

The Texas Renewable Energy Industry



2014

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OF BUSINESS

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Key Terms

This report references a few technical terms to describe energy and power.

Power is the rate at which electricity flows. Power is often measured in gigawatts (GW), which are equivalent to one thousand megawatts (MW). One MW is equal to 1,000 kilowatts (kW).

One MW of electricity is enough to power roughly 300 homes at a typical rate of usage. A single medium-sized wind turbine operating at full capacity can, on average, generate one MW.

Energy is the total amount of electricity consumed over a period of time. Energy is often measured in megawatt-hours (MWh), which are equivalent to 1,000 kilowatt-hours (kWh). British thermal units (BTU) are also used to measure energy. One MWh is equal to 3.4 million BTU.

Kilowatt-hours are the most commonly used billing units for electricity in the United States (U.S.). A household appliance, such as an air conditioner or microwave, rated at 1 kW operating for one hour uses 1 kWh.

Texas Renewable Energy Headlines

Texas ranks No. 1 in the nation for wind energy capacity and biodiesel production

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If **Texas** were a country, it would rank No. 6 globally for installed wind energy capacity



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Southern Power Company's Nacogdoches Generating Facility in Sacul, Texas, is the largest biomass power plant in the nation

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Texas ranks #2 nationally for employment in the renewable energy industry



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RBF's Port Neches Facility, located in the Houston area, is the nation's largest biodiesel production plant

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Texas A&M's **Center for Solar Energy** will be the world's largest solar PV R&D facility when complete

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CPS Energy is working on a landmark 400 MW solar project in San Antonio that will be the nation's largest when complete



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Royal Dutch Shell relaunches its Shell Technology Center in Houston with a focus on biomass-sourced biofuels

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Overview



For over a century, Texas has been an international leader in the oil and gas industry. In recent years, the state has built upon its energy experience and trained workforce to take the lead in renewable energy production and services. As a result, Texas has become the top state in wind generation capacity and biodiesel production.

The Lone Star State's energy potential is among the largest in the nation, with abundant wind, solar, and biomass resources found across the state's geographically diverse regions.

Ernst & Young ranked Texas No. 3 in the nation in its *U.S. Renewables Attractiveness Indices* in August 2013. A variety of factors are used to determine a state's ranking, and in Texas' case, relied primarily on wind and solar resources, followed by biomass and lastly geothermal resources.

The state has developed a strong foundation in the growing renewable energy industry. According to Texas Workforce Commission data, over 102,000 Texans are directly employed in renewable energy sectors, and thousands more work in industries closely tied to the renewable energy industry. Texas' business climate encourages renewable technology innovation and commercialization, and the state is home to leading research institutions working in renewable energy industry areas.

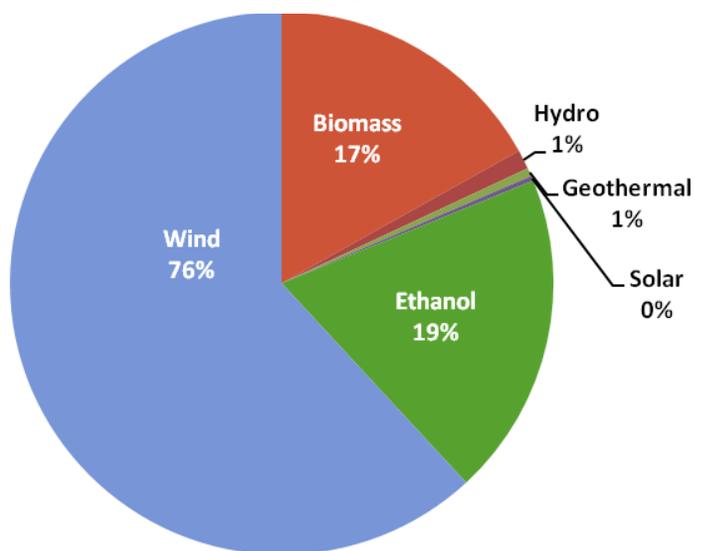
The Texas Energy Industry

According to the U.S. Energy Information Administration (EIA), Texas is the leading state for overall energy production and consumption. The state is also the leading producer, importer, and refiner of oil and gas products. Innovation in the natural gas industry has further solidified Texas' role as the nation's energy leader over the past few years. The energy industry is an important part of the diverse and growing Texas economy.

Texas ranks No. 1 in the nation for wind energy capacity and biodiesel production

Renewable energy is a vital component of Texas' all-of-the-above strategy for energy independence and leadership. Reliance on a single source of energy can threaten energy security and heighten price volatility. Energy diversification across different sectors (fossil fuel, nuclear, and renewable) and geographies (high plains wind and coastal wind, for example) can help make Texas energy more robust and flexible. A diverse energy portfolio can also better respond to changing economic and geopolitical conditions.

Texas Renewable Energy Consumption 2011



Source: U.S. Energy Information Administration

Key Texas Renewable Energy Rankings

- No. 1 in wind energy capacity
- No. 1 in wind energy-related manufacturing
- No. 1 in wind industry employment
- No. 2 in total renewable energy employment
- No. 1 in biodiesel production
- No. 1 in solar potential
- No. 6 in solar energy industry employment
- No. 4 for clean energy-related patents

Top 5 Texas-Based Companies with Renewable Energy Operations



*Semiconductor/PV products
HQ: Dallas*



*Semiconductors/inverters
HQ: Austin*



*100% renewable energy utility
HQ: Austin*



*Ethanol production
HQ: Plano*



*Utility operating landfill gas sites
HQ: Houston*

Texas Attracts Renewable Energy Investment from around the World

Selected foreign companies with renewable energy operations in Texas:



China

Growatt: Houston



France

Alstom: Amarillo, Lubbock, etc.

EDF Energies Nouvelles: Statewide (wind farms)



Germany

E.On: Austin, statewide (wind farms)

Kako new energy GmbH: San Antonio



Italy

Enel S.p.A.: Hermleigh



The Netherlands

Royal Dutch Shell: Houston, statewide (wind farms)



South Korea

OCI Solar Power: San Antonio

Samsung: Austin



Spain

Gamesa: Statewide (wind farms)

Energia ERCAM: San Antonio

Iberdrola: Statewide (wind farms)



United Kingdom

BP: Houston, statewide (wind farms)

RES Ltd: Statewide (wind farms)

Renewable Energy in Texas

While renewable energy has a relatively small impact on energy consumption in Texas, its share is growing rapidly. Renewable sources accounted for 4.1% of all energy consumed in Texas in 2011, according to the EIA. This ratio has increased substantially over the past decade as renewable energy sources have expanded, while total statewide energy consumption has remained steady over the past 15 years.

Wind energy accounts for 76% of Texas' renewable energy consumption

Wind generation in the state was twelve times larger in 2011 than 2002, and wind's share of the Texas Interconnection Region's electric power generation was 19.7% at the end of December 2013. Wind energy now comprises over three quarters of

Texas' renewable energy usage, followed by biofuels and biomass (see chart on page 1).

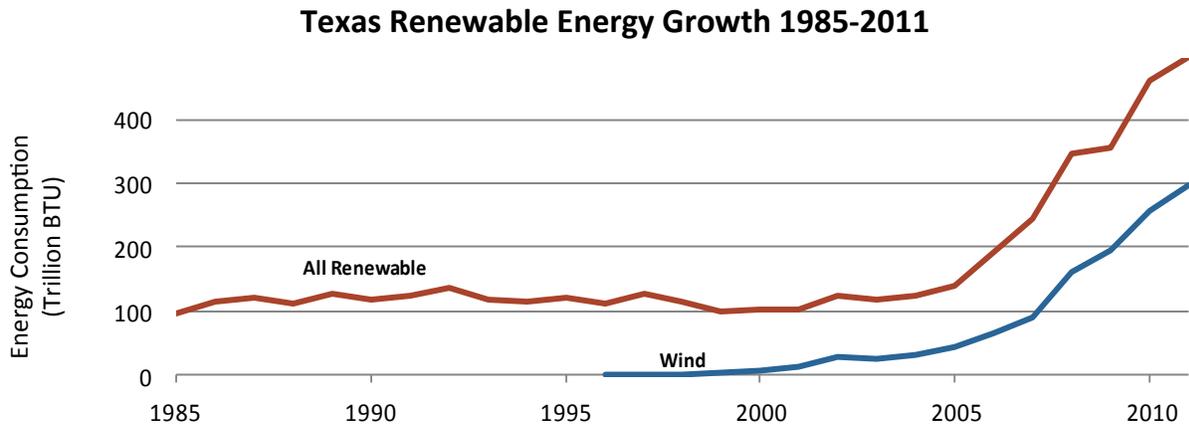
The 2000s was the decade wind accelerated in Texas,

and **solar** deployment has the potential to be similarly meteoric over the current decade. According to ERCOT, statewide solar generation increased 265% from 2011 to 2012 alone, from 36,580 MWh to 133,642 MWh. Texas currently ranks No. 6 nationally in installed solar photovoltaic PV capacity.

Biomass and biofuels account for 36% of Texas' renewable energy consumption

The strength of the Texas **biomass and biofuels** industry lies in the state's natural resources, skilled workforce, and existing petroleum-based infrastructure. More biodiesel is made in Texas than in any other state, and biomass facilities harvest usable energy from landfills, wastewater, and byproducts of forestry, livestock, and agriculture across the state. Biomass and biofuels account for 36% of Texas' renewable energy consumption.

Texas also has small amounts of renewable energy resources from **geothermal and hydroelectricity**. Altogether, these account for less than 3% of the state's total renewable energy portfolio.



Source: U.S. Energy Information Administration

Electricity Market and Distribution

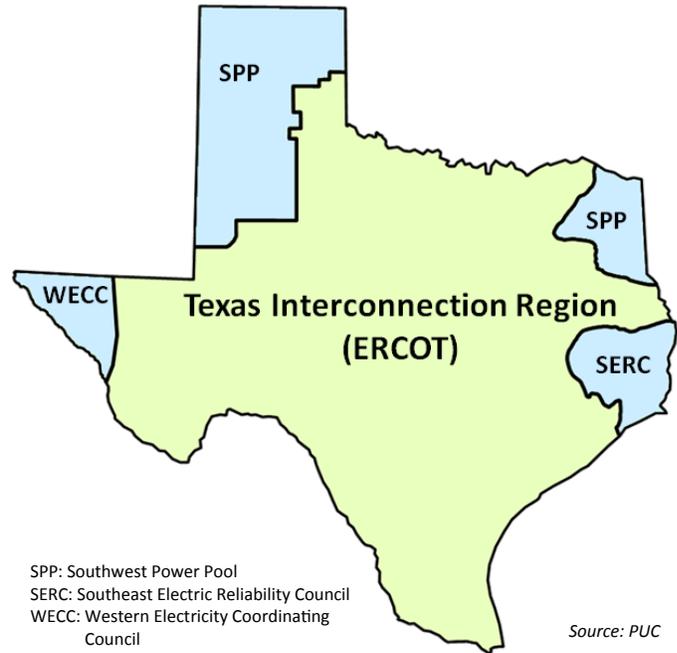
The Texas Electric Grid

In the continental United States, the electricity system consists of three regions, the Eastern Interconnection, the Western Interconnection, and the Texas Interconnection. The latter, operated by the Electric Reliability Council of Texas (ERCOT), is separate

Texas is the only state in the lower 48 with its own power grid

from the rest of the nation, making Texas the only mainland state with its own grid. As a result, the utilities within ERCOT are exempt from most federal regulation.

ERCOT is a membership-based, non-profit corporation whose members include electric utilities, generators, and transmission providers. The organization works to ensure generation, transmission, and frequency regulation services are available to meet the state's energy needs. ERCOT is subject to oversight by the Public Utility Commission of Texas (PUC), a state agency responsible for monitoring the electric and telecommunications industries in the state.

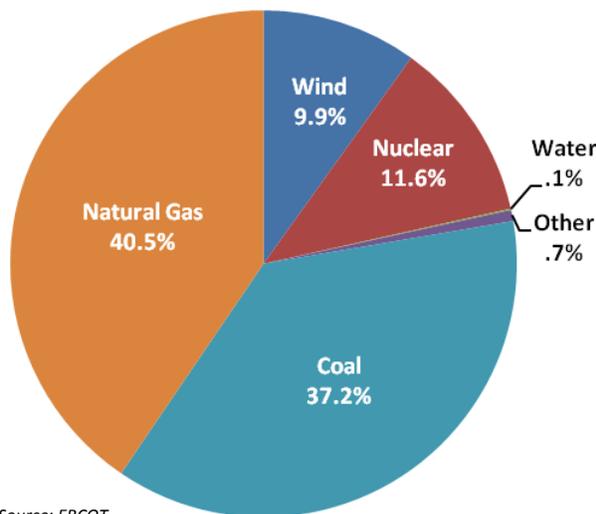


ERCOT's Texas Interconnection Region covers 75% of the state's landmass and 85% of the electrical load (see map above). The 23 million Texans within the ERCOT region consumed 331,624 gigawatt-hours (GWh) of electricity in 2013, including 32,705 GWh from wind.

Wind energy accounts for nearly 10% of Texas' energy production

In 2013, around 78% of the state's generated power came from fossil fuels (natural gas and coal). Nuclear was next with 11.6% while wind generation has grown to almost 10% (see chart at left).

2013 ERCOT Generation by Fuel Type



In 1999, the Texas Legislature restructured the state's electric industry and allowed consumers to begin choosing their Retail Electricity Provider (REP). In 2002, the law was enacted, thus deregulating the Texas electricity market. Deregulation has fostered competition among REPs, driving down costs and improving service. Deregulation also allows some customers to select and receive renewable energy. At least 26 REPs in Texas offer a 100% renewable plan to their customers as an option.

State Government Initiatives

Renewable Portfolio Standard

Adopted in 1999, the Texas Renewable Portfolio Standard (RPS) required 2,000 MW of new renewable energy capacity to be installed statewide by 2009. In 2005, the Texas Legislature extended the RPS to expand the state's generating capacity from renewable energy sources to 5,880 MW by 2015 and included a target of 10,000 MW by 2025, with 500 MW coming from non-wind sources. The state's installed capacity reached the 10,000 MW target in early 2010, 15 years ahead of schedule.

Texas reached its renewable energy target 15 years early

The Texas legislation also established requirements for electric utilities and other REPs to serve a specified amount of customer demand with sources of renewable electricity. Although thirty eight states now have RPS laws in place, the Texas RPS remains one of the most effective and successful in the nation.

Business Incentives

In 2003, the Texas Legislature authorized the \$295 million Texas Enterprise Fund (TEF), a “deal closing” fund created to attract businesses and new jobs to Texas. The TEF was reauthorized most recently in 2013. Through this fund, the state has invested over \$4.7 million in renewable energy-related projects that are expected to create over 270 jobs.

The Texas Emerging Technology Fund (TETF) was created by the Texas Legislature in 2005 to provide Texas with an advantage in the research, development, and commercialization of emerging technologies. The TETF was reauthorized most recently in 2013. To date, the TETF has awarded over \$46 million to renewable energy-related projects, spanning technologies such as solar cells, algae biofuels, and advanced batteries. These investments are intended to create

Texas Emerging Technology Fund Renewable Energy-Related Awards		
Recipient	Sector	Award
21-Century Silicon	Polysilicon	\$3,500,000
ActaCell	Energy Storage	\$1,000,000
Algae Bio Fuels Consortium	Research	\$4,025,000
BetaBatt	Energy Storage	\$500,000
Ctr. for Commercialization of Electric Technologies	Research	\$500,000
EQMA	Biomass	\$250,000
Faradox Energy Storage	Energy Storage	\$1,000,000
Ideal Power Converters	Inverters	\$1,000,000
KLD Energy Technologies	Electric Motors	\$2,800,000
Lynntech	Batteries	\$600,000
National Wind Resource Ctr.	Research	\$8,400,000
OptiSense	Smart Grid	\$1,500,000
Photon8	Algae Biofuels	\$1,000,000
SolarBridge Technologies	Inverters	\$1,500,000
Solarno	Solar Cells	\$1,000,000
Sunrise Ridge Algae	Algae Biofuels	\$250,000
Superconductivity Applied Research Hub	Research	\$3,675,000
Terrabon	Biomass	\$2,750,000
Texas A&M Wind Energy Center	Research	\$2,200,000
Texas BioEnergy Alliance	Research	\$3,412,500
Texas Micropower	Energy Capture	\$750,000
Turbo Trac USA	Power Transmissions	\$2,000,000
TXL Group	Energy Capture	\$500,000
Xtreme Power	Energy Storage	\$2,000,000
TOTAL		\$46,112,500

long-term economic benefits to the state through investments in early-stage technology companies, regional innovation centers, and academic research recruitment. See the table above for more information.

Renewables Franchise Tax Deduction

Companies solely engaged in manufacturing, selling, or installing solar or wind devices are exempt from the Texas franchise tax. Other businesses that install solar or wind energy systems are eligible for a franchise tax deduction of 10% of the system’s cost.

Renewables Property Tax Exemption

Residential, commercial, and industrial renewable energy devices are exempt from property tax under Texas law. This exemption is applicable to most renewable technologies, including solar, wind, and biomass.

Outlook for Texas Renewable Energy

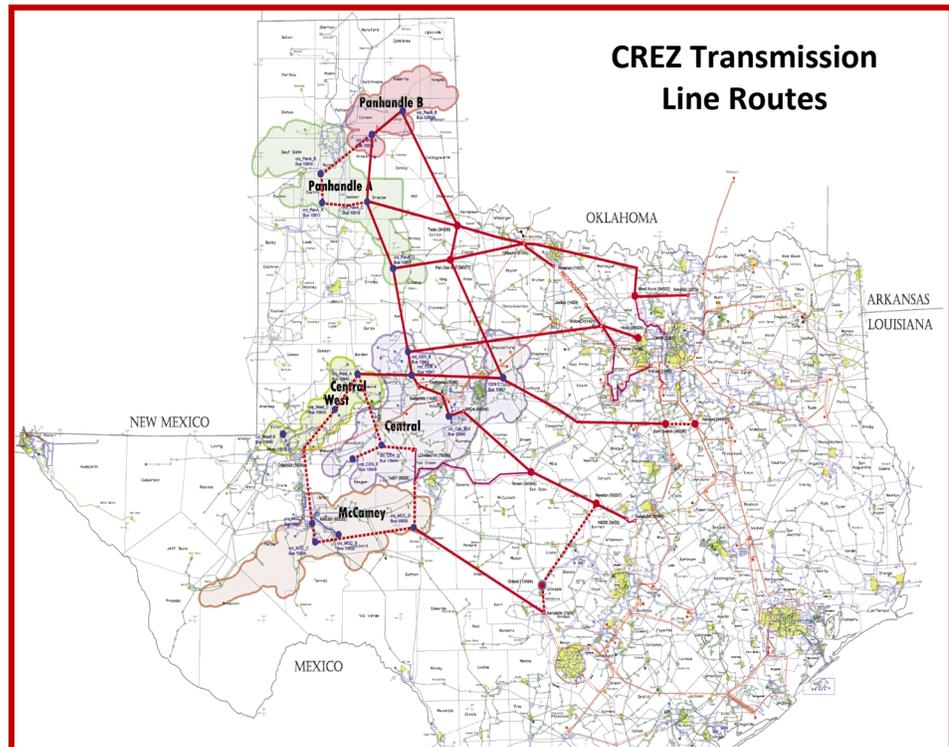
While renewable energy has grown rapidly in Texas, the industry is still evolving. Most renewable technologies are not yet price-competitive with traditional fossil fuel generation. The recent extraordinary growth in shale gas recovery technology drove natural gas prices to record lows throughout most of 2013 and widened the gap for renewable energy to achieve cost parity.

As renewable energy generation continues to advance, the electric infrastructure must adapt to allow growth

to continue. The success of the state’s RPS and wind industry has led to emerging constraints in transmission capacity. Texas wind resources are greatest in West Texas, while the majority of the population and power demand lies in the eastern half of the state. Furthermore, West Texas wind blows hardest at night when energy demand and prices are low.

In response to these challenges, the PUC collaborated with ERCOT to establish the **Competitive Renewable Energy Zone (CREZ)** transmission project in West Texas (see details on page 7). Completed in 2013, the \$6.9 billion CREZ transmission project relieves statewide east-west congestion and transmits 18.5 MW of windpower to the more populous areas of Texas. The new transmission lines will enable Texas to provide three times as much available wind power as any other state.

In addition to infrastructure projects, emerging technologies can provide cost effective ways to maximize the state’s energy assets as patterns of



Source: Texas State Energy Conservation Office

OVERVIEW

generation and transmission change. Emerging technologies may provide cost effective ways to maximize the state's energy assets as patterns of generation and transmission change. Under **demand response management**, participating consumers agree to reduce or modify electricity use when the grid's capacity is stressed. Incentives are available to participating large electricity users in the ERCOT market to compensate for the reductions.

Utility-scale energy storage technology is being adapted in Texas to mitigate intermittency by absorbing short-term fluctuations in renewables output so that customers can receive reliable electric service. Energy storage systems also store excess energy for later use when demand is higher. There are a wide variety of energy storage technologies currently in use or undergoing research.

In 2011, the Texas Energy Storage Association (TESA) helped pass a bill to clarify that storage resources participating in the wholesale market have the same rights as generators with regard to interconnection and transmission access. This law, SB 943, is

critical to energy storage project developers in ERCOT territory, where transmission utilities are responsible for the cost of interconnection, not project developers. Regulatory hurdles are also being cleared. In March 2012, the PUC adopted a set of rules allowing energy storage facilities to buy and sell electricity at wholesale rates, in order to competitively service the grid as dispatchable plants for both ancillary services and longer term energy storage.

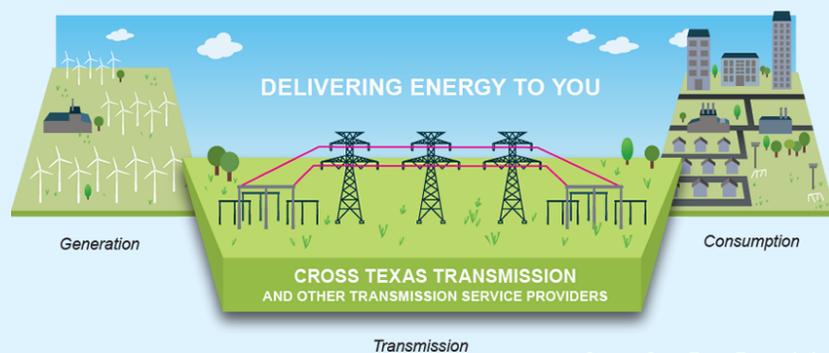
Demand response, energy storage, and many other grid management tools rely on **smart grid technology** to enable their effectiveness. Smart grid technology enables far-flung facilities on the grid to communicate and coordinate actions with one another. According to the GridWise Alliance and Smart Grid Policy Center, Texas is tied with California as the top-ranked states for smart meter deployment. Texas' deregulated and competitive energy markets allow retail power providers to use those assets to increase customer pricing programs and engagement efforts, while that hasn't happened as quickly in California's regulated utility environment.

Completed CREZ Infrastructure and Smart Grid Technology Deliver Texas' Wind Energy

In March 2012, ERCOT implemented its new **Transient Stability Analysis Tool**, which helps manage the flow of electricity across the state in real time. This smart grid technology helps ERCOT maximize the potential wind generation capacity in the state.

In December 2013, the last portion of the 3,600 miles of the **CREZ transmission lines project**, which was primarily designed to move wind energy resources from West to East Texas, was completed.

Together, the CREZ infrastructure and smart grid technology assure the maximum use of wind generated energy, which is delivered to the ERCOT service areas that need it the most.



Research & Development

Texas businesses and institutions are key drivers of U.S. research and development activity in the renewable energy sector. Texas ranked No. 4 in the nation in clean energy-related patents with 102 in 2012, according to intellectual property law firm HRFM. Additionally, Texas ranks No. 4 in the nation for overall venture capital investment in 2013, according to the National Venture Capital Association. Energy (NVCA). Energy and biotech deals accounted for a substantial amounts of the state's investments.

Texas ranks No. 4 nationally for clean energy-related patents issued

The **Austin Technology Incubator (ATI)** at the IC² Institute at the University of Texas at Austin (UT-Austin) is home to ATI's Clean Energy Incubator (CEI). One of the businesses currently at the CEI is ActaCell, an early stage lithium-ion battery technology company in which the TETF has invested.



The **San Antonio Clean Energy Incubator (SACEI)** opened its doors in 2011 to foster business activity in the renewable energy sector. SACEI is a part of the University of Texas at San Antonio's (UTSA) Sustainable Energy Research Institute (SERI), which played a



role in developing a rooftop solar array at UTSA for research and demonstration purposes. SERI was created in 2010 with a \$50 million donation from the City-owned utility, CPS Energy. The Institute is devoted to investigating sustainable energy technologies, including renewable energy.

Since its founding in 1999, the **Houston Technology Center (HTC)** has supported over 300 early stage technology businesses, including companies in the renewable energy sector.



Established in 2009, **Pecan Street Inc.** is a research and development organization affiliated with UT-Austin. The organization takes a multifaceted approach to clean energy with a smart grid demonstration project, a research consortium involving several Fortune 500 companies, and a technology commercialization lab.



The interdisciplinary **Energy Institute at UT-Austin** was founded in 2009 to focus university research on energy storage, carbon capture and storage, artificial photosynthesis, and other energy technologies. One recent carbon-based nanotechnology project at the institute investigated activated graphene supercapacitors, a fast-discharging energy storage device.



The **Richard E. Smalley Institute for Nanoscale Science and Technology at Rice University** pioneers wide-ranging research and commercialization efforts in nanotechnology, including those with energy applications. One such nanotech innovation is a quantum wire capable of transmitting electricity across long distances without suffering transmission losses.



Texas A&M University's Advanced Research Initiative for Sustainable Energy (ARISE) serves as a focal point for scientific research activities throughout the University in the renewable energy field.



The **University of North Texas's (UNT) Zero Energy (ZOE) Research Laboratory** researches and tests alternative energy generation technologies, including solar, wind, and geothermal energy.



Major Companies

Leading Renewable Energy Companies with Operations in Texas

Company Name	Primary Location(s)	Type	Details
Royal Dutch Shell	Houston, Statewide	Biofuels, Wind	Shell Wind Energy Inc. HQ and biofuels pilot plant in Houston, 2 wind farms in the state
BP plc	Houston, Statewide	Wind, Biofuels	BP Alternative Energy division HQ in Houston, 4 wind farms in the state
Samsung Austin Semiconductor	Austin	Solar	Semiconductors/PV products
E.ON Climate & Renewables, N.A.	Statewide	Wind	10 wind farms in the state
EDF Energies Nouvelles	Statewide	Wind	5 wind farms in the state
Alstom Wind	Amarillo	Wind	Wind nacelles manufacturer
Duke Energy	San Antonio, West Texas	Wind, Solar	5 wind farms in the state and one solar farm in San Antonio
EDP Renewables N.A.	Houston, Statewide	Wind	Operates 2 wind farms in Texas, North American HQ in Houston
NextEra Energy	Statewide	Wind	9 wind farms in the state
Texas Instruments	Dallas, Richardson, etc.	Solar	Semiconductors/PV products
Freescale Semiconductor	Austin	Solar	Semiconductors/Inverters
SunEdison	Pasadena, Statewide	Solar	2 solar plants in the state, MEMC SunEdison manufactures granular polysilicon in Pasadena
Maxim Integrated Products	Austin, Dallas, San Antonio	Solar	Semiconductors/Inverters
TECO-Westinghouse Motor Company	Round Rock	Wind	Wind turbine manufacturer
KACO new energy	San Antonio	Solar	PV inverters
MFG Wind (MFG Energy Services)	Gainesville	Wind	Windmill blades manufacturer
RES-Americas	Austin, Statewide	Wind, Solar	13 wind farms in the state and one solar farm near Austin
White Energy	Dallas, Hereford, Plainview	Biofuels	Largest ethanol producer in Texas



Sources: Company websites, D&B

By ultimate parent revenues, representative sample only

Energy Workforce

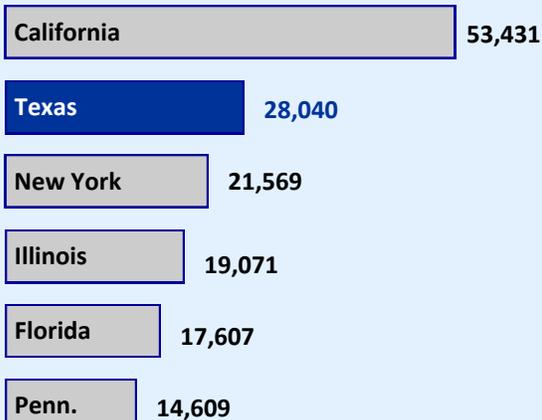
Employment

Texas ranks No. 2 nationally with over 28,000 renewable energy workers, according to the latest information from the Clean Jobs Index. These jobs span a number of industries, from wind turbine maintenance to semiconductor manufacturing.

Job growth in the renewable energy industry is expected to remain strong over the next decade. According to a report by the Cynthia and George Mitchell Foundation, the expanding wind and solar energy industries are projected to add 6,000 jobs in Texas per year through 2020.

More than 1,300 Texas companies employ around 102,000 workers in industries directly and indirectly related to renewable energy, according to Texas Workforce Commission data. These workers are highly skilled and well paid, earning an average annual salary of \$78,257, which is 85% above the state average. The table below shows employment statistics for selected industry areas related to renewable energy.

Texas Ranks No. 2 in the U.S. in Renewable Energy Employment



Source: Clean Jobs Index, Ecotech Institute, 2012 data

Texas' experience in energy runs deep. In addition to abundant natural resources, the state's workforce cluster has decades of experience in energy-related land and project development, industrial scalability, and energy trading. While most of this know-how developed in traditional energy sectors, in recent years the state's energy industry has applied its knowledge to the expanding renewable energy fields.

Renewable Energy-Related Employment in Texas

Second Quarter 2013

Sector (Industry Code)	Firms	Employees	Average Annual Wage
Electric Power Generation (22111)	103	12,087	\$98,228
-Wind Electric Power Generation (221115)	17	833	\$114,920
Electric Power Transmission, Control, & Distribution (22112)	217	31,393	\$88,140
Power Line and Related Structures Construction (23713)	689	18,426	\$58,760
Turbine & Power Transmission Equipment Mfg. (333611)	23	1,249	\$77,220
Semiconductors, Solar Cells, and Related Devices Mfg. (334413)	125	28,775	\$114,920
Electrical Equipment, Generator Mfg. (33531)	188	9,595	\$66,560
Battery Mfg. (33591)	12	276	\$69,004
TOTALS	1,374	102,634	\$78,257

Source: Texas Workforce Commission

Training Initiatives

Texas universities, community colleges, and industry certification programs are continuously developing and expanding renewable energy course offerings. The Environmental Defense Fund’s *Texas Green Jobs Guidebook* identifies over 50 Texas community colleges that offer an array of low-cost programs to prepare students for green jobs.

The Texas Higher Education Coordinating Board estimates that over 28,500 renewable energy-related degrees were awarded at Texas public institutions from 2009 to 2013 (see chart below). Detailed sector-specific training initiatives are discussed in the wind, solar, and biofuels sections of this report.

The **Texas Renewable Energy Education Consortium (TREC)** is a group of twelve statewide Texas colleges devoted to educating Texas’s renewable energy workforce.

From Amarillo to Harlingen, the consortium works to offer degrees, certificates, professional development, and technical training. TREC courses are offered in wind, solar, energy-efficient building design, and fuel cells.



Wind energy program student at Texas State Technical College (TSTC), a TREC member. Photo courtesy of TSTC

Renewable Energy-Related Degrees Awarded in Texas, 2009-2013

All Texas Public Institutions, All Degree Levels

<i>Electrical Engineering</i>		7,391
<i>Computer Science</i>		6,786
<i>Mechanical Engineering</i>		6,479
<i>Engineering Technicians*</i>		4,406
<i>Chemical Engineering</i>		2,260
<i>Computer Engineering</i>		1,227
	TOTAL	28,549

*Includes electrical, industrial, manufacturing, and mechanical technicians

Source: Texas Higher Education Coordinating Board

Wind Power



Wind is a clean, affordable, and renewable energy resource which plays a significant and growing role in the U.S. and Texas energy markets. According to the Wind Energy Foundation, wind is currently the fastest growing source of electricity production globally. Wind generation technology is mature and proven, and increasingly cost competitive. Texas is the leading state for wind energy generation, with over 20% of the nation's installed wind capacity. If Texas were a country, it would rank sixth in installed capacity.

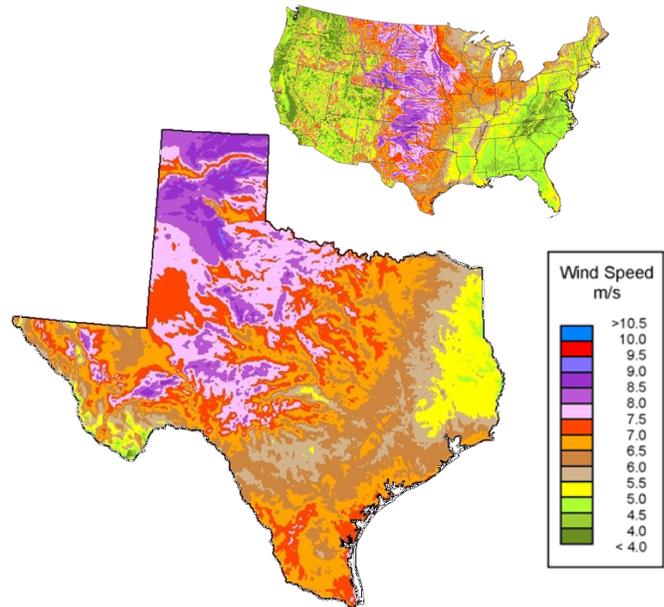
Wind generation has proven popular because it is cheaper than solar, requires no water or other scarce resources, and emits no greenhouse gases. Since windmills must be spaced out to maximize their

Wind Power Capacity by Place 2012

	Country/State	Installed Capacity (MW)
1	China	75,234
2	United States	60,007
3	Germany	31,308
4	Spain	22,796
5	India	18,421
6	Texas	12,214

Sources: Global Wind Energy Council, American Wind Energy Association

Wind Resources in Texas and the U.S.



Source: U.S. National Renewable Energy Laboratory

efficiency, much of the underlying land can still be used for its original purposes, such as agriculture and livestock production.

Because of wind power's cost and efficiency advantages, wind installations far outpace solar. A decade after surpassing solar production, U.S. wind generation is ten times greater than solar generation, according to the EIA.

Texas' world-class wind industry comes from its abundant natural wind resources. With plentiful wind on the Great Plains and along the Gulf Coast, the state ranks first nationally for wind generation potential, according to the American Wind Energy Association (AWEA). The state's Renewable Portfolio Standard, enacted in 1999, also played a major role in encouraging wind energy development in Texas.

If Texas were a nation, it would rank No. 6 globally for installed wind power capacity

Wind Power Generation

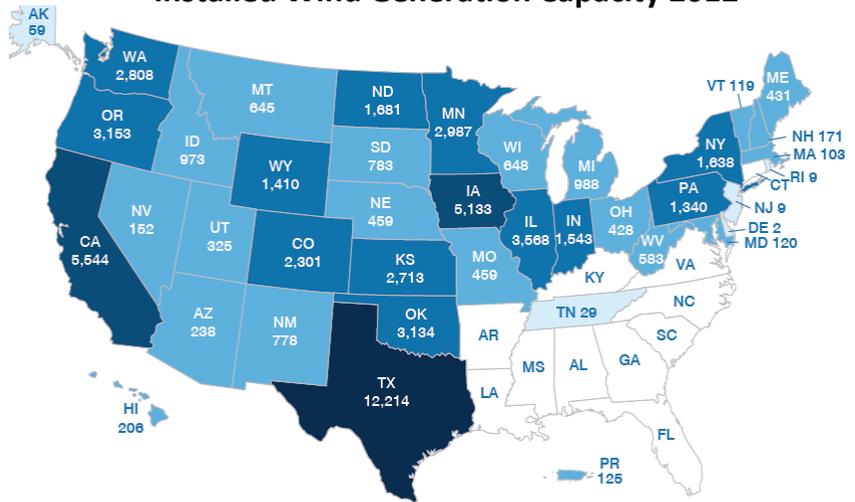
Texas is by far the leading state in wind energy generation with 12,214 megawatts (MW) of installed capacity — enough to power over 3.3 million homes. Wind capacity in Texas is 45% greater than in California, the second-ranked state.

Texas ranks No. 1 nationally for wind energy installed capacity

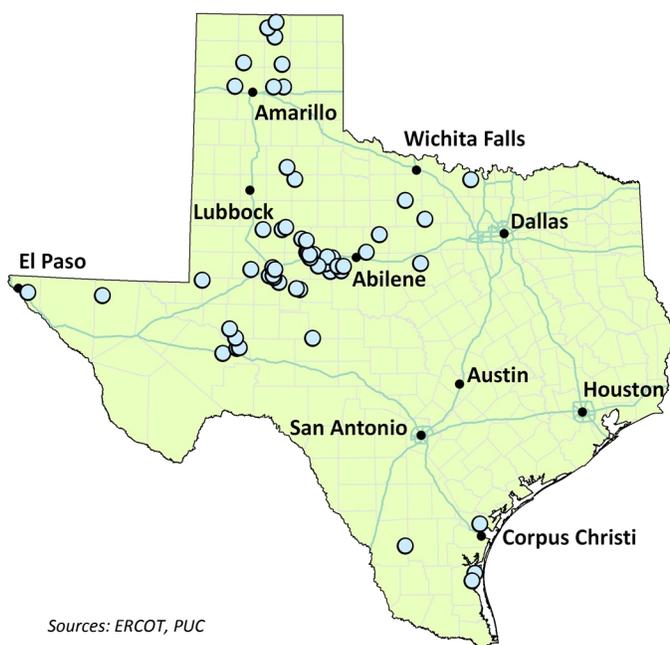
The Texas wind industry has seen a tremendous boom since the first commercial wind farm was built in 1995, and by 2012, 116 wind projects were operational in Texas, according to AWEA. The wind industry employs over 10,000 in Texas, and six of the nation’s ten largest wind energy generation projects are located in the state, according to AWEA (see chart on page 14).

In 2007, Texas became the first state to reach the milestone of one gigawatt of wind capacity installed in a single year. In 2012 alone, the state added 1,826 MW of wind generating capacity.

Installed Wind Generation Capacity 2012



Texas Wind Farm Locations



Sources: ERCOT, PUC

The **Roscoe Wind Farm**, which stretches across Nolan, Mitchell, Scurry, and Fisher counties, is the nation's second largest wind farm with over 600 wind turbines and a total installed capacity of 782 MW. The \$1 billion project was completed in 2009 by **E.ON Climate & Renewables (EC&R)**, a Chicago-based subsidiary of E.ON AG, a global energy company based in Germany. EC&R has ten wind projects in Texas alone, with over 2,700 MW of generating capacity.

The 736 MW **Horse Hollow Wind Energy Center** in Taylor and Nolan counties was the largest wind farm in the world when it was completed in 2006 by Florida-based **NextEra Energy Resources**. It currently is the second largest wind farm in Texas. NextEra operates 9 Texas wind farms totaling 3,454 MW of generating capacity, including the 662 MW **Capricorn Ridge Wind Energy Center**, the third largest wind farm in Texas.

Duke Energy began production of its 402 MW **Los Vientos Windpower Project** in January 2013. Los

Vientos is located on the Gulf of Mexico just north of Harlingen, Texas. Coastal wind generation is a small but growing component of the Texas wind industry portfolio. Texas coast-based wind farms currently account for almost 1,700 MW, or approximately 14% of the state's wind capacity.

The 161 MW **Spinning Spur Wind Project** near Amarillo, Texas, went into service in December 2012. The \$190 million project was co-developed by Austin-based **Cielo Wind Power** and **EDF Renewable**

Energy (ERE), the U.S. subsidiary of the French global energy company EDF Energies Nouvelles. The project was later purchased by ERE. In June 2013, ERE began construction on the 161 MW **Spinning Spur Wind II**, which is scheduled for completion in 2014. ERE is a leading wind and solar project developer, with over 90 renewable energy projects in North America. The company has 2 completed wind projects in Texas totaling 324 MW and has 3 projects underway totaling 561 MW.

Five of the nation's 10 largest wind farms are in Texas

The Nation's 10 Largest Wind Energy Generation Projects

Installed Capacity (MW)	Project Name	State
845	Shepards Flat	Oregon
782	Roscoe	Texas
736	Horse Hollow	Texas
720	Alta Wind Project	California
663	Capricorn Ridge	California
585	Sweetwater	Texas
523	Buffalo Gap	Texas
501	Meadow Lake	Indian
470	Flat Ridge 2	Kansas
458	Panther Creek	Texas

Source: American Wind Energy Association, end of 2012

Wind Equipment Manufacturing

In addition to leading the nation in wind energy generation capacity, Texas plays a major role in the national and global wind energy manufacturing industry.

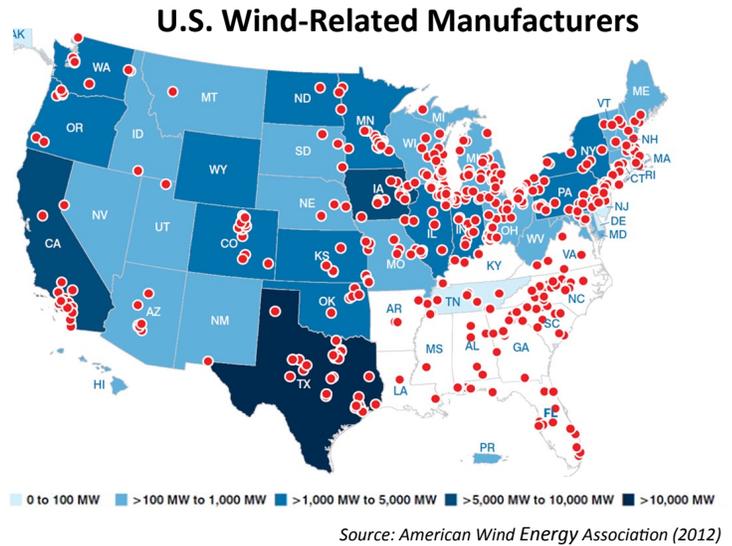
Texas ranks first nationally in the number of manufacturing facilities related to wind, including assembly plants, tower manufacturing, and other component production. AWEA estimates that at least 45 Texas facilities are involved in the windmill manufacturing business.

Texas ranks No. 1 in the U.S. for wind energy-related manufacturing

The state is home to manufacturing facilities for all three primary components of windmills: towers, blades, and nacelles. Nacelles are the boxes attached to the top of towers that contain the turbine, gearbox, and other electronic equipment.

Manufacturing in Texas

TECO-Westinghouse in Round Rock was the first wind turbine production facility in Texas. The company built the Austin-area plant in 1972 to manufacture gas turbines, and in 2006, began operating its Wind Business Energy Unit there. TECO



assembles turbines for **DeWind**, a major wind power plant developer with Texas operations.

Molded Fiber Glass (MFG) Companies, an Ohio-based manufacturer, operates a 155,000-sq.-ft. windmill blade manufacturing facility in Gainesville, Texas. MFG ships precision manufactured blade sets globally. The companies specialized blade repair subsidiary **MFG Energy Services**, also operates out of Gainesville.

In early 2012, the French wind turbine company **Alstom Wind**  began operations in a new 115,000-sq.-ft. turbine nacelle assembly plant in Amarillo, Texas. The company received local and federal incentives to create 275 full-time engineering, production, and technical support jobs at the plant.

Trinity Structural Towers, a subsidiary of Dallas-based Trinity Industries, is a leading manufacturer of wind towers. The company has a manufacturing facility in Coleman, Texas.

In 2011, Illinois-based **Broadwind Energy** opened a \$7 million drivetrain service center in Abilene, Texas. The Broadwind facility remanufactures and refurbishes windmill blades, gearboxes, and turbines, and fabricates steel parts for wind towers.

Outlook for Texas Wind Power

Research & Development

Ongoing research is aimed at improving existing wind power equipment designs and innovating new ones. Researchers are experimenting with different windmill sizes and configurations designed for specific situations, such as small scale generation and offshore wind farms. Texas universities house leading researchers and nationally recognized degree programs that are key to the development of wind energy technologies and management for the future.



Founded in 1977 in Canyon, Texas, **West Texas A&M University's Alternative Energy Institute** conducts research, evaluates wind turbine designs, collects wind data, and conducts workforce training programs.

The **National Institute for Renewable Energy (Group NIRE)** was formed in 2009 in Lubbock, Texas. The public-private partnership focuses on wind energy R&D and advocacy.



The **Texas A&M Wind Energy Center (WEC)** was established in 2010 as a part of the Texas Engineering Experiment Station (TEES) in College Station, Texas. The WEC's mission is to support wind energy research and development in Texas. The Center is focusing on the commercialization of offshore wind potential.

Texas Tech's National Wind Institute (NWI) opened in Lubbock, Texas, in 2009, after the merger of the former Wind Science & Engineering Research Center and the Texas Wind Energy Institute. The NWI supports interdisciplinary research, educational, and commercialization opportunities in wind science, engineering, and energy.



SWiFT facility, Photo courtesy of SWiFT

In April 2012, Texas Tech, the U.S. Department of Energy, Sandia National Laboratories, Denmark-based Vestas, and Group NIRE formed a partnership to create a new state-of-the-art wind turbine test facility in Lubbock called the **Scaled Wind Farm Technology (SWiFT)** facility. SWiFT is operational and can support highly sensitive proprietary R&D projects.

Government Initiatives

The state-run Texas Emerging Technology Fund (TETF) invests in R&D and commercialization of disruptive new technologies, including renewable energy. To date, the fund has invested more than \$12 million in wind technology firms and research groups.

In July 2010, Gov. Rick Perry announced an \$8.4 million TETF research superiority investment through Texas Tech and Group NIRE. The investment helped create the **National Wind Resource Center (NWRC)**, a non-profit organization formed by Texas Tech in Lubbock that focuses on wind power research and education through collaboration with national laboratories, academic institutions, and trade organizations.



In 2009, the TETF invested \$2 million in **Turbo Trac USA**, a Frisco, Texas-based company investigating heavy-duty infinitely variable transmissions. The technology is expected to increase the efficiency of drivetrain systems in various activities, including windmill gearboxes.

Texas Invests \$2.2 Million in TAMU Wind Energy Center

On April 4, 2014, Gov. Rick Perry announced the Texas Emerging Technology Fund (TETF) was awarding \$2.2 million to the **Texas A&M University (TAMU) Wind Energy Center** for a collaborative project that will bring together researchers from universities across the state to develop and increase the capacity of offshore wind energy technology, and help bring it to market. The state's TETF award will be matched with a \$50 million award from the U.S. Department of Energy, an initial \$13.3 million investment from industry members of the GoWind consortium, and a \$1 million total investment from the participating Texas universities.

TAMU will be working with the Texas Tech University National Wind Resource Center, the University of Texas at Austin Center for Electromechanics and Department of Civil, Architectural and Environmental Engineering, TAMU-Corpus Christi Conrad Blucher Institute, and the University of Texas at Brownsville School of Business and Department of Chemistry and Environmental Sciences.



The Texas wind industry has also benefited from the federal **Production Tax Credit (PTC)**, which provided a \$23 per 1 MW income tax credit for wind energy production. The PTC expired at the end of 2013 and its future is uncertain. This credit has been a boon to the wind industry, and the ongoing policy uncertainty is hindering wind investments in Texas and across the country.

Workforce & Training

The American Wind Energy Association (AWEA) ranks Texas No. 1 nationally in wind industry employment with over 10,000 jobs, which includes manufacturing, installation, and maintenance jobs.

Workers across the state play a fundamental part in the international supply chain of the industry. Texas is a leader in steel fabrication and transportation for wind energy, and in advanced materials such as carbon fiber, which are exported from Texas to wind energy companies around the globe.

Texas ranks No. 1 in the U.S for overall wind energy-related employment

In addition to supporting Group NIRE and NWRC, **Texas Tech University (TTU)** offers a doctoral program in Wind Science and Engineering. TTU also offers undergraduate degrees, minors, graduate certificates, and professional development through the

Offshore Wind in Texas

While there is currently no commercial offshore wind generation yet in the U.S., Texas is likely to be on the first states to welcome offshore wind generation to its coastline. Since gulf wind hits its peak strength during the day when electricity demand is at its highest, offshore generation addresses an inherent problem that faces existing inland wind farms, which generate best at night.

Texas' unique coastal sovereignty allows the state to claim jurisdiction 10.3 miles into the Gulf of Mexico, more than three times the distance claimed by other states.

This in turn allows Texas projects to be located further into the gulf, while reducing the burden of federal review.

The state's General Land Office (GLO) currently has seven offshore leases in various stages, including two active leases with **Baryonx Corp.**, the lead developer of a project that won a \$4 million federal grant in 2012. Baryonx has been awarded a total of 76,000 acres in wind energy leases, making it the state's largest owner of such leases.



school's Wind Science and Engineering Research Center.

Located in Sweetwater, **Texas State Technical College -West Texas (TSTC)** offers associate degrees and certificates in Wind Energy Technology. TSTC-West Texas has partnered with TTU and created the **Texas Wind Energy Institute** to coordinate workforce training programs between the two schools.



In addition to its pioneering wind program in West Texas, **TSTC's Harlingen Campus** offers programs at its Renewable Energy Education Center in Ingleside, Texas. TSTC-Harlingen currently offers an online-hybrid certificate in wind energy & turbine technology. The courses are taught on the former site of Naval Station Ingleside near Corpus Christi.

Amarillo College offers wind training courses through its Wind Energy Program. The program offers wind technician certificates for students interested in wind energy operation, maintenance, and manufacturing. In addition, the college offers a renewable associate degree in Wind Energy.

West Texas A&M's Alternative Energy Institute (AEI) in Canyon, Texas, conducts workforce training programs in addition to its research activities. AEI offers online courses for wind energy, as well as information seminars for land owners with potential wind assets.



High Tech Giants Purchase Texas Wind Farms

High tech giants Google and Microsoft have recently announced a number of major wind power deals in Texas. As part of the companies' goals to pursue carbon neutrality and energy independence, both have announced plans to add significant power to the state's energy grid, with similar deals likely to follow.

To date, **Google** has announced three wind farm purchases in Texas. In January 2014, the company acquired a \$75 million, 182 MW wind farm outside of Amarillo, Texas. The Panhandle 2 project, under development by Panhandle Energy Group LP, is due online by the end of 2014. In September 2013, Google reported it will also purchase the entire output of the 240 MW Happy Hereford wind farm outside of Amarillo and due online in 2014. Google plans to send the power to a data center in Oklahoma and sell overflow power into the regional grid on the wholesale market. Additionally, in January 2013, Google acquired the \$200 million, 161 MW Spinning Spur wind project, also outside of Amarillo.

In November 2013, **Microsoft** announced a 20-year contract to secure all the power from RES America's 110 MW Keechi wind project, due online in June 2015 and located about 70 miles northwest of Fort Worth, Texas. Without Microsoft's backing, the developers indicate the wind project would not have been built.



Wind Energy-Related Employment in Texas

Second Quarter 2013

Sector (Industry Code)	Firms	Employees	Average Annual Wage
Wind Electric Power Generation (221115)	17	833	\$114,920
Power Line and Related Structures Construction (23713)	689	18,426	\$58,760
Turbine & Power Transmission Equipment Mfg. (333611)	23	1,249	\$77,220
Electrical Equipment, Generator Mfg. (33531)	188	9,595	\$66,560
TOTALS	917	30,103	\$63,654

Source: Texas Workforce Commission

Solar Power

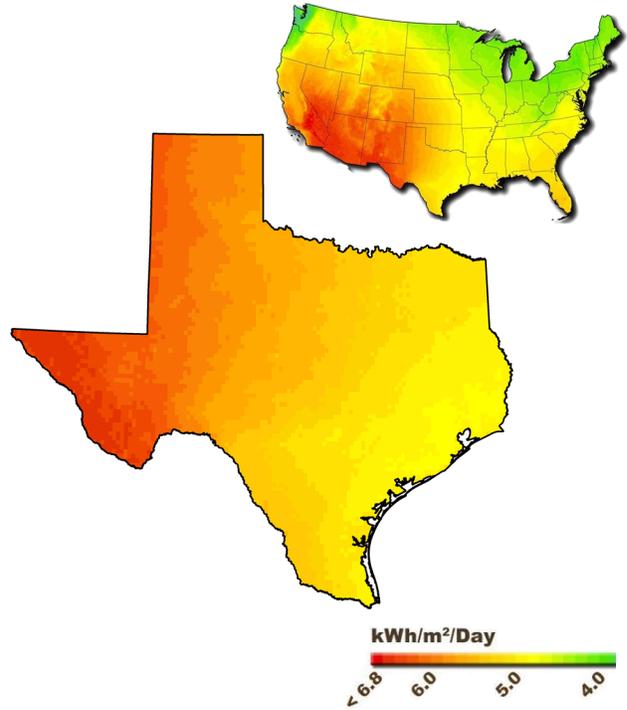


Solar panel installation (Photo courtesy CPS Energy)

In the U.S., solar power lags behind wind in terms of installed capacity, yet solar industry growth is accelerating as equipment prices fall. Photovoltaic cell prices continue to trend lower (see chart below) as a result of new technology, improved manufacturing techniques, and better economies of scale from expanding production.

The most common solar technology is photovoltaics (PV). As depicted in the photograph above, PV modules are glass-covered semiconductor cells which convert sunlight into an electric current. Although PV systems are frequently used for larger utility-scale projects, their modularity makes them a popular choice for small-scale energy generation near the point of use (also called distributed generation), such

Solar Resources in Texas and the U.S.

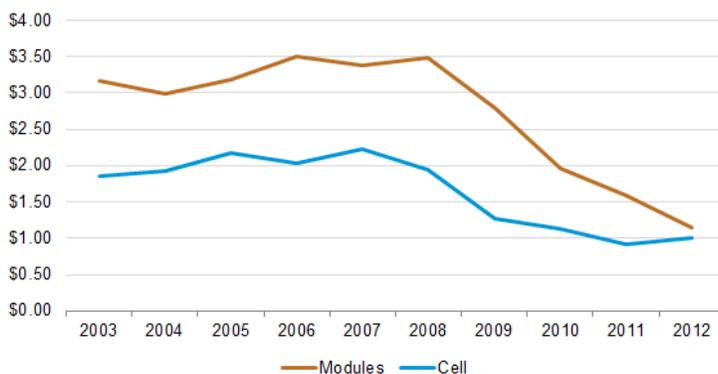


Source: National Renewable Energy Laboratory

as on residential or commercial rooftops.

In the U.S. market, PV modules have been installed on less than 250,000 homes to date, with the potential to grow exponentially as installation prices fall. And while residential systems accounted for 90% of U.S. PV projects in 2012, they only accounted for 16% of the nation's PV capacity, according to the Interstate Renewable Energy Council (IREC). Utility scale solar projects comprise the remaining 84% of the U.S. solar market.

Average Prices of PV Cells and Modules



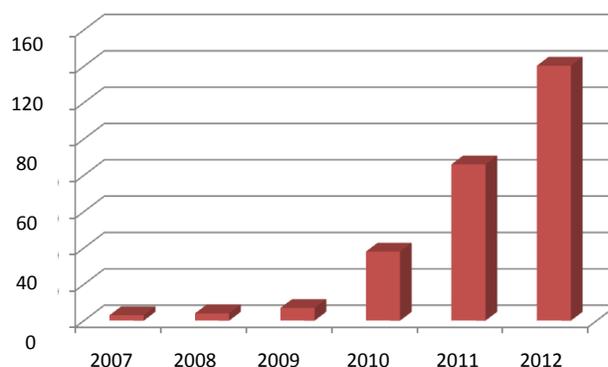
Source: U.S. Energy Information Administration

Solar Power Generation

Due to its abundant sunshine, specialized manufacturing base, and growing research institutions, Texas is well positioned to compete in the solar energy market. Texas is ranked No. 1 nationally in solar potential, according to the Texas State Energy Conservation Office. West Texas in particular has some of the nation's highest levels of solar radiation, making it ideal for utility-scale solar power plants. Large solar farms have also sprouted up elsewhere in the state,

Texas ranks No. 6 nationally for solar industry employment

Texas Grid-Connected Solar PV Capacity (MW)



Source: Interstate Renewable Energy Council

Texas' Three Largest Solar Farms



Texas' largest solar farm is the 41 MW **Alamo 1 Solar Farm** in Bexar County, Texas, completed in December 2013. It is the first phase of a 400 MW solar project, which is a partnership between the City of San Antonio's CPS Energy, the nation's largest municipally owned utility, and OCI Solar Power, a Texas-based subsidiary of South Korea's OCI Company Ltd. (See details on p. 21).



The state's second largest solar farm is the 35 MW **Webberville Solar Farm** in Webberville, Texas. The \$100 million project went online in December 2011. RES Americas, a leading renewable energy developer, worked with Austin, Texas' municipally owned utility, Austin Energy, which committed to buy all of the facility's power for 25 years.



The 22 MW **Barilla Solar Project** in Pecos County, Texas, announced in January 2014, will be the state's third largest solar farm when completed in mid-2014. Arizona-based **First Solar**, one of the world's largest solar developers, may eventually expand the facility to 150 MW, which would make it the state's second largest solar farm.

including the Austin and San Antonio regions (see box at left).

Cumulative installed U.S. PV installations in 2012 totaled 7,374 MW, less than .3% of all electricity generated nationwide. While solar is a relatively small portion of the entire U.S. energy industry, its rapid growth has outpaced that of the larger wind sector in recent years. The number of PV installations in the U.S. grew by 46% in 2012 after more than doubling in 2011.

Over the past decade, solar energy has played second fiddle to other major renewables, like wind. Solar energy is currently more expensive than either wind or traditional fossil fuel sources. As costs continue to fall, however, the promise of solar energy continues to be.

The Interstate Renewable Energy Council (IREC) ranked Texas No. 12 nationally in grid-connected cumulative installed PV capacity in 2012 with 140.3 MW. Rooftop PV systems comprise the bulk of Texas solar projects. According to ERCOT, statewide solar generation increased 265% from 2011 to 2012 alone, from 36,580 MWh to 133,642 MWh.

Solar Equipment Manufacturing

Texas’ solar equipment manufacturing sector is anchored by a world-leading cluster of semiconductor design and fabrication companies. As a fundamental component of PV cells, semiconductor technology forms a link between the microelectronics industry and solar power. Texas has been a leader in the semiconductor industry since its beginnings in the 1950s, and the state’s electronics industry workforce is currently the second largest in the nation. Global semiconductor leaders and a number of solar energy equipment companies are directly engaged in solar energy manufacturing in Texas (see chart at right).

Companies in Texas		
Company	Location	Activity
Applied Materials	Austin	Semiconductor/PV products
Entech Solar	Fort Worth	PV power systems
ERCAM Trackers	San Antonio	Dual-axis trackers
Freescale Semiconductor	Austin	Controllers/MCU devices
Growatt New Energy North America	Houston	PV inverters
Ideal Power	Spicewood	PV inverters
KACO new energy	San Antonio	PV inverters
MEMC SunEdison	Pasadena	Granular polysilicon mfg.
Mission Solar Energy	San Antonio	PV cells
SolarBridge Technologies	Austin	PV microinverters
SunPower Corp	Austin	Solar panels
Texas Instruments	Richardson	Semiconductor/PV products

Sources: Company websites, D&B. Representative sample only

San Antonio Builds Nation’s Largest Solar Utility Project



In 2012, San Antonio’s municipally owned utility, **CPS Energy**, signed a contract to create 400 MW of solar energy capacity by 2016 with San Antonio-based **OCI Solar Power**. OCI Solar will build, develop, and manage the 400 MW **Alamo Solar Farm** in San Antonio, while CPS Energy has committed to a 25-year power purchase agreement for all energy generated by the project. Forecast to be the nation’s largest solar utility project, Alamo Solar is expected to create over 800 professional and technical jobs, as well as business opportunities for new and existing suppliers and installers in the solar power field. The project is also expected to generate over \$1 billion in construction investment and \$700 million in annual economic impact, as well as power for nearly 70,000 homes.

Following the project’s announcement, Germany-based **KACO new energy** opened a PV inverter manufacturing plant in San Antonio and announced plans to move its North American headquarters and 65 jobs from California to San Antonio.

ERCOM Trackers, a subsidiary of Spain-based Energia ERCOM, relocated from California and opened a San Antonio manufacturing facility to produce 500 MW of dual-axis trackers, employing 120 workers through 2017.

Mission Solar Energy, a subsidiary of South Korea’s **OCI Solar Power**, has begun construction of a new \$115 million solar panel manufacturing plant at San Antonio’s Brooks City Base. The plant is expected to employ over 400 when completed in 2014.



Outlook for Texas Solar Energy

Research & Development

Texas universities and businesses are actively developing solar energy technology. Current solar industry research and development (R&D) has led to improved performance, lowered costs, and innovative technologies, while the pursuit to improve efficiencies in capturing the sun's energy continues. Although PV technology companies have reported solar conversion rates of over 44%, most conventional solar power systems' conversion rates remain far lower.

Several universities in the state operate solar vehicle racing teams, including Rice University, Texas A&M University, Texas Tech University, and UT-Austin. These programs provide students a hands-on opportunity to work with solar technology as well as automotive design.



The U.S. Department of Energy's (DOE) National Renewable Energy Laboratory's (NREL) Cooperative Network for Renewable Resource Measurements (CONFRM) is a joint effort between NREL and selected state entities to conduct long-term solar radiation measurements research. Texas has five participants, more than any other state, including UT-Austin, West Texas A&M University, UT-Rio Grande Valley, UT-El Paso, and NASA's Lyndon B. Johnson Space Center.

Texas State University's Advanced Functional Materials Laboratory is an important part of a collaboration awarded \$4.5 million in 2013 to participate in the DOE's SunShot Foundational Program to Advance Cell Efficiency (F-PACE). The DOE program aims to increase the efficiency of PV cells in the laboratory and manufacturing process.



In 2013, UT San Antonio's (UTSA) Texas Sustainable Energy Research Institute received a 3-year, \$750,000 grant from the DOE's SunShot initiative to develop solar technology and train minority students for jobs in the solar energy industry.

In 2011, the National Science Foundation (NSF) and DOE jointly awarded an \$18.5 million grant to the Engineering Research Center for Quantum Energy and Sustainable Solar Technologies (QESST), a multi-institution collaboration that includes the University of Houston. The consortium currently works to develop more efficient solar power technologies.



Texas A&M Launches World's Largest Solar PV R&D Facility

In June 2013, **Texas A&M University (TAMU)-Central Texas** announced a collaboration with California-based **PPA Partners**, a leading solar energy firm, to launch the **Center for Solar Energy (CSE)**, a research and development facility that, when completed, will be the largest of its kind in the world. Located



on 800 acres in Central Texas, the \$600 million facility will host a large assortment of leading-edge PV technologies, serve as a test site, and generate electricity for the entire TAMU campus. The center will also serve as an incubator for solar entrepreneurs to fast-track technologies to market, with access to a prototype manufacturing facility.

Government & Utility Initiatives

Multiple government programs in Texas have stepped in to support the advancement of solar power companies in the state. The Texas Emerging Technology Fund (TETF), which invests in research and commercialization of innovative technologies, and the Texas Enterprise Fund (TEF), created as a state deal-closing fund for economic development, have each invested in solar-related projects. To date, the two programs have invested \$10.5 million in solar technology firms (see chart below).

The Texas Emerging Technology Fund and Texas Enterprise Fund have awarded \$10.5 million to solar energy-related projects

Many Texas communities and utilities have adopted innovative financing mechanisms aimed at encouraging residential and commercial solar installations. **Oncor, Energy, AEP Texas, Southwestern Electric Power Company, El Paso Electric, and Austin Energy** are among the Texas utilities that offer incentives, to help consumers deal with the high upfront cost and long payback periods associated with solar PV systems, generally ranging from \$.75 to \$2.50 per watt installed. These installation incentives

Texas Emerging Technology Fund Solar-Related Awards

Recipient	Technology	Award
21-Century Silicon	Polysilicon	\$3,500,000
Ideal Power Converters	Inverters	\$1,000,000
SolarBridge Technologies	Inverters	\$1,500,000
Solarno	Solar cells	\$1,000,000
TOTAL		\$7,000,000

Texas Enterprise Fund Solar-Related Award

Recipient	Technology	Award
HelioVolt	Solar panels	\$1,000,000
SunPower	Solar panels	\$2,500,000
TOTAL		\$3,500,000

Texas Army Bases Go Solar for Army's Net Zero Energy Use Initiative

Two Texas army bases are implementing solar power projects as part of the **U.S. Army's Net Zero Energy Initiative (NZEI)**, launched in 2011. The Army's goal is to source approximately 25% of its power from renewable energy by 2025.

In April 2013, **Fort Bliss** launched a \$120 million, 20 MW solar field project, the largest renewable energy project in U.S. military history and a major step in reaching the facility's goal to generate all the power it uses and become net zero by 2018. It is Fort Bliss' third solar project to date. The post previously announced projects for 13.4 MW and 1.4 MW. Solar power is an excellent choice for the base, which is located in El Paso, Texas, where solar resources are optimal.

In March 2012, **Fort Hood** in Central Texas activated a 4-acre, 1 MW solar installation to provide power to 300 houses. The base's goal is to become net zero by 2020.



are frequently combined with a 30% federal tax credit to greatly reduce the cost of installing solar panels. A number of Texas utilities, such as **CPS Energy** and **Texas New Mexico Power Company**, offer solar PV system rebates. **TXU Energy** offers North Texas homeowners a solar panel leasing program called SolarLease, which includes customized system design, installation, maintenance, and related services over the life of the lease.

At the state level, Texas House Bill 1937, passed in 2009, enables cities to establish solar panel financing programs. Cities can now fund the installation of solar panels on residential properties and allow the homeowners to pay over several decades via a small line item on their property-tax bills. Austin was the first city to implement this legislation.

Workforce & Training

According to The Solar Foundation’s *National Solar Jobs Census 2013*, Texas ranks No. 6 among states in solar energy industry employment with 4,100 jobs, an increase of 900 since 2012.

Texas ranks No. 6 nationally for solar energy industry employment

Nationally, solar energy industry employment was estimated at nearly 143,000 in 2013, and is projected to grow more than 15% in 2014.

Texas is home to one of the largest microelectronics industries in the country, with 158



Solar Training Initiatives in Texas

The **Texas State Technical College** offers solar courses and a Solar Energy Technology Associate Degree at its Waco Campus and West Texas Campus in Sweetwater.



Austin Community College in Austin, Texas offers design and installation courses for solar photovoltaic systems.



Houston Community College offers a Solar Energy Technology PV certificate program.



ImagineSolar is a licensed school that offers a variety of solar training programs in Austin, Texas, for new and experienced solar industry workers.

semiconductor and related equipment manufacturing firms employing nearly 30,000 workers. The semiconductor manufacturing industry produces solar cells, as well as integrated circuits, memory chips, microprocessors, transistors, and other devices related to the solar energy industry.

A variety of educational programs, from one-day short courses to solar energy certificates and associates degrees are offered within the state. See the factbox above for details.

Solar Energy-Related Employment in Texas

Second Quarter 2013

Sector (Industry Code)	Firms	Employees	Average Annual Wage
Semiconductors, Solar Cells, and Related Devices Mfg. (334413)	125	28,775	\$114,920
Semiconductor Machinery Manufacturing (333242)	23	608	\$85,748
TOTALS	158	29,383	\$114,316

Source: Texas Workforce Commission

Biofuels & Biomass



Texas has leveraged its position as a center of global petroleum refining to develop a strong lead in the developing biofuels sector. Along with the concentration of refining industry knowledge, Texas also boasts plentiful and diverse biomass resources which provide the raw materials.

Biofuels and biomass are related renewable energy sectors that are well established, comprising 5.5% of national energy consumption and 50% of all renewable energy nationally in 2012. While solar and wind energy are primarily sold into the electric grid for residential and commercial users, biofuels and biomass are mostly used in the transportation and industrial sectors. The U.S. transportation sector alone accounted for 26% of renewable energy consumption in 2012, most of which was biofuels.

The biomass industry generates energy largely by burning organic materials, such as wood chips, as a substitute for fossil fuels. Landfills, wastewater treatment plants, and dairy farms are other common sources of biomass material. As the nation's No. 3 crop & livestock producing state and home to a large forestry industry, Texas is rich in potential biomass resources. The U.S.

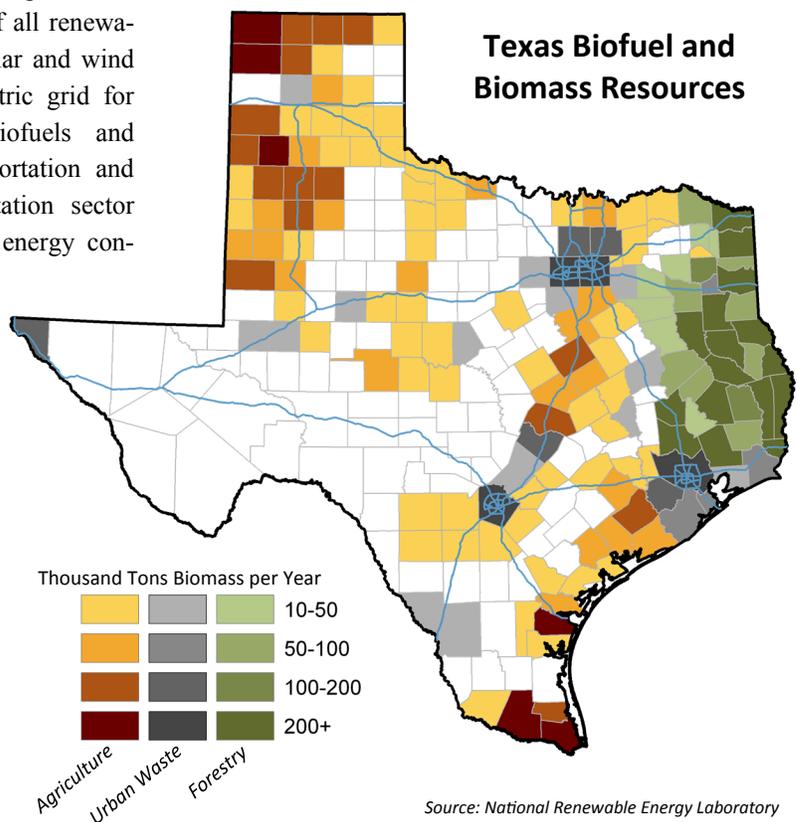
DOE ranks Texas among the top 10 states for biomass potential, including crop and forest residues, methane emissions, and crops.

Biodiesel

Biodiesel is a biofuel typically made from soybean oil, canola oil, animal fat, or waste vegetable oil, and is usually blended with traditional diesel before use. Soybean oil is the most common feedstock for U.S.-produced biodiesel with 67% of the market. Other vegetable oils (23.7%) and animal fats (9.2%) make up the remainder.

Texas is home to the nation's largest biodiesel plant

In 2012, 991 million gallons of biodiesel were produced in the U.S., accounting for approximately 1.8% of national diesel consumption. Biodiesel is less common than ethanol primarily because ethanol benefits from a



Source: National Renewable Energy Laboratory

more favorable set of federal mandates. As of November 2013, Texas was the largest biodiesel producing state, with 428 million gallons of production capacity from thirteen refineries.

Ethanol

The biofuel ethanol can be produced from corn and other crops or non-crop plant material rich in sugar or starch, and is usually blended with gasoline. While the Midwestern corn belt accounts for most of the nation’s ethanol production, Texas currently ranks No. 11 nationally for ethanol production capacity. Four ethanol plants with a total of 365 million gallons per year capacity have been built in the Texas Panhandle since 2008.

RBF Port Neches Biodiesel Production Facility is Nation’s Largest

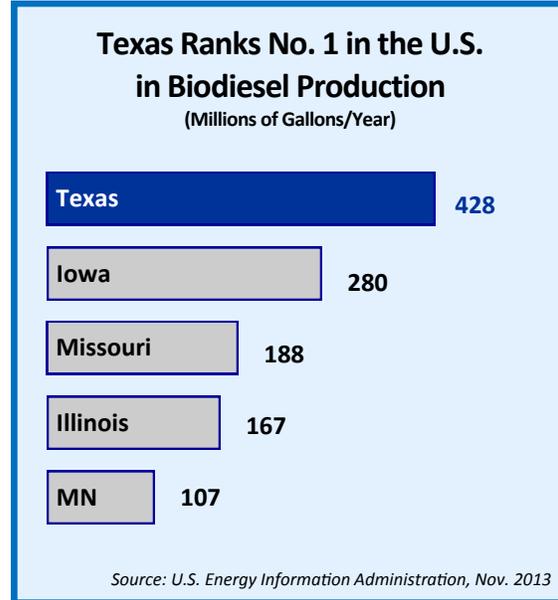
The largest biodiesel plant in the U.S. is the **RBF Port Neches Biodiesel Production Facility** located in Port Neches, Texas. The 180 million gallon per year facility was built in 2008 and is owned by Houston, Texas-based **Renewable Biofuels Inc. (RBF)**.

The RBF Port Neches Biodiesel Production Facility



Biomass

Biomass generation plants use wood products, landfill waste, agricultural byproducts, and livestock waste to generate electricity. Although ethanol and biodiesel have higher profiles, more biomass-derived energy is



produced and consumed nationwide, especially in the industrial and commercial energy sectors.

Most biomass energy is generated on-site for industrial use, a common practice in the wood and paper industry. Increasingly, new facilities are being constructed to generate and sell biomass energy to the electric grid. According to ERCOT, Texas had 231.6 MW of biomass generation capacity in 2012, a 43% increase from 2011. These figures don’t include companies generating biomass energy for on-site industrial use.

Some biomass facilities harvest natural gas and landfill gas (or biogas) from decomposing materials, such as landfill waste or cow manure. The resulting biogas, composed of methane, carbon dioxide, nitrogen, and other trace elements, can be burned to generate electricity or further processed and fed into commercial natural gas pipelines. As of July 2013, the EPA listed 34 Texas landfill gas operations capable of generating 101 MW of electricity.

Municipalities have discovered landfill gas-to-energy (LFGTE) projects can provide a significant revenue stream, create jobs, and reduce greenhouse gases. Some recently announced Texas municipal LFGTE

Houston's Shell Technology Center Focuses on Biomass-Sourced Biofuels

In January 2013, **Royal Dutch Shell** relaunched its Shell Technology Center in Houston, Texas (STCH). The facility underwent extensive modernization and expansion to become one of the largest industrial technology centers in the world.



Staffed by 2,000 Shell scientists and engineers, the STCH is focused on finding solutions for current and future energy challenges. A **Shell biofuels plant** is located at the Center, allowing staff scientists to study ways to replace gasoline with biofuels made from waste and inedible crops.

projects in Texas include Denton, Lebanon, Needville, and San Antonio.

Southern Power Company's wood-fueled Nacogdoches Generating Facility in Sacul, Texas, is the largest

biomass power plant in the nation. The facility began commercial operations in June 2012, has a 100-MW capacity, and is operating under a 20-year contract to supply electricity to municipally-owned Austin Energy. Low natural gas prices have negatively impacted the plant, which

is fueled by approximately one million tons annually of wood processing residues and other biomass materials.

Texas is home to the nation's largest biomass power plant

Cellulosic Biofuels

Cellulosic ethanol is produced using a method similar to the corn-based ethanol process, with an additional step added to convert cellulose-rich plant material into starches and sugars. The feedstock for cellulosic ethanol can be almost any plant material, which allows the industry to focus on non-food feedstock. Agricultural and forestry waste are prime candidates,

such as corn stalks and cobs, cotton gin trash, and lumber residue.

Current cellulosic biofuels research focuses on purpose-grown energy crops that can flourish on low value land, in semiarid climates, and using brackish water. For example, Texas A&M University researchers are studying potential feedstocks suitable for arid climates, such as switchgrass, a fast-growing native grass that can be cultivated on marginal land. They are also investigating crop residues, sorghum, and genetically modified sugarcane that can be grown outside the tropics.

Algae Biofuels

Algae biofuels utilize algae as a feedstock. Algae cells are oil-rich and can rapidly grow in either closed tanks or open ponds. The fast-growing characteristics of microalgae make this evolving technology very promising in terms of land use. Algae-derived biofuels are also attractive because microalgae are capable of thriving with brackish water and marginal land, inexpensive resources which don't compete with food crops.

In 2010, **Joule Unlimited** built a 5-acre biofuels pilot plant in Leander, Texas, which serves as Joule's R&D facility as it continues to work toward commercialization. The Massachusetts-based company has developed a closed-loop process using sunlight,



UTEX Microalgae Culture, Photo courtesy of UT-Austin

Texas A&M AgriLife Wins DOE Grant for Algae Research

In October 2013, the U.S. Department of Energy awarded \$8 million over four years to the Regional Algae Feedstock Testbed (RAFT) partnership, which includes **Texas AgriLife Research**, part of Texas A&M University. RAFT participants will research how algae can be grown year-around outdoors in different climates for use in biofuels.

The TETF awarded \$4 million to Texas AgriLife Research (TALR) in 2007, as a component of the national \$49 million Algae Biofuels Consortium. In addition to studying algae-based biofuels, TALR is also researching biomass production and nutraceuticals.



carbon dioxide, non-potable water, and a microorganism catalyst, similar to algae, to create ethanol and diesel.

UT-Austin is home to one of the world's largest collections of algae, the **Culture Collection of Algae (UTEX)**. It has more than 3,000 strains and supplies them to scientists and businesses around the world for research and development purposes. **UT-Austin** researchers are conducting multidisciplinary algae biofuel research in consultation with over 35 international companies on extracting bio-oils from algae to produce fuel.

Outlook for Texas Biofuels & Biomass

Texas concentrates on creating biofuels using non-food crops and agricultural byproducts, instead of using edible crops. Building on the state's strong agricultural and forestry production base, Texas researchers and businesses are investing in new renewable biofuels and biomass technologies to maintain the state's position as the nation's energy capital.

Similar to other forms of renewable energy, the modern biofuels and biomass industry is relatively young and expected to evolve further before achieving widespread adoption. Considerable research has been conducted on these technologies, although some have not reached commercial production status for reasons including the glut and low cost of natural gas, high corn prices, low-cost ethanol imports, and increasingly fuel efficient vehicles.

The **Southwest Research Institute (SwRI)** in San Antonio is one of the oldest and largest independent applied R&D organizations in the nation. SwRI investigates a wide range of engineering challenges, including biodiesel fuel production and testing (include algae). SwRI also operates the **International Alternative Fuel Technology Center (IAFTC)**, assisting clients with many types of non-conventional fuel types, including biodiesel. The institute's full-service facilities include chemical analysis, fuel blending, lab-scale production, and emissions testing.

SwRI[®]



Government Initiatives

Federal and state governments play an important role in developing the biofuels and biomass industry through renewable fuel standards, production tax credits, and support for R&D activities.

The biofuels industry has received federal subsidies for R&D, production, and fuel taxes for many years. As of early 2014, only federal biofuel research-related subsidies continue. The ethanol subsidy, an income

The Texas Emerging Technology Fund has invested \$11.7 million in biofuels-related projects

tax credit for companies blending biofuels into the petroleum-based fuel supply, were first enacted in 1978 and expired in December 2013. The ethanol subsidy ranged between \$0.40 and \$0.60 per gallon over the years. The federal subsidy for cellulosic ethanol also

expired in 2013. A similar \$1.00 per gallon federal tax credit for biodiesel blending, first established in 2005, was allowed to expire in December 2013.

At the time this report was published, there were efforts underway to reinstate federal biofuel subsidies and the renewables industry was pushing for an increase in the biofuel mandate under the Environmental Protection Agency’s (EPA) Renewable Fuel Standard (RFS) program. U.S. Congress first passed legislation in 2005 establishing the original RFS program, which mandated 7.5 billion gallons of ethanol production by 2012. Congress passed expanded legislation in 2007, mandating 36 billion gallons of production by 2022. In 2013, the biomass-based diesel RFS was 1.28 billion gallons and the advanced biofuel RFS was 2.75 billion gallons. However, in November 2013, the EPA called for the first-ever reduction in the amount of corn-based ethanol and advanced biofuels that refiners must blend into gasoline. The EPA reported that there isn’t enough gasoline nationwide to warrant continued ethanol increases. As of early 2014, debate over the EPA’s proposed reductions continues.

Texas Emerging Technology Fund Biofuels-Related Awards		
Recipient	Technology	Award
Algae Bio Fuels Consortium	Research	\$4,025,000
EQMA	Biomass	\$250,000
Photon8	Algae Biofuels	\$1,000,000
Sunrise Ridge Algae	Algae Biofuels	\$250,000
Terrabon	Biomass	\$2,750,000
Texas BioEnergy Alliance	Research	\$3,412,500
TOTAL		\$11,687,500

The Texas Tax Code offers a biofuel tax exemption; biodiesel or ethanol blended with taxable diesel is exempt from the diesel fuel tax.

Created in 2005 by the Texas Legislature, the Texas Emerging Technology Fund (TETF) provides Texas with an advantage in the research, development, and commercialization of new technologies. To date, the TETF has invested almost \$11.7 million in emerging biofuels and biomass technology. (See chart above).

TETF Invests in Photon8

Founded in New Jersey, **Photon8**, an algae biofuels company, moved to Brownsville, Texas, in 2010 upon receiving incentives from the Greater Brownsville Incentives Corp. and \$1 million from the Texas Emerging Technology Fund to commercialize a novel process that converts algae-based lipids into renewable biofuel.



Photon8 works in partnership with the University of Texas-Brownsville, where the company has its offices and labs.

Workforce & Training

The biofuels and biomass industry employs a wide range of workers with a variety of occupations, ranging from agricultural and construction workers to many types of scientists and engineers. Over 62,000 were employed nationwide in the biodiesel industry in 2013, according to the National Biodiesel Board, a national trade association. Additionally, national ethanol production created over 86,500 direct jobs in 2013, according to the Renewable Fuels Association. And according to the Biomass Power Association, the nation's biomass industry employed over 15,500 in 2012.

Texas has the nation's largest fuel refining and chemicals workforce

Texas arguably has the largest pool of skilled workers related to the biofuels sector. The Lone Star State leads the nation in petrochemical refining and chemical production, and is home to the nation's largest energy and chemicals

workforce (see table below). Many of the industrial processes and chemical transformations used in biofuels production are similar to processes used in oil refining and petrochemical manufacturing. While most of these workers are not currently involved in the biofuels and biomass industry, their skills are translatable from the fossil-fuel based industries.

Texas Music Icon Willie Nelson Is a Biodiesel Pioneer

Texas native son and music legend, **Willie Nelson** is a longtime biodiesel proponent, known for fueling his tour buses with the biofuel (see photo below). Beginning in 2004, Nelson and his wife partnered with Hawaii businessman, Bob King, in several biodiesel ventures, including the founding of the Sustainable Biodiesel Alliance and the building of two biodiesel plants, one of which is in Carl's Corner, Texas.



Currently, Willie's trademarked **BioWillie Biodiesel** is distributed by Pacific Diesel, a Hawaii-based company run by Bob King. The **Pacific BioDiesel Texas** subsidiary was founded in 2005 to operate the Texas biodiesel plant.



Bob King and Willie Nelson, Photo courtesy of BioWillie Diesel

Biofuels and Biomass-Related Employment in Texas

Second Quarter 2013

Sector (Industry Code)	Firms	Employees	Average Annual Wage
Petroleum Refining (32411)	85	21,675	\$123,240
Basic Chemical, Petrochemical, Ethanol, Biodiesel Mfg. (3251)	228	32,484	\$110,812
TOTALS	322	54,159	\$115,786

Source: Texas Workforce Commission



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