Enriching Economy and Environment:

Making Central Texas the Center for Clean Energy

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Powerful ideas generated here.

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Introduction

Texas has been a world leader in energy production – and consumption – for more than a century. Although the state is home to just seven percent of the U.S. population, it accounts for about 12 percent of the nation's total energy consumption. According to recent estimates, in as little as 40 years Texas may need to import more than 80 percent of its energy in order to meet its energy demand. This level of energy imports would make the state highly vulnerable to price fluctuations and political unrest in the oil-producing regions, as well as draining monies from both state and local economies.

Yet it is possible for Texas to meet much of its growing demand for energy with clean, secure, renewable energy. Although renewable energy sources currently provide less than one percent of the state's energy, Clean Energy technologies are emerging that can yield increased volume at reduced costs. Extensive evidence indicates a global shift toward renewable energy as nations erect trade barriers to those economies and trading partners that continue to rely on highly carbon-intensive energy sources. As in any industrial technology shift, the Clean Energy pioneers who are first positioned to facilitate this retooling of the energy infrastructure will benefit most from this new world trend. The State of Texas has the opportunity to prosper in a clean-energy future.

Clean Energy has the potential to support the public interest and enhance economic growth in Texas as well as:

- Increase local employment and income
- Improve local tax revenues
- Enlarge the infrastructure development
- Impart economic flexibility
- Provide a more diverse resource base,
- Increase stability of fuel supply and prices
- Broaden consumer's choices in energy sources
- Contribute to overall system reliability
- Reduce or eliminate pollution associated with the provision of energy services

Clean Energy Industry represents one of the strongest growing and sustainable sectors of the new global economy, with growth rates commensurate with or greater than those for the information economy. Major international corporations and world leaders agreed at the 2000 World Economic Forum (Davos, Switzerland) that sustainable development is the most significant policy issue facing corporations worldwide and represents the greatest opportunity for growth.

Clean Energy creates jobs in direct manufacturing of related technologies (wind turbines, photovoltaics, biogas plants, etc.), research and development, system design, installation and maintenance, education and training, energy auditing and management, and consulting. Select statistics on employment impacts of renewable power include:

- One megawatt (MW) of installed wind power-generating capacity creates jobs for 15-19 people.

- Developing the 500,000 MWs of potential wind power in the United States could create an estimated 1 million short-term construction jobs and employ more than 33,000 operations and maintenance workers, excluding manufacturing jobs associated with building wind turbines.

This study highlights the opportunities associated with Central Texas' Clean Energy resources and the state's potential to become a center for Clean Energy.

Chapter 1 defines Clean Energy and highlights the factors contributing to its growth in the United States.

Chapter 2 discusses the economic opportunities for Clean Energy businesses, provides Clean Energy market forecasts by region and technology, and identifies emerging trends in developing clean-energy technologies and energy efficiency.

Chapter 3 presents the results of a national survey of Clean Energy companies, which provide some industry insights, including economic development needs, the growth expectations of these companies, and their location preferences.

Chapter 4 provides an analysis of Central Texas' strength and why it is well positioned to become a world leader in a Clean Energy future. Government support, well established infrastructure, rich renewable resources, the increasing synergies between Clean Energy and information technology, and the University of Texas at Austin's research facilities and well-educated graduates are some factors encouraging the growth of Clean Energy in this region. Austin's supportive infrastructure for technology and innovation development, coupled with Austin's proximity to large natural resources for renewable energy, makes it an ideal candidate to grow into a clean-energy cluster in the long run. There are 335 enterprises engaged in Clean Energy in Texas, 80 of them in Central Texas. The chapter also profiles five companies engaged in Clean Energy and their reasons for locating in Central Texas.

Chapter 5 highlights the emergence of Texas as one of the nation's most surprising clean-energy success stories. Texas' groundbreaking utility restructuring law enabled the state to increase its wind capacity from 140 MW to 1100 MW in 2001. The renewables standard has been such a success that the state is several years ahead of schedule on its target of adding 2,000 MW of renewable energy by 2009. For many years, the city of Austin and its municipal-owned utility, Austin Energy, has been a national leader in energy-efficiency initiatives promoting Clean Energy. The chapter goes on to benchmark Central Texas and state initiatives against other regions expressing an interest in Clean Energy.

The study concludes that Central Texas is well positioned to play a major role in the development of national initiatives to encourage the establishment of a Clean Energy sector.

CHAPTER ONE

What is Clean Energy?

What is Clean Energy?

Because Clean Energy is a constantly evolving concept, it's a good idea to clarify one's meaning of the term. Although often considered synonymous with green (renewable) energy, an extension of the classification grew from recent developments in the field.

For the purposes of this report, **Clean Energy** is associated with any technology that reduces the environmental impact per unit of emission or reduces the environmental impact per output unit of any product or service that requires the use of any energy conversion procedure, or both. This includes technologies associated with improved sources of energy, more efficient use of energy, and better management of energy waste.

We define **renewable energy** as any energy resource that is naturally regenerated over a short time and derived:

- Directly from the sun (*e.g.*, thermal, photochemical, and photoelectric)
- Indirectly from the sun (*e.g.*, wind, hydropower, and photosynthetic energy stored in biomass)
- From other natural movements and mechanisms of the environment (*e.g.*, geothermal and tidal energy)

Renewable energy does not include energy resources derived from fossil fuels, waste products from fossil sources, waste products from inorganic sources, or nuclear material.

Unlike fossil fuels, renewable sources are available in practically infinite supply, and their retrieval has limited impacts on the environment. In Texas, wind, photovoltaics (direct conversion of solar energy to electricity), and biomass are primary areas of renewable development.

Texas also boasts an emerging fuel cell industry. Fuel cells provide an improved method for producing energy. They convert natural gas, methanol, or hydrogen into electricity silently and without burning. Heat and water vapor are the only by-products of fuel cells directly supplied with hydrogen.

Although natural gas is not considered a renewable source of energy, it is cleaner burning than traditional fossil fuels. There is ongoing debate about whether fuel cells should be classified among Clean Energy technologies; however, when fuel cells use renewable energy sources, the product is generally considered absolutely clean, and is thought to hold great promise for reducing greenhouse gases that may contribute to global warming.

For the purpose of this report, we consider photovoltaics, geothermal generation, wind turbines, fuel cells, biomass generation, and energy efficiency technologies all to be Clean Energy technologies.

Wind

The basic wind energy conversion device is the wind turbine. Wind turbines capture the wind's energy with two or three propeller-like blades, which are mounted on a rotor, to generate electricity. Mounted on high towers, wind turbines take advantage of the stronger and less turbulent wind at 100 feet or more above ground. Most modern wind turbines are three-bladed designs with the rotor position maintained upwind (on the windy side of the tower). This design is usually called the classic *Danish concept*, and accounts for the vast majority of the turbines sold in world. Today, European companies manufacture 90 percent of the world's wind turbines, with Denmark the world's dominant supplier of wind turbines.

Wind turbines come in two basic types, *horizontal axis* and *vertical axis*. Despite their different appearances, the basic mechanics of the two systems are very similar. The turbine converts wind passing over the blades into mechanical power, which is fed through a transmission to a generator. The transmission keeps the generator operating efficiently throughout a range of different wind speeds. The electricity can be used directly, fed into a transmission grid, or stored for later use.

Wind turbines are a modular technology, which means utilities or users can install them as necessary. Small turbines (below 50 kilowatts (kW)) can be used as stand-alone applications to pump water or to power individual homes, farms, and ranches. Such turbines are especially useful in remote areas. For utility-scale sources of wind energy, tens to hundreds of wind turbines (typically 1 to 2 MW) can be erected to form a wind farm.

The workhorses of today's industry are 600 kW to 1500 kW turbines – large enough to supply electricity to 600 to 1,000 modern homes. The megawatt market took off in 1998; megawatt-sized machines are ideal for offshore applications, and for areas where siting space is scarce. In the U.S., only one offshore facility is under development in New England, though not due for actual construction until 2005. A typical 600 kW turbine has a blade diameter of 35 meters and is mounted on a 50-meter concrete or steel tower. Prices vary depending on tower heights and rotor diameters but typically installed cost is $1000 per rated kW. A special low-wind machine with a relatively large rotor diameter will be more expensive than a high-wind machine with a small rotor diameter.

Location is a very important factor that influences the performance of wind turbines. In general, wind speed increases with elevation, which is why most wind turbines are mounted on a tower. The strength of affordable materials limits most towers to heights of approximately 250 feet. On wind farms, turbines are most often spaced at intervals of five to 15 times the blade diameter to avoid turbulence from one turbine affecting the wind flow at others. When there is a strong prevailing wind direction towers can be closer together.

The power generated by a modern wind turbine is related to the cube of the wind speed. This means that a site with twice the wind speed of another will generate eight times as much energy. Consequently, the availability of good wind speed data is critical to the feasibility of a wind project. Although wind is intermittent, annual cumulative production is highly predictable so utilities can integrate the output from wind turbines into existing

electrical grids with a high degree of confidence. A modern wind turbine's capacity factor is in the range of 30 to 40 percent.

The main environmental concerns surrounding the use of wind energy are impacts on land use, noise, effects on wildlife, and disruption of radio transmissions. Since the available wind resource is so spread out, vast areas of land are required to generate significant amounts of electricity. However, wind turbines can be sited on areas used for grazing of animals or land of marginal value. The noise of wind turbines has also been cited as a negative impact of wind turbines but the decibel level of wind turbines has significantly improved over the past decade.

There are also some technological advances that would improve the potential of wind power. New, lightweight composite materials in turbine blades could enable more reliability in larger turbines (over 1 MW) and make them more cost effective. Similarly, advances in control systems could allow larger turbine blades to be used without experiencing damage during storms. Breakthroughs in electricity storage would also make wind power more attractive as an electricity supply option. Since there are large areas in the U.S. that have only moderately strong winds, any improvements that make possible the economical generation of electricity from areas with poor wind resources would have a big impact on the future of wind power.

Solar

Solar technologies use the sun's energy and light to provide heat, light, hot water, electricity, and cooling for homes, businesses, and industry.

There are four different types of solar technologies:

Photovoltaics	A semiconductor-based technology that directly converts sunlight to electricity. This can include very simple cells that power calculators and watches, and complex systems that can light houses and provide power to the electric grid.
Passive Solar Heating	Buildings that are designed for passive solar and daylighting combine building materials that absorb and slowly release the sun's heat and design features, such as large south-facing windows. No mechanical means are employed in passive solar heating.
Concentrating Solar Power	This technology uses reflective materials, such as mirrors, to concentrate the sun's energy. This concentrated heat energy is then converted into electricity.
Solar Hot Water and Space Heating and Cooling	Solar hot water heaters use the sun to heat either water or a heat-transfer fluid in collectors.

Photovoltaic (PV) materials generate direct current electrical power when exposed to light. PV cells are formed from silicon wafers or from thin-films of either vacuum-deposited silicon or other semiconductor materials. PV cells are connected together to form modules or panels. Modules, in turn, are connected to form arrays, and arrays can be interconnected to generate electricity for large loads, such as an office building. The electricity can be used immediately or stored in batteries for later use. The energy can even be fed directly into a building or the electric power grid with an inverter.

Three key elements in a solar cell form the basis of their manufacturing technology. The first is the semiconductor, which absorbs light and converts it into electron-hole pairs. The second is the semiconductor junction, which separates the photo-generated carriers (electrons and holes). The third is the contact on the front and back of the cell that allow the current to flow to the external circuit. The two main categories of technology are defined by the choice of the semiconductor: either crystalline silicon in a wafer form, or thin films of other materials.

Crystalline silicon. Historically, crystalline silicon has been used as the light-absorbing semiconductor in most solar cells, even though it is a relatively poor absorber of light and requires a considerable thickness (several hundred microns) of material. Nevertheless, it has proved convenient because it yields stable solar cells with good efficiencies and uses process technology developed from the huge knowledge base of the microelectronics industry.

Thin films. The high cost of crystalline silicon wafers (they make up 40-50 percent of the cost of a finished module) led the industry to look for cheaper methods of producing solar cells such as through ribbon or epitaxial growth to create silicon wafers that are then processed into PV cells. The selected materials are all strong light absorbers and

only need to be about 1 micron thick, significantly reducing materials costs. The most common materials are *amorphous silicon* (a-Si, still silicon, but in a different form), or the polycrystalline materials: *cadmium telluride* (CdTe) and *copper indium (gallium) diselenide* (CIS, or CIGS).

Each of these materials is amenable to large-area deposition (onto substrates of about three-foot dimensions) and, hence, high-volume manufacturing. The thin film semiconductor layers are deposited onto coated glass, polymer, or stainless steel sheets. The semiconductor junctions are formed in different ways, either as a PIN device in amorphous silicon, or as a hetero-junction (*e.g.*, with a thin cadmium sulphide layer) for CdTe and CIS. A transparent conducting oxide layer (such as tin oxide) forms the front electrical contact of the cell, and a metal layer forms the rear contact.

Thin film technologies are all complex. They have taken at least twenty years, supported in some cases by major corporations, to get from the stage of promising research (about eight percent efficiency at 0.5″ scale) to the first manufacturing plants producing early product.

PV Benefits	**Technical and Market Barriers**
Portability Reliability Low operating costs Low environmental impact Stand-alone capability Modularity Safety Versatility Short lead time Ease of installation	Limited understanding of the technology and its existing commercial potential. High initial costs and the difficulties of securing finance. The low apparent cost of conventional electricity. The lack of proper standards for system components, design and installation. The lack of grid-connection regulations adapted to PV.

Biomass

Biomass technologies include several ways of using organic matter to generate power or heat, process into fuels, or convert to organically derived chemicals and other materials. Since many types of organic matter are constantly renewed, biomass processes offer the benefit of generating oxygen while growing, and their combustion or conversion generates much less carbon and fewer toxins than conventional fossil fuels. Bioenergy ranks second to hydropower in renewable U.S. primary energy production and accounts for three percent of the primary energy production in the United States.

Biomass sources are quite varied, including agricultural food and feed crops, crop waste and residues, wood wastes and residues, dedicated energy crops and trees, aquatic plants, animal wastes, and municipal wastes.

Benefits of biomass	**Disadvantages**
Increase economic and environmental benefits Decrease vulnerability to oil supply disruptions and decrease oil imports Production flexibility Increase in farm income Potential to decrease erosion and the space used for landfills	Amount of land needed for crops Extra incentives needed to encourage farmers to grow crops Plants produce carbon dioxide during combustion Resources currently not sufficient to ensure continuous operation

There are three main kinds of biomass technologies: biopower, biofuels, and biochemicals.

Biopower. Direct firing, gasification, co-firing, and modular systems can generate electricity.

In *direct firing*, or combustion, biomass is burned to produce high-pressure steam. The steam is then used to turn a turbine connected to a power generator to produce electricity. Typical boilers are in the 20 to 50 MW range, compared to the 100 to 1,500 MW range of coal-fired plants. The efficiency of these boilers can reach more than 40 percent.

In *gasification*, biomass, such as wood, wood byproducts, or urban waste, is converted to a combustible gas. The gas can be cleaned of impurities for a lower-polluting fuel to drive combined gas and steam turbines. Efficiencies from gasification can reach 60 percent. Gasification is the main alternative to combustion for power generation.

In *co-firing*, a portion of the coal used in a coal-fired plant is replaced by biomass. About five to 15 percent of biomass, by heat content, can be substituted for coal at an additional cost estimate of less than 0.5 cents/kWh compared to coal firing, according to the Oak Ridge National Laboratory. Co-firing is less expensive because little new or additional equipment is needed to incorporate the biomass with the coal.

A *modular system* uses direct firing, gasification, or co-firing, but is on a much smaller scale, better suited for small villages, farms, and small industries. The U.S. is currently in the research and development mode with modular systems.

Biofuels. Biomass can be converted directly into fuels called biofuels. These biofuels are used primarily for transportation. The two most common biofuels are biodiesel and ethanol. Biodiesel is an ester, similar to vinegar. Ethanol is an alcohol. Fermentation with bacteria, yeasts, and enzymes, breaks down the carbohydrates in the biomass into alcohol. Ethanol, a gasoline additive, is produced through this method using the starch in a crop like corn. The ethanol industry is expected to produce an annual record of more than 2 billion gallons in 2002. Currently, 66 plants can produce more than 2.55 billion gallons per year. Eleven additional plants are under construction.

Biochemicals. Biomass can be heated without oxygen and changed into oil. After the biomass is transformed into oil it can be used to generate electricity. The oil is useful and has many advantages: it is easy to transport and store, and can be mixed with coal to generate power at coal plants. A chemical called phenol can be extracted from it to make wood adhesives, molded plastics, and foam insulation. Biochemicals are still being researched today. The DOE is studying such biomass processing methods as chemical processing, bioprocessing, thermochemical processing, mechanical processing, and integrated/hybrid processes, such as wet corn or pulp mills, to produce chemicals.

Geothermal

Geothermal energy is derived from the natural heat of the earth. Geothermal resources come in five forms: hydrothermal fluids, hot dry rock, geopressured brines, magma, and ambient ground heat. Of these five, only hydrothermal fluids have been developed commercially for power generation. On the temperature scale, geothermal resources are classified as high-temperature (>302°F), medium-temperature (194 to 302°F) and low-temperature (<194°F).

The highest temperature resources are generally used only for electric power generation. Current U.S. geothermal electricity generation is approximately 2,800 MW. Currently identified hydrothermal resources could provide 25,000 to 50,000 MW of power. Uses for low- and moderate-temperature resources can be divided into two categories: direct use and ground-source heat pumps.

Currently, most electricity production using geothermal energy is based on conventional steam turbine and generator equipment, in which expanding steam taken from the ground spins the turbine/generator to generate electricity. Geothermal power plants operate at high capacity (over 70%) and typically have availability factors greater than 95 percent. New steam plants at The Geysers in California, for example, operate more than 99 percent of the time.

Mile-deep or deeper wells can tap steam and very hot water in underground reservoirs to drive turbines that generate electricity. Three types of power plants are operating today:

- *Dry steam plants*, which directly use geothermal steam to turn turbines;
- *Flash steam plants*, which pull deep, high-pressure hot water into lower-pressure tanks and use the resulting flashed steam to drive turbines; and,
- *Binary-cycle plants* pass moderately hot geothermal water through a heat exchanger to boil a secondary fluid with a much lower boiling point than water. This causes the secondary fluid to flash to steam, which then drives the turbines.

Issues for geothermal projects include high capital cost and environmental concerns associated with the emission of sulfur and nitrogen gases. Still, some observers consider geothermal plants one of the cleanest sources of electric power currently available.

Direct use involves using hot water from geothermal resources directly to provide heat for industrial processes, crop drying, greenhouses, aquaculture, or heating buildings. Ground-source heat pumps use the earth or groundwater as a heat source in winter and a heat sink in summer. Geothermal district heating systems supply heat to multiple buildings through a network of pipes carrying water heated by geothermal resources. Using resource temperatures between 40 and 100°F, the heat pump transfers heat from the soil to the house in winter and from the house to the soil in summer. People at more than 120 locations (some of which include as many as 500 wells) use geothermal energy for space and district heating. These direct use systems are located mainly in the western United States. Current U.S. installed capacity of direct use systems totals approximately 500 MW.

Although the present geothermal industry is based solely on hydrothermal (hot water) resources, the long-term viability of geothermal energy lies in developing technology to harness the full range of geothermal energy. These include widespread resources that

require deeper drilling or injection of water to recover the heat stored in the subsurface rock.

The geothermal market, while small, offers significant opportunities for new entrants, particularly in the lucrative refurbishment arena. Improved use of hydrothermal resources, limitation of front-end costs, and increased ground heat extraction are the keys to a steady development of conventional geothermal energy.

Fuel Cells

The beginning of fuel cell technology dates back to the 1800's; Francis Bacon built the first practical cell in 1959. Licensed by Pratt & Whitney for the Apollo space program, fuel cell technology is still used in space; there are three alkaline fuel cells on the space shuttle. However, these technologies are too expensive for commercial applications.

Fuel cells are electrochemical devices that combine hydrogen and oxygen to generate electricity, heat, and water without combustion. Because the fuel is converted directly into electricity, a fuel cell operates at efficiencies comparable to the best internal combustion engines. Hydrogen can be derived from a fuel such as natural gas, propane, methanol, or gasoline. It can also be obtained from the electrolysis of water, biomass gasification photolysis, stored hydrogen, or a hydrogen pipeline.

The potential advantages of fuel cells suggest a promising future. For example, their modular design, few moving parts, near-zero emissions, and ability to generate electricity at remote locations without transmission lines represent significant advantages over traditional electricity generation. Fuel cells' heat is a valuable by-product. When it is utilized with the direct electricity output, the potential total efficiency of such combined heat and power systems can exceed 80 percent. In many states, fuel cells are being classified as the equivalent of such renewable technologies as wind and solar.

The potential applications of fuel cells fall into three major categories:

Stationary power applications include power for residential or commercial buildings. Fuel cell systems can provide on-site power, easing the strain on the power grid and reducing inefficiencies due to transmission losses. Such systems could deliver power to remote residential sites without access to primary grid power, thereby deferring, if not eliminating, the need for expensive grid connections. Fuel cell power plants are so clean that some areas of the U.S. have exempted them from air permit requirements. They are currently available in 200 and 250 kW sizes; a 200 kW module powers more than 100 homes. Smaller units for individual homes are under development. In August 2002 the Houston Advanced Research Center connected a five kW PEMFC system, believed to be the first residential-size system in Texas, to the grid in The Woodlands.

Transportation applications range from wheel chairs to golf carts, cars and buses, space vehicles and satellites. Fuel cell passenger vehicles are expected to be at least twice as efficient as internal combustion engines. Almost every major auto company in the world is testing fuel cell cars on the road. Perhaps more than any other fuel cell application, the motor vehicle market segment has received more attention from the public and from lawmakers. While much has been made of fuel cell-powered vehicles for personal use, mass transit buses and larger fleet vehicles are the most likely markets for near-term commercialization. This is due to the potential to implement more easily fueling infrastructure for such vehicles.

Portable applications include small generators and power for electronic devices such as laptop computers, cellular telephones, and video cameras. Recharging fuel cell-powered electronic devices could take just seconds by inserting a small cartridge of methanol instead of waiting several hours for a battery to recharge.

There are five main technologies used to produce fuel cells as shown below.

Fuel Cell Technology	Operating temperature, F	Efficiency
Phosphoric Acid (PAFC)	300-400	40
Molten Carbonate (MCFC)	1,200	60
Solid Oxide (SOFC)	1,800	60
Proton Exchange Membrane (PEMFC)	175	60
Alkaline (AFC)	300-400	70
Direct Methanol (DMFC)	120-190	40

Source: http://www.fuelcells.org/fctypes.htm

Each of these competing technologies offers certain benefits and drawbacks that lend themselves to different markets and applications. Each type of fuel cell has a characteristic operating temperature, which is perhaps the most critical feature in selecting a fuel cell technology for a given application. For example, because low-temperature operation is critical for a notebook computer application, PEMFC fuel cells are required for this market segment. In an industrial or power plant applications where higher temperatures can be tolerated, and may be desirable for cogeneration purposes, PAFC, MCFC, and SOFC are preferable due to their higher efficiency and steam output. To date, PAFC fuel cells have the largest installed base of these fuel cell technologies.

A promising new generation of fuel cells employing solid oxide should be highly competitive in customer-based and grid-support applications, such as providing power services or deferring transmission and distribution upgrades. Pairing an SOFC fuel cell with a small gas turbine could produce a power cycle with unprecedented efficiency, approaching 70 percent.

Energy Efficiency

Energy efficiency is the concept of using advanced technologies and processes to provide better quality energy services with less energy, *i.e.*, the most productivity from every unit of energy. Energy efficiency ranges from more efficient industrial processes, building materials, and appliances to energy management products and services.

Buildings: In buildings, energy efficiency means using less energy for heating, cooling, and lighting; and installing energy-saving appliances and equipment.

Industrial: Creating industrial products is extremely energy intensive, so simple measures such as optimizing and maintaining equipment can save enormous amounts of energy. Recent technological advances in the design of boilers and furnaces allow them to operate at higher temperatures while using less energy. This technology is not only more efficient, but is also cleaner, releasing fewer emissions. Hotter furnaces have spurred the development of new materials that withstand hotter temperatures. These composite materials are strong, light, and corrosion-resistant, so they are quite durable.

Transportation: The evolution toward more efficient, environmentally friendly transportation fuels is reflected in improvements in vehicle design, components, and materials. Alternative-fuel vehicles (AFVs), which can either switch between two fuels or run on a mixture of two fuels (such as gasoline and ethanol), are now available, and the majority is sold as fleet vehicles. In addition, recent developments in both AFVs and petroleum-based vehicles, such as advances in engines, drive trains, and emission-control technologies, may double or triple the efficiency of current vehicles. These new technologies include hybrid electric vehicles (HEVs), which combine an engine with an electric motor, and fuel cells, which produce electricity by converting a fuel (generally hydrogen and oxygen) into water.

Power: In the power industry, energy efficiency involves getting the most usable energy out of the fuels that supply power plants. At its best, energy efficiency in the power industry can lead to postponing – or altogether avoiding – the construction of new plants.

CHAPTER TWO

The Clean Energy Opportunity

The Clean Energy Opportunity

Clean Energy technologies and markets are becoming commercially viable. This transition is attributable to a confluence of historical events, political will, social demand, environmental concern, and technological maturity. Support for Clean Energy was accelerating prior to the terrorist attacks on September 11, 2001; subsequent concern for energy security and self-sufficiency made interest in Clean Energy all the more acute.

Drivers of Clean Energy market opportunities include:

Technological maturity and declining costs. When first popularized in the 1970s, Clean Energy technologies were not viable outside a research lab and there was no infrastructure to support them. Wind energy costs have achieved parity with natural gas in some areas, and the price of photovoltaics drops 15 percent a year.

Growing demand for power in the developed and developing worlds. Between 1999 and 2020, world energy demand should increase between 57 percent (International Energy Agency, OECD) and 75 percent (Energy Information Agency, DOE). The developing world accounts for half to two-thirds of this increase. Clean Energy technologies present export opportunities; already, United States manufacturers export 70 percent of the photovoltaic units they produce each year. Clean Energy technologies better address the demand in these energy markets for scalability, low maintenance requirements, and ability to deploy in remote areas.

Utility restructuring. Deregulation allows environmentally conscious consumers to purchase energy generated by Clean Energy technologies.

Concern for global climate change and environmental sustainability. Emissions reductions targets specified in the Kyoto Protocol and elsewhere will encourage the adoption of Clean Energy technologies and may make the limitation of emissions an acute need. Texas ranks number one among U.S. states in emission of greenhouse gases, amounting to 166.56 million metric tons (coal equivalent). This amount equals the combined emissions of 119 developing countries. The U.S. currently emits more carbon dioxide than China and India combined.

Recognition of external costs. Public and government concern is rooted in the known external costs; the European Commission estimates that external costs to member countries relying on fossil fuels for a large part of their energy needs amounts from 0.5 to 5.2 percent of GDP.

	Generation Cost Cents per kWh	**Estimated External Cost of Generation** (does not include disposal of nuclear waste) **Cents per kWh**
Coal	3.11 to 3.41	1.94 to 14.6
Gas Turbine	2.54 to 3.41	0.97 to 3.89
Nuclear	3.31 to 5.74	0.19 to 0.58
Good wind site	5.84	0.05 to 0.24
Optimal wind site	3.89	0.05 to 0.24

Source: as cited in Johnson 2002 IEA, Externe, Wind Power Monthly

Potential employment. Clean Energy production is, in most cases, more labor intensive than fossil fuel-based energy production. New employment opportunities include skilled jobs in research, manufacturing, and services as well as less skilled jobs in installation and distribution.

Concern for energy security and oil dependence. Following a business-as-usual scenario, U.S. dependence on foreign oil and natural gas will only increase. The Union of Concerned Scientists estimates that America's current dependence on oil imports costs $200,000 per minute and adds substantially to its trade deficit. Development of diverse Clean Energy resources may reduce by half the U.S. dependence on the Middle East and Russia for oil and gas.

Energy efficiency technologies prove themselves. Since 1973, energy intensity (energy consumption per unit of GDP) has fallen 45 percent.

The current world Clean Energy market is estimated to be $142 billion. Based on growth rates over the last decade and conservative assumptions of increased growth across a limited range of Clean Energy technologies, we estimate the Clean Energy market will turn over approximately $450 billion annually by 2020. This estimate excludes fuel cells, which would add an additional $150 billion with very conservative growth assumptions. Our analysis does not consider the potential impact of initiatives such as a proposed national U.S. renewable portfolio standard, which would require that 10 percent of the energy used to come from renewable resources. Readers may find details of our assumptions in the appendix.

World Clean Energy Market 2002-2020

$billion	Current	2010	2020
Wind	4.2	18.2	112.7
Biomass	15.7	21.5	31.8
Geothermal	3.2	4.3	6.4
PV	1.3	5.6	33.8
Fuel cell	4.0	23.0	168.4
Energy Efficiency	114.2	156.9	256.1
TOTAL	**142.6**	**229.5**	**609.2**

U.S. Clean Energy Market 2002-2020

$billion	Current	2010	2020
Wind	1.0	4.4	27.1
Biomass	2.9	3.4	4.1
Geothermal	0.7	.9	1.3
PV	0.5	2.1	14.0
Fuel cell	1.2	6.9	82.9
Energy Efficiency	37.6	51.3	81.2
TOTAL	**43.8**	**69.1**	**210.6**

Texas Clean Energy Market 2002-2020

$billion	Current	2010	2020
Wind	0.3	0.8	3.1
Biomass	0.1	0.2	0.3
Energy Efficiency	3.9	5.3	8.5
TOTAL	**4.3**	**6.2**	**11.9**

We take the following considerations into account for each technology-based estimate:

- Wind market estimates are based on installed capacity.
- Biomass is power generation from the incineration or gasification of agricultural crops such as switchgrass. Where possible we distinguish biomass from MSW or landfill gas.
- Geothermal market estimates are for centralized power generation. We discuss the growing market for direct-use geothermal-based energy, but insufficient data exists to determine current or potential market value.
- Solar market estimates are derived from photovoltaic shipments only.

- Fuel cell estimates to 2020 are provided for illustrative purposes only and our figures for markets to 2010 rely on extant studies conducted by national business research services. The current fuel cell market is immature and the data are scant; though the outlook is positive for the fuel cell market, the magnitude and pace of growth is uncertain.

- Energy efficient technologies are embedded a wide array of mechanical and electronic devices; our estimates reflect only the share of new construction and building renovation invested in energy efficiency.

Wind

Wind energy is the fastest growing form of energy generation, expanding at an annual rate of more than 25 percent for more than a decade. Global wind capacity more than tripled during the past 4 years. The current global total of 24,000 MW is enough to supply about 6 million homes. The U.S. installed wind generating capacity is 4,260 MW, or enough power for more than one million homes.

Wind is a modular technology that can be erected quickly; developers can build a wind farm in six to 12 months. Generators can also integrate wind turbines into existing grid and off-grid applications. Large, modern wind turbines operate together in wind farms to generate electricity for utilities, while homeowners and remote villages can use small turbines to help meet local, smaller scale energy needs. Possible environmental issues (visual, cultural, land use, bird impacts and noise) necessitate careful planning and environmental assessment.

Wind energy's cost fell more than 80 percent during the last two decades.

New wind energy technologies emerged in the early 1980's in response to the oil shocks of the 1970s. At that time, production costs approached 38 cents per kwh, well above the cost of coal and natural gas in the U.S. Government assistance disappeared in the late 1980s and the U.S. industry faltered. Recent government support coupled with deregulation of energy markets has driven renewed interest in wind energy and the remarkable growth. Due to improved efficiency, economies of scale, increased ability to cope with wind variability, and better site location methods, wind is now a commercially competitive energy resource. The wind industry is also bolstered by the increasing willingness of the public to pay higher utility rates for cleaner energy. Despite these developments, the industry is not without its challenges. Even in the best of circumstances, wind energy technologies have low capacity factors -- amount of energy generated in one year divided by the total amount it could generate if it ran at full capacity -- and the wind resources are frequently located far from where power is required.

The U.S. has the greatest wind capacity in the world but lags well behind Europe in developing this resource. The EU had 14,435 MW of installed wind capacity in 2001 and set a target of 60,000 MW by 2010. About 8,700 MW, 36 percent of the world's current wind capacity, are installed in Germany alone. Other developed countries are also establishing aggressive targets: Canada expects to increase installed capacity from 198 MW in 2001 to 10,000 in 2010, and the Netherlands will install an additional 1,500 MW by 2010.

In addition to the rapid growth in the EU, the European Wind Energy Agency identifies developing countries as the drivers of future growth and claims that Africa will install 25,000 MW by 2020. China has announced plans to develop 2,500 MW by 2005.

Wind Energy Market 2002-2020

$billion	2002	2010	2020
World	4.2	18.2	112.7
US	1.0	4.4	27.1
Texas	0.3	0.8	3.1

Our global and U.S. forecast of 20 percent annual growth is aggressive, but consistent with recent growth trends and assumes a capacity well below established targets for the EU and elsewhere. Our conclusions are consistent with other estimates of the world wind market; Shell estimates the world wind energy market in 2020 will be worth $133 billion. Our estimates for Texas are more modest, with estimated annual growth of 15 percent, a conservative estimate in light of the pace of recent wind developments and the capacity potential of the region. The estimate takes into consideration unresolved transmission issues and the uncertainty of the RPS and production credits beyond 2009.

There are currently 4,265 MW of installed wind capacity in the U.S. and 1,694 MW of this capacity was installed in 2001. As fast as the pace of development has been in the last few years, we anticipate the industry's prospects will only improve. Costs continue to fall and public concerns for the environment and air quality continue to increase. Wind development will shortly approach a size that will attract the competitive financing that is critical to continued growth.

The total amount of electricity that the U.S. could potentially generate from wind has been estimated at 10,777 billion kWh annually -- three times the electricity generated in the U.S. today. Regions of the country ripe for wind development are the central states from the Dakotas to Texas. Optimal wind sites can produce power for as little as four cents per kilowatt-hour.

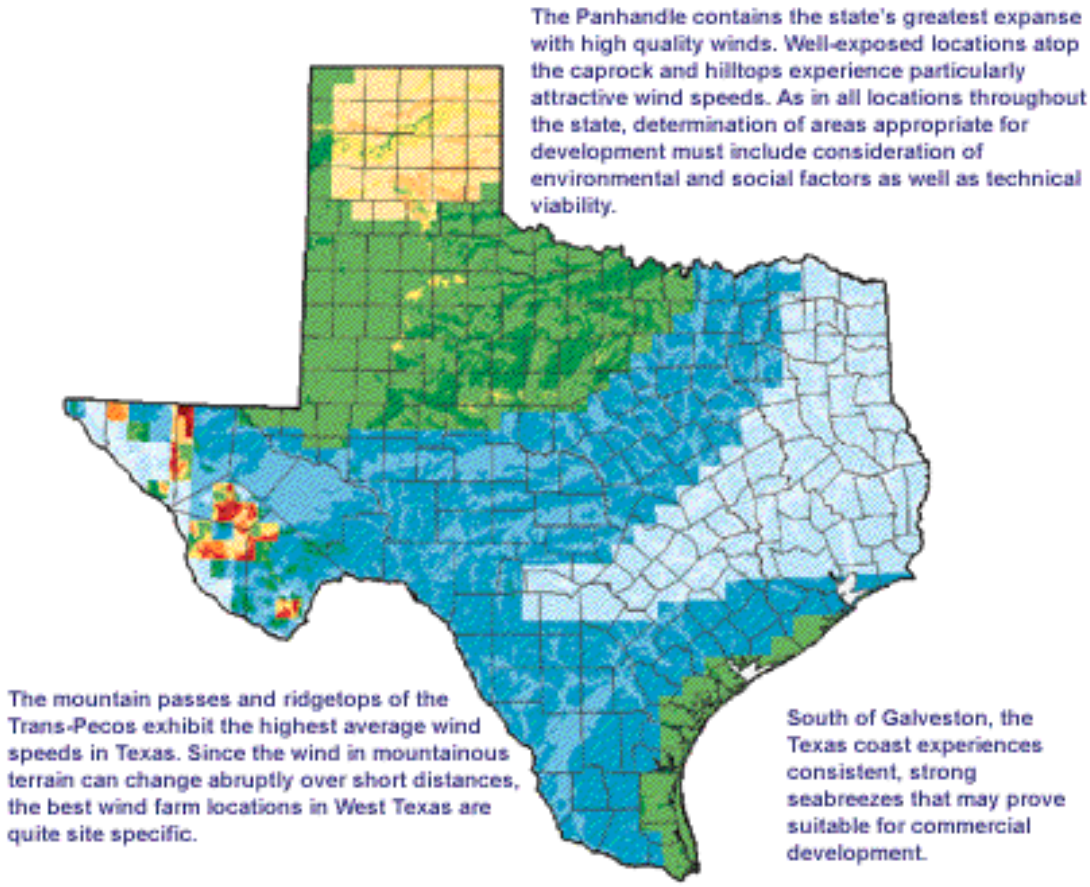
Texas is second in the nation, behind North Dakota, in terms of wind capacity potential and first in actually exploiting that potential. A number of reports take note of Texas' leadership in Clean Energy; the state's wind power initiatives and policy environment account for this emerging reputation. In 2001, Texas installed more wind generation capacity (915 MW) than was installed in the entire country in any previous year. The Texas State Energy Conservation Office estimates that, if fully exploited, Texas could theoretically produce almost 500 percent of the electricity it consumes.

Potential Wind-based Electricity Production in Texas

Wind Power Class	Area (km2)	Percent of State Land	Potential Capacity (MW)	Potential Production (Billion kWh)	% of Texas Electric Consumption
3	143,400	21.13%	396,000	860	371%
4	29,700	4.38%	101,6000	231	100%
5	5,000	0.74%	21,600	48	21%
6	300	0.04%	1,600	4	2%
Total	178,400	26.29%	524,800	1,143	493%

Source: State Energy Conservation Office, www.infinitepower.org

The map below shows the location of Texas' wind resources in the panhandle, west Texas, and along the gulf coast.



Source: State Energy Conservation Office, *www.infinitepower.org*

Most analysts expect wind costs to continue to decline, as turbine manufacturers produce more machines and are able to take advantage of economies of scale. The research and development trend among major manufacturers is toward even larger turbines on taller towers because wind speeds increase with elevation. Most manufacturers are developing or deploying variable speed turbines while continuing to improve the durability of components. The market for small wind systems, i.e., turbines less than 100 kW, is also expanding as a result of policies adopted in a growing number of states.

Photovoltaics

The PV sector is the second-fastest growing energy source in the world after wind power. PV markets have grown rapidly, more than 20 percent each year during the past decade, reaching an annual PV module production of 100 MW in the U.S. and about 400 MW globally.

PV systems have high capital costs and low running costs. Capital costs decreased more than 40 percent in the last 10 years and, as a result, by some estimates the PV industry is growing at 20 times the rate of the oil industry.

PV is more competitive in remote sites, far from the electricity grid, where relatively small amounts of power are required (typically less than 10 kW). The cost of PV cells fell about 95 percent during the last two decades, and industry observers expect that it will continue falling through the end of the current decade as rapidly improving PV technologies emerge. A study coordinated by energy giant BP suggests that investing around $880 million in the mass production of solar panels would make grid-connected solar electricity competitive with fossil fuel electricity.

A PV project has an estimated useful life of 30 years, more than other renewable energy plants, and has low maintenance costs. Solar power tends to generate reliably during peak energy use hours. Use of PV creates no significant environmental issues.

There are some 30 PV technologies, and the majority of development has focused on crystalline and thin-film solar cells. Thin film technologies and concentrator cells are perceived to have the greatest commercial promise due to lower production costs, but there continues to be potential for significant cost reduction in the production of crystalline technologies through improved economies of scale and technological advances.

Measures of PV installed capacity are notoriously difficult to calculate due to the distributed nature of the technology and lack of centralized data. However, existing estimates place Japan in the lead in terms of total installed capacity with more than 200 MW, due in large part to government incentives that have produced a PV market that grew more than 40 percent per year between 1992 and 1999. The United States had 75 MW in 2000 and was second in total installed capacity.

Photovoltaic Market 2002-2020

$billion	**2002**	**2010**	**2020**
World	1.3	5.6	33.8
US	0.5	2.1	14.0

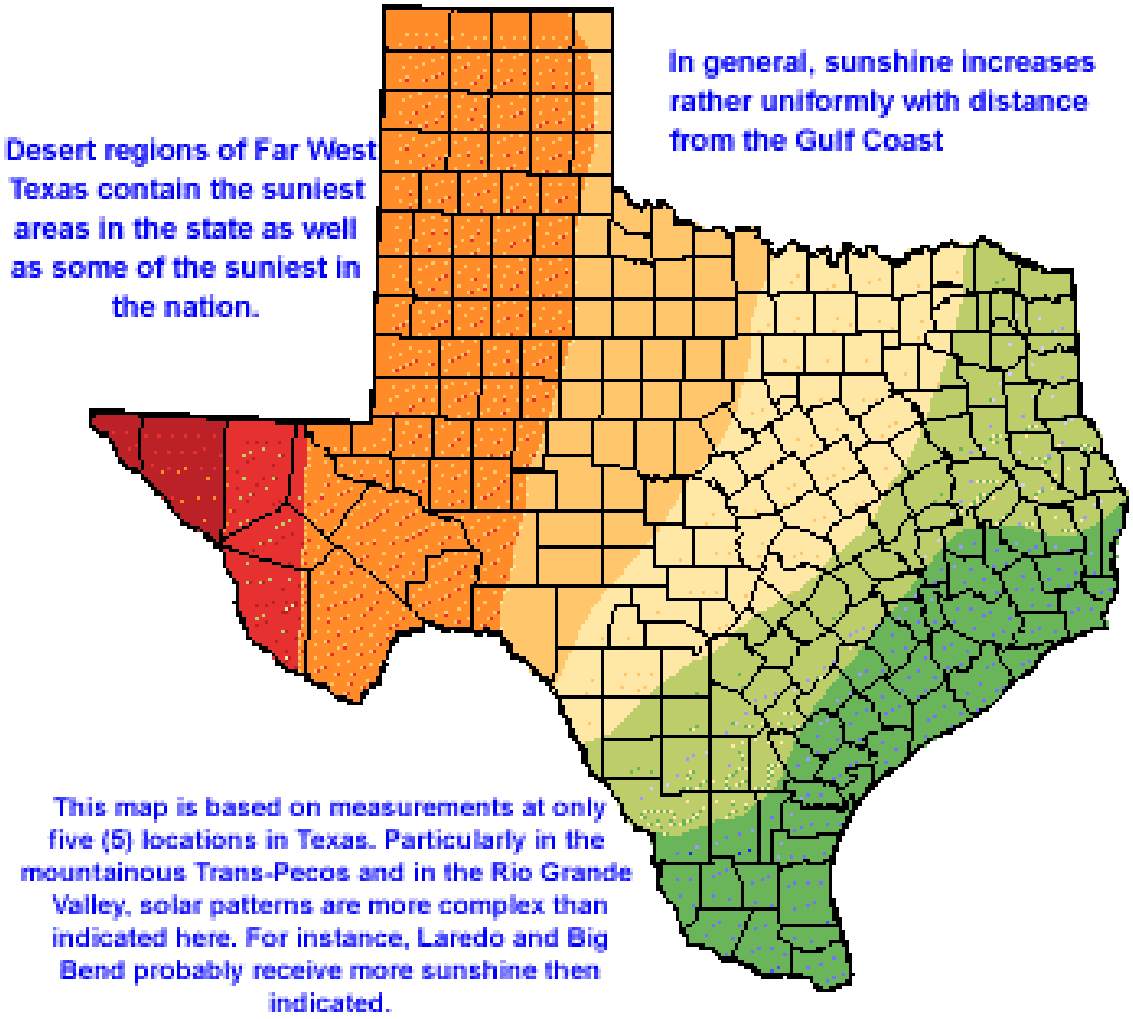
We calculated these market estimates using current shipments of PV units (watts) and projected compound annual grow rates of 24 percent for the world market and 25 percent of the U.S. market. We assume a weighted average base price of $4 per watt (actual price ranges from $2 to $16 per watt, depending on the size of the system) and a decrease in the base price of 3.5 percent a year, which is consistent with patterns of the last decade.

In the National 2000-2004 Photovoltaics Program Plan, the U.S. PV industry and DOE set a goal to maintain a 25 percent annual production growth rate that will result in 7 GW of PV in 2020, 3.2 GW of which will be used in domestic installations. This will require a concerted effort on the part of U.S. producers to develop domestic markets; to date, the growth in U.S.-produced PVs has been export-led and exports comprise 70 percent of PV shipments.

From 1999 to 2000, PV installations worldwide increased 37 percent (IEA). More than 90 percent of this new capacity was installed in Japan, Germany, and the United States. There are approximately 30 PV manufacturers worldwide and Sharp, Kyocera, BP Solar, and Shell Solar produce 50 percent of PVs. Although BP has manufacturing facilities in the United States, the U.S. -- which dominated the industry in the first half of the 1980s -- has been losing market share for more than a decade to Europe and Japan. In 1999 the PV industry, in conjunction with DOE, established an Industry Roadmap to stem this loss. Despite renewed effort to broaden the domestic market and make PVs more cost effective, the industry remains challenged by the continued erosion of federal research support at a time when Europe and, particularly, Japan have increased their research investments dramatically. In the U.S. the private sector spends more than twice what the government spends on PV research and development.

According to National Renewable Energy Laboratory data, Texas ranks fourth in overall installed capacity but is falling behind many other states in terms of planning increased capacity. There are some small producers of solar technologies in Texas, and a number of service providers. However, PV markets and installations remain largely underdeveloped in Texas despite the state's significant potential to benefit from solar energy. According to the Texas State Energy Conservation Office, there is sufficient solar radiation throughout the state to power distributed solar thermal heaters and PVs. West Texas receives sufficient radiation for potential centralized solar power plant development.

Texas Solar Resources



Source: SECO, www.infinitepower.org

Biomass

Biomass includes bioenergy generation from the incineration or gasification of agricultural crops such as switchgrass. Where possible we separate bioenergy from power generation from municipal solid waste and landfill gas, which are sometimes incorporated into biomass production. Our market estimates do not include biofuels or biochemicals, which have significant Clean Energy potential in transportation.

Biomass Energy Market 2002-2020

$billion	2002	2010	2020
World	15.7	21.5	31.8
US	2.9	3.4	4.1
Texas	0.1	0.2	0.3

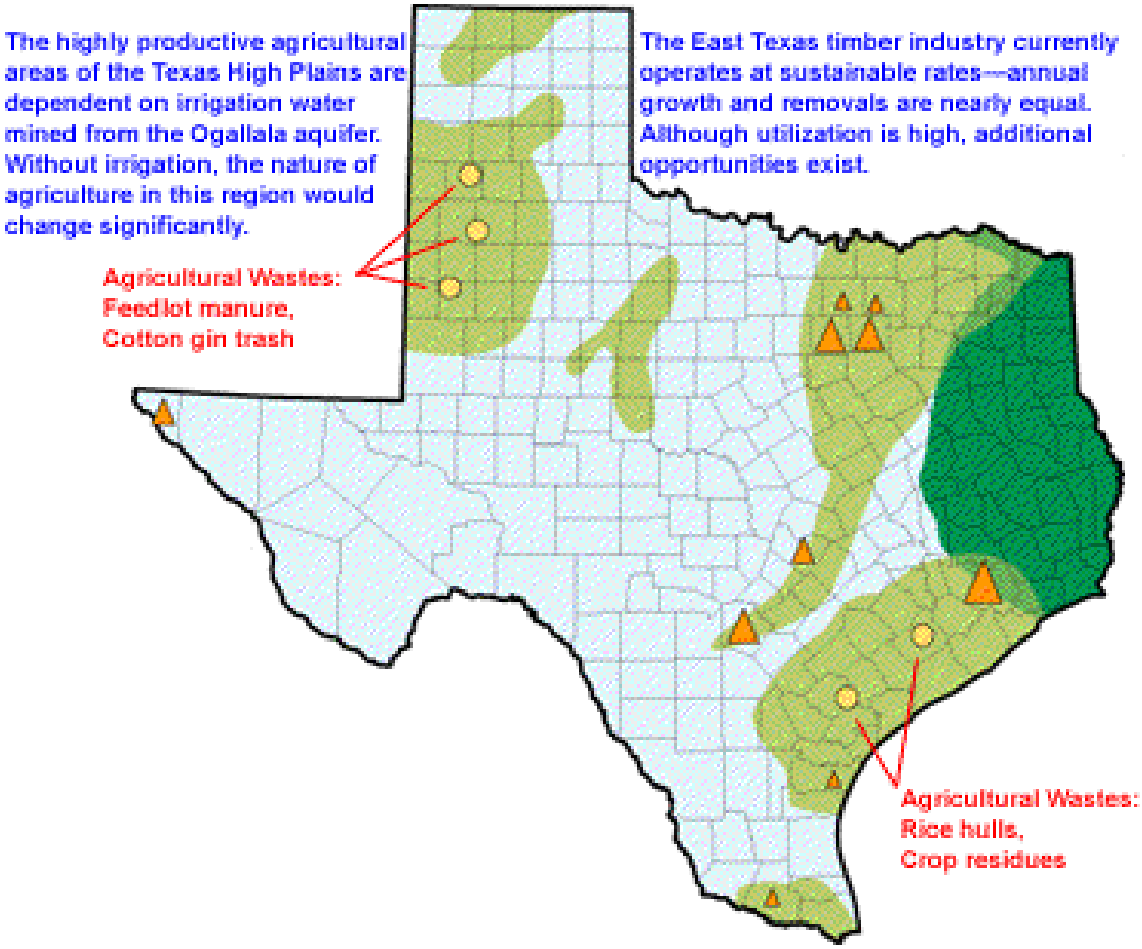
Developing countries are the most promising markets due to rapid economic growth, burgeoning demand for electricity, mounting environmental concerns, and the need for rural electrification and reliable electricity. Most of them also have significant quantities of agricultural or forestry residues. Production flexibility is biomass' strong point: various processes and technologies can produce energy at various scales up to 100 MW. Its constraints are cost and availability. Since bioenergy is often derived from agricultural and forestry waste, the resources may not be sufficient to ensure continuous operation and their availability can be influenced by natural events, such as harvest cycle, weather, and pests.

According to the Department of Energy, the U.S. is the largest biomass energy generator in the world. With installed capacity of 7,800 MW, biomass is the second most utilized renewable energy in the U.S. (after hydro), producing 44 billion kWh of electricity each year, representing 1 percent of total U.S. electric generation capacity.

The U.S. biomass project map covers mostly the east and midwestern areas, such as Indiana, Alabama, Pennsylvania, North Dakota, New York, Kentucky, West Virginia, Iowa, Tennessee, and Texas, areas with the ability to supply the feedstock necessary to produce biomass. There is potential capacity of 30,000 MW, employing 150,000 persons, and producing 150 to 200 billion kWh of electricity by the year 2020. Our estimate is based on a target capacity of 10,000 MW.

The ideal growing locations for biomass resources in Texas are east Texas and the Panhandle, with a potential generating capacity of 30.2 million MWh. Texas has installed capacity of 264 MW in 19 locations that generate $96 million revenue and 714 jobs. Various research has been conducted in bioenergy and bio-based products in Texas with major support from Texas A&M University.

Texas Biomass Resources



TEXAS BIOMASS: GENERAL RESOURCE TYPES		
AGRICULTURE	**FORESTS**	**URBAN BIOMASS**
Harvest Residues Process Wastes Energy Crops	Logging Residues Mill Residues Woody Energy Crops	Municipal Solid Waste Sewage Landfill Gas Used Cooking Oils

Geothermal

Geothermal energy technologies use the heat of the earth for direct-use applications, geothermal heat pumps, and electric power generation. Geothermal resources come in five forms:

- hydrothermal fluids
- hot dry rock
- geo-pressured brines
- magma
- ambient ground heat

Of these five, only hydrothermal fluids have been developed commercially for power generation. Geothermal power, tapped by drilling into underground beds of hot steam or water, costs between 4.5 and 7 cents per kWh, and could become cheaper if it qualifies for the next round of federal energy development credits.

Geothermal plants have a capacity factor as high as 95 percent, which is more reliable than coal-fired and nuclear power plants. New steam plants at The Geysers in California, for example, operate more than 99 percent of the time.

Issues for geothermal projects include high capital cost and environmental concerns associated with the emission of sulfur and nitrogen gases. The geothermal market, while small, offers significant opportunities for new entrants. Although geothermal plants produce only 0.3 percent of all electricity in the U.S., it has the potential to produce much more.

Geothermal Energy Market 2002-2020

$billion	**2002**	**2010**	**2020**
World	3.2	4.3	6.4
US	0.7	1.6	4.0

The estimates are for electricity generation alone, a sector we expect to grow at a rate of 4 percent a year. These estimates do not take into account direct-use capacity, which comprises a majority of total geothermal capacity. Geothermal heat pumps account for a large portion of direct-use technologies and the market for heat pumps is growing at a rate of 10 percent a year. Current direct-use world capacity of 8,604 MW could grow to more than 57,000 MW by 2020, and U.S. direct capacity could grow from 2,228 MW in the year 2000 to nearly 15,000 MW if growth maintains its present trajectory. If the U.S. DOE's new initiative, GeoPowering the West, is successful in installing 20,000 MW in western states alone by 2020 the potential market size will double.

Texas has no installed geothermal electric capacity. However the Bureau of Economic Geology estimates there is 20,000 MW of geothermal potential in that state. As technologies advance a variety of geothermal resources opportunities in Texas should emerge.

Fuel Cells

Fuel cells have been 40 years in the making and their scalability, reliability, and substantial energy efficiency encourages the future growth of fuel cells to replace batteries, electrical generators, vehicle engines, and conventional stationary generators. The timing of commercialization of fuel cell or hybrid vehicles seems uncertain but stationary application of fuel cells, such as for distributed generation, combined heat and power, UPS, and back-up power, looks promising in the near future, primarily due to the high efficiency of small scale applications of greater than 50 percent.

The principal barrier to commercializing fuel cell products is their manufacturing cost. Other issues effecting fuel cell commercialization include government rules and regulations on siting, insuring, and certifying fuel cell products. Also, business issues such as the depreciation rate allowed to purchasers of fuel cell products will affect the introduction of fuel cell products. In addition, regulatory issues concerning criteria pollutants could become more restrictive in the future, thereby facilitating the compulsory installation and use of fuel cells.

There is a robust private sector support for fuel cells. Car companies, governments, and other leading industries have invested at least $7 billion in fuel cell systems in the last decade. **Some 4,000 companies worldwide are thought to be developing applications.** For some, it is reminiscent of the start of the IT revolution, which took off at a speed that no one foresaw. PriceWaterhouseCoopers recently estimated the market for fuel cells may rise to as much as $1.7 trillion by 2020.

The U.S. Department of Energy estimates fuel cell development could add 750,000 jobs to the U.S. economy by 2030.

For illustrative purposes we provide an estimate of the world and U.S. fuel cell market using an average annual growth rate of 22 percent and 24 percent respectively. Other market studies assume annual growth rates as high at 70 percent for the same time period.

Fuel Cell Market 2002-2020

$billion	2002	2010	2020
World	4.0	23.0	168.4
US	1.2	7.4	82.9

One study estimates the 2004 markets for fuel cells to break down as follows:

2004 Fuel Cell Market Breakdown

Fuel cell use	Market share
electric power generation	36%
motor vehicles	31%
portable electronic equipment	8%
military/aerospace	8%
other	17%

Several efforts have been taken to enhance the implementation and development of fuel cells in Texas. Texas passed House Bill 2845, which give the authority for the State Energy Conservation Office (SECO) to develop plans to further promote the commercialization of fuel cells in Texas. The target is to achieve 1,000 MW installed capacity by 2010, up from an estimated 25 MW in 2004. In 2002, Austin saw an opening of fuel cell generator in the RBJ Health Clinic with 200 kW capacity. Texas Commission on Environmental Quality (formerly TNRCC) promoted the application of fuel cells through its three-month demonstration project in 2001 in which a 3000-watt hydrogen fuel cell powered a continuous air monitoring station in Austin.

Energy Efficiency Technologies

The importance of energy efficiency (EE) came to light after the oil crisis in the late 1970's. Fuel-dependent economies recognized that to mitigate similar supply and price risks in the future, they would either have to develop alternate sources of fuel or curb their demand. This need drove the emergence of EE technologies in sectors such as buildings, power, transportation, and industrial processes. In some states, the Seasonal Energy Efficiency Ration (SEER), such as Texas, is being increased from 10 to 12.

One of the best measures of energy efficiency is the energy intensity for each country, which is derived from the following formula:

$$\frac{\textbf{Energy Consumption}}{\textbf{Economic or Physical Output}}$$

At a national level, energy intensity is the ratio of total domestic primary energy consumption or final energy consumption to gross domestic product (GDP) or physical output. Falling energy intensity is a strong indicator of advancement in EE efforts and technologies.

According to the International Energy Agency's World Energy Outlook 2002, energy intensity is projected to decline in all regions. From 2000 to 2030, global energy intensity will fall 1.2 percent per year. Intensity will fall most quickly in the non-OECD regions, largely because of improved energy efficiency and structural economic changes towards lighter industry. The average rate of decline in energy intensity in these regions will accelerate from past trends. The transition economies (Eastern Europe, Russia, and others), in particular, will become much less energy-intensive as more energy-efficient technologies are introduced, wasteful energy practices are tackled, and energy prices are reformed. The shift to services is so far advanced in the developed countries of the OECD that their energy intensity is set to fall more slowly than in the past.

Several industry associations estimate that savings from adopting EE technologies could range between 20 and 30 percent of a typical electricity bill. The U.S. Department of Energy estimates that increasing energy efficiency throughout the economy could cut national energy use by 10 percent or more in 2010 and about 20 percent in 2020, with net economic benefits for consumers and businesses.

Energy Efficiency Markets 2002-2020

$billion	**2002**	**2010**	**2020**
World	114.2	156.9	256.1
US	37.6	51.3	81.2
Texas	3.9	5.3	8.5

These market estimates exclude any consideration of energy efficiency technology in the transportation sector or in industrial processes, so the actual potential in this model is understated.

According to a new study by the American Council for an Energy-Efficient Economy (ACEEE), the United States can reduce its projected energy use in 2020 by 25 percent

and save consumers more than $600 billion. One study shows that, by following a proposed "Innovation Path," the U.S. could cut carbon dioxide emissions to ten percent below 1990 levels, while saving consumers money and creating additional jobs. Specifically, by 2010, EE has the potential to reduce national energy costs $530 per average household and create nearly 800,000 additional jobs.

Numerous studies have examined the energy, economic, and environmental impacts of a national energy strategy that emphasizes greater energy efficiency. *America's Energy Choices*, for example, showed that vigorous adoption of cost-effective energy efficiency and renewable energy measures could reduce national energy intensity in 2030 by nearly 50 percent, dramatically reduce the nation's petroleum dependence, save consumers more than $2 trillion and cut carbon dioxide emissions in 2030 by more than 70 percent relative to emissions in 1988. However, *America's Energy Choices* and similar studies only consider direct economic impacts -- the cost of energy efficiency measures and the value of the energy savings.

Texas is the only state in the nation with a legislatively mandated energy efficiency goal. In addition to restructuring the utility industry, Texas Senate Bill 7 included provisions that require each investor-owned utility to offer selected "standard offer" programs in order to reach a mandate that each utility shall meet at least 10 percent of the electric utility's annual growth in demand through cost-effective energy efficiency. The standard offer programs are designed to offer a uniform template for program design and services across the state. Each utility chooses which programs to offer and can vary the services and structure of the programs. Most of these programs will be offered as full-scale programs beginning in 2002, although many were operated at a reduced or pilot scale in 2001. Funding of all such on-going programs, both by private and public sector players, will cost approximately $130 million in 2002.

According to our database on Clean Energy companies in Texas, there are 111 companies related to EE technology (including energy management). Texas, California, Pennsylvania, and New Jersey, account for 44 percent of all energy service company (ESCO) activity in the country. It is estimated that the ESCO industry completed $1.8 billion to $2.1 billion in projects in 2000 of which Texas accounts for approximately $330 million. On the basis of our calculations, when other components of EE are added to the ESCO activity, the total EE market in Texas will be a $3.9 billion industry in 2002.

Employment Potential

Our projections show that the world market for Clean Energy technology will grow by approximately 330 percent between 2002 and 2020. This extraordinary growth provides a potential source for new job creation, driving domestic and global economic development. Analysis shows that during the period 2002 to 2020, the world's Clean Energy markets will create a total of approximately 6.8 million jobs. We assume these employment numbers are understated, as estimates for employment driven by fuel cells and certain aspects of the energy efficiency market were not included in the analysis.

To derive job creation estimates, we used two different methodologies: for renewable energy, market estimates for jobs per MW of installed capacity; for energy efficiency measures, full-time equivalent (FTE) per dollar of investment.

Estimated Clean Energy Job Growth 2002-2020

World	Jobs created in 2010	Jobs created in 2020	Average jobs created per year 2002-2020	Total jobs created 2002-2020
Biomass	10,362	15,338	11,219	201,934
Geothermal	2,574	3,810	2,787	50,164
Solar	13,588	116,686	32,806	590,503
Wind	42,164	261,075	83,756	1,507,600
Fuel Cells				
Job creation				
EE	179,023	389,844	228,284	4,109,113
Total	247,711	786,753	358,851	6,459,314

US	Jobs created in 2010	Jobs created in 2020	Average jobs created per year 2002-2020	Total jobs created 2002-2020
Biomass	853	1,050	885	15,928
Geothermal	744	1,112	807	14,532
Solar	5,366	49,971	13,631	245,352
Wind	10,150	62,847	20,162	362,917
Fuel Cells				
Job creation				
EE	58,270	112,375	66,805	1,202,488
Total	75,382	227,354	102,290	1,841,216

Texas	Jobs created in 2010	Jobs created in 2020	Average jobs created per year 2002-2020	Total jobs created 2002-2020
Biomass	97	159	108	1,949
Wind	1,393	5,636	2,206	39,715
Fuel Cells				
Job creation				
EE	6,410	12,361	7,349	132,274
Total	7,900	18,156	9,663	173,938

Excluding job potential associated with fuel cell development, we used a weighted average of 8.5 jobs per MW of installed capacity for the calculations. This assumption includes jobs derived from manufacture, installation, retail, service, and maintenance. The following table illustrates the jobs per MW assumptions used for the model:

Type of renewable energy	Jobs/MW of installed capacity
Fuel cells	N/A
Solar PV annual shipment	35.4
Wind	2.77
Biomass	5
Geothermal	5.67

Since energy efficiency measures are embedded in several existing systems and new technologies are pioneering new services, it is difficult to isolate the level of job creation for each particular technology. We assumed that the FTE per unit was 0.003 percent of each dollar invested.

Following the world trend in areas of development, analysis suggests that the largest growth in renewable energy is likely to be in fuel cells, solar, and wind, followed by geothermal. Even though biomass is currently the second most popular source of renewable energy (after hydro, which is considered by many to be a 'clean' renewable source), this energy source is not expected to grow as quickly.

U.S. projections suggest that Clean Energy will create a total of 1.9 million jobs by 2020. Of these new jobs, 1.2 million will come from energy efficiency and approximately 35 percent of the remaining will come from development in solar technologies.

The Texas estimates include only two renewable energy technologies and energy efficiency. This would imply that the job potential is much greater in the Clean Energy cluster as a whole (*i.e.*, creation of indirect, integrated industries). Wind is expected to experience a much higher growth rate than biomass from 2002 to 2020. However, windmills bring skilled engineering jobs to rural areas, and windmill owners pay farmers to rent land for their installations. These two sources of steady income may help rejuvenate some struggling rural economies.

For energy efficiency, Texas is one of the top four states in the country in terms of energy service companies (ESCOs), which together represent 44 percent of all market sales in the U.S. Although Texas is the largest energy-using state, and is also the only one that has enacted the 10 percent energy efficiency adoption measure, we assumed that Texas represents only 25 percent of this 44 percent market share.

Given such assumptions about market growth, we estimated that the biomass, wind, and energy efficiency industries will create a total of 174,000 jobs in Texas between 2002 and 2020.

The potential employment from Clean Energy is underestimated. In the renewable energy section, employment in the fuel cell industry has not been included. In energy efficiency, the investment dollars do not include the transportation and industrial processes sectors. Just assuming a 5 percent increase of current numbers would change the total incremental job creation by approximately 323,000. At a world average GDP per capita of $4,500, this could mean an injection of an additional $1.5 billion into the world economic system to the potential $29.1 billion already estimated for 2002 to 2020. If we consider a multiplier effect based on the fund injection *each year*, indirect job creation and the economic development potential are enormous.

CHAPTER THREE

Profile of the Clean Energy Industry

Profile of the Clean Energy Industry

In September 2002, ACE initiated a survey of the Clean Energy Industry in the U.S. in order to gain a better understanding of the industry, the growth expectations of these companies, and their locational preferences. The economic development of regions in the U.S. have been highly affected by a small group of technology industries in the 1990s, and new industries such as Clean Energy have the potential to have a similar effect. Assisting new startup industries is a top goal for economic development officials, and understanding the needs of these industries is critical to their success.

Specifically, the survey was designed with the following questions in mind:

- What is the market size and potential for Clean Energy products and services?
- Where are Clean Energy companies located today and what are their growth expectations ?
- What issues are of most importance to Clean Energy companies in supporting their future growth ?

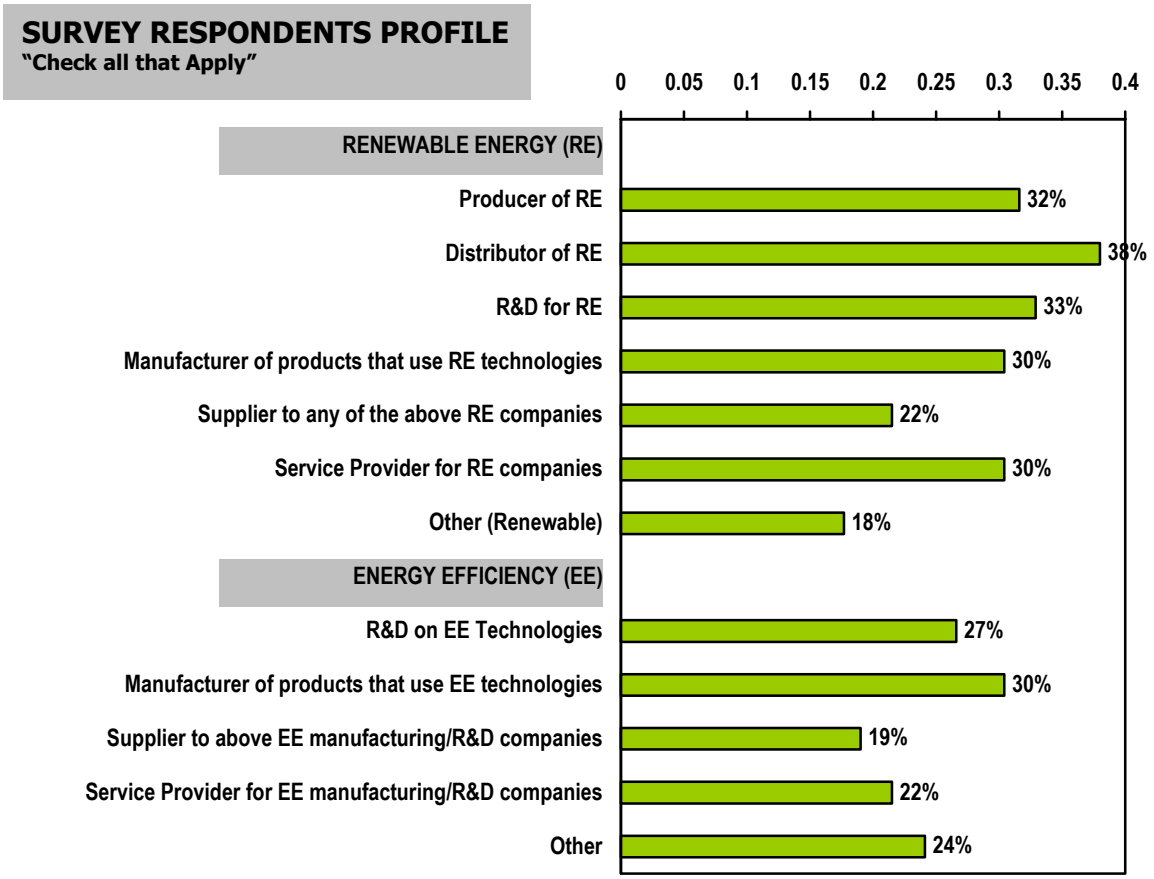
Site selection surveys of this type are conducted regularly by economic development organizations around the country. To our knowledge, no survey of this type has ever been conducted for the Clean Energy Industry in the U.S.

Respondent Profile

In total, 80 Clean Energy companies submitted responses to the survey.

Survey respondents reflect the diversity of the industry: large and small firms, manufacturers and distributors, local and global firms.

It is often difficult to define the Clean Energy Industry. Respondents to this survey ranged from producers and distributors of Clean Energy to manufacturers of Clean Energy and energy efficient products. Many respondents fell into multiple categories of business activity. Overall, this survey represents an even distribution of businesses within the Clean Energy Industry.

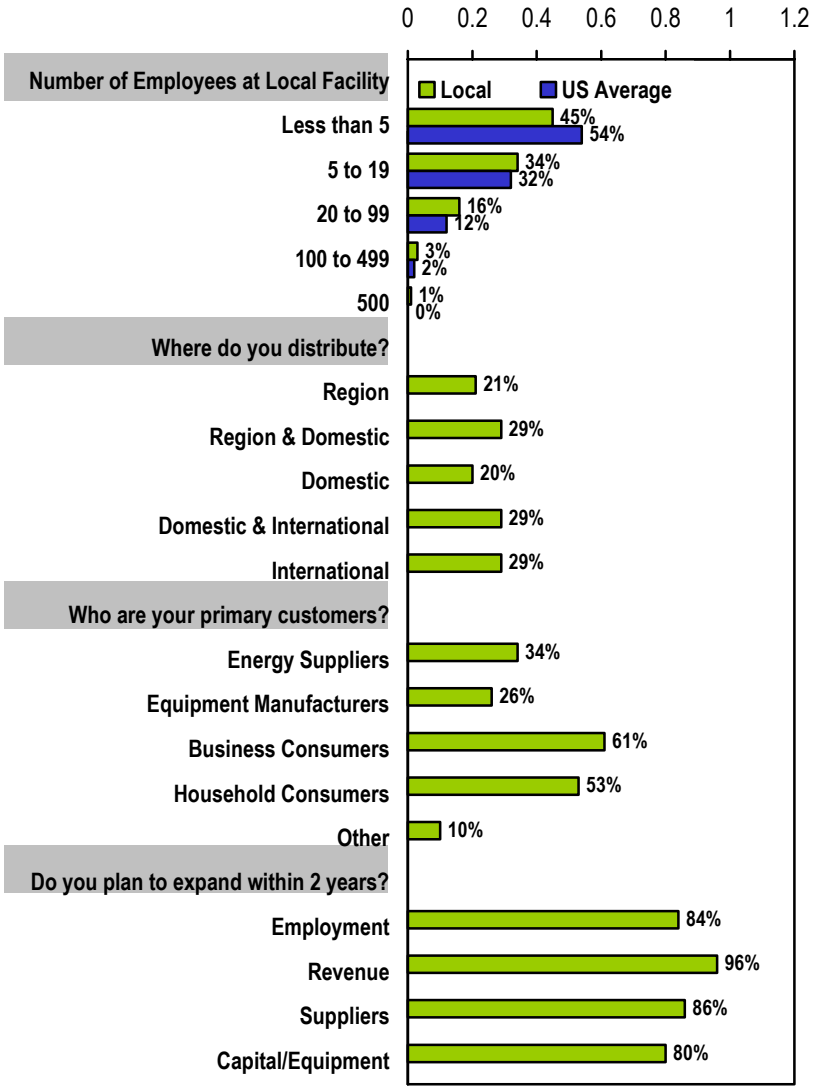


100 percent of survey respondents indicated that they sell renewable energy products, and an additional 18 percent indicated that they also sell energy efficiency products.

A large share of respondents (56 percent) indicated that they either manufacture Clean Energy products or are suppliers to manufacturers.

Distribution by Size of Firm
Respondents to the survey were primarily small companies of less than 20 employees: 40 percent employ 1 to 4 workers, and just one company with more than 500 employees responded. 94 percent of respondents employ fewer than 100.

Overall, the Clean Energy Industry is an industry of startups. Despite this, the distribution of respondents by firm size closely resembles the average distribution of all U.S. firms, as shown by the side chart.



Where do they sell, and to whom?
Survey respondents sell goods and services to both local and international markets. 79 percent sell outside their immediate area, and 58 percent sell internationally.

These high percentages are reflective of the global nature of Clean Energy. Several international markets, particularly regions within Europe, have actively promoted the use of clean technologies for power production and household appliances for many years. This ongoing international demand has provided a strong outlet for U.S. Clean Energy products.

Respondents also sell to a wide variety of customers. Most sell to businesses and households. 26 percent sell their products as inputs to equipment manufacturers. Thirty-four percent sell to energy suppliers.

Growth Expectations
Clean Energy companies anticipate high levels of growth in the coming years. While a positive outlook for revenue growth is common for most entrepreneurs, the extent to which these companies plan to expand their operations is significant. Nearly all companies plan to expand their revenue in the next two years, while only 4 percent of respondents said they expect revenue to stay constant.

These companies also intend to hire large numbers of workers. Respondents indicated that 2,300 jobs would be created to meet anticipated demand over the next 2 years, essentially doubling their current employment base.

The Clean Energy Industry will likewise be investing in new capital equipment and supplies, while nearly doubling employment and increasing revenue. During a time when the U.S. technology industry is stagnant, it is positive news to discover that new sectors, such as Clean Energy, are emerging and indicating potential for future growth.

Factors of Importance to Clean Energy Firms

Respondents were asked to rate the factors that are important to the industry, and indicate how well their current location satisfied these needs. In total, respondents rated 19 factors. Topping the list of site selection factors was "quality of life." Factors that reduce operating costs also top the list. As most of respondents were self-funded startup companies, cost issues ranked high in their list of importance. Incentives are likewise viewed as important by this young industry.

State environmental regulations that are strict on pollution, such as those in California, increase demand for Clean Energy products and services. Companies also prefer to locate in regions whose regulatory environment encourages the adoption of Clean Energy products and services.

As with many start up businesses, the personal choice of company founders impacts the location of Clean Energy companies. However, high-growth, a global nature, and need for low cost environments will likely accelerate the relocation of Clean Energy companies within the U.S.

Survey results also indicate that Clean Energy companies are not necessarily limited by the need to locate near raw material suppliers or other peer companies. These two factors ranked lowest in the list. While it may be too early to conclude, the results of this survey suggest that the Clean Energy Industry lacks a strong need to "cluster" like other industries have needed to, such as biotechnology.

Factors of Importance
to the Clean Energy Industry

Factor	Average Rating
Quality of life	4.3
State and local incentives	3.9
State regulatory environment	3.8
Personal reasons	3.8
Cost of living	3.7
Tax climate	3.7
Environmental regulations	3.7
Cost of labor	3.7
Availability of skilled workers	3.7
Cost of utilities	3.6
Proximity to customers	3.4
Good domestic airline connections	3.4
Good int'l airline connections	3.3
Availability of degreed engineers	3.1
Proximity to suppliers	2.9
Presence of a Research University	2.9
Availability of unskilled workers	2.7
Proximity to industry peers	2.5
Proximity to raw materials/inputs	2.3

Question: How IMPORTANT are the following factors to your business?
(1=Not Important, 5=Very)

Satisfaction factors
Many of the factors considered important to site decisions are those same factors respondents are currently least satisfied by.

Clean Energy companies stated that site factors influencing business costs – incentives, tax climate, and labor, living, and utility costs – are not being addressed sufficiently by government. They also indicated that the U.S. and state regulatory environment is not as encouraging as it could be for Clean Energy R&D.

Overall companies felt that access to transportation infrastructure, quality of life, and skilled workers is good in the regions in which they are located.

Factors of Least Satisfaction	
Factor	**Average Rating**
State and local incentives	2.9
State regulatory environment	3.1
Environmental regulations	3.1
Tax climate	3.2
Cost of labor	3.2
Cost of living	3.2
Cost of utilities	3.3
Proximity to suppliers	3.4
Proximity to industry peers	3.5
Proximity to raw materials/inputs	3.5
Availability of unskilled workers	3.6
Availability of skilled workers	3.6
Availability of degreed engineers	3.6
Presence of a Research University	3.7
Proximity to customers	3.8
Good int'l airline connections	3.8
Quality of life	3.9
Personal reasons	3.9
Good domestic airline connections	4.0
Question: How SATISFIED are you with the following factors? (1 = Not Satisfied, 5= Very Satisfied)	

Importance vs. Satisfaction
By comparing how respondents rank factors on importance and satisfaction, we can identify which factors will most influence the location of firms. Simply stated: if a company ranks a factor (such as "cost of utilities"), as "important" and also ranks this factor low in "satisfaction", this company may consider relocating to a location that does provide an adequate level of satisfaction for this factor.

To do this analysis, each factor's rating was compared against the average rating for all 19 factors. Factors whose average rating was above the 19-factor average were considered "important". A similar process was done for the satisfaction rankings.

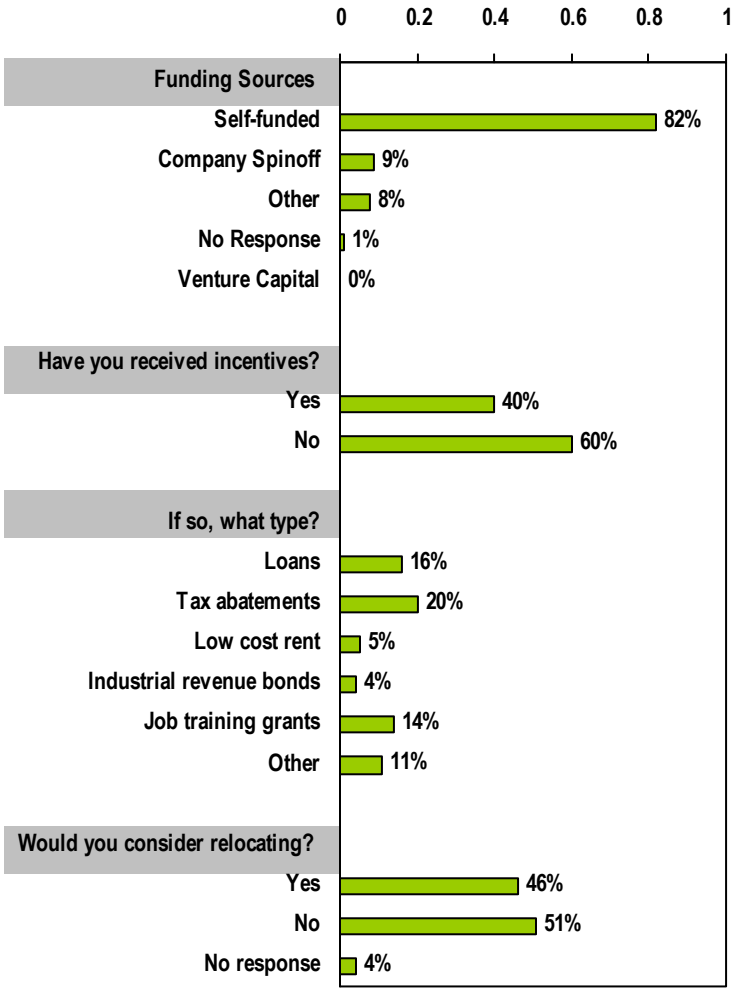
The results of this analysis again show that cost factors and regulatory environment are primary areas of concern for the Clean Energy Industry.

Importance vs. Satisfaction Matrix	
Important and Satisfied	**Important, Not Satisfied**
Quality of life	State and local incentives
Personal reasons	State regulatory environment
Availability of skilled workers	Cost of living
Proximity to customers	Tax climate
Good domestic airline connections	Environmental regulations
	Cost of labor
	Cost of utilities
Not Important, but Satisfied	**Not Important, Not Satisfied**
Good int'l airline connections	Proximity to suppliers
Availability of degreed engineers	Proximity to industry peers
Presence of a Research University	Proximity to raw materials/inputs
Availability of unskilled workers	
Important: all factors with average ranking above the average for all factors (3.8) Satisfied: all factors with average ranking above the average for all factors (3.4)	

Funding Sources
Few companies surveyed have received funding from outside sources, such as venture capital. 82 percent of respondents indicated that they were self-funded startups. Therefore, incentives and financial assistance by local governments are a top concern for this industry.

Incentives
While respondents indicate that they are dissatisfied with state and local incentives, a large percentage have received some form of assistance. 40 percent of Clean Energy companies surveyed have received some type of incentives. 20 percent of companies received incentives in the form of tax abatements, and 14 percent took advantage of available job training grants. 16 percent received loans.

Though respondents indicate they have not been satisfied with the level of incentives they have received, it is difficult to find another industry with such a high percentage of businesses receiving tax abatements. Clearly, the capital-intensive nature of some Clean Energy businesses may make them particularly eligible for tax incentives related to capital investment. Others may have received incentives tied to R&D or small business assistance. In most states, job-training grants of some level are available to all business.



Communities targeting the Clean Energy Industry should consider tailoring incentives packages to the industry. Incentives could be tied, for example, to companies who increase energy efficiencies of production processes.

In most cases, incentives are already in place for companies who utilize renewable energy, but companies are not aware that they are available. In this case, communities should first create a good profile of a Clean Energy company. Next, they should identify all incentives applicable and market them to these businesses. The promotion of a Clean Energy specific incentives package could help communities differentiate themselves in the competition for new investment by the industry.

Relocation Potential

A large number of respondents, nearly half (46 percent), indicated that they would consider relocating their companies. This high percentage is a clear indication of a developing industry. Companies are clearly open-minded in their desire to increase their competitiveness through relocation.

When asked what states they consider to be leading Clean Energy communities, California ranked #1, followed by Texas, Florida, and New York. These states can expect to receive top consideration by relocating Clean Energy companies.

Top Mentions: What states do you consider to be leading Clean Energy communities?	
California	40
Texas	12
Florida	9
New York	9
Colorado	8
Arizona	5
Hawaii	5
Oregon	5

Survey Observations

The results of the survey bode well for regions seeking to encourage the growth of the Clean Energy Industry. No clear clustering pattern has emerged for this industry. Companies appear to be well distributed around the country and are open to relocating to help grow their business. These trends are good news for small to medium-sized communities in the U.S. Respondents indicated that proximity to suppliers, peer companies, and strong R&D universities are less important to site decisions than cost issues. This opens the door to many communities interested in growing their Clean Energy sector. While respondents may be overestimating the importance of financial assistance, cities dedicated to recruiting these companies should focus on creating incentive packages, a regulatory environment, and a tax climate that makes operating a Clean Energy business more competitive.

While most individuals and companies rank "quality of life" high on their list of priorities, in this case, "quality of life" may suggest that Clean Energy companies may choose locations that are progressive toward the environment, and leaders in clean industries.

All respondents indicated they expected to grow over the next 2 years, and most expressed optimistic comments on the future of the industry. The cost of Clean Energy products is expected to continue to decline, and respondents hope that U.S. regulations will encourage the adoption of Clean Energy uses.

Several technologies were mentioned in comments as future growth engines for the industry, including:

- Fuel Cell Technologies
- Photovoltaics
- Wind Energy
- LEDs

CHAPTER FOUR

Central Texas' Emerging Clean Energy Cluster

Central Texas' Emerging Clean Energy Cluster

Austin and the surrounding Central Texas region offer an ideal environment for the Clean Energy technology industry. To appreciate why, one must first examine the nature of technology commercialization and its centrality to the region's past and present economic development strategies.

Efficient and effective technology commercialization, regardless of the specific sector, depends on parallel goal-directed investments of intellectual, financial, and political capital. From the mid-1960s on, brokers of these three essential capital stocks in the Austin-San Marcos-Round Rock area of Central Texas understood this. They developed strategically aligned investment plans targeting economic development led by technology. While this approach earned Austin-San Marcos respect as a location for technology-based production, it did not at first position the community at the cutting edge of new technologies commercialization.

The community's pioneering development of the *technopolis* framework of economic development changed that. The technopolis model favors development of ideal environments for technology-based economic development, ecologically friendly, and with educational, health care, and recreational services. The model attracted high-tech companies who were seeking locations for primary product development facilities. The technopolis model achieves this goal by coordinating investment commitments and incentive strategies across the three vital capital stocks, according to a shared, unified vision. This approach maximizes latent synergies and minimizes internal conflicts. Beyond simply calling for coordination, the technopolis framework mobilizes quasi-public organizations – such as the IC^2 Institute – to act as bridges connecting the three essential capital silos.

Two critical contextual aspects supported the technopolis framework: it fit the community's social values, and it had a window of opportunity in which to realize rapid success. Regarding the first, Central Texas has long stressed the need to preserve its natural resource base, which sets it apart from much of the state, and has sought to augment high natural capital with high social capital. The region leverages these two stocks for a high quality of life that creates positive human capital feedback loops, sympathetic to conscious efforts at strengthening and coordinating deployment of the three vital capital stocks. With respect to seizing a brief opportunity, the launch of the technopolis model coincided with at least three key trends that allowed the model to target key projects to rapidly build its reputation:

- low oil prices and a hard recession in Texas brought a sense of urgency that induced support from key capital brokers across the state;
- the intensified shift toward a knowledge-based economy; and,
- trends toward collective investment in the computer industry by high-tech companies.

While the current downturn in the national economy has curbed the growth of the Austin-San Marcos technopolis, all capital stocks remain high and the corresponding capital brokers are refocused on leveraging greater diversity. Moreover, previous economic growth sharpened awareness of the need to preserve and augment natural capital stocks. Commercialization of Clean Energy technology fits this new mainstream

agenda, and the community has already staked out the high ground and all that is required is the intensification of current efforts.

Civic Infrastructure

According to the technopolis framework, the four fundamental steps in transforming a region into a technopolis include:

- Achieve scientific pre-eminence in technology-based research.
- Develop new technologies for emerging industries.
- Attract major technology companies.
- Create homegrown technology companies.
- Support growth of existing local companies.

These steps reflect the far-reaching goals of an iterative process requiring sustained dialogue and planning among nodes of government, research, and private sector institutions. The Austin-San Marcos technopolis model emphasizes the establishment of hybrid quasi-public organizations that coordinate and facilitate a civic infrastructure. It was for this reason that the IC^2 Institute and, later, the Austin Technology Incubator were born in the late 1980s: to serve as technology development catalysts for high-tech ventures linking University of Texas researchers with investors. As the following sections indicate, even before the IT sector began to lose steam, the Austin-San Marcos community set about modifying its civic infrastructure to accommodate growth and commercialization in the Clean Energy sector.

Clean Energy Incubator

In late 1999, the Austin Technology Incubator (ATI) and the National Renewable Energy Laboratory (NREL) first conceptualized the idea of an incubator that would accelerate the pace of clean-energy technology commercialization. On the basis of these discussions, ATI committed to launch the Clean Energy Incubator (CEI) with federal funding under NREL's National Alliance of Clean Energy Business Incubators. When federal funding was delayed, state and Austin-based interests mobilized a grant from the Texas State Energy Conservation Office to launch CEI in August 2001. Today, CEI is recognized as a charter member of the ten-member Alliance, and is one of the two members focused exclusively on Clean Energy technology business development and commercialization. In its first full year of operation, it fielded inquires from more than 65 companies, of which six joined the incubator portfolio. On the strength of its initial work, CEI secured $120,000 of federal funding to expand its efforts in its second year. Through CEI's continued affiliation with IC^2, it maintains access to Clean Energy researchers across the UT system as well as early-stage venture and seed capital sources.

Austin Energy's Sustainable Energy Task Force & GreenChoice

Austin's municipal electric utility, Austin Energy, constitutes a key component of the Clean Energy civic infrastructure. In 1997-8, Austin Energy chaired the City Council's Sustainable Energy Task Force, established to guide utility investment strategy toward continued commercial viability with improved environmental performance in the context of pending electric sector deregulation. Although a temporary public-private bridge, the task force marshaled the political capital necessary for the Austin-San Marcos technopolis to stimulate Clean Energy development. In 1999, the City of Austin enacted regulations requiring Austin Energy to source 5 percent of its power from renewable generation by 2005. This renewables portfolio standard (RPS), and the GreenChoice Program

subsequently implemented to market renewable power, have become respected models for municipal utility districts nationwide. The GreenChoice Program sources renewable energy from such diverse technologies as wind, solar, biomass, and landfill gas sources, enhancing associated commercialization opportunities. With one of the lowest tariffs of any green energy program in the US, the GreenChoice Program also positively portrays the economic viability of Clean Energy technologies. Evidence of this perception exists in the more than 6,000 residential customers and 200 businesses, including some large businesses and government agencies, currently enrolled the GreenChoice Program. As such, the City anticipates having more than 120 MW of renewable generation to its portfolio by the end of 2003, which would increase renewables' share of generating capacity to 4.5 percent.

Austin's Green Building Program

Austin's civic effort at creating and filling demand for Clean Energy technologies predates the Sustainable Energy Task Force. It began with energy conservation programs that established Austin as a leader in the emerging field of sustainable building design and construction. The Austin City Council in the early 1980s initiated activity in this area by calling for energy conservation programs to reduce the amount of new generation capacity needed. By 1991, private sector leadership equally influenced market opportunities, notably through the efforts of energy consultants Laurence Doxsey, Pliny Fisk, and Gail Vittori of the Center for Maximum Potential Building Systems, to conceptualize Austin's Residential Green Building Program. They based the program on a market-pull mechanism, promoting green building practices, and rating buildings that feature these practices, creating public demand by ensuring that "green" buildings were attractive to consumers.

The focus has since expanded from residential to commercial and municipal buildings, with technical staff to provide design guidelines and rating systems for each type of building construction. Staff also provides technical assistance to the public and to building professionals, and assists in marketing and promoting green projects. Consumer education and awareness are just as important as fostering acceptance within the building professions.

Austin's Green Building Program directly increased economic development by saving owners utility, maintenance, and liability expenses, and it stimulated businesses using recently commercialized Clean Energy technologies. Businesses now sell new products such as Faswall, Rastra, and low-VOC paints. Other businesses provide services such as installation of autoclaved aerated concrete, straw bale and cobb walls, and gray water and rainwater harvesting systems. Financial capital brokers have also mobilized around the program, with two local mortgage companies now providing financing for green building.

The University of Texas at Austin

The University of Texas at Austin is a primary broker of intellectual capital in the community's technopolis framework, and it was the University's links to public and private sector resources that allowed it to become the leading research institution it is today. Up to the mid-1950s, UT had only one graduate-level engineering division and was therefore limited in producing skilled employees and partnering with public and private sector consumers of high-tech research. Gradually, and with great determination, UT's leadership transformed the University into a research-focused institution with prominent engineering departments headed by leading scholars with industry experience. Armed with a growing reputation, UT-Austin secured positions in top-level federally funded research programs. With the advent of the electrical

engineering department's long-range strategic plan, crafted with input from industry and alumni donors, links to financial capital continued to improve. With financial resources and a strategic vision informed by industry needs, UT-Austin established endowed chairs across its engineering and science departments and recruited more leading researchers with significant industry experience, reinforcing existing links.

UT-Austin's strategic development plan conspicuously de-emphasized the role of the College of Business Administration in these early days. For a public institution, changing an established business curriculum typically presents significant challenges. However, the dean of the business school, George Kozmetsky, envisioned hybridization not only of curriculum but also of organization. Kozmetsky founded the IC^2 Institute, through which he catalyzed implementation of his technopolis framework.

UT-Austin's role with respect to Clean Energy technology commercialization leverages its past successful transformation into a leading research institution. Several engineering departments have established courses, degrees, and programs focused on Clean Energy, notably mechanical engineering and electrical and computer engineering. The same is true for the College of Architecture.

Curricula have begun to coalesce primarily around solar photovoltaic technology in engineering and passive solar design in architecture departments. The Department of Electrical and Computer Engineering teaches renewable energy engineering through a recently developed power electronics laboratory, in which students investigate solar panel characteristics, methods for linking solar panel output to the grid, and optimizing solar panel power output. The lab will soon have a small 300 watt wind generator that will be used to investigate wind-solar-battery hybrid designs. The architecture school offers a graduate-level specialization through its Design with Climate Program (DWC). In 2002, DWC and engineering students partnered with the Center for Maximum Building Potential Systems (CMBPS) and private-sector sponsors to compete in the U.S. DOE's Solar Decathlon – a national competition to design, build, and operate the most effective and efficient solar-powered house.

Technology and Entrepreneurship in the Central Texas Technopolis

Austin boasts a deep and rich network of support organizations that exists to support entrepreneurs and to aid in the development of new technologies. The IC^2 Institute, ATI, and, more recently, CEI specialize in helping young companies shorten product development cycles by broadening entrepreneurs' understanding of market research, finance, sales and service, and other elements critical to successful entrepreneurship. ATI also helped create the Capital Network, a non-profit seed capital (angel) network and the largest network of its kind in the United States. Many other support organizations, including the Austin Technology Council and the Business Success Center, have been created. For new businesses in Austin, there is no shortage of advice, mentoring, or networking opportunities.

High-Tech Transformation and Distributed User Models

The civic infrastructure discussed above has proven extremely successful at attracting and building major technology companies. As late as the mid-1980s, state government and the University of Texas dominated the community's economy. Today, the city is home to more than 2,000 technology companies, 70 percent of which have their headquarters in Austin. The market capitalization of the top 25 Austin firms exceeded $124 billion in 1999. The table indicates that the Austin-San Marcos transformation exceeds that of other leading technopoli.

As subsequent data show, new businesses focused primarily on IT, telecom, and technology management services. When considering Clean Energy technologies, many of which are modular, applications tend to fit a distributed generation model much like the Internet's linked, distributed computing model. The move to distributed models in both sectors is not coincidental: distributed computing and distributed energy both respond to and empower end-users while increasing efficiency. The key is that distributed Clean Energy generation will also rely on IT and telecom products and services to link them into a smart network feeding or supplanting the old "mainframe" model of central power plants.

Most High-Tech Metro Area Economies		
Rank	**Metro Area**	**Score**
1	Austin	9.00%
2	San Francisco	8.60%
3	Raleigh-Durham	8.00%
4	Boston	7.10%
5	Denver	5.10%

Source: Metropolitan New Economy

Fully appreciating this entrepreneurial and technological advantage requires making comparisons with other upper echelon US technopoli. The rest of this section, therefore, provides greater detail about the relative role and composition of the technology companies found in the Austin-San Marcos community and contrasts these findings against those of other current and emerging technopolis regions, including Albuquerque, Chicago, Minneapolis-St. Paul, Portland, San Francisco, and Seattle.

Technopolis' Relative Strengths
The table below provides a sense of the technology sectors around which leading technopoli have consolidated, as determined by a ratio of the number of businesses in a sector to the total number of businesses in a technopolis. The sectors in the non-shaded portion of the table reflect the previous paragraph's discussion of the importance of energy and environment, IT, telecom, and technology management and services to the commercialization of Clean Energy technologies in a distributed setting. These data indicate that the Austin-San Marcos community has more energy and environmental businesses on a per-business basis than its high-tech competitors. This sector remains in early stages of development, however, with less than 1,200 companies across all seven markets. Other technopoli could easily match or surpass Austin-San Marcos' initial commitment. In fact, Austin-San Marcos ranks 6th in terms of its share of these 1,200 companies, while Chicago ranks first and accounts for a third.

How Austin-San Marcos Stacks Up – by Sector's Weight (Rank Order of % of Total Companies in Technopolis)	**Albuquerque**	**Austin**	**Chicago**	**MSP**	**Portland**	**Seattle**	**San Francisco**
Energy & Environment	7	1	5	2	3	4	6
Telecom Services	2	1	3	6	7	5	4
Management and Services	3	2	5	7	6	4	1
IT-Hardware	5	2	6	3	4	7	1
IT-Services	4	2	7	6	5	3	1
IT-Software	4	3	2	6	7	5	1
Telecom Products	7	6	5	4	3	2	1
Aerospace	3	6	7	5	2	1	4
Biotech	7	6	2	1	4	5	3
Technology Manufacturing	7	6	1	2	3	4	5
Transportation	7	5	1	4	2	3	6

Calculated using Reference US Database of business establishments

The data also point out the community's strong leadership position in vastly more competitive ancillary sectors (non-shaded). The San Francisco/Bay Area technopolis, however, almost categorically surpasses Austin-San Marcos in these important sectors. Slightly more than three times the size of Austin, the SF/Bay Area technopolis also possesses nearly twice the total number of energy and environment companies as Austin-San Marcos.

Clearly, it remains an open question whether the Austin-San Marcos technopolis will pick up the mantle of commercializing energy and environmental technology, even though all the components and the experience are available.

Entrepreneurial Activity
It is estimated that roughly 175 to 200 new technology firms start up in the Austin region each year. Quantifying levels of entrepreneurial activity presents a challenge from the standpoint that not all new businesses are created equally. Some grow into thriving private and public companies, individually capable of significantly impacting local and national economies. In terms of technology commercialization, such dynamic companies play a much larger role than slower growing small and medium-sized new businesses. IPOs of high-tech firms provide a reasonable proxy for such fast-growing, technopolis-relevant companies.

Although IPO data exclude earlier stage private companies with potentially large research and development functions, IPO companies tend to reflect higher long-run growth potential and a commitment to home technopoli. As the table shows, Austin ranks fifth nationally and third among the technopoli selected in this report. The significant gap in scores between the top two places and Austin is no doubt due to the relative lack of mega-technology firms (*e.g.*, Cisco in San Francisco and Microsoft in Seattle) that tend to buy start-up firms in stock transactions. Although Austin has its homegrown technology leaders, most notably Dell, they are less focused on research and development acquisition through the purchase of start-ups. Indeed, the third- and fourth-ranked areas nationally scored much closer to Austin than to Seattle. Additionally, Austin's score more than doubles the national average.

Whether a start-up high-tech firm launches an IPO or not, its capacity to bring innovative technologies to market tends to impact existing companies using outdated technologies or business models. The Austin area exhibited 60 percent employment growth between 1989 and 1998 -- second in the U.S. only to Las Vegas -- but many other areas flourished during this period as well. A more robust measure of change would, therefore, also consider the rate at which new companies supplant inefficient firms (which ultimately go out of business). Such a churn rate provides a proxy of a technopolis' appetite for the creative destruction of formerly mainstay sectors.

IPO's as a Measure of Entrepreneurial Activity

Rank	Metro Area	Score
1	San Francisco	32.3
2	Seattle	28.1
3	West Palm Beach	11.8
4	Boston	10
5	Austin	9.4
11	Portland	4.1
15	Minneapolis	3.6
16	Chicago	3.5
	U.S. Average	4
	Top 50 Metro Average	4.8

Table 4 indicates that, despite Austin's rapid transformation, it trails leaders including Denver, Atlanta, Dallas, Las Vegas, and Phoenix – each of which represent regional commerce capitals where entrepreneurs might logically congregate. Austin's heritage as a government- and education-oriented economy offers some an explanation of its lower score, as these sectors have few substitutes. In comparison with the technopolis elite and the average of the nation's top 50 economies, though, Austin fares quite well.

Technopolis Churn Rates		
Rank	**Metro Area**	**Score**
1	Denver	11.7
2	Atlanta	11.2
3	Dallas	11.2
4	Las Vegas	11.1
5	Phoenix	11.0
12	Minneapolis	10.6
13	Austin	10.5
17	Chicago	10.1
19	San Francisco	10.1
28	Portland	9.9
39	Seattle	9.4
	Top 50 Metro Average	9.5
Source: Metropolitan New Economy Index		

Human and Intellectual Capital
At its peak, more than 2,000 people were moving into the area each month. These individuals brought with them skills and experience necessary to fuel the technopolis. Add to this pool the steady stream of students receiving degrees from UT-Austin in technology- and Clean Energy-related fields, and the Austin-San Marcos community is clearly awash in talent.

Graduates for Business Growth
Table 5 provides a sense of just how prolific the growth rate of skilled labor has been in the last half-decade. A few thousand students per year routinely graduate from UT-Austin's science, engineering, and architecture schools, many of whom seek jobs with technology and design firms in the Austin-San Marcos area due to the high quality of life they learned to appreciate during their course of studies.

Total Number of Degrees Conferred by College at UT-Austin (Data includes Bachelors, Masters, and Doctorate degrees)						
	Academic Year					
College/Field of Study	**95-96**	**96-97**	**97-98**	**98-99**	**99-00**	**00-01**
Architecture	159	156	135	118	124	126
Engineering	1,388	1,338	1,398	1,296	1,340	1,279
Natural Sciences	1,459	1,466	1,517	1,608	1,517	1,495
Intercollegial Programs*	2	29	31	50	43	67
Total	**3,008**	**2,989**	**3,081**	**3,072**	**3,024**	**2,967**
* Includes interdisciplinary studies between departments in two of the listed colleges Data Source: UT-Austin's Office of Institutional Research						

Although not reflected in the table, advanced degree students routinely comprise much of the graduate output. Between 41 and 45 percent of engineering degrees were for Masters or Doctorate level work; similarly 18 to 24 percent of graduates in natural science received advanced degrees. Natural sciences and engineering schools were the third and fourth largest, respectively, at UT-Austin in terms of degrees awarded in 2000-01.

Intellectual Property

According to the New Economy Index, Austin ranks fifth among the top 50 U.S. cities considered in the educated workforce index, no doubt largely due to this steady stream of graduates. While many smart workers make for efficient production and management, it does not necessarily correlate to proprietary innovation or invention at the core of commercialization. A more meaningful measure of a community's intellectual capital stocks exists in the number and growth rate of patents awarded to its inventors.

Patent Production by Technopolis
Number of Patents Issued

Inventor City	1996	1997	1998	1999	2000	2001	CAGR 96-01
Albuquerque	156	196	247	244	253	270	11.60%
Austin-San Marcos	899	949	1557	1705	1762	1787	14.73%
Chicago	558	452	705	770	828	889	9.76%
Minneapolis-St. Paul	288	290	373	419	473	472	10.39%
Portland-Vancouver (WA)	482	531	776	733	847	968	14.97%
San Francisco - San Jose	2026	2233	3275	3757	4172	4667	10.63%
Seattle-Bellevue-Everett	570	686	979	966	977	1079	13.61%

Data Source: US Patent and Trademark Office - USPTO Patent Full-Text and Image Database (http://www.uspto.gov/patft/index.html) Metro area data was compiled by searching the database for listings from one city or the other. (e.g. "Minneapolis" and "St. Paul")

As the table shows, from 1996 to 2001 Austin-San Marcos achieved the second highest compound annual growth (14.73 percent) in the number of patents issued, only one-quarter of a percentile behind the Portland metro area in absolute terms. In 2001, Austin received almost twice Portland's patents. Although not shown in the table, Austin-San Marcos also ranked number one in patents per capita, ahead of the longer-standing research centers in the Bay Area and almost three times the level of the next closest competitor, Portland.

Research Foundation for a Clean Energy Economy

Research has been central to the emergence of Austin as an information technology center. In addition to established patterns of cooperation with industry, UT-Austin continues to expand its licensing and commercialization efforts, a promising development for any technology-based business as well as for researchers. UT-Austin has well-established research centers focused on process energetics (aimed at improving the productivity of industrial processes through more effective energy use), energy and mineral resource analysis, and several others under the Center for Energy and Environmental Resources, Bureau of Economic Geology and Center for Petroleum and Geosystems Engineering. The activities of these research centers are detailed in the following section. Apart from these, there are several nationally recognized research

facilities at UT, which is known to be extremely responsive in developing forward-looking areas of research. Alongside UT, Rice, Texas A&M, and private institutions continue to promote research in Clean Energy. This constant source of innovation has improved the technology spillover effect for the entire community and many of the area's established and upcoming firms have benefited from this.

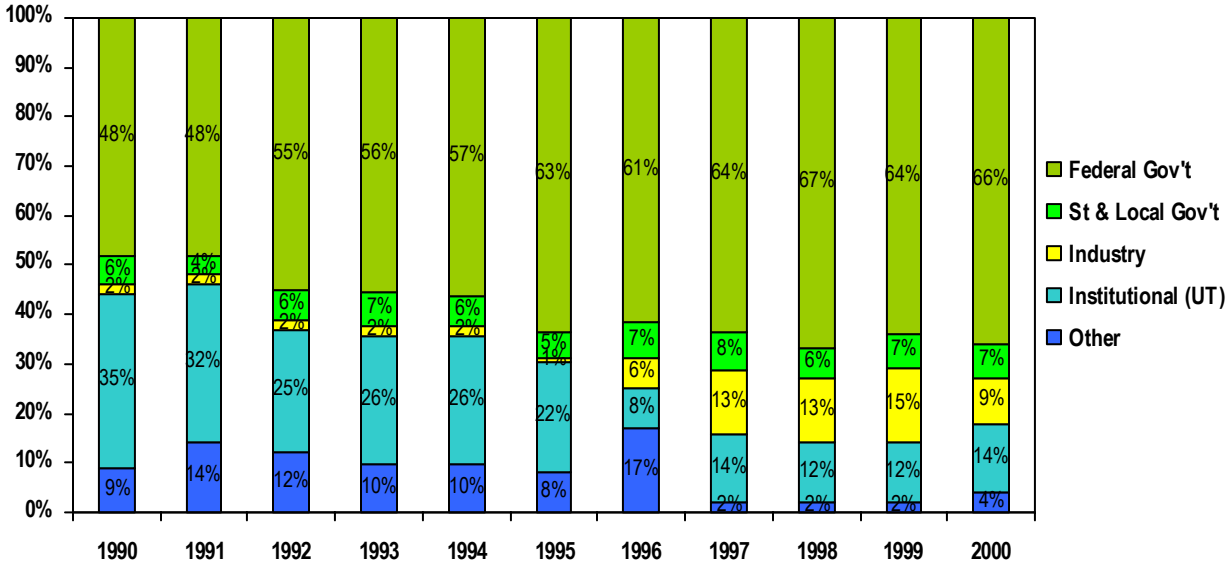
Funding for Science and Engineering Related R&D

UT-Austin embarked on a mission to transform itself into a leading research institution and serve as the wellspring for commercializable intellectual property within the technopolis framework. Perhaps the best measure of UT-Austin's success with this transformation is the increase in research and development funding from federal sources, for which the competition is presumably greatest.

As the table shows, total science and engineering related research and development spending at UT-Austin has steadily increased (with a compound annual growth rate (CAGR) of 3.36 percent from 1997 to 2000), while the accompanying table illustrates federal funding has increased even faster (CAGR 4.16 percent) over the same period. The chart further illustrates a marked increase in industry funding, suggesting increasing commercialization linkages.

UT-Austin's Science and Engineering Related Research & Development Expenditures (by Source) $000

	1997	1998	1999	2000
Federal	151,954	165,082	164,913	178,889
St. & Local Gov't	18,102	15,094	17,698	19,201
Industry	29,887	31,326	39,729	24,740
Institutional (UT)	34,140	28,445	31,220	37,883
Other	4,938	4,896	4,562	12,098
Total	239,021	244,843	258,122	272,811



Source: NSF WebCASPAR Database System

UT's Centers of Research Excellence

Several groups within UT's engineering and science colleges are currently investigating barriers to Clean Energy technology commercialization. Brief descriptions and contact information are provided here along for those interested in more detailed information.

Clean Energy Technologies (CET) Group

(http://www.me.utexas.edu/resources/research.shtml)

Investigations emphasize development of new materials; efficient manufacturing processes; system integration and control; analysis, testing and design of components at both the microscale and system levels; and analysis of off-design and transient behavior. The CET group focuses on:

- Rechargeable Batteries: lithium ion and rechargeable alkaline batteries for portable electronic appliances and electric vehicles

- Fuel Cells/Membrane Filtration/Fuel Reformulation: PEM and direct methanol fuel cells for appliance and vehicle use as well as solid oxide fuel cells for use in stationary power applications. The oxygen separating properties of electrodes used in solid oxide fuel cells are also under investigation for use in membrane filtration systems. Investigations into hydrocarbon reformulation to produce hydrogen for fuel cells are looking at developing a porous media reformer for fuel station and vehicle applications.

- Supercapacitors: electrochemical redox capacitors for use with batteries in hybrid power systems for electric vehicles

- Solar Energy

Center for Energgy & Environmental Resources (CEER)

(http://www.utexas.edu/research/ceer/)

CEER serves as the central liaison for energy and environmental research and public service at The University of Texas at Austin. It focuses on efficient and economical use of energy, and on ensuring a cleaner environment by developing, in cooperation with industry, processes and technologies that minimize waste and conserve natural resources. Several departments focused on pollution control and waste minimization fall under the auspices of CEER, most notably:

- Process Energetics Program: through which investigators conduct research aimed at improving the productivity of industrial processes through more effective energy use.

- Air Resources Engineering: one of the world's largest and most active programs Research activities within the group cover sources of air pollution, laboratory investigations of atmospheric physical and chemical processes, ambient air quality monitoring, ambient air quality modeling, indoor air quality, and air pollution control.

Combustion Research Group
(http://www.me.utexas.edu/resources/research.shtml)
The Combustion and Engines Research Group is a part of the Thermal/Fluid Systems Area of the Mechanical Engineering Department at The University of Texas at Austin. Investigation focuses on combustion in porous media for applications to radiant burners and gas turbine engines. The advantages of using a porous matrix to stabilize a flame are reduced emissions of NOx, unburned hydrocarbons, and CO.

Solar Energy Laboratory
(http://www.me.utexas.edu/~solarlab/)
The solar energy program at the University of Texas at Austin resides within the Mechanical Engineering Department. The Solar Energy Laboratory was established in 1982 and is located in the Mechanical Engineering Building. It includes space and equipment for solar energy related projects and research. Specific projects of the lab include:

- Texas Solar Radiation Data Base: developing a solar radiation resource for Texas with support from the State Energy Conservation Office (SECO).

- SOLSCALE: software for predicting performance loss due to scale formation in solar hot water systems using heat exchangers, and how to avoid such problems through appropriate component sizing. Project is supported by NREL.

- Photovoltaic Powered Cooling Systems: software to model the performance of PV powered cooling systems (thermoelectric, stirling cycle, and vapor compression) for terrestrial and space application and contrast experimental data. Project is supported by NASA

- Screening Software for Renewable Energy Applications: Texas Renewable Energy Evaluation Software (TREES), developed with SECO funding, supports comparison of the economics of solar and wind energy with conventional energy sources for a variety of thermal and electric applications.

Texas Materials Institute

- (http://www.utexas.edu/academic/tmi/index.shtml)
  Electrochemical materials and phenomena play an important role in today's technology. Batteries, fuel cells, supercapacitors, electrochromic devices, gas separation membranes, and sensors are some example applications of electrochemical materials. The success in electrochemical technology is largely due to the continued design and development of newer materials that meet the needs of modern society. The research at the Texas Materials Institute encompasses fundamental electrochemistry, materials development, and electrochemical characterization. Some examples of research programs at the Texas Materials Institute:

- Design and development of new materials for electrochemical power sources such as rechargeable lithium batteries, solid oxide fuel cells, and supercapacitors.

- Development of innovative synthesis and processing procedures to achieve unique compositions and microstructures that can offer superior performance in energy conversion and storage.

- Development of both polymer and ceramic oxide membranes for gas separation.

- Fabrication and study of biosensors, electrochemical DNA, and immunomicrosensor arrays.

- Scanning electrochemical microscopy, ultra-high resolution electrochemistry, otoelectrochemistry at semiconductors and electrogenerated chemiluminescence, and corrosion engineering of metal alloys and ceramics.

Texas Industries of the Future
(http://texasiof.ces.utexas.edu/)
The purpose of the Texas Industries of the Future program is to facilitate the development, demonstration and adoption of advanced technologies that reduce industrial energy usage, emissions, and associated costs, resulting in improved competitive performance. The target sectors include chemicals, refining, forest products, agriculture, and electronics. TIOF does not directly conduct research in these areas but acts as an information clearinghouse.

JJ Pickle Research Center
This shared facility houses The Center for Electromechanics, the Department of Electrical and Computer Engineering, and the Mechanical Engineering Department. These departments conduct cooperative work in one or more of the following categories:

Generation

- *Gas Turbine – Generator*: developing a high-speed generator that eliminates the need for a gearbox and is much smaller than conventional generators.

- *Gas Turbine – Cooling*: examining the degradation process for turbine airfoils and to determine the effect this degradation may have on system optimization.

- *Fuel Cells*: initial focus is assessing the feasibility of intermediate temperature solid oxide fuel cells that can operate at 500 to 600°C. Such fuel cells would have longer productive lives due to reduced materials degradation, avoid requiring expensive heat tolerant materials, and eliminate costly and complex fuel reformers from fuel cell design. Additional research is looking at the possibility of operating lower temperature dry proton conductor fuel cells at higher temperature to increase efficiency and waste heat value, and to avoid catalyst poisoning and humidifier subsystems.

- *Combination of Fuel Cell and Gas Turbine*: analyzing the advantages of using a hybrid gas turbine and fuel cell system to generate power for electric ship applications.

Transmission

- *Smart Grid Activities*: developing techniques for reconfiguring a power system to minimize line overloads and prevent the loss of critical loads, an approach that requires new ways of sensing the network behavior.

Storage

- *Flywheels*: developing the engineering science needed to design and build composite flywheels levitated on magnetic bearings. Composite flywheels can be made smaller and lighter than steel flywheels while storing more energy allowing for efficiencies above 94 percent compared with conventional batteries typically offering 80 percent efficiency. The small size opens new applications for the technology.

Use

- *Transportation*: developing flywheel systems in which buses and trains store otherwise wasted energy from braking and suspension systems, for use in vehicle acceleration. For the bus, the system yields a factor-of-two increase in acceleration while still reducing energy use and air pollution by an estimated 30 percent.

IDEALab

(http://www.me.utexas.edu/~idealab/intro.html)

The Inverse Design of Energy Applications Laboratory (IDEALab) provides industry with design, measurement and control tools for energy systems. IDEALab research uses inverse analysis methods that specify desired design outcomes and thereby optimize energy systems to satisfy the design requirements within prescribed error limits.

Flywheel Case Study

UT's Center for Electromechanics Targets
Flywheels for Space, Utilities, and Transit Buses

Engineers have long searched for efficient and affordable ways to store energy that smoothly meet the power requirements for hybrid electric vehicles and electrical transmission and distribution grids. Many, including the UT-CEM, believe the answer lies with current and enhanced flywheel designs. After developing a high-performance composite rotor and matching system integration electronics, UT-CEM took a significant step towards verifying this belief by partnering with Avcon and AlliedSignal to develop a high-performance 150 kWp, 2 kW-hr transit bus flywheel system. With prototype in hand, UT-CEM engineers took a closer look at their initial commercial use targets.

Unfortunately, UT-CEM found that, as of 2000, the hybrid electric vehicle market had not materialized. Roughly 200 electric transit buses were in service as of August 1999, of which hybrid electrics – the likely adopter of flywheel battery technology – comprised only 10 percent. While high battery replacement costs in non-hybrids suggested future buses would use hybrid designs, the UT-CEM estimated commercial viability required demand of at least 1,000 units a year for several years, while optimistic projections lay closer to a few hundred units a year.

UT-CEM anticipated the immaturity of the hybrid vehicle market at the outset, and with few modifications to the initial design targeted the significant ($1-2B) and growing (12 percent a year) utility market for stationary power quality systems. EPRI concluded that market growth alone justified 4,300 new 250 kW units per year based on a per-kW sales price of $150 to $200/kW. UT-CEM estimated that capturing one-third of the growth market plus 1,000 units to replace existing utility systems would support commercial viability in three to five years. However potential utility, and vehicular, clients balked at paying a premium for UT-CEM's high performance system when lesser, cheaper technology would suffice.

Undaunted, UT-CEM sought and found a high-performance niche market in applications associated with space travel and exploration, which they had previously investigated. TRW and NASA subsequently funded work to modify the prototype as an upgrade for the International Space Station (ISS). Donors estimated that over the system's life, the lower mass, higher power capacity, and a potential for attitude control of UT-CEM's high-performance flywheel relative to maintenance and periodic replacement of ISS battery banks would save over $300 million. Following an extensive test program, UT-CEM will transfer this technology to a commercial manufacturer for fabrication of 48 battery replacement units for the ISS.

The story continues, however, as UT-CEM focused on a second-generation flywheel battery with a more marketable cost/performance profile. It meets the same performance requirements in terms of power and energy, but it is housed in a lighter, more compact package, in part because it operates at a higher rotational speed (60 krpm vs. 40 krpm). The resulting system, which is highly integrated and tightly packaged, can be produced at a lower cost. This more compact design, however, is less flexible for increasing power or energy to meet other applications.

Central Texas' Clean Energy Companies

NREL facilitated the creation of the National Alliance of Clean Energy Business, including the Austin, Texas-based Clean Energy Incubator as its Texas representative and one of the ten members. Other states represented include Alabama, California, Florida, Georgia, Massachusetts, New Mexico, and New York. The Austin Technology Incubator initiated the Clean Energy Incubator as an independent entity specifically dedicated to the Clean Energy sector. The Texas incubator has advantages in its central location in the state and the U.S., and in Austin's supportive infrastructure for nurturing entrepreneurial growth. The Central Texas area is a strong contender to form a robust, nationally recognized Clean Energy cluster and become a center of excellence for this fast-growing sector.

This cluster is already forming. Our research identified 335 enterprises (corporations, privately owned companies, non-profits, public research units and quasi-governmental agencies) engaged in Clean Energy development in Texas, 80 of which are in the five county Central Texas region. Of those 80, we were able to determine revenue and employment information for nearly half, which have more than a quarter billion dollars in annual revenues and employ about 2,600 people. Their products and services include:

Air cooling systems
Alternative fuel vehicles
Batteries
Battery charging and maintenance
BioEnergy
Earth-sheltered home design
Electric utility
Electric vehicles
Energy audits
Energy consulting
Energy efficient buildings
Energy efficient lighting
Energy from hot salt domes
Environmental advocacy
Environmental and project engineering
Flywheel energy storage systems
Fuel Cell products
Legal services to renewable energy industry
Lighting products
Passive solar architecture
Renewable energy
Renewable generation
Residential energy audit software
Retail electricity provision
Solar energy
Solar photovoltaic equipment
Solar products and design
Solar thermal electric
Solar-electric transportation
Straw bale homes and buildings
Transmission system planning
Water heating products
Wind energy
Wind farm development & construction

We selected five companies of diverse size to illustrate emerging trends in the Clean Energy sector and highlight the attractiveness of the business climate in Central Texas.

Active Power, Inc.

Summary

Active Power is a global leader in battery-free, uninterruptible power solutions, with continuing research and development in flywheel energy storage, thermal energy storage, signal processing, power electronics, and power generation.

The company holds 31 patents and has more than 127,000 square feet dedicated to assembly and testing of qualified systems configured to meet individual customer requirements.

Formerly a principal with Fusion Research Center, founder Joseph Pinkerton had directed two joint research projects with the University of Texas at Austin. He came to appreciate the University's role in providing human capital, its students and graduates, and in supporting technology advancement through its diverse research facilities and projects. These advantages, along with Austin's high quality of life and friendly environment, led Mr. Pinkerton to establish his business in Austin.

Company profile

Mr. Pinkerton formed the company as Magnetic Bearing Technologies, Inc in August, 1992, and patented the world's first room-temperature magnetic bearing capable of operating without electronic controls. The company, renamed Active Power, Inc., in 1996, has shown a significant growth, marked with its initial public offering in 2000 when it raised an additional $139 million. In 2001, Active Power reported $22.6 million in revenues, with 232 employees. Active Power has two main products:

- *CleanSource DC*, a patented flywheel-based energy storage system that is a cost-effective, reliable, non-toxic replacement for the lead-acid batteries used in a UPS

- *CleanSource UPS*, integrating UPS electronics and flywheel energy storage system into a single power quality solution

Active Power's customers are Internet service providers, semiconductor manufacturers, telecommunication providers, pharmaceutical manufacturers, hospitals, electric utilities, and broadcasters throughout the United States and in Europe. Export sales accounted for 30 percent of total revenues during 2000.

The Center for Maximum Potential Building Systems

Summary

CMPBS offers services that move professional design and construction communities towards sustainable practices. Their approach focuses on the systemic balancing of internal space and resource needs with available external resources, across the buildings' life cycle stages. These designs

- tailor system parameters to meet occupancy needs
- minimize energy sinks and remote sourcing
- implement renewable energy sources
- facilitate rain-water and wastewater harvesting
- utilize on-site wastewater treatment systems
- match air intake to landscape's ability to regenerate air
- reuse materials.

CMBPS provides design services to projects that extend the boundaries of the state-of-the-art in one or more areas. Through interdisciplinary approaches and the implementation of prototypes, individual projects are used to establish precedents for policy advancements, publications, workshops and lectures.

The Company

Pliny Fisk III and Gail Vittori, individually chose to locate to Austin in the mid-1970s. Fisk took a position with the architecture department at the University of Texas at Austin, where he developed bottom-up, hands-on vehicles to spread the gospel of "appropriate technology" throughout construction and planning communities. Austin communities quickly took to Fisk's ideas, as did private funders, and he was able to launch the Center for Maximum Building Potential Systems (Max's Pot), with the development of the Advanced Green Builder Demonstration structure that would become its centerpiece and main office. Vittori, co-founder of the Austin Women's Appropriate Technology Collective attended one of Fisk's classes and by 1979 had joined the staff at Max's Pot. Vittori brought policymaking skills to the staff, which enabled the organization to pro-actively engage state and local governments, as well as the building and planning communities.

The co-directors have kept CMBPS rooted in Austin over the past 26 years, although they devote much of their time to educating national policy makers in Washington, D.C. or overseeing projects on several continents. Their location at Max's Pot provides them with the "safe space" to pose questions and conceive new design services and products like AshCrete (a concrete substitute that replaces Portland cement with fly ash from coal-burning power plants.) The Austin region remains progressive and willing to collaborate on reform measures, providing the solid platform from which to broadcast its message. Public policy initiatives such as the Austin Green Builder Program (the first municipally-adopted green builder program in the world) and the Texas Architecture and Engineering Guidelines (one of the first instances of integrating sustainability considerations in a state's A&E guidelines) have become national and international models spawning similar programs in cities and states throughout the world. The Green Builder program received recognition at the 1992 Rio Earth Summit as one of a dozen exemplary local government initiatives; since then eleven other US cities have replicated the Austin example.

In addition to AshCrete, the Center continues to develop and roll out new products and informational services. They recognize that customer education makes the difference

between a successful prototype and a new market standard. Their clientele has steadily grown in scope:

- from local government buildings to the Pentagon
- from Austin public schools to the UT Health Science Center in Houston – the largest health science center system in the world
- from demonstration farms in Laredo, Texas to model farm villages in Guanghan City, China.

Wherever cutting edge designers and planners wrestle with resource problems, the Center may eventually turn up.

Cielo Wind Power, LLC

Summary

A privately owned company with headquarters in Austin, Texas, Cielo Wind Power is the leading wind power developer in Texas and one of the leading developers of wind energy in the U.S. Texas' commitment to renewable energy (e.g. its deregulation strategy, Austin's Green Choice Program, and an overall cooperative environment) motivated Cielo to select Austin as its home.

Company Profile

Formed in 1998, Cielo Wind Power, LLC has 49 employees in Austin and West Texas. Originally servicing small wind turbine generators for farmers and ranchers, primarily in the Texas Panhandle, Cielo has grown to develop, maintain and assist with the construction of utility-grade wind power projects. The company now has the largest utility-grade wind power development in Texas, providing about 650 MW of wind energy. It partners with investors and utilities, such as Austin Energy, to bring consumers 'green' power for their businesses and homes. Cielo, currently generating enough power for 75,000 homes and businesses each year, developed projects in 2001 with more than 500 MW of power combined.

In 1999, Cielo launched the Southwest Mesa Wind Farm, a 75 MW facility, providing energy sufficient for 24,966 households per year via American Electric Power. Another Cielo project, a 1 MW facility located on Llano Estacado Wind Ranch at Texico and operated by Southwestern Public Service Company, generates energy for about 330 households per year.

In 2001, Cielo had four projects in Texas, generating 279 MW, 80 MW, 2 MW, and 660 kW respectively. In 2002 TXU Energy and Cielo will build a 240 MW wind farm near McCamey in West Texas, the Noelke Hill Wind Ranch, which will be one of the largest wind projects in the nation. With the addition of Noelke Hill, TXU Energy will be handling 624 MW of renewable energy, making it the third-largest purchaser of wind power in the US. Noelke Hill will potentially serve 420,000 homes or 1.2 million people, 10 percent of TXU customers worldwide. TXU is the number one purchaser of wind generation in Texas and number four contractor for wind power in U.S.

Energy Saving Strategies (ESS)

Summary

ESS provides comprehensive energy management services to the middle-market power consumer (facilities with less than 1 MW of power demand). Its focus is primarily on demand-side efficiency opportunities, but it can also provide supply-side assistance if needed. ESS concentrates its direct sales efforts in retail, commercial, hospitality and healthcare markets, focusing on regional or national companies with multiple locations.

ESS chose Austin as its headquarters because the city is central to Texas' major utility markets. This affords ESS the convenience to explore business opportunities in Dallas-Fort Worth, Houston, San Antonio, and Austin.

Austin has proved a good laboratory for ESS product development. Texas is in the early stages of deregulation, and the market for energy services outside the public utilities is just now emerging.

Company Profile

ESS has partnership agreements that serve as sales channels for its service. With Reliant Energy, a leading Retail Electric Provider, ESS provides efficiency services to its Houston service-area customers. For Reliant, this is a way to add to its existing customer relationships and retain its customer base in the face of emerging retail competition under deregulation. This relationship is expanding into Reliant's other Texas markets, as well.

IEnergy of Houston partners with ESS to include energy services along with the real estate services they offer to major U.S. and international companies. Because Native Americans own IEnergy and its parent company, IDRESCO, companies that work with them can count recurring expenditures toward their annual Minority Supplier Diversity goals.

ESS partners with Austin-based Good Company & Associates to introduce its support for mandated energy efficiency activities to 38 Texas counties affected by deregulation. The major ESCOs are addressing major urban areas, but ignoring the hundreds of smaller entities equally affected by the new legislation.

Green Mountain Energy

Summary

Green Mountain Energy Company relocated from Vermont to Austin to be closer to Austin's high-tech industry as well as Texas-based energy industries. The company saw greater business potential in Texas, especially after electric deregulation, and a potentially robust market for Clean Energy in the future. Austin aligned better with the company's growth plan, given its large talent pool and the population's progressive views on environmental issues. Green Mountain Energy's electricity, generated exclusively by wind farms located within Texas, is the only Green-E-certified product available in the state.

Company Profile

Green Mountain Energy was founded in September of 1997 with a mission to "change the way power is made."

The company had $40 million in revenue in 2000, $80 million in 2001, and hopes to hit $250 million in 2002. It made significant progress as a Clean Energy retailer since relocating to Texas. The company has grown 700 percent in only 5 years, and has 75 employees. Green Mountain is the leading brand of cleaner electricity, with over 500,000 customers in 7 states (California, Connecticut, New Jersey, Ohio, Oregon, Pennsylvania, and Texas). It is the largest and fastest-growing residential provider of cleaner energy in the United States, providing electricity generated from sources including wind, solar, water, geothermal, biomass, and cleaner-burning natural gas.

Green Mountain started supplying cleaner electricity in California, the first state in the U.S. to deregulate electrical utilities, in April 1998. It expanded into Pennsylvania in January 1999. In June 2000, eight 200 foot wind turbines arrived in Garrett, Pennsylvania, the home of Green Mountain Wind Farm, one of the largest wind farms on the East Coast and the first utility-scale wind farm in the state.

In July 2000 Green Mountain Energy Company moved to Austin from Burlington, Vermont, and changed its name from Green Mountain.com to Green Mountain Energy.

In February 2002 the company raised $24 million in investment funds.

To stay competitive, Green Mountain had to adjust its products and marketing efforts according to marketing conditions and availability in different geographical locations. In Texas, where Green Mountain obtained a fair price for wind energy, 100 percent of its products were considered Clean Energy, *i.e.* 100 percent pollution-free. However, in Ohio only 2 percent of its products could be considered clean due to issues of supply cost and availability. Green Mountain's offering in Ohio was mostly natural gas, which is less polluting, but not "clean."

Integrated Power Solutions (IPS)

Summary
IPS designs, manufactures and markets energy-generating and energy-conserving products that are cost-effective, reliable, and fueled by environmentally friendly natural gas. IPS products provide customers with solutions that reduce electricity purchases from the power grid, thus lowering energy costs while offering healthier and more desirable operating conditions.

IPS is based in Kyle, located in Hays County, adjacent to Travis County and Austin. Kyle had inexpensive property and was close enough to Austin to make a daily commute possible. Other major incentives for choosing this location were:

- Austin and other parts of Texas are humid, therefore a good market for some of the IPS products, particularly the desiccants.

- Access to the Austin area's talented workforce, including graduates from the University of Texas and other area universities, and talented professionals previously employed by Dell, Motorola, IBM, AMD and other world-class enterprises operating locally.

- Manufacturing infrastructure**:** Austin-based component dealers who have supplied components for manufacturing companies such as Applied Materials and Dell have been operating below capacity. These facilities have highly developed infrastructures, advanced equipment, and tech-savvy personnel. They are flexible enough to reconfigure manufacturing facilities to meet IPS specifications. This has allowed IPS to create meaningful partnerships, thus eliminating the need to build its own manufacturing plants. The result has been cost savings and sufficient resources for further research and development.

Company Profile
Integrated Power Solutions (IPS) is a start-up that has been operating since January 2001. IPS is a value-added manufacturer that applies three distinct technologies in developing energy-efficient products for customers in residential, commercial, industrial, and public sector markets. IPS manufactures advanced generators, chillers and desiccant dehumidifiers.

Focused on emerging and highly scalable applications for its products, IPS is in a strong position to be a market leader in the niches it serves. IPS reduced time to market while gaining immediate industry acceptance and rapid sales success by establishing strategic partnerships with major component vendors with reputations for quality and durability. Earlier this year, IPS formed alliances with two industry giants -- TECO Partners Inc., a unit of Tampa, Florida-based TECO Energy, and TRC Distributed Generation Group, part of Connecticut-based TRC Cos. Inc. IPS' partnership with TECO is expected to yield $20.7 million for the company, while the partnership with TRC is expected to produce $45 million.

CHAPTER FIVE

Texas' Statewide Clean Energy Assets

Texas' Statewide Clean Energy Assets

Texas: A National Model

Texas is emerging as the nation's most surprising clean-energy success story. Home to the nation's highest per capita energy use and accounting for 14 percent of the nation's total, some have described Texas as the "Saudi Arabia of wind." The state's emergence as one of the country's hottest renewable energy markets has much to do with its recent groundbreaking utility restructuring statute, SB7. Texas took the nation's boldest – and most successful – action to promote the generation and use of Clean Energy from renewable sources. Three years ago, Texas was last in the nation in its percentage use of renewable energy. Today, west Texas is home to the world's largest wind farms. The state increased wind capacity in 2001 by a factor of eight and would rank sixth among the nations of the world in wind capacity if it were a country, based on one year's development alone.

Texas' utility restructuring legislation set ambitious mandatory targets for renewable power supplies, but lets the market decide how to reach those targets most efficiently. With its system of renewable energy trading credits (the nation's first), market forces can produce the most renewable energy at the least cost, with minimal government involvement. The Texas law requires utilities to buy credits for renewable energy. By forcing competitive retailers to directly participate in the credit market instead of mandating direct purchase from chosen suppliers, the program ensures that all providers of certified renewable energy have access to the market, and that investment goes to those projects with the highest return, and thus the most credits, to offer.

The renewables standard has been so successful that the state is several years ahead of schedule toward its goal of adding 2,000 MW of renewable energy by 2009 – enough to provide electricity to a million Texans.

By forcing energy companies to deal with renewable energy on a large scale, the Texas policy has tapped into economies of scale that make renewable power attractive economically. The companies have since invested in more than twice as much of the once-unfamiliar technologies.

Also important is the fact that the regional Electricity Reliability Council of Texas (ERCOT) and the Public Utilities Commission of Texas (PUCT) do more favorable integrates new wind and other plants than happens in other states. Policies include a single transmission rate that takes effect in 2002 (avoiding multiple charges), a one-stop standardized interconnection process since 1998 (avoiding discriminatory requirements on new plants wishing to connect to transmission lines), and a market-based subzonal congestion management scheme that allocates congested lines fairly among generators. These provisions ensure that pricing for transmission does not discriminate against new market entrants and intermittent generators like producers of wind energy.

Texas provides a number of tax and other incentives to develop renewables. Such incentives include solar and wind-powered energy systems tax exemptions, a solar and wind energy device franchise tax deduction, a solar and wind energy system manufacturer franchise tax exemption, and other financial rewards.

As mentioned above, Texas' restructuring legislation includes a Renewables Portfolio Standard (RPS) requirement for 2,000 MW of renewable energy capacity by 2009. That

is equivalent to approximately 3% of the state's current maximum demand. The RPS is essentially a minimum content requirement that grows over time, and allows the market to choose which renewable energy technologies are the most cost-effective. Specifically, the Texas RPS calls for 400 MW of new renewables by 2003, another 450 MW by 2005, another 550 MW by 2007, and a final installment of 600 MW of new renewables by 2009. The state's excellent wind resources suggest that much of that amount will come from wind energy.

The researchers note that this amount is modest relative to "the enormous potential for renewable energy development in Texas. Nevertheless, it represents a marked increase in renewable energy capacity in the state, and represents one of the most ambitious contemporary state renewable energy policies in the U.S. in terms of capacity additions."

The requirement for renewable energy as defined in the Texas RPS is set high enough (2,000 MW of new renewable energy) above the 880 MW that existed prior to enactment of the RPS to trigger market growth. Setting an ambitious, yet achievable, level for an RPS is a critical first step, and this should consider both the RPS's definition of renewable energy and its existing level. Failure to make these considerations can result in a meaningless requirement. For example, Maine's 30% RPS may sound ambitious, but about 40% of Maine's electricity already comes from hydropower, a form of energy that qualifies as renewable under that state's RPS.

The Texas requirement specifies tradable renewable energy credits (RECs), which ensure flexibility and encourage adoption of least-cost solutions. Credits favor development of the renewable energy source with the lowest cost, and allow utilities to meet the RPS at their lowest cost. Credits also provide a simple accounting system for tracking new generating capacity and monitoring compliance with the RPS. Texas is the only state so far to base the RPS obligation on credit trading from the outset.

While the Texas RPS jump started the wind energy market in the state, the federal wind energy production tax credit (PTC) is also accelerating the rate of investments here.

Local leaders from Texas to California recognize the many benefits of Clean Energy from renewable sources and are looking to it as the path to a new, cleaner era of power generation. Austin is a great example of a city with a commitment to Clean Energy. In 1983, Austinites voted in favor of revenue bonds for the generation of electricity from renewable energy sources. In February 1999, the City Council resolved that 5 percent of Austin's electricity should come from renewable energy sources by 2005. In June 2002, the City Council approved a landmark resolution that endorses the Clean Energy Industry as an attractive industrial cluster and a welcome addition to the local economy. This resolution extends the city's quality of life emphasis, which contributes to the city's position at the top of several different "best place to live" lists and complements perfectly the city's "smart growth" initiatives.

To meet those goals, Austin's municipally owned utility, Austin Energy (AE), launched its *GreenChoice* program in early 2000. AE announced it would commit $7.8 million per year for the next 10 years to purchase renewable energy from wind, landfill methane, and solar power facilities. To date, the program has added nearly 7,000 residential customers, 160 small businesses, and 30 large companies. These entities combined subscribe to 300 million kWh per year of clean power – sufficient to power 20,000 average homes year-round.

In July 2002, AE installed a 200 kW fuel cell system to provide distributed power at a health center in Austin, and feed electricity into the AE electric grid, making it the first fuel cell in Texas to do so. This groundbreaking AE initiative may help create an early market for fuel cells in Texas.

AE was the first public power utility, and one of only two electric utilities in the nation, to participate in a new carbon dioxide (CO^2) emissions trading program. Only CO^2 reductions achieved through residential energy efficiency programs are eligible for the program.

Major utilities operating in Central Texas have also shown interest in newer and less-polluting methods of electricity generation. The Lower Colorado River Authority (LCRA), considered a pioneer utility in wind power, began including wind in its resource mix in 1995, and has contracted to buy 105 MW in wind power alone. Under ideal conditions it draws about 15 percent of its generation from six hydroelectric dams and two existing wind projects, making it the largest supplier of Clean Energy in the state.

Comparison of State Clean Energy Initiatives

Clean Energy is growing steadily in the United States. Policies such as state energy funds, state mandates for renewables, environmental regulations, improved technology and retail consumer interest have led to increases in the installed capacity. Nearly 55 percent of the projected demand for renewables in 2020 is for electricity generation. Landfill, wind, and biomass are seen as the most important renewable energy sources in the U.S.

A recent report released by PennFuture, "Electricity Competition: The Story Behind the Headlines - A 50-State Report," reveals that states with restructured utility legislation lead the way with lower prices and Clean Energy policies, including policies that encourage development and use of renewable energy. 17 restructured states and 2 monopoly states have Clean Energy policies, which include creating state funds for renewable energy development and requirements that electricity companies produce increasing ratios of Clean Energy. These states and their policies are driving a mushrooming renewable energy market.

Analyses of subsidies versus electricity generated during the first 15 years of federal support for nuclear power and renewables reveals surprising differences. Notably, commercial nuclear power development received subsidies worth $15.30/kWh between 1947 and 1961, compared with subsidies worth $7.19/kWh for solar and 46¢/kWh for wind between 1975 and 1989. In their 15 years, nuclear and wind technology produced roughly the same amount of energy (2.6 billion and 1.9 billion kWh, respectively), but the subsidy for nuclear power outweighed the subsidy for wind energy by a factor of more than 40. A recent study points to the need to reevaluate energy subsidies in light of larger energy and environmental goals that favor renewables.

Below, we examine six states that have expressed the most interest in Clean Energy and the potential for electricity generation from renewable resources.

California

California has long been at the forefront of progressive environmental policy making. In 2000, the state generated 10 percent of its electricity from renewable sources. However, it still depends on fossil fuels and nuclear power for 71 percent of its electricity needs.

The state's Clean Energy Industry has been growing since the mid-1980s, creating nearly 400 full-time jobs. California provides a number of rebates and incentives to encourage the use of renewable energy. The state set the bar for all other renewable energy funds with the creation of a $540 million fund for renewables back in 1996. The success of that program lead to legislation in 2002 that extends that funding — at the same annual levels — for another ten years, creating an additional $1.35 billion in renewables funding. However, the PUC suspended retail direct access in September 2001, which was a cornerstone of the state's 1996 electricity restructuring law. At one point, about 2 percent of California customers had switched to alternative suppliers, many of whom were selling green power. Due to several “gaps” in the state’s power situation, Californians can no longer choose green energy to meet their electricity needs. To correct the situation and boost the fledgling Clean Energy market, the state passed a bill in September 2002 establishing a statewide renewable energy portfolio and requiring electricity retailers to increase their use of renewable resources by at least 1 percent per

year. By 2017, retailers must produce at least 20 percent of their retail electricity sales from renewable sources, or nearly double the existing base.

According to a recent report, a 20 percent increase in renewable energy and energy efficiency investment in the year 2000 would create 77,400 jobs in California by 2010 and 141,400 jobs by 2020. If Texas adopted a 20 percent RPS as California did, that could translate into 71,500 jobs by 2010 and 123,400 jobs by 2020.

Massachusetts

In 2000, Massachusetts generated 94 percent of its energy from fossil fuels and nuclear and six percent from renewable sources. The state has a potentially promising renewable resource base; Cape Cod and the islands provide perhaps the best wind resources in New England (Class 5 and 6), while the Berkshire Mountains in the western portion of the state have Class 4 potential. A strong agricultural base in the western half of the state promises some biomass potential, and concentrated metropolitan areas in the eastern portion provide opportunities for landfill gas generation.

The 1997, utility restructuring legislation included a number of provisions designed to support development of renewable energy resources in the state. Massachusetts was the first state to enact both a portfolio standard and a renewables fund. In April 2002, the Massachusetts Division of Energy Resources issued its final regulations for the RPS, which require all retail electricity providers in the state to use renewable energy sources for at least 1 percent of their power supply in 2003, increasing to 4 percent by 2009. Electricity suppliers can avoid the requirement by purchasing credits. The Renewable Energy Trust Fund is supported through a system benefits charge with total funding of roughly $150 million over a five-year period, and with approximately $20 million per year for an undefined period beyond 2002.

Nevada

In 2000, Nevada generated 89 percent of its electricity from fossil fuels and 4 percent from non-hydro renewable sources. Hydroelectric power accounted for 7 percent of the state's total. Nevada gets a large percentage of its renewable power from geothermal sources, hot underground water or steam, mostly at sites in northern Nevada. The state uses more geothermal energy per capita than any other state in the country.

An updated study by the Union of Concerned Scientists shows Nevada will be a major producer of green power by 2012. The organization estimates that Nevada will place third in the country in renewable power (excluding hydroelectric) capacity with 1,248 MW, compared with 5,124 MW for California and 2,000 MW for Texas.

As part of its 1997 restructuring legislation, the Nevada legislature established a renewable portfolio standard. In 2001, the legislature revised the minimum amounts to increase by 2 percent every 2 years, starting with a 5 percent renewable energy requirement in 2003 and achieving a 15 percent requirement by 2013 and each year thereafter. No less than 5 percent of the renewable energy must be generated from solar renewable energy systems. It is estimated that this law will stimulate $3 billion in new renewable energy investment in Nevada during the next ten years.

Oregon

In 2000, Oregon generated 24 percent of its electricity from fossil fuels and 1 percent from non-hydro renewable sources. Hydroelectric power accounted for 75 percent of the state's total energy mix.

Oregon provides a number of incentives, such as business and residential energy tax credits and rebate programs, to promote renewables. The City of Portland, Oregon, has realized more than $1 million in annual energy savings since 1991 through its City Energy Challenge program. Portland also has an agreement with the local utility to receive 5 percent of its electricity from wind power, replacing energy from coal and saving an additional $175,000 annually.

Oregon's 1999 utility restructuring legislation included a 3 percent public benefits charge to be paid by all electricity users. The charge is expected to generate about $60 million per year during the next 10 years for renewable resources, energy conservation, market transformation, weatherization programs, and school energy programs.

Pennsylvania

In 2000, Pennsylvania generated more than 98 percent of its electricity from fossil fuels and nuclear power and 1 percent from renewable sources. Pennsylvania relied on nuclear power for more than a third of its energy needs, making it one of the most nuclear-dependent states in the country.

Home to more than 35 MW of wind power facilities, Pennsylvania plans to add more than 110 MW of wind energy scheduled for installation in the next several years. More than $170 million worth of wind equipment will be installed in rural Pennsylvania over the next two years. According to the American Wind Energy Association, these new wind farms will result in tax payments to counties and schools totaling $1.2 million each year.

Pennsylvania's December 1996 electricity restructuring law did not establish a renewable portfolio standard. But, as with the state's public benefits funds for renewables, a renewable portfolio standard was subsequently established through individual utility restructuring settlements. Twenty percent of all residential customers must be assigned to a provider of last resort, a default supplier other than their local electrical distribution company. The Competitive Default Service bidding process is being used to select the Energy Generator Supplier (EGS). In order to qualify for the CDS bidding process, an EGS must supply at least 2 percent renewables, increasing by 0.5 percent each year.

Washington

In 2000, the state of Washington generated 25 percent of its energy from fossil fuels and nuclear power and 1 percent from renewable sources. Hydroelectric power accounted for 74 percent of the state's total energy mix.

Washington has enormous capacity to generate electricity from renewable sources. The Stateline Wind Project, located near Walla Walla, is the largest single wind-powered renewable energy development in the Northwest. Completed in January 2002, it consists of almost 400 wind turbines with the capacity to produce about 300 MW of electricity — enough energy to power about 70,000 homes. Maiden Wind Farm will produce 150 MW of Clean Energy when completed, generating enough power to meet the needs of more than 36,000 homes. Bonneville Power and Washington Winds, which will operate the plant, hope to install another 250 MW in the future. The Mt. Ranier National Park in

Washington State has just installed a hybrid solar energy system in its White River facility.

The City of Seattle has pledged to meet 5 percent of its power needs from renewable energy. In 2001, the city announced a 50 MW wind power purchase, which could increase to as much as 175 MW by 2004. Seattle City Light received approval from the City Council to offer a green pricing program to its 340,000 customers.

State Comparison of Energy Generated from Renewables

State	Current Generation %	Renewable Portfolio Standards
AZ	0.0	0.4% in 2002, growing to 1.1% for 2007 – 2012 (60% from solar for 2004 through 2012)
CA	10.0	Growing 1% annually to reach 20% by 2017
CT	6.0	7% by 2009
HI	0.0	9% by 2011
IL	0.0	5% by 2010, 15% by 2020
MA	0.0	1% in 2003, 4% by 2009
ME	30.0	30% over 2 or more years for all electric providers
MN	0.0	0.5% by biomass by 2010 and 1% by 2015
NJ	0.0	1% by 2006, 4% by 2012
NV	4.0	5% by 2003, growing 2% biannually to 15% in 2013 and each year thereafter (min 5% solar)
OR	1.0	N/A
PA	1.0	N/A
TX	1.0	2,000 MW (~ 3%) by 2009 in addition to existing 880 MW
WI	0.0	0.5% by 2002, 2.2% by 2011

State Clean Energy Funds

State	Clean Energy Funds
CA	Renewable Resources Trust Fund: Originally $540 million; funding extended through 2012 to reach a total of $1.35 billion.
CT	Clean Energy Fund: $118 million total over 5 years from 2000.
DE	Public Benefit Fund: $1.5 million annually for efficiency and renewable programs.
IL	Renewable Energy Resources Trust Fund and Clean Energy Community Trust: ~ $50 million over ten years ending 2007.
MA	Renewable Energy Trust Fund: $150 million over a five-year period from 1997, with ~$20 million per year for an undefined period beyond 2002.
ME	Public Benefits Program: There is no mandate funding level for renewables. However, the Maine Public Utilities Commission has ruled that utilities must offer customers the option to check off a contribution of $1, $5, $10 or other amount each month on their electric bill.
NJ	Societal Benefits Charge: $358 million through 2003 (75% for efficiency programs and 25% for renewables).
MN	Renewable Development Fund: $4.5 million in 1999, rising to $8.5 million per year in 2003 for renewables only.
MT	Universal System Benefits Program: ~ $50 million until 2006, ~ $2 million per year for renewables only.
NM	Electric Industry System Benefits Fund: ~ $4 million.
NY	New York Energy $mart Program: $208 million for R&D, including wind, photovoltaics, and biomass.
OH	Energy Efficiency Revolving Loan Fund: funds low-income assistance programs and a weatherization program; renewable energy projects are also eligible for loans through the fund. Total fund: $100,000, with a max of $25,000 for residential (5 years) and $500,000 for business renewable projects (8 years).
OR	Public Benefits Fund: $8.7 million per year until 2009.
PA	Public Benefits Programs: vary by utility; PECO: $32 million by 2007; PECO/Unicom merger to bring another $20 million; GPU: $12.1 million by 2005; West Penn Power: $11.4 million by 2006.
RI	System Benefits Charge for DSM and renewables: $3 million per year for renewables for 5 years from 2001.
TX	System Benefit Fund: a customer-supported fund used to finance 4 different programs, including energy efficiency programs, $18 million for 2002-2003.
WI	Public Benefits Fund: $3.8 million per year.

Source: Database of State Incentives for Renewable Energy, http://www.ies.ncsu.edu/dsire/; Union of Concerned Scientists, http://www.ucsusa.org/index.html, Clean Energy Funds Network, http://www.cleanenergyfunds.org/Renewable_Energy_SBCFund_Summaries.htm; Energy Information Administration, DOE, http://www.eia.doe.gov/cneaf/electricity/chg_str/pbp.html

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Appendices

Renewable Forecast Assumptions

Estimate Assumptions	Current Installed Capacity (MW)	Capacity Factor	Price per kWh	Projected Annual Growth Rate 2002-2020	Actual Annual Growth Rate	Other Annual Growth and Market Estimates
WIND						
World	17,700 (2001)	35%	$0.065	20%	1995-2000, 24.2%	IEA: 1999-2020, 11% Power Engineering Intl: 2001-2010, 15.5% EWEA: 2001-2005. 17.5%
US	4261 (2001)	35%	$0.065	20%	1998-2001, 28%	IEA: 1999-2020, 13%
Texas	1096 (2001)	35%	$0.065	15%	1999-2001, 151%	SECO: 1999-2009, 12.5%
BIOMASS						
World	35,000 (1999)	70%	$0.065	4%		IEA: 1999-2020, 4.2% DOE: 2001-2020, 4% Reuters: 1999-2010, 6.5 % (EU only)
US	7000 (2001)		$0.65	5%	1978-1995, 22% 1995-2001, 5%	EIA: 2000-2020, 1.5% IEA: 1999-2020, 2.6% DOE: 1996-2020, 8% (target)
Municipal Solid Waste	2500 (2001)					
Landfill gas	500 (2001)					
Texas	264 (2001)			5%		

Estimate Assumptions	Current Installed Capacity (MW)	Capacity Factor	Price per kWh	Projected Annual Growth Rate 2002-2020	Actual Annual Growth Rate	Other Annual Growth and Market Estimates
GEOTHERMAL						
World			$0.065			
Direct use	15,145 (2000)	32%		10%	1995-2000, 12%	
Electricity Generation	7,974 (2000)	75%		4.0%	1995-2000, 3%	IEA: 1999-2020, 4.0%
US						
Direct use	3,766 (2000)	32%		10%	1995-2000, 15%	
Electricity Generation	2,228 (2000)	75%		4.1%	2000-2005, -4.5%	IEA: 1999-2020, 4.1%
Texas	0					

SOLAR/PV	Current shipments (MW)	Price per Watt	Projected Annual Growth Rate to 2020	Actual Annual Growth Rate	Other Annual Growth and Market Estimates
World	231 (2000)	$4 in 2000 decreasing yearly by 3.5%	24%	1996-2002, 25% 1992-2000, 15.5% 1980-2000, 20-25% 1999-2000, 37%	SalomonSmithBarney, 2001-2005, 20% NREL: 2000-2020, 25%
US	65 (1999)	"	25%	1995-2000, 20%	NREL, 2000-2005, 25%+

Energy Efficiency Forecast Assumptions

World EE Market

World GDP numbers obtained from IMF and EIA.
We assume that the % of GDP dedicated to EE is the same as that in the US. This is based on the premise that there are several other advanced countries such as Japan, Switzerland and others that are ahead of US in their EE measures. Therefore, as a world average, it is conservatively assumed that the US measures may be fairly representative for the rest of the world.

$billion	**2002**	**2010**	**2020**
World GDP	$32,630	$43,063	$59,733
% of EE	0.35%	0.37%	0.43%
$ in EE	$114.20	$156.90	$256.10

US EE Market

	2002	**2010**	**2020**
Improvements in existing systems			
Households			
Weatherization			
Federal Agencies		300	
Schools		450	
Retrofits & Services	1900	5812	23513
Renovations	$358,858	$465,697	$633,782
$ of renovations invested in EE	$25,120	$32,599	$44,365
New			
Households	8000	8000	8000
Non-Residential Building	$213,668	$347,106	$440,000
Value of NRB implementing EE	$32,050	$52,066	$66,000
Value of EE investment in NR bldg	$641	$1,041	$1,320
Projections			
Exp. GDP growth rate	1.30%	3.80%	3.00%
US GDP	$10,194,832	$13,230,024	$18,005,159
TOTAL	35,661	$48,202	$77,198

Energy Efficiency as a percentage of the World GDP is assumed to be the same as that the one derived for the US market. This is to account for the much higher percentages of Energy Efficiency measures in other advanced countries such as Japan, Switzerland and other EU countries.

Households: Approximately a million homes will be built per year till 2020 (according to a linear regression model run on data from the US Bureau of Census).
Given that Japan is the leader in adopting energy efficiency technologies, according to the stringent building standards that they have enacted in April 2001 the incremental cost of incorporating these standards into new homes is approx. $8,000/home.
Therefore the potential in household is 8,000 X 1M = 8,000,000,000 i.e. $8B per year

Weatherization: According to an Issue Brief for Congress, ER3 seeks to weatherize at least 123,000 households per year from 2003 to 2005. That is 369,000 homes. As assumed by DOE, the average cost of weatherization per home is $2500. Therefore, expected expenditure in this sector: 369,000 X $2,500 = $922,500,000
This will be in addition to the potential $8B cost for the new homes.

Federal Agencies: According to studies done by the Office of Technology Assessment, if federal agencies were to enact currently available energy efficiency measures, they could save approximately $1B annually. Given that the average payback on commercial buildings are about 3-5 years, to be conservative, let's assume that the payback is in 3 years. This would imply that current potential investment could be 3*$1B = $3B. Assume that the projects will start getting implemented in 2003. Also assume that implementation would be done over a period of 10 years. According to a study done by NAESCO, annualized growth rate in the ESCO industry has been 24% over the last decade. The assumption for this case, to be conservative, is that the retrofit for federal buildings will only be addressed for 10% of all buildings each year. Note: these are all potentials in the industry. There are no current government mandates to adopt such measures for federal agencies on a national scale even though some EE measures have been decreed.

Schools: DOE estimates that if all public schools were to adopt currently available energy efficiency measures, they could save approximately $1.5B annually. Given that average payback on commercial building are about 3-5 years, to be conservative, let's assume that the payback is in 3 years. This would imply that current potential investment could be 3*$1.5B = $4.5B. Assume that the projects will start getting implemented in 2003. Also assume that implementation would be done over a period of 10 years. According to a study done by NAESCO, annualized growth rate in the ESCO industry has been 24% over the last decade. The assumption for this case, to be conservative, is that the retrofit for school buildings will only be addressed for 10% of all buildings each year. Note: these are all potentials in the industry. To the best of our knowledge, there are no current government mandates to adopt such measures for school buildings.

Retrofits and services: According to NAESCO, ESCO's wide range of energy efficiency related services represent an annual market of $1.9 - $2.1 B. This market has seen an annualized growth rate of 24% over the last 10 years. Using the lower range of $1.9B for 2003 and then using a much more conservative annual growth rate of about 15%, projections have been made till 2020 (this is based on the notion that over time, this explosive growth rate will taper down).
Let us assume that this amount includes all the projected improvement projects for commercial and industrial buildings.

US GDP:

US Population today is approximately	278,058,881
Per capita income (2001 numbers)	$36,200
Therefore, total GDP	$10,065,731,492,200

Value of Non-residential buildings investing in EE: ESS interview - approximately 75% of eligible new buildings implement EE technologies. Assume a more conservative 60% and that this percentage does not improve over the years.

% of Renovations invested in EE: According to a report from California Public Utility Commission, in the residential sector, retrofits and renovations represent 49% of the state's public goods (Nonresidential). =(103.6*1000000)+(125.2*1000000) (in Dec. 2001; To be conservative we will use this same number for 2002)

According to Rebuild America, per dollar of DOE expenditure on energy efficiency programs result in a $10.53 private investment. Extrapolating the same idea at a state level, let us assume that per dollar of CPUC investment in EE programs result in a $5 private investment. This also discounts for retrofits since it is already counted under retrofits & services. This would mean that for a PGC expenditure of $228.8 M, private investment is $1,144,000,000 in the renovations arena.

Given that California is one of the most aggressive states in pushing such standards, let us assume that, on average, other states will only achieve 40% of this potential. Therefore the total potential for EE in the renovations arena in the United States is $24,024,000,000.
As a percentage of total renovations expenditure for 2002, this is 7%. To be conservative, we will maintain 7% as a flat percentage for EE spending in renovations for the next 20 years.

Value of investment in EE in non-residential buildings: Since the standards of EE have been improved across the board, incremental cost for implementing EE is very low (source: ESS). Let us assume that only 2% of the value of the new buildings will be dedicated to EE. This flat percentage will also discount for the fact that investment may increase again in the future as standards change.

Miscellaneous: According to DOE budget for 2001, spending on renovations is presented to be 3.52% of the GDP. Let us assume that there is no compounded growth in the percentage of GDP spent on new buildings, renovation or modification (the latter 2 represent 3.52%).

Limitations: This excludes any consideration of Energy efficiency technology usage in the transportation sector or its use in industrial processes. Fuel efficiency is an increasingly important area of development and as such the actual dollar potential in this model is highly understated.

Texas EE Market

$millions	**2,002**	**2010**	**2020**
US Market	$35,661	48,202	$77,198
$ in EE	$3,923	$5,302	$8,492

Texas is the only state in the nation with a legislatively mandated energy efficiency goal. In 1999, Texas Senate Bill 7, which restructures the state's electric utility industry, took effect. SB7 requires electric utilities to fund efforts that will result in 10% of the state's growth in demand for electricity being met though cost-effective energy efficiency.

According to a database built by NAESCO and LBNL, NY, NJ, CA and TX account for 44% of all market activity in the ESCO industry. Even though Texas is very progressive in this area and was the first state to adopt building Energy Star homes, we will assume that of this 44%, Texas only accounts for 25% i.e. which is 11% of the total in the US.

The assumption, therefore, is that Texas accounts for 11% of the total EE market in the US.

Employment Forecast Assumptions

According to http://sme.belgium.eu.net/climnet/pubs/jobs/Exec.html, which sites a study done by the Center for Energy Conservation and Environmental Technology, "Saving the Climate, that's my job", the data on the last page can be used to estimate the employment figures for Texas, the US and the World.

The data says that for EY2.5 B investment per year, it created 70,840 jobs; taking the job creation number as a % of total investment gives 0.003%. This percentage was extrapolated for all of Texas, US and World investment numbers derived earlier.

Investment by $million	**2,002**	**2010**	**2020**
Texas Investment	$3,923	$5,302	$8,492
Employment	113,562	153,499	245,836
US Investment	$35,661	$48,202	$77,198
Employment	1,032,381	1,395,445	2,234,868
World Investment	$114,169	$156,896	$256,108
Employment	3,305,173	4,542,096	7,414,285

Time Frame	1995 - 2005
Total CO2 Reduction (Mt)	440 Mt
Investment (in ECU)	investment in 2.5 bn per year
Employment	71,000 (net)
Jobs/Mt C02	161
Key assumptions underlying the study	Baseline: GDP growth 1.5% per year; CO2 and energy growth 1.3% per year. Energy prices constant 1990 level; Model: ICARUS database for static input-output model; no change in energy prices, import and export; new technologies as in ICARUS database;
Other benefits (economic & environmental)	saved energy costs amount to ECU7.71 bn per year; additional money for households: ECU4.03 bn; reduction of SO2 and Nox

State Financial Incentives for Renewable Energy

California

Emerging Renewables Buydown Program: The California Energy Commission provides rebates for the purchase of four types of renewable energy generating systems (PVs, small wind turbines—10 kW or less, fuel cells using renewable fuels, and solar thermal systems) through its Emerging Renewables Buydown Program. The program offers a rebate of $4.50/W or 50% off the price of purchasing the system, whichever is less. This rebate is offered to all grid-connected utility customers within the electric utility service area of Pacific Gas and Electric, San Diego Gas & Electric, Southern California Edison, or Bear Valley Electric Company.

Glendale Solar Electric Rebate: Glendale Water & Power (GWP) is a municipally-owned utility. The City Council decided on August 21, 2001 to provide residential electric customers a rebate for PV installations. The one-time rebate is $3/W up to 10,000 W. Funding for this rebate is $150,000, and the city hopes to assist about 25 homeowners with rebates for 2,000-W systems estimated at $6,000 each.

Los Angeles - Residential and Commercial PV Buydown Program: In June 2000, the LADWP Board of Commissioners approved a solar buydown program designed to encourage the use of renewable energy through the installation of photovoltaic systems by residents and businesses in Los Angeles. The rebate program began September 1, 2000. In August 2001, the rebate was increased, and will continue until August 31, 2005. The program, which could be extended beyond the initial five-year period, also seeks to entice PV manufacturers to locate their businesses in Los Angeles. LADWP's goal is to have 100,000 systems on rooftops in Los Angeles by the year 2010. The current financial incentives include a maximum of $4.50/W for systems manufactured outside the City of Los Angeles, and a maximum of $6.00/W for those manufactured within the City. The maximum payment per site is $50,000 for residential and $1 million for commercial customers. Developers may receive a maximum incentive payment of $1,000,000 a year.

Pasadena - Solar Power Installation Rebate: Pasadena Water & Power (PWP) is a community-owned utility. Currently, PWP is providing its residential electric customers (and commercial customers on a case-by-case basis) a rebate for photovoltaic (PV) installations. The one-time rebate is $5 per watt or $10,000, based upon available funding.

Public Interest Energy Research Grants (PIER): Signed into law in 1996, Assembly Bill 1890 provided authority for a fundamental restructuring of California's electric services industry. Among other things, AB 1890 requires that at least $62.5 million be collected annually from investor-owned utility ratepayers for "public interest" energy RD&D efforts not adequately provided by competitive and regulated markets. The legislation required that the program portfolio focus on projects in five subject areas: renewable energy technology, environmentally preferred advanced generation, energy-related environmental research, strategic energy research, and end-use efficiency.

Sacramento - Solar Water Heater Program: SMUD offers rebates and loan financing to customers who install solar water heating units. The program was started in 1991 as part of the utility's demand-side management program. Performance-based rebates, typically around $700, are available for SMUD residential customers who have electric water heating. In addition to the rebate, SMUD offers 100% financing, with an 8.5% interest rate over a ten-year repayment period. Most loans come to an average of $2,300. To date, approximately 3,000 solar water heating units have been installed under this program, which comes to over half the systems currently installed in the city of Sacramento.

Self-Generation Program: On March 27, 2001, the California Public Utilities Commission announced new incentive programs to encourage residential and commercial customers to install grid-tied renewables and clean distributed generation resources. The Self-Generation Program provides incentives to encourage customers to produce energy using microturbines, small gas turbines, wind turbines, photovoltaics, fuel cells, and internal combustion engines. The incentives include payments of $1 - $4.50/W depending on the technology used.

Solar Tax Deduction: This personal tax deduction allows taxpayers to deduct the interest paid on loans used to purchase energy-efficient products or equipment for a residence in California. The deduction is for loans from a publicly owned utility company for the purchase of energy-efficient heating, ventilation, air-conditioning, lighting, solar, advanced metering of energy usage, windows, insulation, zone heating products, and weatherization systems. Customers of publicly owned utility companies that do not offer customer financing may be able to deduct the interest from a home equity or home improvement loan used to purchase energy efficient products and equipment.

Massachusetts

Solar and Wind Power Systems Excise Tax Exemption: This statute exempts solar and wind energy systems from the corporate excise tax for the length of the system's depreciation period. The state excise tax in Massachusetts is applied at a rate of $7.00 per $1,000 of assessed valuation.

Renewable Energy State Income Tax Credit: This statute, which was first enacted in 1979, provides a 15% credit against the state income tax for the cost of a renewable energy system (including installation) installed on an individual's primary residence. The maximum limit to the credit is $1,000 and can be carried over in the case that the credit is greater than one's income tax liability in one year.

Renewable Energy Equipment Sales Tax Exemption: This statute exempts from the state sales tax solar, wind, and heat pump systems and all related equipment. This exemption is limited to systems that will be used in an individual's principal residence and is not available to commercial users.

Nevada

Boulder City Public Works - Energy Efficient Appliance Program: The Conservation Department of the City of Boulder City Public Works offers renewable energy rebates to its customers under its Energy Efficient Appliance Program. Both commercial and residential customers located in Boulder City, NV, are eligible for this program. These rebates only cover conversions from existing electric water heaters to solar water heaters. The utility offers $200 from its own funding reserves for each forty-gallon tank that is replaced.

Renewable Energy Producers Property Tax Exemption: Enacted in 1993 and revised in 2001, this statute allows a 50% property tax exemption for businesses.

Renewable Energy Sales Tax Exemption: The sales/use tax rate for any sales, storage, consumption or use of products or systems designed or adapted to use renewable energy to generate electricity and all of its integral components is 2% in all counties for those purchases made from January 1, 2002 through June 30, 2003.

Oregon

Ashland Electric - The Bright Way to Heat Water: The City of Ashland's Electric Utilities Department offers a solar water heating program to its residential customers who are currently using an electric water heater. Under "The Bright Way to Heat Water Program," qualified home owners may take advantage of the City's zero-interest loan program or a cash rebate. The rebate amount varies depending on a system's energy savings. The State if Oregon also offers residents with solar systems a renewable energy tax credit that is deducted from a person's income tax bill.

Business Energy Tax Credit: Oregon's Business Energy Tax Credit is for investments in energy conservation, recycling, renewable energy resources, or less-polluting transportation fuels. Any Oregon business may qualify.

Residential Energy Tax Credit: The Residential Energy Tax Credit is for premium-efficiency appliance and duct systems, closed-loop geothermal space or water heating systems, solar water and space heating systems, photovoltaics, wind, fuel cells, and alternative fuel vehicles and charging or fueling systems.
Utility Independent Home Rebate Program: The Oregon Office of Energy offers financial and technical support for people interested in buying a solar electric system for their home. In addition to the residential tax credits, the Oregon Office of Energy offers a rebate of up to $2,000.

Washington

Plug and Play Off-Grid PV Buydown: The Washington State 5,000 Solar Rooftops by 2005 Collaborative is introducing four pre-packaged, pre-engineered modular systems. Purchasers of up to one hundred of these off grid 'Plug and Play" solar electric systems will be awarded rebates by the Collaborative. Participants will receive a 25% rebate upon satisfactory installation of a solar electric system purchased under this program. These rebates are available to any Washington state resident.

Whatcom 1000 Solar Rooftop Project: This revolving loan fund makes solar electric systems (grid-tied PV solar panels and solar thermal hot water systems) affordable to home and business owners in Whatcom County, Washington. The Whatcom 1000 Solar Rooftop Project makes funds available at a low interest rate for up to a 25-year loan repayment period. The maximum loan per site is $5,000.

Sales and Use Tax Exemption: In 2001 the sales and use tax exemption for solar, wind, and landfill gas electric generating facilities was expanded to include fuel cells. In addition, the exemption now applies to smaller systems -- those that have a generating capacity of at least 200 W, instead of the previous requirement of at least 200 kW.

Pennsylvania

Solar PV Grant Program: The Sustainable Development Fund offers grants for PV systems that are purchased by PECO Energy distribution company customers. Systems between 1 kW and 5 kW are eligible; preference will be given to systems that will be interconnected to the electric grid.

Commercial Energy Loans Program: Low-interest commercial loans ranging from $25,000 to $250,000 are available to finance the start-up and expansion of manufacturers, distributors and installers of advanced Clean Energy technologies, including distributed generation, quality and assured power (back-up energy systems for critical systems and fuel cell applications).