, and the industry still remains a major contributor to the state's economy. Its future is likely to be characterized by more expensive production methods, both on- and offshore; the increasing importance of unconventional methods of retrieving oil and gas resources; higher import volumes and prices; better conservation technology; and government policies designed to increase conservation.

Crude oil, which is refined to create gasoline and diesel fuel, remains the dominant source of transportation fuel in Texas and the U.S., accounting for nearly 97 percent of transportation energy. Natural gas, meanwhile, accounts for about half of all electricity generation in Texas. Liquefied petroleum gases (LPG), such as propane, can be used for heating, cooking and motor fuel and in Texas play a critical role as a feedstock to produce other products; chemical feedstock uses account for 90 percent of LPG consumption in Texas.

Coal is the next-largest source of electricity generation in Texas, and is the nation's leading source of electricity. In 2005, coal was used to generate a little more than one-third of Texas' electricity, but about half of the U.S. total. Demand for coal is increasing across the globe and some governments, including the U.S., are considering limitations on greenhouse gas emissions. Such factors could impact the development of new coal plants, at least until technology to capture carbon emissions becomes cost-effective.

Nuclear fuel derived from uranium is another source of electricity generation capacity. Though nuclear power only provides about 10 percent of Texas' total electricity generation, rising prices of other fuel sources, along with revised federal regulation intended to encourage the development of nuclear power plants, mean that nuclear generation capacity in Texas is likely to grow.

Renewable Fuels

By definition, renewable energy is abundant and constantly replenished. It includes energy from the sun, earth (geothermal power), biomass and wind. While most renewable sources of energy are used to produce electricity, some biomass sources are well-suited, through appropriate technology, for conversion into transportation or boiler fuels.

Texas currently uses relatively little renewable energy, but it has an abundance of renewable energy resources, especially wind and solar power. Prior to the start of the 2009 legislative session, the State Energy Conservation Office (SECO), which is administered by the Texas Comptroller of Public Accounts, will issue a report to the legislature detailing renewable energy resources available to Texas.

Wind energy accounts for about three-quarters of all renewable electricity generated in Texas. Wood and hydtropower, the next largest renewable fuel sources, accounted for about 11 percent and 8 percnet, respecitively, of renewable electricity generated in the state in 2006.

In the arena of renewable transportation fuels, Texas has taken the lead in producing biodiesel, but is not as strong in ethanol production and consumption. Texas is the nation's leading producer of biodiesel, with 22 plants capable of making more than 100 million gallons of the fuel each year.

Ethanol in the U.S. currently is produced from corn, although other materials can be used. At present, there are two ethanol production facilities operating in Texas, and two more facilities are under construction that are expected to begin operations in 2008. Ethanol can be blended with gasoline to fuel vehicles. E85 is 85 percent ethanol and 15 percent gasoline and can be used by special flexible fuel vehicles (FFVs), which are widely available in Texas. But E85 fueling stations are scarce; there are fewer than 30 public fueling stations in the state.

The following pages contain short summaries of each fuel source. These summaries are intended to provide a brief description of each fuel source and allow for comparisons of fuel sources across different categories. Each fuel source summary provides information on:

- Cost;
- Economic Impact in Texas;
- Economic Viability in Texas;
- Availability and Current Infrastructure in Texas;
- Environment, Health, and Safety;
- Fuel Characteristics; and
- Other Issues.

These fuel source summaries are divided into two sections, the first covering non-renewable fuels and the second summarizing renewable fuels (**Exhibit 9**).

Note: the following summaries include data on costs per million Btu for each fuel source. This is the cost of the fuel as an input for direct heat use, to produce transportation fuel or for generating electricity. 2005 data are used because they are the most recent data available upon which comparisons across fuel sources can be made. For transportation fuels, per gallon costs are given based on January 2008 prices. In other instances, we have used the most recent data available and have noted the relevant year.

Also, in discussing the resource requirements of various energy sources, these summaries distinguish between water *withdrawal* and water *consumption*. Withdrawal refers to the amount of water extracted from surface or groundwater sources; consumption is the portion of those withdrawals that is actually used and thus no longer available in the area.

More information for each of these fuel sources and other topics covered in this *Executive Summary* can be found in the *Energy Report*, which is on the Web at www.window.state.tx.us/specialrpt/energy/.

EXHIBIT 9
Fuel Sources

Non-Renewable	Renewable
Crude Oil	Solar
Natural Gas	Wind
Liquefied Petroleum Gas (LPG)	Ehtanol
Coal	Biodiesel
Nuclear Energy	Wood
	Feedlot Waste
	Landfill Gas
	Municipal Solid Waste
	Hydropower
	Ocean Power
	Geothermal
	Hydrogen

Crude Oil

Crude oil is refined into hundreds of products such as gasoline, diesel, jet fuel, natural gas, heating oil, kerosene, asphalt, road oil, lubricants and liquid petroleum gases such as butane and propane. Crude oil byproducts also are useful as petrochemical feedstocks used to make waxes, plastics, chemicals and pharmaceuticals. Oil and natural gas built modern Texas. Texas has been a major producer of both and will continue to be for the foreseeable future. The industry accounts for a significant share of the gross state product and jobs.

Crude oil, when refined into gasoline and diesel, powers the vast majority of vehicles in Texas, the U.S. and the world. Gasoline and diesel were once comparatively the least expensive transportation fuels, but recent increases in the price of oil are changing their economics and spurring a renewed search for better ways to use them. The U.S. imports crude oil from sources around the globe, in addition to producing it domestically.

Cost

Per Million Btu (2005)[19]	Direct use: $7.36;[20] Electricity: $1.75 (Electricity cost based on a weighted average of the following: Residual fuel, $6.91; Distillate fuel, $10.45; Petroleum coke, $0.72)[21]
Per Gallon (motor vehicle fuel)	Regular unleaded gasoline: $2.99; Diesel: $3.40 (January 2008)[22]
Per Gallon of Gasoline Equivalent	Regular unleaded gasoline: $2.99; Diesel: $3.05 (January 2008)[23]
Direct Subsidy Share of Total Consumer Spending	Federal: 0.5 percent (oil and gas combined); State and Local: 1.5 percent (oil and gas combined).[24]
Notes	The daily posted domestic spot price per barrel of oil (for West Texas Intermediate delivered at Cushing, Oklahoma) on April 15, 2008 was $113.77.[25]

Economic Impact and Viability

Wages and Jobs	In 2006, more than 312,000 Texans, or 3.1 percent of the state workforce, were employed in the oil and natural gas industry combined, which accounted for more than $159.3 billion, or 14.9 percent of Texas' gross state product. Oil and gas industry wages totaled $30.6 billion that year, or about 6.9 percent of all wages in Texas.[26]
Regulatory Climate	Oil refineries must obtain air and wastewater permits from the Texas Commission on Environmental Quality (TCEQ), a process that usually takes about one year. Drilling, operating and related environmental permits are required by the Railroad Commission of Texas.[27]
Texas Competitive Advantage	Texas is the nation's largest producer and consumer of oil.[28] Texas has more than one-fourth of all U.S. oil refining capacity.[29]
Notes	Oil industry executives are concerned about the aging U.S. oilfield workforce, particularly in highly technical or dangerous occupations where experience is critical.[30] Unlike other coastal states that own their offshore lands out to three nautical miles, Texas and Florida (in the latter case, only its Gulf coastline) own their offshore lands out to 10.3 nautical miles, greatly increasing their potential for economic benefits from crude oil exploration and production.[31]

Availability and Current Infrastructure

Estimated Resources in Texas	Approximately 28,251 trillion Btu (2006)[32]
Current Fuel Production	Approximately 2,303 trillion Btu (2006)[33]
Consumption in Texas	5,671.1 trillion Btu (2005)[34]
Number of Fueling Stations in Texas	16,500[35]
Vehicle Availability	More than 20 million vehicles registered in Texas use gasoline or diesel.[36]
Notes	Texas has a daily refining capacity of 4.7 million barrels.[37]

Environment, Health and Safety

Greenhouse Gas Emissions[38]	The combustion of oil products for electricity generation releases an average of 490 pounds of carbon dioxide (CO_2) per million Btu of heat energy produced. Gasoline burned in motor vehicles releases an average of 156.5 pounds of CO_2 per million Btu; diesel burned in motor vehicles releases an average of 159.7 pounds of CO_2 per million Btu.[39]
Air Pollution (Non-Greenhouse Gas)	Burning oil products for electricity generation releases an average of 3.5 pounds of sulfur dioxide (SO_2) and 1.2 pounds of nitrogen oxides (NO_X) per million Btu of heat energy produced, although high-sulfur diesel oil used in some backup plants produces much higher emissions. Some mercury may be released depending upon the oil's composition.
Solid Waste	Hazardous materials such as salt water, drilling muds and chemicals that are used in and produced by the drilling process must be disposed of after a well is complete. Oil refining creates waste containing metals and other toxic compounds that must be treated and disposed of safely.
Land Use	Oil production and refining produces waste products that can cause land contamination, and oil spills can degrade soil. Petroleum products are stored in both above and below ground tanks. Any storage tank can leak, releasing hazardous fuels and chemicals into soil, water and air.[40]
Water Withdrawal	Depending upon the plant type, electricity generation from oil requires withdrawals of zero to 14,658 gallons of water per million Btu of heat produced.[41]
Water Consumption	Crude oil production and refining can require up to 2,500 gallons of water per million Btu of heat energy produced, depending on production methods.[42]
Water Quality	Refineries release treated wastewater into surface water sources, potentially harming aquatic life and reducing water quality if the wastewater is not treated properly. Accidental releases during oil and gas drilling can cause ground and surface water contamination. Salt water mixed with various metals and hydrocarbons is a common byproduct of drilling that must be disposed of properly. Leaky underground petroleum storage tanks can contaminate groundwater. Oil spills from transporting vessels can damage water quality and harm wildlife. TCEQ regulates and permits these discharges.[43]
Notes	Petroleum refineries are a source of air pollutants such as BTEX compounds (benzene, toluene, ethylbenzene and xylene), particulate matter, carbon monoxide, hydrogen sulfide, NO_X and SO_2. Most are toxic and regulated by the EPA.

Fuel Characteristics

Energy Content	Regular unleaded gasoline provides 115,400 Btu per gallon; diesel fuel provides 128,700 Btu per gallon.[44]
Renewability	Oil is a fossil fuel and is not renewable within a human life span.

Other Issues

Dependence on Foreign Suppliers	Net imports of foreign oil represented 59.9 percent of the oil consumed in the U.S. in 2006.[45]
Price and Supply Risks	Oil is a global commodity with prices determined in a global market. Factors that may influence prices locally include taxes, regulation, availability, environmental concerns and weather.

Natural Gas

Natural gas is used primarily to generate electricity, to assist industrial processes and to provide home heating. It also can be used to power vehicles, to assist enhanced oil recovery efforts and as a chemical feedstock. Texas is the nation's largest producer and consumer of natural gas, providing one-fourth of U.S. supplies and consuming a fifth, primarily in the industrial and electricity generation sectors.[46]

Natural gas was used to produce 48.9 percent of the electricity generated in Texas in 2006, making it the most common fuel used for electricity generation in the state.[47] It has fewer harmful emissions than coal, Texas' next-leading source of electricity generation. Natural gas is, however, more expensive than coal per Btu and its price is relatively volatile compared to coal, renewables and nuclear fuel.

The largest issue involving natural gas is supply. Demand is expected to keep growing. Natural gas is produced domestically or imported from Canada or Mexico. By chilling natural gas to a liquid state to create liquefied natural gas (LNG), the gas can be transported overseas economically. The U.S. imports LNG from Algeria and Nigeria, with other sources available in a few years. In Texas, new technology is expected to allow us to produce from ever-deeper and more unconventional reserves.

Cost

Per million Btu (2005)	Direct use: $8.08;[48] Electricity: $7.90[49]
Per Gallon	$1.47 (January 2008)[50]
Per Gallon of Gasoline Equivalent	$1.93 (January 2008)[51]
Direct Subsidy Share of Total Consumer Spending	Federal: 0.5 percent (oil and gas combined); State and Local: 1.5 percent (oil and gas combined).[52]
Notes	Transportation costs of natural gas include pipeline construction and maintenance. Electricity generation includes transmission costs.

Economic Impact and Viability

Wages and Jobs	In 2006, more than 312,000 Texans, or 3.1 percent of the state workforce, were employed in the oil and natural gas industry combined, which accounted for more than $159.3 billion, or 14.9 percent of Texas' gross state product. Oil and gas industry wages totaled $30.6 billion in that year, or about 6.9 percent of all wages in Texas.[53]
Regulatory Climate	Natural gas-fired electricity generation plants are required to obtain air and wastewater permits from TCEQ, a process that usually takes about one year. Drilling, operating and related environmental permits are required by the Railroad Commission of Texas.[54]
Texas Competitive Advantage	Texas is the nation's largest producer and consumer of natural gas, with more miles of natural gas pipeline than any other state.
Notes	Unlike other coastal states that own their offshore lands out to three nautical miles, Texas and Florida (in the latter case, only on its Gulf Coast side) own their offshore lands out to 10.3 nautical miles, greatly increasing their potential for economic benefits from natural gas exploration and production.[55]

Availability and Current Infrastructure

Estimated Resources in Texas	Approximately 63,753 trillion Btu, including state-owned offshore reserves (2006)[56]
Current Fuel Production	Approximately 6,487 trillion Btu (2006)[57]
Consumption in Texas	Approximately 3,540 trillion Btu (2006)[58]
Number of Fueling Stations in Texas	Texas has 15 natural gas fueling stations, but none of these stations is open to the public.[59]
Vehicle Availability	4,500 fleet vehicles and buses.[60]
Notes	Currently, natural gas exploration and production are strong in the Barnett Shale natural gas deposits found in and around Tarrant County.

Environment, Health and Safety

Greenhouse Gas Emissions	The combustion of natural gas to produce electricity produces an average of 332.7 pounds of CO_2 per million Btu of heat energy produced.[61]
Air Pollution (Non-Greenhouse Gas)	The combustion of natural gas produces an average of 0.5 pounds of NO_X and 0.03 pounds of SO_2 per million Btu of heat energy produced.[62]
Solid Waste	None.
Land Use	Natural gas extraction and power plant construction can harm plant and animal habitat. Natural gas production can cause erosion, loss of soil productivity and landslides. Most land use impacts are temporary, however.[63]
Water Withdrawal	Depending upon the generation plant type, electricity generation from natural gas requires from zero to 5,863 gallons of water per million Btu of heat energy produced.[64]
Water Consumption	Power generation with natural gas requires between 2 and 56 gallons of water per million Btu of heat energy produced, depending upon plant type.[65]
Water Quality	Natural gas power plants discharge heated water that may contain pollutants, potentially harming aquatic life and reducing water quality.[66] TCEQ regulates and permits these discharges.
Notes	Combined-cycle natural gas power plants are growing in popularity. These plants use combustion turbine exhaust to drive a steam turbine, in effect using the fuel twice, resulting in higher efficiency.

Fuel Characteristics

Energy Content	1,031 Btu per cubic foot.[67]
Renewability	Generally speaking, natural gas is a fossil fuel and is not renewable. The main component of natural gas, however — methane — is produced by the decomposition of organic material of any age above or below ground and as such may be considered renewable in some instances.
Notes	Natural gas is readily transported via pipeline with little processing. Pipeline-quality natural gas has predictable heat values regardless of the source.

Other Issues

Dependence on Foreign Suppliers	Texas supplies the nation with 28 percent of its natural gas.[68] The U.S. imports 19 percent of its natural gas, primarily from Canada and Mexico.[69] Liquefied natural gas (LNG) offers access to overseas supplies of natural gas, but LNG imports are highly dependent on price, availability, transportation and producing countries' limited ability to create and export LNG.
Price and Supply Risks	Factors that may influence prices locally are supply, regulation, transportation and weather.

Liquefied Petroleum Gas (LPG)

LPG is produced as a byproduct of natural gas purification and oil refining. Its most common commercially available form, propane, is widely used as a fuel for heating, cooking and transportation. LPG also is used to generate small amounts of electricity for homes and commercial establishments. LPG electricity generation is still undergoing research and development.

Texas is the nation's largest producer and consumer of LPG, as its production is intertwined with the oil and gas industries. LPG is mostly propane, butane or a mix of the two. It also includes ethane, ethylene, propylene, butylene, isobutene and isobutylene; these are used primarily as chemical feedstocks rather than fuel. LPG has seen its market share for transportation decline as other alternative fuels have increased. LPG for heating and cooking is expected to continue to be common in Texas, as is its use as a chemical feedstock.

Cost

Per Million Btu (2005)	Direct use: $12.21[70]
Per Gallon	$3.12 (January 2008 national average for propane)[71]
Per Gallon of Gasoline Equivalent	$4.31 (January 2008 national average for propane)[72]
Direct Subsidy Share of Total Consumer Spending	Federal: 0.5 percent (oil and gas combined); State and Local: 1.5 percent (oil and gas combined).[73]
Notes	Propane is produced from both crude oil refining and natural gas processing; its price is more influenced by the cost of crude oil because propane competes mostly with crude oil-based fuels. LPG transportation costs include costs for pipeline construction and maintenance as well as for trucking, rail and water transport. The residential cost of propane per gallon on March 18, 2008, was $2.60.[74]

Economic Impact and Viability

Wages and Jobs	LPG production is intertwined with that of oil and gas and it is therefore difficult to separate them to estimate LPG's economic impact. In 2006, about 3,075 Texas LPG dealers earned a total of $31.9 million.[75]
Regulatory Climate	LPG is a byproduct of oil and natural gas production, so its regulatory implications are similar to those for oil and gas.
Texas Competitive Advantage	Texas is the nation's largest producer and consumer of LPG. Chemical feedstock uses account for 90 percent of Texas' LPG use; nearly all of the remaining 10 percent produces energy.[76]
Notes	A report commissioned by the National Propane Gas Association estimated propane's contribution to the Texas economy was $3.8 billion in 2002. This study accounted only for propane, the most common form of LPG, and not other varieties such as butane.[77]

Availability and Current Infrastructure

Estimated Resources in Texas	Reserves of LPG are tied to those of crude oil and natural gas.
Current Fuel Production	Approximately 305 trillion Btu (2006)[78]

Consumption in Texas	Approximately 1,497 trillion Btu (2005)[79]
Number of Fueling Stations in Texas	556 (2006)[80]
Vehicle Availability	LPG-fueled vehicles are becoming uncommon. Original equipment manufacturers no longer produce LPG-fueled light-duty vehicles in the U.S.
Notes	In 2005, Texas consumed 55.8 percent of all LPG consumed in the U.S.[81]

Environment, Health and Safety

Greenhouse Gas Emissions	Burning LPG produces 139 pounds of CO_2 per million Btu of heat energy produced.[82] Transportation uses of LPG produce approximately 20 percent less CO_2 than gasoline.[83]
Air Pollution (Non-Greenhouse Gas)	LPG vehicles release 20 percent less nitrogen oxide and 60 percent less carbon monoxide than gasoline vehicles.[84]
Solid Waste	LPG refining produces sludge that must be processed and disposed of.
Land Use	LPG is a byproduct of oil and natural gas production, so its land use implications are similar to those of oil and gas.
Water Withdrawal	LPG is a byproduct of oil and natural gas production, so its water withdrawal implications are similar to those of oil and gas.
Water Consumption	LPG is a byproduct of oil and natural gas production, so its water consumption implications are similar to those of oil and gas.
Water Quality	LPG is a byproduct of oil and natural gas production, so its water quality implications are similar to those of oil and gas.
Notes	Natural gas purification produces about 55 percent of all LPG, while crude oil refining produces about 45 percent.[85]

Fuel Characteristics

Energy Content	Propane has an energy content of 91,000 Btu per gallon.[86]
Renewability	LPG is derived from fossil fuels, so it is not a renewable resource.

Other Issues

Dependence on Foreign Suppliers	LPG is a byproduct of oil and natural gas production, so its import implications are similar to those of oil and gas.
Price and Supply Risks	The price and availability of LPG are tied to the price of crude oil and natural gas and therefore to their risks.

Coal

Of the 103 million tons of coal Texas consumed in 2006, 96 percent was used to generate electricity; the remainder was used for various industrial purposes.[87] Coal is abundant and competitive with natural gas, the leading fuel source for electricity generation in Texas. But it also produces substantial amounts of atmospheric pollutants when burned. By volume, coal produces the highest emissions of carbon dioxide, nitrogen oxides, sulphurous oxides, mercury and arsenic of any fuel, with the exception of high-sulfur fuel oil used in some older plants. Coal mining also can release methane, another greenhouse gas. In Texas, lignite coal deposits are below the surface and must be excavated. Subbituminous coal is shipped by rail from Wyoming and Montana to Texas.

If future governments implement the CO_2 reduction strategies being contemplated in the U.S. and elsewhere, coal could face some of the toughest restrictions of all fossil fuels unless new technologies in development, such as carbon sequestration, reduce its emissions.

Still, coal is relatively abundant and is likely to continue to be an important component of the state's fuel mix. In fact, if new technologies such as carbon sequestration prove effective, coal could have increased prominence.

Cost

Per Million Btu (2005)	$1.34 for electricity generation;[88] $1.54 for direct uses[89]
Direct Subsidy Share of Total Consumer Spending	Federal: 6.9 percent; State and Local: none.[90]
Notes	Coal can be transported by rail, truck, conveyor and water. The transmission of electricity produced from coal entails additional costs. In the long term, synthetic fuels derived from coal may become commercially available as a transportation fuel.

Economic Impact and Viability

Wages and Jobs	Coal production contributed 2,241 mining jobs to the Texas economy in 2006 and wages of $167.6 million.[91] Available data do not distinguish other jobs attributable to the use of coal at electric utility plants.
Regulatory Climate	Coal-fired power plants must obtain air, water and wastewater permits from TCEQ, a process that can require up to four years.[92]
Texas Competitive Advantage	Texas has abundant deposits of lignite coal, though many of its coal plants use cleaner-burning coal from Wyoming. Coal can be less expensive than natural gas, depending on its quality and ease of availability. Texas has the potential for permitting coal plants in West Texas that can be located sufficiently close to areas of high energy demand or near electricity transmission resources. In addition, Texas has opportunities for the sequestration of carbon from integrated gasification combined cycle (IGCC) plants, with potential application to use the waste CO_2 for enhance oil recovery.
Notes	Coal was used to generate 36.5 percent of Texas electricity in 2006, compared to 49 percent for the U.S. in the same year.[93]

Availability and Current Infrastructure

Estimated Resources in Texas	Approximately 9,490 trillion Btu (2006)[94]
Current Fuel Production	Approximately 592 trillion Btu (2006)[95]
Consumption in Texas	Approximately 1,611 trillion Btu (2006)[96]
Notes	IGCC technology may offer a cleaner future for coal-generated electricity. In the U.S., 12 IGCC plants are in planning stages; one is under construction in Illinois, and another is planned to be built near Sweetwater, Texas.[97]

Environment, Health and Safety

Greenhouse Gas Emissions	Burning coal releases an average of 659.3 pounds of CO_2 per million Btu produced. Coal mining also can release methane, another greenhouse gas.[98]
Air Pollution (Non-Greenhouse Gas)	Burning coal for electricity produces 1.8 pounds of NO_X, 3.8 pounds of SO_2 and 0.01 pounds of mercury per million Btu produced.[99]
Solid Waste	Coal combustion creates ash waste, made up primarily of metal oxides and alkali, at an average rate of 10 percent of the volume of coal burned. Coal mining and processes used to remove air emissions during power generation also create waste.[100]
Land Use	Texas lignite coal requires strip mining, which can cause erosion and disturb the surface for the life of the mine. Federal and state laws require reclamation of the soil when a surface mine closes. Traces of mercury, arsenic and other elements from coal can leach into the nearby soil and water. [101]
Water Withdrawal	Depending upon the plant type, electricity generation from coal requires withdrawals from zero to 14,658 gallons per million Btu of heat produced. [102]
Water Consumption	Coal-fired power generation consumes between zero and 150 gallons per million Btu produced, depending on the plant type.[103]
Water Quality	Water is required for plant cooling. When discharged, this water may contain pollutants that could harm aquatic life and reduce water quality. Uncontrolled runoff from mines can cause surface water pollution. TCEQ regulates and permits these discharges.[104]
Notes	Coal miners face significant occupational risks due to the use of heavy equipment and subsurface conditions. Miners are at risk from exposure to coal dust, methane, arsenic, mercury, sulfur and other hazardous substances that contribute to pulmonary disease.

Fuel Characteristics

Energy Content	Lignite coal such as that found in Texas contains an average 13 million Btu per ton. Subbituminous coal, such as that imported from Wyoming, contains an average 17 to 18 million Btu per ton.[105]
Renewability	Coal is a fossil fuel and is not renewable within human lifespans.

Other Issues

Dependence on Foreign Suppliers	The U.S. imports very little coal and most of that is from Canada.
Price and Supply Risks	Texas imports much of the coal it uses from Wyoming and Montana by rail. Rail capacity and transportation costs can restrict the supply and cost of coal imported into Texas.

Nuclear Energy

Texas has two operating nuclear power facilities, Comanche Peak near Glen Rose and the South Texas Project in Matagorda County. But more facilities are planned. Owners of the South Texas Project have submitted an application to expand their facility. And over the next two years, the U.S. Nuclear Regulatory Commission expects to receive applications for six more new nuclear reactors in Texas.

All U.S. commercial nuclear power plants use enriched uranium fuel pellets in their reactor cores. Texas' two uranium mining companies produced more than one million pounds of yellowcake (mostly uranium oxide) in 2006, more than 35 percent of total U.S. production.[106]

Nuclear energy has among the cheapest fuel costs of any option for generating electricity. Nuclear plants, however, are extremely expensive (often costing more than $5 billion). Nuclear power produces no emissions, though critics fear the potential environmental impact of accidents at nuclear reactors.[107] Disposal of high-level radioactive waste also is a concern. A number of factors including new technology, rising energy demand, higher natural gas costs and concerns about greenhouse gas emissions point to a renaissance for nuclear energy. However, both regulatory and economic hurdles must be overcome before the next generation of reactors comes online.

Cost

Per Million Btu (2005)	$0.38 (nuclear fuel)[108]
Direct Subsidy Share of Total Consumer Spending	Federal: 20.9 percent; State and Local: none.[109]
Notes	The transportation of fuel assemblies by truck, rail, air or water entails additional costs. Electricity generation entails transmission costs. Spent fuel storage and disposal represents an additional cost. Nuclear energy's subsidy share of total expenditures may increase since future plants are likely to qualify for additional tax credits and loan guarantees.

Economic Impact and Viability

Wages and Jobs	Texas' two commercial nuclear power plants employ more than 2,000 people with a combined payroll of nearly $200 million annually.[110]
Regulatory Climate	The federal Nuclear Regulatory Commission (NRC) sets standards and regulations for nuclear power plants and grants Combined Operating licenses (COLs) to qualifying facilities. The COL process is expected to take about three and a half years. Nuclear power plants also must obtain a wastewater permit from TCEQ, a process that usually takes about one year.[111]
Texas Competitive Advantage	Texas has four operating reactors at two facilities, and the South Texas Project has submitted an application to expand its facility. Over the next two years, the NRC expects to receive applications for six more new nuclear reactors in Texas, two more at Comanche Peak and four at two new sites. These new reactors will require several thousand employees. Four of the 22 applications that NRC expects to receive for new nuclear power plants in the next few years are in Texas, more than any other state.[112]
Notes	There are three companies with permits to mine uranium in Texas. Two are producing uranium and one has a mine in reclamation. A fourth company expects to be producing uranium by the end of 2008.

Availability and Current Infrastructure

Estimated Resources in Texas	In 2003, Texas had an estimated 18 million tons of uranium ore, or about 4.2 percent of the nation's uranium reserves. Texas' reserves could be refined into about 23 million pounds of uranium oxide, which theoretically could produce enough fuel assemblies to generate electricity for more than 60 million homes.[113]
Current Fuel Production	Texas' two operational uranium mines produced more than 1 million pounds of yellowcake in 2006. This amount is equivalent to approximately 261.5 trillion Btu.[114]
Consumption in Texas	Comanche Peak and the South Texas Project have a combined generating capacity of about 5,000 megawatts (MW). In 2006, nuclear energy supplied 10.3 percent of Texas' electricity.[115]
Notes	Some countries reprocess spent nuclear fuel, turning some waste into new reactor fuel. Currently, the U.S. does not reprocess nuclear waste, but research by the U.S. DOE is underway. Reprocessing nuclear fuel would extend the availability of nuclear fuel by hundreds of years.

Environment, Health and Safety

Greenhouse Gas Emissions	No significant emissions.
Air Pollution (Non-Greenhouse Gas)	No significant emissions.
Solid Waste	Nuclear plants produce high-level radioactive waste. Currently, this waste is stored on site, either in containment pools or dry casks.
Land Use	Land is required for plant sites and permanent waste disposal. Accidental radioactive releases, though unlikely, could have substantial effects on the natural environment.[116]
Water Withdrawal	Depending upon the plant type, electricity generation from nuclear power requires withdrawals of between zero and 17,590 gallons per million Btu of heat produced.[117]
Water Consumption	Depending upon the plant type, nuclear energy requires between zero and 211 gallons of water for each million Btu of heat energy produced.[118]
Water Quality	Water is required for plant cooling. When discharged, this water is heated and can contain pollutants such as heavy metals, potentially harming aquatic life and reducing water quality, according to EPA. TCEQ regulates and permits these discharges. Uranium mining potentially could contaminate groundwater and surface water with heavy metals and traces of radioactive materials.[119]
Notes	A permanent U.S. repository for radioactive waste being developed at Yucca Mountain, Nevada will begin accepting spent nuclear fuel no earlier than 2017.

Fuel Characteristics

Energy Content	One uranium pellet weighing 0.24 ounces contains as much energy as almost 1,800 pounds of coal or more than 18 million Btu.[120]
Renewability	Although uranium is technically a non-renewable fuel source, if waste were reprocessed, the availability of nuclear fuel could be extended by hundreds of years.

Other Issues

Dependence on Foreign Suppliers	Canada is the world's largest producer of uranium, supplying 25 percent of the world's supply in 2006, while the U.S. produced only 4 percent.[121]
Price and Supply Risks	The price of uranium oxide has risen 79 percent since 1994, reaching $18.61 per pound in 2006.[122]

Solar Energy

Solar energy has many direct uses, including passive architectural applications such as lighting and thermal comfort provided by the use of proper building materials and orientation, as well as active water and space heating.

Solar photovoltaic (PV) cells and concentrating solar power (CSP) systems can generate electricity on a small or large scale. In addition, PV cells are used in a variety of cost-effective and "off the grid" applications, including calculators, wrist watches, road and railroad warning signs, flashing school zone lights, telecommunication equipment and emergency lighting on offshore oil rigs.

Solar energy is an inexhaustible renewable resource. The sun constantly produces vast amounts of renewable solar energy that can be collected and converted into heat and electricity. Texas is among the states with the most solar energy resources. Several other states, however, lead the nation in terms of *using* solar energy, mostly due to state policies and incentives that encourage the installation of solar energy systems. Texas has the sunshine, manufacturing base and research institutions to become a leader in the development of solar energy. While production costs have dropped since the 1980s, they remain high compared to fossil fuels.

Cost

Per Million Btu	Sunlight has no fuel cost.
Direct Subsidy Share of Total Consumer Spending	Federal: 12.3 percent; State and Local: 9.2 percent.[123]
Notes	Large, central-station electricity generation entails transmission costs, but small-scale passive, thermal and distributed photovoltaic applications do not. Solar energy is still more expensive for bulk energy supply than many other energy sources. In 2006, photovoltaic electricity cost 18 to 23 cents per kWh; electricity produced by CSP systems cost about 12 cents per kWh. The U.S. Department of Energy (DOE) expects improved PV technologies using cheaper materials, higher-efficiency components and advanced manufacturing techniques to reduce the price of PV electricity to between 11 and 18 cents per kWh by 2010. DOE also expects the cost of energy produced by parabolic-trough CSP systems to fall to about 8.5 cents per kWh by 2010.[124]

Economic Impact and Viability

Wages and Jobs	Economic data on the Texas solar energy industry are not available.
Regulatory Climate	Any large-scale CSP installation in Texas would have to obtain a wastewater permit from TCEQ because the most promising large-scale plants use water as a cooling medium. The process usually takes about one year.[125]
Texas Competitive Advantage	The National Renewable Energy Laboratory (NREL) has determined that the nation's most plentiful solar resources are found in the Southwest. California, Nevada, Arizona, New Mexico, Utah, Colorado and Texas possess some of the best "insolation" values in the world, a term referring to the amount of solar radiation striking the planet's surface over a period of time. In addition, solar PV panels that are integrated into buildings and other structures can offer clean power sources to Texas cities that enjoy ample sunlight.[126]

Notes	A study commissioned by Austin Energy, the city's utility, concluded that construction of a 100 MW manufacturing plant in the Austin area could create nearly 300 new jobs and add about $1 billion to the regional economy by 2020.[127] The Solar Energy Industries Association estimates that every megawatt of solar capacity installed in the U.S. supports 32 jobs.[128]

Availability and Current Infrastructure

Estimated Resources in Texas	A mid-1990s study commissioned by the State Energy Conservation Office found that Texas has 250 "quads" (quadrillion Btu) of accessible solar energy available per year.[129]
Current Fuel Production	N/A
Consumption in Texas	No statewide data available.
Notes	Texas has only a small amount of solar electricity generating capacity — about 1.7 MW in 2006 — available to the state's electric grids. This amount likely would increase if net metering — an arrangement that allows owners of PV systems to sell excess power they generate back to the utility — becomes widely available across Texas.

Environment, Health and Safety

Greenhouse Gas Emissions	No significant issues.
Air Pollution (Non-Greenhouse Gas)	No significant issues.
Solid Waste	PV systems do not generate solid waste in creating electricity. Their manufacture generates small amounts of hazardous materials. CSP plants do not produce solid waste when generating electricity.[130]
Land Use	Photovoltaic systems require little land use, because typically they are affixed to existing structures. CSP installations require significant amounts of land.
Water Withdrawal	Solar thermal energy may require cooling water, but most of this water can be recycled.
Water Consumption	Depending on the type of installation, electricity generation from solar power can require between zero and 270 gallons of water per million Btu generated.[131] PV systems and dish-Stirling systems, or glass mirrors in the shape of a dish that reflect sunlight onto a small area, do not require water.
Water Quality	No significant issues.
Notes	Though CSP installations do not damage the land, they require about five to 10 acres per MW.[132]

Fuel Characteristics

Energy Content	Peak energy content of sunlight at ground level is approximately 1,000 watts per square meter, though the amount of solar radiation available at any time and location varies depending on geographic location, time of day, season, local landscape and local weather.[133]
Renewability	Solar power is a renewable resource.

Other Issues

Dependence on Foreign Suppliers	No significant issues.
Price and Supply Risks	Most current PV modules are made of high-purity crystalline silicon, which recently has been in short supply globally, constraining solar cell production and increasing their cost. Solar thermal systems typically use copper for heat exchange surfaces, and copper prices have recently risen considerably. New types of PV cells, however, are less dependent on scarce raw materials.

Wind

Texans traditionally used wind energy to pump well water for cattle, but today wind power increasingly is used for commercial-scale electricity production. During the last decade, wind energy growth rates worldwide exceeded 30 percent annually, driven in part by improved technology and government policies.

In the last three years, the U.S. and Texas wind energy markets have experienced a rapid expansion of capacity. Wind power was the leading source of electricity capacity added in Texas during 2006 and 2007, exceeding additions of all other types of power plants combined.[134]

Wind power is an abundant, widely distributed energy resource that has zero fuel cost, zero emissions and zero water use. Wind's drawbacks are largely related to its variable nature and the fact that the best areas for generating wind energy are often found far from Texas' urban centers. Wind speed and direction can change by the season, day and hour and thus require backup from power plants that can run anytime, such as coal or gas plants. Wind farms in parts of Texas also require hundreds of miles of new transmission lines to carry wind-generated electricity from its source to customers in more populated areas of the state, resulting in significant transmission costs. Wind energy has high up front capital costs that currently make it dependent on federal subsidies.

Cost

Per Million Btu	Wind has no fuel cost.
Direct Subsidy Share of Total Consumer Spending	Federal: 11.6 percent; State and Local: 0.2 percent.[135]
Notes	Transmission costs may be higher for wind than for other fuels since wind resources typically are located far from major cities. The subsidy share of total spending may increase in coming years as school district property tax appraised value limitations under Tax Code, Chapter 313, become fully vested.

Economic Impact and Viability

Wages and Jobs	Economic data on the Texas wind energy industry are not available. The National Renewable Energy Laboratory estimates that six to ten permanent operations and maintenance jobs are created for every 100 MW of installed wind capacity. One hundred MW of installed wind capacity also creates about 100 to 200 short-term construction jobs.[136]
Regulatory Climate	In Texas, the siting of wind and other types of power plants is unregulated by state and county governments. Wind plants must adhere to city zoning ordinances and obtain any applicable state permits regarding air, water or wastewater. Federal involvement is limited, although wind turbines are subject to Federal Aviation Administration requirements and are discouraged from locating where they could adversely affect air traffic or radar systems.
Texas Competitive Advantage	Texas has led the U.S. in wind power installations for three consecutive years due to its exceptional wind sites, attractive market structure and business-friendly regulatory environment. The Pacific Northwest Laboratory, a federal research center, has ranked Texas second among states in wind potential.
Notes	As with other energy projects, wind projects can strengthen rural economic development by bringing economic activity to areas of the state with few other industries.

Availability and Current Infrastructure

Estimated Resources in Texas	A mid-1990s study commissioned by the State Energy Conservation Office found that Texas has enough wind power potential to generate a total of 524,800 MW.[137] This estimate assumes that wind turbines spaced 10 blade diameters apart cover all windy areas of the state and are operating at maximum capacity. Since wind is variable, actual generation would be substantially less than this amount. Utility-scale wind turbines typically operate with a capacity factor ranging from 25 to 40 percent, though they may exceed these amounts during windy months and decline during the peak summer months. The state's largest power grid (ERCOT) currently has 68,793 MW of generating capacity.[138]
Current Fuel Production	N/A
Consumption in Texas	The Electric Reliability Council of Texas (ERCOT), which manages the state's largest power grid, reports that wind energy accounted for 2.9 percent of the electricity generated in its region in 2007.[139] However, due to the variable and seasonal nature of wind energy as well as seasonal fluctuations in demand for energy, the proportion of energy from wind tends to vary month-to-month. For example, in 2007 wind accounted for 1.4 percent of electricity generated in July and 4.3 percent in December. Wind accounted for 4.5 percent of the electricity generated in ERCOT in January 2008, compared with 1.9 percent the previous January.[140]
Notes	Given the variable nature of wind, other power plant capacity is required to provide electricity when wind resources are not available.

Environment, Health and Safety

Greenhouse Gas Emissions	None.
Air Pollution (Non-Greenhouse Gas)	None.
Solid Waste	No significant issues.
Land Use	Wind farms may extend over thousands of acres, but the wind turbines themselves occupy only a small percentage of the land, allowing farmers and ranchers to use the land for other activities.[141] Transmission lines for wind-generated electricity often cross the property of many landowners. Property owners leasing land for wind turbine development receive a steady income, while landowners with transmission towers and lines passing through their land receive only a one-time payment.
Water Withdrawal	No significant issues.
Water Consumption	No significant issues.
Water Quality	No significant issues.
Notes	Turbines may interfere with wildlife migration and cause bird and bat mortality.[142]

Fuel Characteristics

Energy Content	Variable — depends on location, weather conditions and time of day.
Renewability	Wind energy is a renewable resource.

Other Issues

Dependence on Foreign Suppliers	No significant issues.
Price and Supply Risks	Prices are intrinsically less volatile than other sources of energy that depend on purchased fuel, but higher upfront capital costs mean that this energy source depends upon government subsidies to remain affordable for consumers.

Ethanol

Ethanol is made from feedstock crops such as corn, barley and sugarcane that contain significant amounts of sugar or materials that can be converted into sugar, such as starch. About 90 percent of ethanol in the U.S. is made from corn.[143] Ethanol is blended with gasoline to fuel vehicles. E10 is 10 percent ethanol and 90 percent gasoline and can run in all gasoline engine vehicles sold in the U.S.; E85 is 85 percent ethanol and 15 percent gasoline and can be used only by special "flex-fuel" vehicles. Ethanol also is used as an additive, replacing natural gas-derived MTBE, a fuel oxygenate.

Cellulosic ethanol, by contrast, can be produced from a variety of plant matter, including wheat straw, corn stalks, energy cane, sawdust, rice hulls, paper pulp, wood chips, miscanthus grass and switchgrass. Cellulosic biomass crops require less energy, fertilizer, pesticides and herbicides to grow.[144] Scientists are working to make the cellulosic process more economical for commercial production.

Federal subsidies and mandates have resulted in the expansion of ethanol production. As a result, an increasing percentage of the U.S. corn crop goes to ethanol, contributing to increased feed costs for poultry and livestock feeders.

Cost

Per Million Btu	Data comparable to other fuel sources not available.
Per Gallon	$2.51 (E85, January 2008)[145]
Per Gallon of Gasoline Equivalent	$3.55 (E85, January 2008)[146]
Direct Subsidy Share of Total Consumer Spending	Federal: 26.5 percent; State and Local: none.[147]
Notes	The use of ethanol entails costs for transportation by truck, rail or water.

Economic Impact and Viability

Wages and Jobs	Texas has two operational ethanol plants at this writing, and another two are under construction. The largest of the operational facilities employs 40 people and expects to have an annual local economic impact of $100 million. There are also jobs associated with the construction of new plants and the research and development of cellulosic ethanol.
Regulatory Climate	Ethanol plants must obtain air and wastewater permits from TCEQ, a process that requires an average of about one year.[148]
Texas Competitive Advantage	Technological advances in cellulosic ethanol could confer an economic advantage to Texas, as the state's climate is amenable to growing many potential sources of cellulosic ethanol, such as sorghum, energy cane and switchgrass.
Notes	Since Texas has an ample supply of plant matter that could be used to produce cellulosic ethanol, emerging technologies could result in significant economic impact for Texas if they prove viable.

Availability and Current Infrastructure

Estimated Resources in Texas	Texas is a "grain deficit" state, in that it is a net importer of grain. Therefore, ethanol production in sufficient quantities could prove impractical and could negatively affect animal agriculture.[149]

Current Fuel Production	Currently there are 140 million gallons per year of installed capacity in Texas; 6.5 billion gallons were produced in the U.S. in 2007.[150]
Consumption in Texas	In 2005, Texans used 29 million gallons, or 2.4 trillion Btu, of ethanol as a transportation fuel.[151]
Number of Fueling Stations in Texas	Texas has 26 E85 public fueling stations.[152]
Vehicle Availability	415,207 flex-fuel vehicles in Texas can run on E85.[153]
Notes	The two operating ethanol plants and the two under construction are expected to have a combined refining capacity of 355 million gallons per year.[154]

Environment, Health and Safety

Greenhouse Gas Emissions	Although ethanol releases carbon dioxide when combusted, these emissions are considered part of the earth's natural carbon cycle and represent no net increase in CO_2.
Air Pollution (Non-Greenhouse Gas)	Ethanol combustion emits nitrogen oxides, although the use of ethanol reduces NO_X emissions when used with gasoline. Volatile organic compounds (VOCs) also may be emitted from ethanol plants.
Solid Waste	No significant issues.
Land Use	Land is needed to grow ethanol crops and for refinery sites.
Water Withdrawal	Beyond the water consumed by ethanol production (see below), no additional water withdrawals are required.
Water Consumption	Depending upon climate conditions, corn-based ethanol requires between 2,500 and 29,000 gallons of water per million Btu of energy produced, primarily for crop irrigation. On average, 784.6 gallons of water are needed to irrigate enough corn to produce one gallon of ethanol.[155] In 2002, water use at ethanol plants averaged 4.7 gallons per gallon of ethanol produced.[156]
Water Quality	Depending on production practices, uncontrolled crop runoff may contain pollution from pesticides and fertilizers. Appropriate conservation practices can significantly reduce these effects.
Notes	According to two 2008 studies in the journal *Science*, some biofuels may contribute more to greenhouse gas emissions than conventional fuels if the full consequences of the conversion of existing rainforests and other lands to cropland is taken into account. These studies suggest that a shift to biofuels derived from agricultural waste, sugar cane or other feedstocks may be necessary to prevent the increase in carbon that occurs during the conversion of natural ecosystems to cropland.[157]

Fuel Characteristics

Energy Content	E85 has an energy content of 81,800 Btu per gallon.[158]
Renewability	Ethanol is a renewable resource.

Other Issues

Dependence on Foreign Suppliers	Use of ethanol can reduce gasoline use and thus, may reduce dependence on foreign oil. In 2007, 6 percent of U.S. ethanol demand was met by foreign imports, mostly from Brazil.
Price and Supply Risks	The price of ethanol is highly dependent on the price of corn, which has been volatile in recent years. The increased demand for corn for ethanol has affected the livestock industry, by increasing feed prices and reducing livestock feed supplies. Demand for ethanol and biodiesel crops has contributed to rising prices for food commodities.

Biodiesel

Biodiesel, an alternative transportation fuel made from animal or vegetable materials that has been used in motor vehicles since the beginning of the automobile industry, can be substituted for petroleum-based diesel (petrodiesel) fuel. Vehicles using biodiesel emit fewer pollutants than petrodiesel, although they also generally get fewer miles per gallon.

Retail biodiesel is described by the percent of biodiesel blended with petrodiesel. For example, "B20" is a 20 percent blend.

Texas is the nation's leading producer of biodiesel and, as such, it is well positioned to benefit from any expansion in its use. Because of the high price of soybean oil, the raw material most often used to produce biodiesel, and resulting high production costs, most Texas biodiesel is currently exported to Europe, where it is price competitive.

Cost

Per Million Btu	Data comparable to other fuel sources not available.
Per Gallon (motor vehicle fuel)	$3.37 (B20, January 2008)[159]
Per Gallon of Gasoline Equivalent	$3.08 (B20, January 2008); B20 is $3.43 in diesel gallon equivalents.[160]
Direct Subsidy Share of Total Consumer Spending	Federal: 9.9 percent; State and Local: 3.1 percent.[161]
Notes	Very sharp increases in the price of feedstocks (primarily soybean oil, which doubled from October 2006 to January 2008) have resulted in higher costs for biodiesel producers. Petrodiesel prices have risen, but not enough to make biodiesel price competitive.[162] Each gallon of biodiesel requires approximately 7.35 pounds of soybean oil, each of which requires slightly more than one pound of soybeans to produce.[163] Given the current high price of soybeans, it is not currently possible to produce and sell biodiesel on a competitive price basis in Texas, even with subsidies.[164] As noted, most Texas biodiesel is exported.

Economic Impact and Viability

Wages and Jobs	Economic data on the biodiesel industry in Texas are not available. Texas has 22 commercial biodiesel plants and 12 more under construction. Jobs associated with biodiesel are related to its production and distribution and the construction or expansion of biodiesel plants.[165]
Regulatory Climate	Biodiesel plants must obtain air and wastewater permits from TCEQ, a process that requires an average of about one year.[166]
Texas Competitive Advantage	Texas has a concentrated and advanced fuels industry. It has some biodiesel feedstocks but no significant soybean oil production.
Notes	In 2007, Texas produced 3 million bushels of soybeans, or a little more than one-tenth of one percent of the U.S. total of 2.59 billion bushels.[167]

Availability and Current Infrastructure

Estimated Resources in Texas	Vegetable oils and animal fat for biodiesel are available from Texas sources, though Texas biodiesel refiners currently import soybean oil because the state has no soybean crushing plants.

Current Fuel Production	In 2007, Texas made 72.9 million gallons of biodiesel, or approximately 9 trillion Btu.[168]
Consumption in Texas	Texas drivers consumed less biodiesel in 2007 than in 2006. The high cost of the fuel and rising costs of feedstock affected sales across the state. Actual consumption numbers are not available.[169]
Number of Fueling Stations in Texas	Texas has 51 retail fueling stations offering biodiesel blends.[170]
Vehicle Availability	All diesel-engine vehicles are capable of running with B20. As of 2006, 528,705 diesel vehicles were registered in Texas, and most farm and industrial vehicles run on diesel as well.[171]
Notes	Texas' current biodiesel production capacity is more than 100 million gallons annually, with another 87 million gallons of capacity under construction.[172]

Environment, Health and Safety

Greenhouse Gas Emissions	Although biodiesel releases carbon dioxide when burned, these emissions are considered part of the earth's natural carbon cycle and represent no net increase in CO_2.
Air Pollution (Non-Greenhouse Gas)	Biodiesel combustion emits nitrogen oxides. Experts have disputed whether NO_X emissions from biodiesel are greater or less than those from fossil fuels, but recent studies by the National Renewable Energy Laboratory concluded that B20 has no net impact on NO_X emissions.[173]
Solid Waste	No significant issues.
Land Use	Agricultural land is needed to grow biodiesel crops. Land is also required for refinery sites.
Water Withdrawal	Beyond the water consumed by biodiesel production, no additional water withdrawals are required.
Water Consumption	Depending upon climate conditions, soy-based biodiesel requires between 14,000 and 75,000 gallons of water per million Btu of energy produced, primarily for crop irrigation.[174] Water use at biodiesel plants is negligible.
Water Quality	Uncontrolled feedstock crop runoff can contain pollution from pesticides and fertilizers. Appropriate conservation practices can significantly reduce these effects.
Notes	According to two 2008 studies in the journal *Science*, some biofuels may contribute more to greenhouse gas emissions than conventional fuels if the full consequences of the conversion of existing rainforests and other lands to cropland is taken into account. These studies suggest that a shift to biofuels derived from agricultural waste, sugar cane or other feedstocks may be necessary to prevent the increase in carbon that occurs during the conversion of natural ecosystems to cropland.[175]

Fuel Characteristics

Energy Content	B20 has an energy content of 126,800 Btu per gallon.[176]
Renewability	Biodiesel is a renewable resource.

Other Issues

Dependence on Foreign Suppliers	No significant issues.
Price and Supply Risks	The price of biodiesel depends primarily on the price of the feedstock used to make it. Soybean oil prices have been rising since 2005. It takes 7.35 pounds of soybean oil to produce a single gallon of biodiesel. As a result of soybean oil price increases, the cost of feedstocks alone has reached over $4 per gallon.[177]

Wood

Wood is an excellent source of energy. It can be used to create biofuels, burned directly, turned into a synthetic gas or pyrolyzed (turned into a liquid) to create electricity. Wood biomass is used to produce electricity for the grid in various places throughout the U.S. At present, Texas has no operating wood-to-electricity facilities, but two are being developed. Some Texas mills and pulp and paper plants burn their wood waste to generate heat and electricity for their own use.

Potential fuel sources for wood-fired power plants include mill residues, sawdust, wood trimmings and construction debris. East Texas, home to much of the state's lumber industry, has a particularly large resource base. In 2005, East Texas wood products companies produced 9.5 million tons of logging and mill residues.[178]

Cost

Per Million Btu (2005)	$0.82 for electricity (wood and waste biomass);[179] $3.30 for direct use (wood and waste)[180]
Direct Subsidy Share of Total Consumer Spending	Federal: 0.4 percent (wood and waste biomass); State and Local: none.[181]
Notes	The use of wood waste entails costs for transportation by truck, rail or water. Using wood for electricity generation entails transmission costs. Electricity generation facilities using wood waste must be within about 50 miles of the fuel source to be economically feasible.[182]

Economic Impact and Viability

Wages and Jobs	There are no wood-fired power plants in Texas, although some projects are being developed.
Regulatory Climate	Wood-fired power plants must obtain air and wastewater permits from TCEQ, a process that requires an average of about two years to complete.[183]
Texas Competitive Advantage	East Texas would have a competitive advantage in this area due to its large potential fuel supply.
Notes	One NREL study found that 4.9 jobs are created for every additional MW of renewable energy capacity; Texas has an estimated potential wood biomass capacity of 4,600 MW, potentially equating to more than 22,000 Texas jobs.[184]

Availability and Current Infrastructure

Estimated Resources in Texas	East Texas has an estimated 3.1 million "green tons" (tons before drying) of logging residue that could be used to produce electricity, enough to power about 300,000 homes.[185]
Current Fuel Production	In 2005, East Texas produced 9.5 million tons of logging and mill residue that contained 106 trillion Btu of potential energy.[186]
Consumption in Texas	No electricity is being put on the grid in Texas from this source, although some is produced and consumed on site at mills and pulp and paper facilities. The U.S. consumed about 2,114 trillion Btu from wood in 2006.[187]
Notes	Wood waste is used to heat and provide electricity to some industrial facilities, but no data on total capacity are available.

Environment, Health and Safety

Greenhouse Gas Emissions	Although wood releases carbon dioxide when burned, these emissions are considered part of the earth's natural carbon cycle and represent no net increase in CO_2.
Air Pollution (Non-Greenhouse Gas)	Wood biomass combustion also releases nitrogen oxides and some SO_2, but these emissions are significantly lower than those from fossil fuels.
Solid Waste	The use of wood biomass can reduce the absolute volume of waste generated by the forest products industry. Combustion produces ash that typically includes only very low levels of hazardous elements.
Land Use	Biomass grown for fuel purposes can require large land areas and can contribute to soil erosion and soil nutrient depletion. Land is also required for plant sites.[188]
Water Withdrawal	Depending upon the plant type, electricity generation from wood biomass requires withdrawals of between nine and 14,658 gallons per million Btu of heat produced.[189]
Water Consumption	Electricity generation from wood biomass requires between zero and 150 gallons per million Btu produced.[190]
Water Quality	Plant discharge is heated and contains pollutants, potentially harming aquatic life and reducing water quality. TCEQ regulates and permits these discharges. Biomass crop runoff can contain pollution from pesticides and fertilizers. Appropriate conservation practices can significantly reduce these effects.
Notes	Increased truck traffic due to the delivery of wood waste to power plants could cause wear to local roads and increase pollution. Although impractical, harvesting all available logging residues to produce electricity could require foresters to fertilize land for new plantings.[191]

Fuel Characteristics

Energy Content	The energy content of wood depends upon its moisture content. Fresh-cut wood typically has a moisture content of about 30 percent and an energy yield of about 5,950 Btu per pound.[192]
Renewability	Wood biomass is a renewable resource.

Other Issues

Dependence on F oreign Suppliers	No significant issues.
Price and Supply Risks	Wood waste could not replace fossil fuels, but is a good source of energy in localized markets.

Feedlot Waste

Growing environmental concerns, coupled with higher energy prices, have led to a renewed interest in using animal manure to produce power. This can be accomplished either by burning manure directly for fuel, gasifying it with heat or by turning it into "biogas" through biological decomposition. Each of these methods disposes of massive accumulations of manure while mitigating its potentially negative environmental effects.

Manure-based power plants can boost rural economic development and provide dairy producers and beef cattle feedlot operators with another source of revenue, or at least cut their disposal costs.[193]

Texas is the nation's leading cattle state and has significant potential resources for the use of manure to create energy. Thus far, however, such uses are relatively rare in the state. Some ethanol plants currently being developed in the Panhandle will use manure as a fuel. Other plants are planned, but the industry is still in its early stages in Texas. In addition, Microgy's Huckabay Ridge Plant near Stephenville converts dairy manure into gas for sale to the Lower Colorado River Authority, which uses it for electricity generation.

Cost

Per Million Btu (2005)	$0.82 for electricity (wood and waste biomass).[194]
Direct Subsidy Share of Total Consumer Spending	Federal: 0.4 percent (wood and waste biomass); State and Local: none.[195]
Notes	The transportation of animal manure by truck, rail or water entails costs. Electricity generated from manure would involve transmission costs.

Economic Impact and Viability

Wages and Jobs	No estimate of the economic impact of turning manure into energy is available; at present, its effects are small compared to fossil fuels and other renewables. A Huckabay Ridge plant that turns dairy waste and restaurant grease into natural gas supports seven full-time jobs. An ethanol plant under construction in Hereford will use manure for fuel and have 61 employees.[196]
Regulatory Climate	Manure-to-energy plants are required to obtain air and wastewater permits from TCEQ, a process that usually takes about one year.[197]
Texas Competitive Advantage	Substantial supplies of manure, concentrated in areas with major feedlot and dairy operations such as the Texas Panhandle, might make it economically feasible to produce energy from this fuel source.
Notes	Using manure for energy can help cattle feeders with environmental compliance issues. It may have other positive economic results for animal feeders including the prospect of electricity sales, providing electricity or gas for farm use, or lower disposal costs.

Availability and Current Infrastructure

Estimated Resources in Texas	Texas, as a livestock-producing state, has access to large amounts of animal waste that could be used to generate electricity. A study by the Houston Advanced Research Center estimates that Texas beef and dairy cattle manure could produce 107.1 MW of electricity, enough to power 67,366 homes.[198]

Current Fuel Production	The Huckabay Ridge plant expects to produce one billion cubic feet of natural gas per year, or about 650,000 million Btu, enough energy for 10,000 homes.[199]
Consumption in Texas	Minimal for energy production.
Notes	The plant at Huckabay Ridge is producing gas from dairy manure that is in turn used to generate electricity. Similar plants are in the planning stages.

Environment, Health and Safety

Greenhouse Gas Emissions	Although feedlot biomass releases carbon dioxide when burned, these emissions are considered part of the earth's natural carbon cycle and represent no net increase in CO_2. Using animal manure for energy production also reduces methane emissions that would occur from natural decomposition.[200]
Air Pollution (Non-Greenhouse Gas)	Although feedlot biomass produces some NO_X and SO_2 when burned, these emissions are significantly lower than those from fossil fuels.[201]
Solid Waste	Using animal manure for energy production can reduce the absolute volume of waste.[202]
Land Use	Land is required for plant sites. Combustion of feedlot biomass can reduce the area of land needed for waste disposal.
Water Withdrawal	Depending upon the plant type, electricity generation from feedlot biomass requires withdrawals of between zero and 14,658 gallons per million Btu of heat produced.[203]
Water Consumption	Requires between zero and 150 gallons per million Btu of energy generated.[204]
Water Quality	Plant discharge is heated and contains pollutants, potentially harming aquatic life and reducing water quality. TCEQ regulates and permits these discharges.[205]
Notes	Combustion of feedlot biomass can reduce the area of land needed for waste disposal.[206]

Fuel Characteristics

Energy Content	8,500 Btu produced per pound of dry, ash-free poultry and livestock manure. The heat value decreases with increasing moisture and noncombustible ash content.[207]
Renewability	Feedlot biomass is a renewable resource.

Other Issues

Dependence on Foreign Suppliers	No significant issues.
Price and Supply Risks	Supply is abundant but dispersed, entailing some costs related to transportation and processing.

Landfill Gas

Methane makes up about 50 percent of the gases emitted by landfills. Created by natural decomposition, landfill gas has about half the energy potential of natural gas. Landfill methane can generate electricity, fire boilers or otherwise substitute for other energy sources.

To operate under federal regulations, landfills must monitor their methane production or collect and burn it to prevent air pollution. Therefore, using landfill methane to generate electricity, fire boilers or substitute for other energy sources can turn a potential liability into a benefit.[208]

According to a U.S. Environmental Protection Agency (EPA) landfill database, Texas has 24 landfill gas energy projects, most of which began after 2000. All but two of these are generating electricity, with a total collective capacity of 79 megawatts.[209]

Cost

Per Million Btu (2005)	$0.82 for electricity (wood and waste biomass).[210]
Direct Subsidy Share of Total Consumer Spending	Federal: 0.4 percent (wood and waste biomass); State and Local: none.[211]
Notes	The use of landfill gas for electricity generation may entail transmission costs if it is transported to offsite locations.

Economic Impact and Viability

Wages and Jobs	Economic data on the Texas landfill gas industry are not available.
Regulatory Climate	Landfill gas facilities must obtain air and wastewater permits from TCEQ, a process that usually takes about one year.[212]
Texas Competitive Advantage	Texas has relatively good potential for exploiting this resource.
Notes	Texas is a relative newcomer to using landfill gas for energy. With 187 operating landfills and at least 57 sites that could be used to develop landfill gas, the state has the potential to turn much more of its waste into energy.[213]

Availability and Current Infrastructure

Estimated Resources in Texas	Texas has at least 24 ongoing landfill gas energy projects.[214] TCEQ estimates that 59 Texas landfills are good candidates for energy projects.[215] EPA's landfill database, however, indicates that Texas has 57 sites that could be developed.[216] Under either estimate, Texas has significant potential for using this energy source.
Current Fuel Production	Texans threw away 30.5 million tons of garbage in fiscal 2006.[217]
Consumption in Texas	No data available.
Notes	The total generating capacity of Texas' existing landfill gas energy projects is an estimated 74 MW.[218]

Environment, Health and Safety

Greenhouse Gas Emissions	Although landfill gas releases carbon dioxide when burned, these emissions are considered part of the earth's current carbon cycle and represent no net increase in CO_2.[219]
Air Pollution (Non-Greenhouse Gas)	Burning landfill gas produces NO_X, although the amount released depends on the composition of the waste from which the gas is produced, as well as other factors. The combustion of landfill gas also can release trace elements of some toxic chemicals, again depending upon the composition of the waste as well as the temperature of the flame.[220]
Solid Waste	The production of landfill gas itself does not produce solid waste; however, it takes advantage of solid waste sites.
Land Use	Landfill gas is produced on existing landfills.
Water Withdrawal	No significant issues.
Water Consumption	No significant issues.
Water Quality	While landfills, if not managed properly, may negatively affect water quality, the production of landfill gas does not.
Notes	Burning landfill gas to produce electricity can reduce methane emissions from landfills.

Fuel Characteristics

Energy Content	Landfill gas has about half the energy potential of natural gas, which contains 1,031 Btu per cubic foot.[221]
Renewability	Landfill gas is a renewable resource.

Other Issues

Dependence on Foreign Suppliers	None.
Price and Supply Risks	None.

Municipal Solid Waste

Some cities, primarily in the eastern U.S., burn part of their municipal solid waste. Hemmed in by major population centers, landfill space there is limited, so burning waste to reduce its volume and weight is practical. Combustion reduces the volume of material by about 90 percent and its weight by 75 percent.[222] But the heat generated by burning wastes has other uses, such as being used directly for heating, to produce steam or to generate electricity.

Texas had one permitted waste-to-energy facility in 2006.[223] This facility, in Carthage, does not produce electricity. At this time, the Sharps Environmental Service Solid Waste Incineration Facility has the capability of producing steam for sale, but it is currently operating the facility only as an incinerator. In another part of the state, Dyess Air Force base has an agreement with two energy contractors to build a waste-to-energy facility that will turn waste from Abilene into energy for the base.[224]

The primary advantage of waste-to-energy plants is that they consume wastes from highly populated urban areas that otherwise would be put in landfills. The electricity the plants generate, however, is more costly than energy produced by coal, nuclear or hydropower plants.[225] Furthermore, burning solid waste can release harmful emissions into the air.[226]

Cost

Per Million Btu (2005)	$0.82 for electricity (wood and waste biomass).[227]
Direct Subsidy Share of Total Consumer Spending	Federal: 0.4 percent (wood and waste biomass); State and Local: none.[228]
Notes	The transportation of solid waste by truck, rail or water entails additional expense; electricity generation from solid waste entails transmission costs.

Economic Impact and Viability

Wages and Jobs	Economic data on the municipal solid waste combustion industry in Texas are not available.
Regulatory Climate	Municipal solid waste facilities must obtain air and wastewater permits from TCEQ, a process that usually takes about one year.[229]
Texas Competitive Advantage	Texas has an abundance of raw material available, but the construction costs of waste-to-energy plants are high.
Notes	The cost of waste-to-energy facilities is much greater than the cost of landfills — if the latter are available.[230]

Availability and Current Infrastructure

Estimated Resources in Texas	Texas has just one waste-to-energy plant. Yet Texans threw away 30.5 million tons of garbage in 2006, and most of this waste was deposited in one of the state's 187 operating landfills.[231]
Current Fuel Production	Texans threw away 30.5 million tons of garbage in fiscal 2006.
Consumption in Texas	No data available.
Notes	Texas has one plant that is capable of producing steam for sale.

Environment, Health and Safety

Greenhouse Gas Emissions	Burning solid waste produces an average of 876 pounds of CO_2 per million Btu of heat energy produced.[232]
Air Pollution (Non-Greenhouse Gas)	Burning solid waste produces 1.6 pounds of NO_X and 0.23 pounds of SO_2 per million Btu of heat energy produced, as well as dioxins, furans and trace amounts of mercury.[233]
Solid Waste	Burning municipal solid waste reduces its volume, but may produce a hazardous ash byproduct that must be disposed of safely.[234]
Land Use	Power plants that burn municipal solid waste require land for their sites. Any hazardous ash byproduct requires land for disposal.[235]
Water Withdrawal	Depending upon the plant type, electricity generation from municipal solid waste requires withdrawals of between zero and 14,658 gallons per million Btu of heat produced.[236]
Water Consumption	Electricity production from the combustion of municipal solid waste requires between zero and 150 gallons of water per million Btu of heat energy produced.[237]
Water Quality	Water is required for boilers and for plant cooling. When discharged, this water is heated and contains some pollutants, potentially harming aquatic life and reducing water quality. TCEQ regulates and permits these discharges.[238]

Fuel Characteristics

Energy Content	Variable, depending on the waste contents and moisture content.
Renewability	Municipal solid waste is considered to be a renewable resource.

Other Issues

Dependence on Foreign Suppliers	No significant issues.
Price and Supply Risks	Generation of electricity or steam is dependent on having a steady, reliable supply of waste to burn. Down-time either from the lack of waste or mechanical issues would interrupt the supply of energy.

Hydropower

Most American hydroelectric power is generated through the force of falling water, by damming a stream or river to raise its water level and then allowing the water to fall against a turbine connected to a generator.

Texas has produced hydropower for more than 70 years.[239] It still contributes to the state's overall electricity supply, although in very limited amounts. While hydropower is the most common source of renewable electricity in the U.S., it provides just 11 percent of Texas' renewably generated electricity.

The terrain in Texas is not well-suited to large hydroelectric projects that use swift rivers in locations with steep drops. Although the state has some limited potential for additional hydropower, there are no current plans to develop it. The importance of surface water resources for water supplies is what drives plans for new reservoirs in Texas, not the need for additional electricity.

Dams and reservoirs are expensive to build. The cost of the proposed Marvin Nichols reservoir in northeast Texas, for example, has been estimated at $2.2 billion, with no power plant included.[240] And water dammed for use in city water systems is unlikely to be released for other purposes, even to generate low-cost electricity.

Cost

Per Million Btu	No cost as an input for generating electricity.
Direct Subsidy Share of Total Consumer Spending	Federal: 0.5 percent; State and Local: none.[241]
Notes	Electricity generation from hydroelectric power entails transmission costs.

Economic Impact and Viability

Wages and Jobs	Economic data on the Texas hydroelectric power industry are not available. Today's hydroelectric dams are managed, monitored and operated with computers, often from a distant location. Few employees are required for their maintenance. Dam building creates jobs, but new dams currently planned in Texas probably will have no hydroelectric capacity. In all, hydroelectricity has a very limited impact on jobs and wages.
Regulatory Climate	Hydroelectric generation is a mature technology with an established regulatory structure that includes dam safety standards. These facilities must obtain wastewater permits from TCEQ, a process that generally requires about one year.[242] Building a new reservoir, however, is a lengthy process that can entail several years of planning, permitting, land acquisition and construction.
Texas Competitive Advantage	Texas has few sites offering good conditions for hydroelectric dams, and most of these are already developed. Water management is taking precedence in the use of and planning for water resources.
Notes	Hydropower can come online quickly in response to peak demand, provided water is available to be released from the reservoir. This makes hydroelectricity particularly valuable because it can be obtained almost instantaneously, and much less expensively than would be the case if utilities had to fire up additional fossil fuel plants to meet peak loads.

Availability and Current Infrastructure

Estimated Resources in Texas	Little beyond current generating capacity.
Current Fuel Production	N/A
Consumption in Texas	661,971 megawatt-hours or 2.3 trillion Btu (2006)[243]
Notes	Texas' current hydropower generating capacity is 673 MW.[244]

Environment, Health and Safety

Greenhouse Gas Emissions	Hydroelectric power generates some greenhouse gases, primarily methane from decaying vegetation. The release of methane and CO_2 is enhanced when water passes through turbines. The amount of greenhouse gases from hydropower varies and is not currently measured.[245]
Air Pollution (Non-Greenhouse Gas)	No significant issues.
Solid Waste	No significant issues.
Land Use	Reservoir construction requires the flooding of land. Reservoirs also can lead to erosion and destroy wildlife habitat.[246]
Water Withdrawal	No significant issues.
Water Consumption	Due to the evaporation of the water held in reservoirs, hydroelectric power generation costs an average of 1,319 gallons of water per million Btu generated. Because the water stored in reservoirs usually has multiple purposes, including water supply, flood control and recreation, experts typically do not attribute these evaporative losses exclusively to hydroelectric power.[247]
Water Quality	No significant issues.
Notes	The initial energy input required to build dams is high but hydroelectricity is produced for decades afterwards. Damming rivers and creating reservoirs can harm ecosystems and decrease water flows.[248]

Fuel Characteristics

Energy Content	Variable; kinetic energy is dependent on the volume of water and length of its fall.
Renewability	Hydroelectric power is a renewable resource.

Other Issues

Dependence on Foreign Suppliers	No significant issues.
Price and Supply Risks	Risks include the limited supply of water and the cost associated with using reservoir water for generating electricity, rather than for other purposes, such as irrigation and municipal water supplies.

Ocean Power

Texas does not generate energy from ocean power, and its Gulf of Mexico waters do not produce the ideal conditions needed to convert wave or tidal energy to electricity. The Gulf is generally too shallow and enclosed to produce a good potential for ocean power. There has been speculation about using the "Loop Current," a stream of ocean water running from the Caribbean into the Gulf, but its route is inconsistent and generally does not approach the Texas coast.

Ocean power includes technologies that tap the sea's energy, not only that of crashing waves but also the motion of tides and even the heat stored in the oceans, which are the world's largest solar collectors. Ocean power, then, includes three types: wave power, tidal power and thermal energy conversion. But none of these types of ocean power are well suited for the Gulf of Mexico.

Cost

Per Million Btu	No cost as an input for generating electricity.
Direct Subsidy Share of Total Consumer Spending	N/A
Notes	Electricity generation from ocean energy entails transmission costs.

Economic Impact and Viability

Wages and Jobs	None in Texas.
Regulatory Climate	N/A
Texas Competitive Advantage	None. The Gulf of Mexico is generally too enclosed and shallow to have good potential for ocean energy production.

Availability and Current Infrastructure

Estimated Resources in Texas	None. Texas has no energy generated from ocean power, and its Gulf of Mexico waters do not provide the conditions needed to convert wave or tidal energy to electricity.
Current Fuel Production	N/A
Consumption in Texas	None.

Environment, Health and Safety

Greenhouse Gas Emissions	No significant issues.
Air Pollution (Non-Greenhouse Gas)	No significant issues.
Solid Waste	No significant issues.
Land Use	The use of ocean power to produce electricity can interfere with sea life migration, cause seabed sedimentation and interfere with naval navigation.
Water Withdrawal	No significant issues.
Water Consumption	No significant issues.
Water Quality	No significant issues.

Fuel Characteristics

Energy Content	Variable; depends on tidal flows and currents.
Renewability	Ocean power is a renewable resource.

Other Issues

Dependence on Foreign Suppliers	No significant issues.
Price and Supply Risks	No significant issues. As with the development of all new technologies, there have been and will be failures of prototypes and other such challenges.

Geothermal

Geothermal energy uses the high temperatures found beneath the earth to generate electricity from heated water, as well as for various direct uses (such as hot springs spas, lumber drying or aquaculture). Geothermal heat has some direct uses in Texas, such as in spas and hot-water heating in buildings. Geothermal heat pumps provide energy-efficient cooling and heating to homes and schools in the state. But geothermal energy is not currently being used to generate electricity in Texas.

Geothermal energy, which produces no air emissions other than steam, is the focus of considerable interest and activity in Texas. Exploration of oil and gas fields for geothermal energy could bring new lease income and jobs. Although Texas' geothermal electricity production has been experimental thus far, the energy produced by the heat of the earth's core is essentially inexhaustible, and research into ways to tap that energy is ongoing and accelerating. Both universities and energy companies are assessing the state's geothermal potential.

Cost

Per Million Btu	No cost as an input for direct heat use or generating electricity.
Direct Subsidy Share of Total Consumer Spending	Federal: 0.5 percent; State and Local: 0.24 percent.[249]
Notes	Any future use of geothermal power for electricity generation would entail transmission costs.

Economic Impact and Viability

Wages and Jobs	No economic data on the geothermal energy industry in Texas are available. Texas has no geothermal power plants.
Regulatory Climate	Geothermal power plants would have to obtain a wastewater permit from TCEQ, a process that usually takes about one year.[250]
Texas Competitive Advantage	Texas has hundreds of thousands of oil and gas wells drilled, many in areas with good geothermal energy potential, and large amounts of data regarding those wells. The costs of exploration and drilling are a significant portion of geothermal development, so Texas has a large potential to realize savings in this area, as well as a work force skilled in drilling techniques.
Notes	Heating and air conditioning companies install geothermal heat pump systems (which also involves excavation, drilling and design work, often by separate businesses or subcontractors), and some of their businesses are solely geothermal.

Availability and Current Infrastructure

Estimated Resources in Texas	Estimates of Texas' potential geothermal capacity range from 400 to 10,000 MW; 2,000 MW is thought to be realistic in the near term.[251] Resources for heat pumps are practically unlimited.
Current Fuel Production	None.
Consumption in Texas	None, other than heat pumps and limited direct uses.
Notes	Geothermal generation of electricity, because of new technologies that can take advantage of lower temperature resources and Texas' large number of existing oil and gas wells, has good potential in the state.

Environment, Health and Safety

Greenhouse Gas Emissions	No significant issues.
Air Pollution (Non-Greenhouse Gas)	No significant issues.
Solid Waste	No significant issues.
Land Use	Land would be required for plant sites.[252]
Water Withdrawal	Geothermal electric generation requires withdrawals of 586 gallons of water per million Btu produced.[253]
Water Consumption	Geothermal electric generation requires an average of 410 gallons of water per million Btu produced.[254] According to the Geothermal Energy Association and the power plant company ORMAT, one promising technology, the binary turbine, does not consume water since all of it is reinjected back into the ground. These types of plants are more likely to be used in Texas.
Water Quality	Geothermal electric generation can lead to groundwater contamination during well drilling and water extraction. However, such contamination can be prevented with proper management techniques.[255]
Notes	Geothermal heat pumps are extremely efficient space conditioning systems that can be used to reduce peak electricity demand.

Fuel Characteristics

Energy Content	Depends on the temperature of the geothermal resource.
Renewability	Geothermal energy is generally considered renewable, although a particular site can be depleted of heat or water if it is not reinjected.

Other Issues

Dependence on Foreign Suppliers	No significant issues.
Price and Supply Risks	The price of geothermal electricity would depend upon its production cost and would have to be made competitive with other electricity to be commercially viable.

Hydrogen

The Texas petrochemical industry uses hydrogen to remove sulfur impurities in the oil refining process. It is also used to make fertilizer.

Texas makes no significant use of hydrogen as transportation fuel today. A hydrogen fueling station is being built in Austin with three hydrogen-fueled buses scheduled to operate there in 2008. Large warehouse operators and distribution centers are considering replacing battery-powered forklifts with hydrogen-powered units.

Research and demonstration projects using hydrogen fuel cells are under way at Texas universities, energy companies and scientific laboratories.[256]

Official studies show that hydrogen fuel cell vehicles powered using hydrogen created from natural gas emit less carbon than conventional internal combustion engines after the entire production cycle is taken into account.[257] Fuel cells are more efficient in converting fuel to power than internal combustion engines. They yield almost no pollutants and are quiet.[258] When hydrogen is used in a fuel cell to power an electric vehicle, the emissions include only water and heat. The biggest hurdle to widespread commercial use of hydrogen for power is cost reduction. Durability of fuel cells and the size and weight of storage tanks are barriers to retail hydrogen use.

Cost

Per Million Btu	Data comparable to other fuel sources not available.
Per Gallon (motor vehicle fuel)	Data comparable to other fuel sources not available.
Per Gallon of Gasoline Equivalent	$17.69 (based on a DOE survey with only seven respondents).[259]
Direct Subsidy Share of Total Consumer Spending	N/A
Notes	The cost of hydrogen for large industrial applications is dependent upon the cost of the feedstock. Hydrogen at refineries may be produced for under $2.00 per gallon equivalent. Transportation and storage add costs to a delivered price of hydrogen (up to $30 per gallon of gasoline equivalent). Consequently, on-site hydrogen generation from either water or natural gas is viewed as a more commercially viable choice for transportation fuel applications.

Economic Impact and Viability

Wages and Jobs	Economic data on the hydrogen energy industry in Texas are not available. Hydrogen is not widely used as an alternative fuel today. Economic impact is from federal, state and privately funded hydrogen research and product development activities.
Regulatory Climate	Local safety code officials in Texas generally have more experience with hydrogen than in most parts of the nation. Industrial hydrogen codes are well established, but codes development organizations are currently modifying building, fire, electrical and mechanical codes and standards for emerging "retail" hydrogen applications. This effort is being performed in national forums with help from the U.S. DOE.
Texas Competitive Advantage	Texas has about 1,000 miles of hydrogen pipeline in place and a workforce skilled in handling hydrogen.[260] The state has an extensive production and distribution network for natural gas, the most common feedstock for hydrogen.

Notes	More research is needed to determine whether hydrogen can become economically viable in the U.S. or Texas.

Availability and Current Infrastructure

Estimated Resources in Texas	Hydrogen must be produced from a fossil fuel, biomass or from water using electrolysis.
Current Fuel Production	N/A
Consumption in Texas	Texas consumes only tiny amounts for purposes such as fuel cell demonstration projects.
Number of Fueling Stations in Texas	One permanent hydrogen fueling station is being built in Texas today; a number of temporary fueling sites have been established for vehicle demonstrations in the state.
Vehicle Availability	Commercial buses are available on a custom-order basis. Major auto makers are beginning to distribute hydrogen-fueled vehicles to selected markets in other states such as California and New York on a limited basis. [261] Hydrogen-fueled forklifts are commercially available.
Notes	Hydrogen is very expensive to store and move in useful amounts because it has a very low energy density in terms of volume, and thus large volumes are needed to generate power, necessitating expensive methods to compress or cool the gas for fuel use.

Environment, Health and Safety

Greenhouse Gas Emissions	Production of hydrogen using hydrocarbons produces greenhouse gases, but in lower quantities than with conventional fuels. The use of hydrogen in vehicle applications produces no emissions.
Air Pollution (Non-Greenhouse Gas)	The use of hydrogen produces no significant emissions. Hydrogen production can generate emissions from most production methods, except for 100 percent renewable sources.
Solid Waste	No significant issues.
Land Use	Generally, the storage and production of hydrogen is much cleaner than for conventional fuels as there are no soil or water contamination issues to address. Because hydrogen is not typically stored underground, slightly larger "setbacks" are required for hydrogen stored for transportation applications.
Water Withdrawal	Aside from the water that is consumed in the production of hydrogen, there are no significant issues related to water withdrawal.
Water Consumption	On average, 43 gallons per million Btu generated are required for hydrogen produced through the steam reformation of natural gas.[262] Production of hydrogen from water via electrolysis, by contrast, requires 21 gallons per million Btu, or as much as 100 to 200 gallons per million Btu.[263]
Water Quality	Pure water is needed to produce hydrogen. All current production technologies use commercially available water purification and filtration as part of the hydrogen generation process.

Fuel Characteristics

Energy Content	Between 113,400 (lower heating value) and 134,200 (higher heating value) Btu per kilogram (2.2 pounds).[264]
Renewability	Hydrogen can be produced from renewable, nuclear or fossil fuels.

Other Issues

Dependence on Foreign Suppliers	No significant issues.
Price and Supply Risks	Supply is abundant, but the price to produce and use hydrogen for power purposes is higher than for conventional technologies.

Energy Uses

Energy is used in four distinct sectors: transportation, industry, residential and commercial. The three major types of energy consumed in these sectors are:

- *Direct heat*, the burning of combustible materials to heat buildings, cook food and transform raw materials by melting and combining them to make finished products.
- *Transportation fuel*, used to power vehicles.
- *Electricity*, used to provide heat, power and light to industry, homes and businesses.

Direct Heat

For most of human history, fire was mankind's main source of energy. Today, much of the energy we use comes from what are considered secondary sources; the heat from burning combustible materials is used to generate energy, typically in the form of electricity or transportation fuels.

EXHIBIT 10

Fuels Used for Direct Heat

Fuel Source	Average Fuel Cost per MMBtu (2005)	Percent of Total Spending Subsidized by Government	Annual Resource Availability in Texas (Trillion Btu, 2006)	Average Greenhouse Gas Emissions (CO_2, lbs./MMBtu)	Average Water Consumption (gallons/ MMBtu)	Renewable?
Crude Oil*	$7.36	Federal: 0.5% State & Local: 1.5%	2,303.9 (produced) 9,110.0 (refined)	161.4**	1 to 2,500	no
Natural Gas	$8.08	Federal: 0.5% State & Local: 1.5%	6,487.2 (produced) 4,114.6 (processed)	117.1	less than 5	no
LPG	$12.21	Federal: 0.5% State & Local: 1.5%	304.4	139.0	oil and gas byproduct	no
Coal	$1.54	Federal: 6.9% State & Local: 0.0%	592.1	212.7***	1 to 30	no
Solar	$0.00	Federal: 12.3% State & Local: 9.2%	250,000.0****	0.0	0	yes
Wood Biomass	$3.30	Federal: 0.4% State & Local: 0.0%	105.9****	195.0	0	yes
MSW	$3.30	Federal: 0.4% State & Local: 0.0%	57.1	199.9	0	yes
Geothermal	$0.00	Federal: 0.5% State & Local: 0.2%	1,000.0	0.0	0	yes

*Distillate, Kerosene, Residual Fuel, Asphalt and Road Oil and Lubricants
**Value for distillate fuels
***Value for subbituminous coal
****These estimates are from the 1995 report *Texas Renewable Energy Resource Assessment*, which is being updated by the State Energy Conservation Office and will be released before the start of the 2009 Texas Legislative Session.
MMBtu – Million British thermal units
Sources: U.S. Energy Information Administration, U.S. Department of Energy, U.S. Census Bureau, Oak Ridge National Lab, Texas Commission on Environmental Quality, Texas State Energy Conservation Office, Texas Forestry Association, Texas Comptroller of Public Accounts.

In 2005, 32.6 quadrillion Btu, or approximately 32.4 percent of all energy used nationwide, could be attributed to the burning of combustible materials to produce heat for direct use. The raw materials burned for direct uses include natural gas, liquefied petroleum gas (LPG), heating oil, kerosene, wood, biomass (waste products) and coal. In addition to these raw materials, geothermal energy, or heat produced from deep within the Earth's crust, also represents direct use.[265]

In 2005, Texans used about 237.4 trillion Btu of direct-use energy to heat homes and another 190.4 trillion Btu to heat commercial buildings.[266]

Between 1980 and 2005, U.S. direct-use energy consumption by the residential sector fell by 7.8 percent and the industrial sector by 4.2 percent; the commercial sector's energy use grew by less than one percent.[267] These reductions were made possible by advances in efficiency, conservation and a gradual shift from direct-use energy to energy provided through electricity. According to the U.S. Energy Information Administration, overall energy demand will increase by 1.1 percent through 2030; direct-use energy in the residential, commercial and industrial sectors is expected to stay flat or slightly decrease.[268]

Exhibit 10 summarizes important data for the fuels that can be used for direct heat.

Transportation

The rapid and dependable transportation of people and materials from place to place is essential to modern American society. Americans have become ever more reliant on gasoline-powered vehicles, both for personal and commercial uses. In 2005, the U.S. accounted for 21.5 percent of the cars and 42.7 percent of the trucks and buses registered worldwide.[269]

In that year, Americans owned nearly 240 million cars and light trucks.[270] Texans owned just over 20 million of these vehicles.[271] In addition, almost 5.2 million commercial vehicles — those weighing more than 10,000 pounds — used American roadways to transport people and goods. And Americans relied on more than 224,000 aircraft, about 53,000 boats and ships and hundreds of thousands of locomotives and railcars to reach places not served by roadways.[272]

Nearly all of these vehicles depend upon oil.

In 2005 (most recent data available for both the U.S. and Texas), Americans used nearly 28.3 quadrillion Btu of fuel to transport people or goods from one place to another (**Exhibit 11**).[273]

Approximately 80.5 percent of all energy devoted to transportation in the U.S. was used on local roadways and highways; the other 19.5 percent

EXHIBIT 11

U.S. and Texas Transportation Fuel Sources, 2005
(In Trillions of Btu)

Fuel Source	U.S. Amount of Fuel Used (Trillion Btu)	Percent	Texas Amount of Fuel Used (Trillion Btu)	Percent
Petroleum Products	27,301.6	96.5%	2,640.9	96.8%
Natural Gas*	626.3	2.2	85.4	3.1
Ethanol**	342.0	1.2	2.4	0.1***
Electricity	25.7	0.1	0.3	
Total	28,295.6	100.0%	2,729	100.0%

*Natural gas used in the transportation sector is consumed in the operation of pipelines, primarily in compressors and gas consumed as vehicle fuel.
**On the original EIA document, ethanol is listed twice: once as blended into motor gasoline and also separately, to display the use of renewable energy by the transportation sector.
***Ethanol and electricity used for transportation in Texas together accounted for 0.1 percent of all transportation fuel used in the state.
Source: U.S. Energy Information Administration.

EXHIBIT 12

U.S. Transportation Energy Use by Mode*
In Trillions of Btu, 2005

Use by Mode	Amount of Btu Used (Trillion Btu)	Percentage of Total
Highway	22,042.7	80.5%
Cars, Light Trucks & Motorcycles	17,275.1	63.1
Medium/Heavy Trucks	4,576.9	16.7
Buses	190.7	0.7
Non-Highway	5,341.9	19.5%
General, Domestic & International Aviation	2,476.6	9.0
Water	1,366.1	5.0
Pipeline	842.4	3.1
Rail	656.8	2.4
Highway & Non-Highway Total	27,384.6	100.0%

*Includes civilian consumption only.
Source: U.S. Department of Energy.

was used for other forms of transportation, including air, water, railroads and other non-road vehicles (**Exhibit 12**).[274] Data on the amount of energy used on transportation modes in Texas were not available.

While mechanized transportation helped build the U.S. into a global industrial power, its evolution has not been without drawbacks. The emissions from fuels used by most vehicles can be harmful to the environment, and the majority of that fuel is produced and controlled by foreign governments.

To attempt to reduce oil use, the federal government has adopted vehicle fuel efficiency standards. U.S. fuel efficiency standards for light duty vehicles, passenger cars and light trucks are currently at 27.5 miles per gallon (MPG), but new legislation requires those standards to be increased to 35 MPG by 2020.[275]

In 2006, nearly all Texas vehicles ran on gasoline, with the remainder being hybrids, flexible-fuel vehicles or vehicles using other alternative fuels.[276] (Hybrids supplement a conventional gasoline engine with power from electric batteries; flexible-fuel vehicles can use multiple fuels to power their engine, such as either regular gasoline or an ethanol-gasoline mix.)

To encourage more Texans to switch to vehicles using alternative fuels, the production and refining of these fuels and the distribution network must continue to expand and improve.

Exhibit 13 summarizes important data for the fuels that can be used for transportation.

EXHIBIT 13

Fuel Sources for Transportation

Fuel Type	Average Cost per Gallon, at the Pump (January 2008)	Average Cost at the Pump, Gallon of Gas Equivalent January 2008	Percent of Total Spending Subsidized by Government	Annual Resource Availability in Texas (Trillion Btu, 2006)	
Motor Gasoline	$2.99	$2.99	Federal: 0.5% State & Local: 1.5%	2,867.4	
Petrodiesel	3.40	3.05	Federal: 0.5% State & Local: 1.5%	1,443.3	
LPG (Propane)	3.12	4.31	Federal: 0.5% State & Local: 1.5%	304.4	
Natural Gas	1.47	1.93	Federal: 0.5% State & Local: 1.5%	6,487.2 (produced) 4,114.6 (processed)	
Ethanol (E85)	2.51	3.55	Federal: 26.5% State & Local: 0.0%	-	
Biodiesel (B20)	3.37	3.08	Federal: 9.9% State & Local: 3.1%	9.2***	
Hydrogen	n/a	17.69*	n/a	n/a	

*Based on a U.S. Department of Energy Survey with seven respondents.
**Because data on diesel fueling stations were not available, the number of gasoline fueling stations was used.
***Fiscal 2007 data.
MMBtu – Million British thermal units
Sources: U.S. Energy Information Administration, U.S. Department of Energy, U.S. Environmental Protection Agency, Texas State Energy Conservation Office, Texas Comptroller of Public Accounts, Texas Department of Transportation, The Texas Almanac, Alliance of Automobile Manufacturers, Conoco Phillips UK, Westart-Calstart Inc., National Association of Fleet Administrators.

	Number of Fueling Stations in Texas	Vehicle Availability	Average Greenhouse Gas Emissions (CO_2, lbs./MMBtu)	Average Water Consumption (Gallons/MMBtu)	Renewable?
	16,500	19,000,000	156.5	1 to 2,500	no
	16,500**	528,705	159.7	1 to 2,500	no
	556	15,031	125.2	oil and gas byproduct	no
	15	4,500	101.7	less than 5	no
	27	415,207	33.1	2,500 to 29,000	yes
	56	528,705	129.2	14,000 to 75,000	yes
	0	n/a	n/a	less than 200	yes

Electricity

Electricity is essential for Texas factories, businesses, homes and recreation. Texas leads the nation in its generation and consumption of electricity.[277]

In 2006, 49 percent of electricity generation in Texas was powered by natural gas, compared with 36.5 percent for coal.

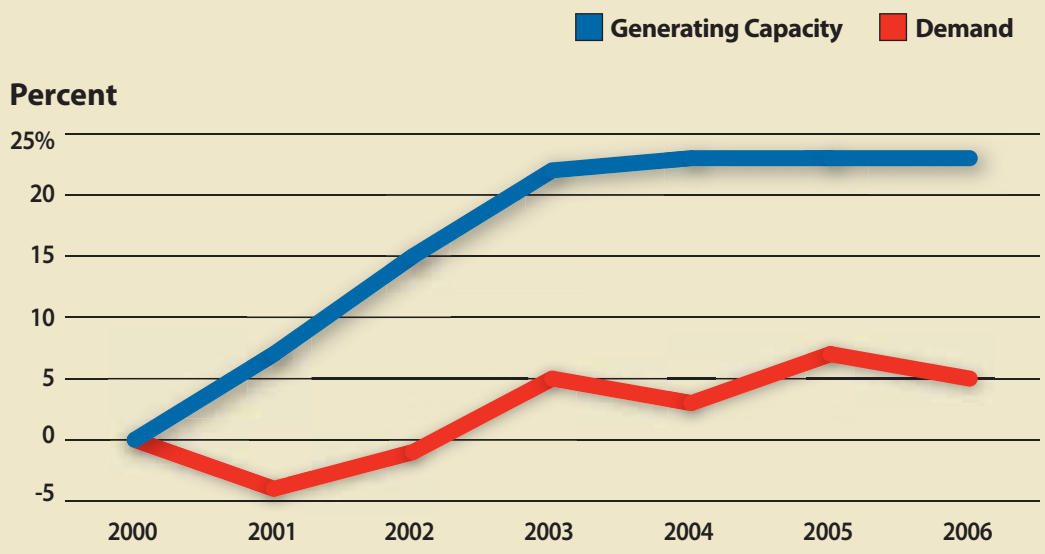
Electricity is a *secondary* energy source, meaning that it comes from the conversion of other sources of energy, such as coal, natural gas, nuclear, hydroelectric and wind power. The energy sources used to make electricity can be renewable or nonrenewable, but electricity itself is neither. It can be considered a *carrier* of energy rather than an energy source.[278]

Texas has approximately 230 electric utilities responsible for delivering electricity to consumers in their service areas.[279] In 2006, their net generation capacity totaled 100,754 megawatts, or 91.9 percent of total "nameplate" capacity (the installed generating capacity running at 100 percent). Net generation capacity has risen by 72 percent since 1995.[280]

Exhibit 14 shows the change in Texas' net generation capacity and demand for the last six years.

EXHIBIT 14

Cumulative Change, Texas Electricity Generating Capacity and Demand, 2000-2006



Sources: U.S. Energy Information Administration, Electric Reliability Council of Texas and Texas Comptroller of Public Accounts.

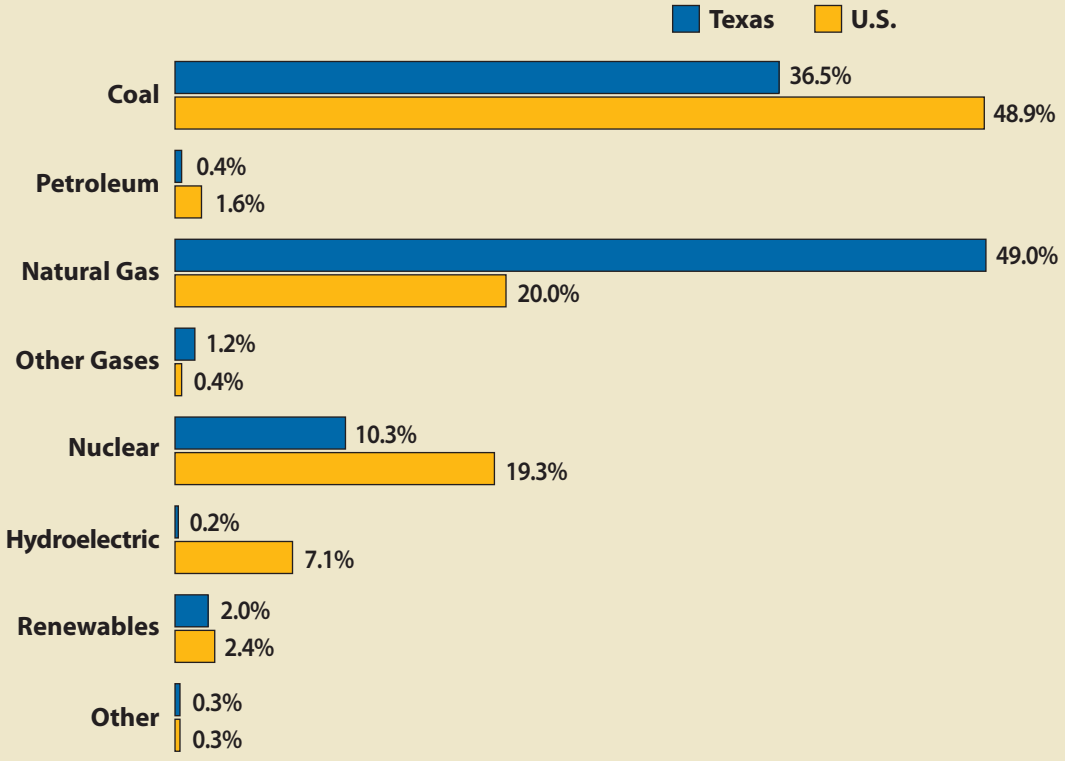
Exhibit 15 shows the relative shares of electricity produced by various fuel sources in Texas and the U.S. in 2006. In 2005, 49 percent of electricity generation in Texas was powered by natural gas, compared with 36.5 percent for coal.[281]

Texas has access to enough energy resources to meet its projected electricity demands through 2030 and beyond. But meeting that demand will require new generation and transmission capacity. ERCOT expects to spend $3.1 billion on transmission lines from 2006 through 2011, and another $3 billion from 2011 through 2016 to ensure adequate transmission capacity.[282] Substantial investments in new generating capacity also will be needed.

Exhibit 16 summarizes important data for the fuels that can be used to generate electricity.

EXHIBIT 15

Percent of Total Electricity Generated by Fuel Source, 2006



Note: Numbers may not total due to rounding.
Source: U.S. Energy Information Administration.

EXHIBIT 16

Fuel Sources for Electricity Generation

Fuel Source	Average Fuel Cost per MMBtu (2005)	Percent of Total Spending Subsidized by Government	Annual Resource Availability in Texas (Trillion Btu, 2006)	Estimated Net Existing Generation Capacity (MW, 2006)	Availability/ Capacity Factor (percent)***
Crude Oil*	$1.75	Federal: 0.5% State & Local: 1.5%	2,303.9 (produced) 9,110.0 (refined)	220.0	99.1%
Natural Gas	7.90	Federal: 0.5% State & Local: 1.5%	6,487.2 (produced) 4,114.6 (processed)	71,737.0	98.0
Coal	1.34	Federal: 6.9% State & Local: 0.0%	592.1	19,843.0	96.9
Nuclear Fuel (Uranium Oxide)	0.38	Federal: 20.9% State & Local: 0.0%	261.5	4,860.0	97.9
Solar	0.00	Federal: 12.3% State & Local: 9.2%	250,000.0**	1.7	PV: 20 Trough: 26-29
Wind	0.00	Federal: 11.6% State & Local: 0.2%	4,000.0**	2,739.0	39.0
Biomass: Wood	0.82	Federal: 0.4% State & Local: 0.0%	105.9	0.0	n/a
Biomass: Feedlot	0.82	Federal: 0.4% State & Local: 0.0%	26.0**	n/a	n/a
Biomass: Municipal Solid Waste	0.82	Federal: 0.4% State & Local: 0.0%	57.1	0.0	n/a
Biomass: Landfill Gas	0.82	Federal: 0.4% State & Local: 0.0%	0.7	74.0	n/a
Hydropower	0.00	Federal: 0.5% State & Local: 0.0%	1,000.0**	673.0	99.5
Ocean – Tidal, Wave & Ocean Thermal Conversion	0.00	n/a	0.0	0.0	n/a
Geothermal	0.00	Federal: 0.5% State & Local:0.2%	1,000.0**	0.0	95.0
Hydrogen	high	n/a	n/a	0.0	n/a

*In the United States, oil is used for only a very small amount of all electricity generation, including less than 1 percent of electricity generation in Texas. Data associated with electricity generation from oil are included primarily for comparison purposes.
**These estimates are from the 1995 report *Texas Renewable Energy Resource Assessment*, which is being updated by the State Energy Conservation Office and will be released before the start of the 2009 Texas Legislative Session.
***Availability factor refers to amount of time a generating unit could run over a given period. Capacity factor refers to the amount of output from a generating unit during a time period divided by the amount of output that could have been produced if the unit had operated at full capacity during that time period. Due to its variable nature, capacity factor is used to compare the availability of wind and solar power to other sources of electricity.
****Due to evaporation.
MMBtu – Million British Thermal Units.
Sources: U.S. Energy Information Administration, U.S. Department of Energy, U.S. Census Bureau, U.S. Environmental Protection Agency, Texas Commission on Environmental Quality, Texas State Energy Conservation Office, Texas Forestry Association, Texas Comptroller of Public Accounts, USA Uranium Corp., Mesteña Uranium LLC, Uranium Resources Inc.

	Average Greenhouse Gas Emissions, Electricity Generation (CO_2, lbs./MMBtu)	Average NO_x Emissions (lbs./MMBtu)	Average Other Emissions (lbs./MMBtu)	Average Water Consumption (gallons/MMBtu)	Renewable?
	490.0	1.17	3.52 (SO_2) trace amounts (Mercury)	0-150	no
	332.7	0.50	0.03 (SO_2)	2-56	no
	659.3	1.76	3.81 (SO_2) 0.01 (Mercury)	0-150	no
	0.0	0	0	0-211	no
	0.0	0	0	0-270	yes
	0.0	0	0	0	yes
	0.0	n/a	n/a	0-150	yes
	0.0	n/a	n/a	0-150	yes
	875.7	1.60	0.23 (SO_2) trace amounts (Mercury)	0-150	yes
	0.0	n/a	0	0	yes
	0.0	0	0	1,319****	yes
	0.0	0	0	0	yes
	0.0	0	0	410	yes
	n/a	n/a	n/a	less than 200	yes

Government Financial Subsidies for Energy

For many years, federal, state and local governments have provided subsidies to energy producers and purchasers to encourage the development and production of various fuels. Governments provide financial energy subsidies through tax incentives; direct spending for government services; the assumption of certain types of liability or risk by the government; government ownership of energy production; access to resources on government-owned lands; tariffs; and homeowner incentives.

As a result of this complex web of subsidies, Texans — as both energy consumers and federal, state and local taxpayers — pay more for some energy sources than is reflected in their electric bills or the price at the gas pump.

The Comptroller's office **estimates** that the total amount of federal energy subsidies for 2006 was $13.6 billion. In addition, Texas state and local energy subsidies totaled $1.4 billion in 2006.

EXHIBIT 17

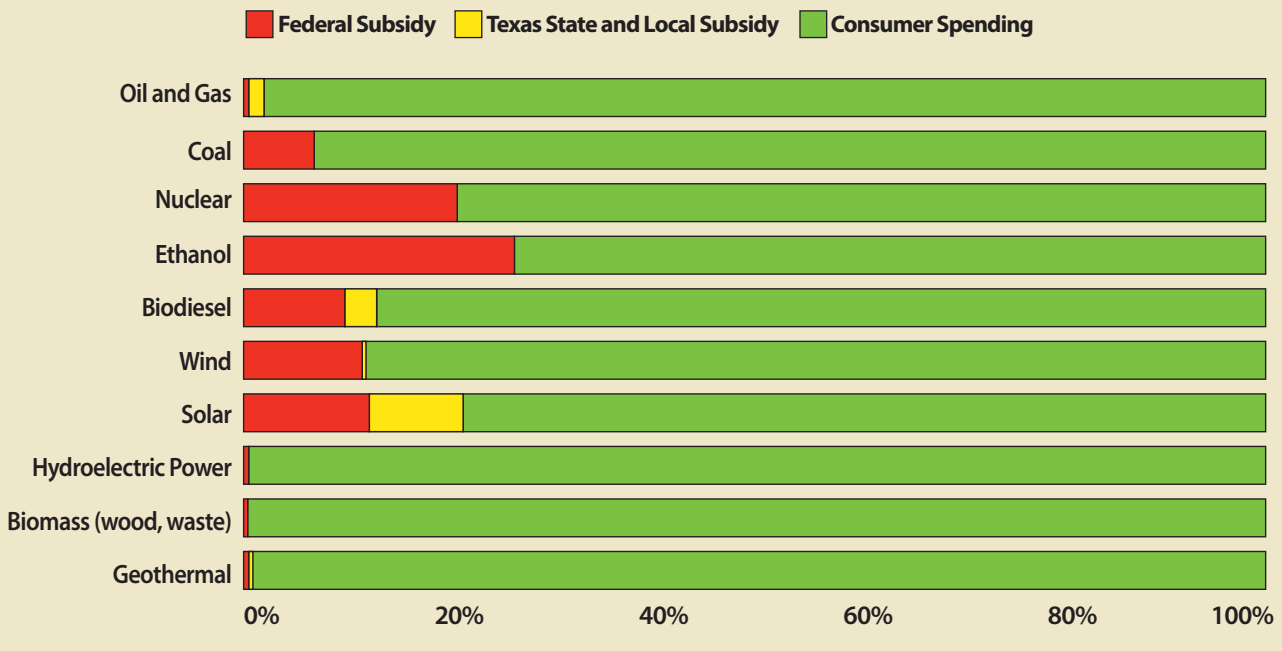
A Simple Formula

***Taxpayer* Energy Subsidies**
+
***Consumer* Energy Spending**
=
Total Energy Spending

Source: Texas Comptroller of Public Accounts.

EXHIBIT 18

Estimated Subsidies and Consumer Spending as a Percentage of Total Expenditures in 2006



Source: Texas Comptroller of Public Accounts.

The Comptroller's study focuses on identifying the total energy spending on different types of fuels through a relatively simple formula (**Exhibit 17**).

Government subsidies for energy vary widely; for hydroelectric power, for instance, federal subsidies accounted for just 0.5 percent of total spending in 2006, while federal subsidies accounted for 26.5 percent of ethanol spending in that year (**Exhibit 18**).

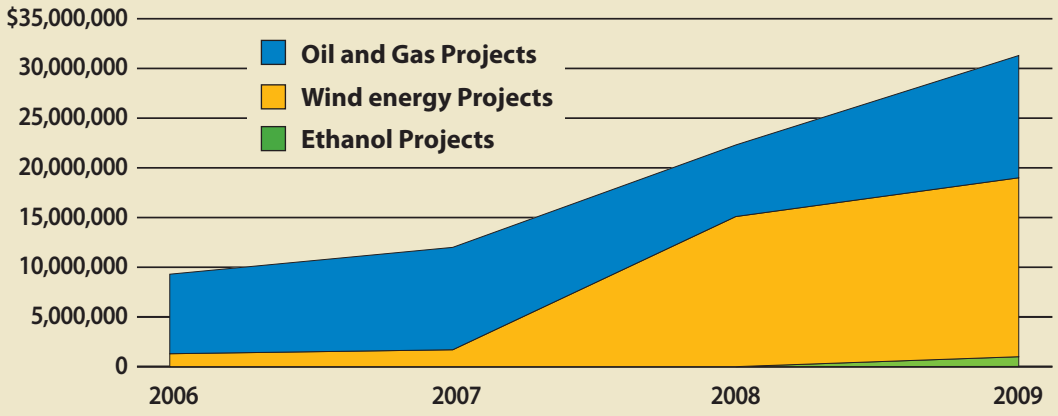
Chapter 313 Property Value Limitations

It is important to note that **Exhibit 18** does not reflect changes in federal, state and local subsidies that occurred after 2006. One notable change is the rising trend in Texas property tax value subsidies, such as Chapter 313 property value limitations, which have a significant impact on the Texas budget.

Under Chapter 313 of the Texas Tax Code, school districts may provide *Property Value Limitations* to businesses by offering a tax credit and an eight-year limitation on the appraised value of a property, for the maintenance and operations portion of the school district property tax. In exchange for the value limitation and tax credit, the property owner must enter into an agreement with the school district to create a specific number of jobs and build or install specified types of real and personal property worth a certain amount.[283] The 2007 Legislature required the Comptroller to provide a report before the beginning of each regular legislative session assessing the progress of each agreement made under Chapter 313.[284] **Exhibit 19** illustrates the projected increase in the Chapter 313 incentive. Based on data collected for the legislatively mandated study, these estimates may be revised later in 2008.

EXHIBIT 19

Estimated State Impact* of Energy-Related Chapter 313 Agreements



* The state impact is the result of tax loss and tax credit costs incurred each year under Tax Code, Chapter 313. Tax Year 2006 amounts were reported to the Comptroller by appraisal districts for the Tax Year 2006 Property Value Study. Amounts for Tax Years 2007 through 2009 were taken from the latest application documents available to the Comptroller for each project, and were used to prepare the Comptroller's estimate of the Chapter 313 cost for the 2007 Tax Exemptions and Tax Incidence report.

Source: Texas Comptroller of Public Accounts.

Conclusion

Texas has the resources it needs to meet its energy demands for the foreseeable future, though tomorrow's fuel mix may be quite different than today's. The days of near-total reliance on cheap and abundant fossil fuels may be decreasing. Instead, we will rely on a mix of fuels and improved efficiency.

Still, it is important to remember that traditional fossil fuels will remain our primary sources of energy for many years. Gasoline and diesel will continue to provide the vast majority of our transportation fuel. Natural gas and coal will not be displaced anytime soon as our primary sources of electricity. In fact, worldwide demand for fossil fuels is accelerating, and China in particular is investing hugely in fossil fuels, opening coal-fired power plants at an average rate of one per week.[285]

This demand, however — and the shrinking reserves being tapped to meet it — make it vitally important that we learn how to use these fuels in a more efficient manner.

Any source of energy has its benefits and problems. The fuels we have relied on for decades generally are still the least expensive for most uses. But they can carry costs that are not necessarily reflected in the prices consumers pay. The costs of pollution, for instance, may be borne by all.

U.S. policymakers, however, are increasingly likely to quantify and impose some of these costs on producers and consumers. In particular, greenhouse gas emissions seem likely to be restricted in some manner.

The expectation of such policies, along with rising fuel prices, has directed a great deal of attention toward renewable energy sources and nuclear power. Investment in the technologies needed to tap these resources is rising rapidly, driven in part by government subsidies.

Policymakers face a number of difficult decisions regarding energy policy in the coming years. And just as choices made by energy producers and individual consumers carry costs and benefits, so do choices made by governments. Furthermore, as much as decisions made by private businesses can have spillover effects whose costs are paid by society, government policies intended to encourage the development of a chosen resource can have unintended consequences.

For example, federal law subsidizes the use of ethanol and now requires that a portion of the U.S. transportation fuel supply come from ethanol and other biofuels. Critics have noted that the rapid rise in demand for corn has driven corn prices higher and has encouraged farmers to replace existing crops with corn, which has contributed to increasing prices for a wide array of other food products.[286]

The unintended consequences of new government action can be made worse by establishing policies that favor given resources — "picking winners" — instead of setting policy goals and establishing broad guidelines that will allow the market to meet those goals in the most efficient means possible, regardless of the fuel source or technology employed.

Government has played a large role in the development of both fossil fuels and alternative energy sources. The development of wind energy, biofuels and nuclear power has been assisted by the application of government subsidies to make new energy technology affordable. Yet such assistance must be applied carefully. Public policies that attempt to pick winners in the race for new energy technologies are an inefficient way to achieve policy goals, and run the risk not only of wasting taxpayer money, but also of directing private investment away from more promising uses.

Fortunately, Texas is in a position to lead on national energy policy, due to its unique experience in conventional energy technology, its vibrant research community and its vast reserves of energy resources. Breakthroughs made in Texas can have an enormous economic impact on the state — and the world.

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