State of Texas
Energy Cluster Assessment

August 2005

Table of Contents

1 – Executive Summary and Recommendations

1.1 – Overview of the Texas Energy Cluster Assessment Report

When "energy" and "Texas" are used in the same sentence, the picture that comes to mind is one of pump jacks and offshore rigs, of windmills and pipelines. The energy sector is one of the oldest and most diverse industries in Texas. Since the discovery of the Spindletop oilfield in 1901, Texas has embodied the production of energy. The Texas energy industry enters its second century as a leader in energy production, while issues like reservoir depletion, opportunities in diverse and emerging new alternative energy technologies, and a dynamic and inter-related global marketplace cast a new light on economic development and investment in the energy sector.

The vision of Texas as a leader in "Energy" and not only "oil and gas" is the product of a dramatic and long-term change. This evolution builds on the work ethic of the Texas workforce- a pool of knowledge and labor that is known worldwide for excellence and innovation. It encompasses the advantages of Texas' geography, its highways and ports, its railways and airways, and its many natural resources that make up the diversity of the opportunities in the energy industry. The path to this new industry is based on Texas' leadership, not only in energy, but also in environmental research. The Lone Star state presents an open opportunity for innovation, for research, and for commercialization of new technologies in the traditional oil and gas sectors, and in the new sectors of emerging energy sources, in one of the world's largest marketplaces. To this end, the Industry Cluster Initiative and the Energy Cluster were christened.

The Energy Cluster Team held its first meeting in Houston on January 12, 2005. On April 12th, the team reported out its findings and recommendations. In that three-month period, the team held three cluster meetings, six work group meetings, and five regional forums. The team, along with consultants from New Economiy Strategies, interviewed over 45 leaders of the Texas energy community, and conferred with some 115 more in meetings in Midland, Dallas, Houston, San Antonio and Corpus Christi. The team was made up of economic development professionals, oil and gas executives, and technology innovators from the wind, solar, biomass, and geothermal energy generation communities. It included executives from large utilities, small public interest firms, Texas A&M University, the University of Texas, Texas Tech University, Lamar University, and four community colleges. It included four trade associations, a start-up energy incubator, and one regulatory agency.

In its April meeting, the team returned its recommendations for energy-related challenges and opportunities in Texas. At their highest level, the team's recommendations centered on collaboration, workforce development, and industry regulation. The team also listed specific initiatives. Some initiatives are very industry - specific, while others are written more broadly, and touch on challenges in education, business climate, and the development of technologies to meet new challenges.

1.2 – Recommendations

Following an initial meeting of the entire core group, the Energy team divided into three industry sub-groups – oil and gas, electricity/coal/nuclear, and renewable / sustainable energy sources – to discuss sector-specific issues. Each sub-group reviewed opportunities for state involvement through tax policy, workforce, technology, and regulation matched to the basic business processes of production, delivery and research/development.

Each sub-group was asked to select a single issue from among the four state activities - tax policy, workforce, technology, and regulation – as the one area that would have the greatest positive impact on economic development and job growth in the sector. These results were then reported back to the full team at which time the findings from the three sectors were compared and common issues prioritized.

1. Collaboration

Advanced Energy Consortia – Of all its considerations and recommendations, the team agreed that the greatest opportunity for large-scale, long-term positive impacts on job growth and capital investment in the energy industry in Texas lies in the state's promotion of and participation in collaborative research in energy technologies. To that end, the team recommends that the state use its resources to help create and support advanced energy consortia in Texas. These consortia would:

- Make use of the available natural, human, technical, and academic resources in Texas
- Reduce the initial cost and risk associated with pre-competitive R&D
- Greatly leverage the investment of participating companies
- Improve and accelerate innovation
- Develop technologies needed to maximize the state's vast energy resources
- Attract significant federal participation to further leverage investments
- Identify and achieve otherwise unavailable efficiencies
- Attract and retain people, skills, jobs, investment and other technologies
- Respond to a current threat of losing energy pre-eminence to other states and countries
- Provide the long-term focus and participation needed to continued break-throughs in energy production, generation and transmission technologies
- Allow the state to broker collaboration within industries, address regulatory barriers, and consider incentives to promote participation

***Clean Coal / future*Gen –** As an immediate opportunity that offers long-term, large-scale advances to the state's energy sector, the team highly recommends that the state employ all necessary resources to locate the federal government's *future*Gen project in Texas. *future*Gen is a $1 billion partnership between federal and state government and private industry to design, build, and operate a nearly emission-free, coal-based electric and hydrogen production plant. The prototype will be the cleanest fossil fuel based power plant in the world. The *future*Gen project will not only engender growth in the coal mining and electric

generation sectors, but will generate research and development around a host of other energy processes.[1] The potential economic output of the project is valued by the Texas Comptroller's Officer at over $1.2 billion.[2]

2. Workforce

Energy Workforce Assessment – The team identified workforce challenges as the single greatest factor that will limit job creation and capital investment in the Texas energy industry of the future. Manpower and the availability of adequate skills at all levels of the industry comprise this most significant threat. In the short-term, the team recommends that the state commission a comprehensive demographic study and gap analysis to assess and compare industry needs with energy-related labor markets in Texas.

Assessments performed by this study should include

- Average age of workers in each industry segment
- Required skillsets
- Projected rate of retirement/turnover for each skill set
- Years required to replace workers by skill set
- Impacts on retired workers re-entering employment (social security, benefits, taxes, health insurance, etc.)
- Impact of language skills on safety
- Geographic considerations

Participants in the study should include the Texas Workforce Commission, industry trade associations, company and contractor personnel and the education community in Texas.

Energy Workforce Council – As a long-term project, the team recommends that the state establish an Energy Workforce Council within a larger Energy Advisory Council, to develop a strategic plan and implementation strategy to attract skilled workers to careers in the Texas energy industry. This Council would

- Inventory existing programs related to energy education in Texas
- Inventory existing education and recruitment efforts by private corporations
- Identify programs that have achieved positive results and assess means of broadening their reach
- Identify potential sources of funding, such as:
    - State funds
    - Industry contributions
    - Federal funds and matching funds
    - Foundations and other philanthropic organizations
- Develop strategies designed to maintain Texas' position as a leading global provider of Energy expertise, technology and workforce

The implementation plan would develop the pipeline of new workers and maintain a stable labor pool by identifying methods to

- Improve energy-related skill set education
- Upgrade students' image of energy industries and careers
- Transfer knowledge from the aging workforce
- Establish programs that address generational and/or current worker expectations for flexibility in the workplace (i.e. resistance to shift work, job sharing, phased retirement, etc.)
- Assist displaced workers and military personnel transition to areas of demand
- Update worker skills (collectively) by offering customized training programs
- Remove barriers and provide information to retired workers considering a return to the workforce

Members of the council would include the Texas Workforce Commission, industry trade associations, industry companies and contractors, community colleges, universities, representatives of the Texas Education Agency, and the military. This would be a part of an Energy Advisory Council, as discussed below.

3. Regulatory Environment

The team was charged with identifying opportunities to enhance the competitiveness of the energy industry in Texas through regulatory solutions that do not require new legislation or regulation.

Energy Advisory Council – The team's primary recommendation is the establishment of an Energy Advisory Council, composed of representatives of state regulatory agencies (TRRC, TCEQ, etc), local and regional governments, industry (oil and gas production, renewable and sustainable sources and electric / coal / nuclear), and the general public. This advisory group would discuss issues, coordinate regulatory aspects of major energy projects, enhance communication among agencies, and identify "downstream" resource needs as energy projects are developed. This Council would include the Energy Workforce Advisory Council envisioned under Workforce Issues, outlined previously.

Energy Projects Website – The workgroup also felt it would be beneficial for the state and industry to collaborate on the establishment of a website, where energy projects and possible funding sources could interface. This "Energy Projects Website" would serve as a portal through which the research, projects, funding, and regulation of information sources could be clustered for maximum effectiveness.

1.3 – Sector-Specific Recommendations

The workgroup also developed a series of sector specific recommendations.

1. ***Oil and Gas –*** State regulatory agencies need better coordination of and information relating to permitting activity among applicants, state agencies, and local government. As an

example, a permitting schedule at the early stages of a project and communicated to all participants in the project would be an attractive regulatory contribution to the industry.

2. ***Renewable and Sustainable Energy Sources***
   - Increased use of state incentives for emerging sources in this area, in addition to the current efforts in wind energy.
   - Provide matching funds for a demonstration and testing facility for offshore wind energy generation.
   - Host a conference on renewable and sustainable energy similar to the Western Governors' Association Energy Conference held in Albuquerque.
   - Increased funding for research, as well as for commercialization. The State should promote research consortia within this sector.

3. ***Electric / Coal / Nuclear –*** Permitting of electric generating facilities was identified as the largest capital cost for the production of electricity. The Cluster team recommends designation of certain geographic areas, based on common requirements, for electric generating facilities and encourages siting in these areas through incentives such as streamlined regulatory permitting.

Cross-Sector Opportunities and Recommendations Summary		
	Immediate Focus	**Longer Term Focus**
Collaboration	• Clean Coal / CO_2 Capture & Sequestration • *Future*Gen • Demonstration and testing facilities for energy generation from wind	• Advanced Energy Consortia located in Texas • Regional Centers for Innovation and Commercialization
Workforce	• Demographic Study • Credentialing (curricula, delivery strategy, siting, etc) for "Certified Energy Industry Technician"	• Energy Workforce Council (as a part of a larger, more comprehensive advisory group, such as the Energy Advisory Council)
Regulatory	• Streamlined, integrated permitting process for energy projects • Integrated transmission and power plant siting planning	• Energy advisory group (as a part of a larger, more comprehensive advisory group, such as the Energy Advisory Council)

Figure 1. Cross-Sector Opportunities and Recommendations

2 – Assessment Methodology and Approach

The Energy Cluster team and their consulting firm used a multi-modal methodology to gain valuable insights, commentary and guidance from over two hundred fifty industry leaders, economic development practitioners, and vendor-suppliers supporting the growth of the cluster in their regions. In order to engage this broad set of stakeholders and to capture their ideas regarding building an innovation strategy, both high-level and grassroots activities were utilized, including:

- A statewide electronic survey to assess attitudes toward innovation and competitiveness,
- Interviews with key stakeholders, including government, academia, and industry, to gain insights and anecdotes about Texas' strengths and weaknesses in the scientific, technological, and entrepreneurial assets,
- Regional forums in four of the major energy "hubs" in Texas,
- On-going legislative and policy discussion with the Cluster Team, and
- Quantitative data collection from several third-party and original sources, including RAND Corporation's RaDiUS (Research and Development in the US) database on federal funding, Schoenfield & Associates database on private sector research and development, the CHI patent database, and Texas Workforce Commission employment data, along with a number of other sources, provided the information on assets and activities.

This approach culminated in a series of recommendations for discussion among the cluster team, along with data providing appendices of related supporting documentation.

3 – Summary of Findings

3.1 Qualitative Data - Survey of the State and Regional Mindset

In a statewide electronic survey, industry stakeholders were asked a series of questions pertaining to technology, innovation, and competitiveness. Those interviewed included core team members, regional forum attendees, and members of industry associations.

How important are these challenges to firms in the State's and specifically your region's technology sectors?	**Very Important**	**Important**		**Has made significant progress**	**Has made progress**
Retaining talented scientists and engineers	77%	20%		4%	0%
Attracting talented scientists and engineers	73%	20%		4%	7%
Commitment of state and regional leaders to improving the environment for growing a business	70%	7%		4%	11%
Access to financial capital	67%	23%		11%	4%
Interaction among innovators, production, and financial capitalists	57%	33%		4%	7%

Figure 2. Survey Key Results

The top two issues identified by the respondents in terms of technology were the ability to (1) retain and (2) attract quality technologists. This is reinforced anecdotally by comments in team meetings and regional forums that fewer college graduates are choosing to pursue careers in energy.

There are two very significant findings from these data.

- The first is that the "demographic cliff" is a reality. The current group of technical professionals in the industry is approaching retirement age, and there is an inadequate "pipeline" of replacement professionals. Assuming a reasonable learning curve, it may take three to five years for these "knowledge workers" to be fully prepared to make significant contributions to the company's efforts.
- The second finding reinforces the difficulty of attracting talented technical professionals. The issue of retaining these technical professionals is even more of an issue to management. Since there is little or no pipeline from which to draw replacement workers, companies are forced to compete on employee retention, and tend to "poach" each other's employees.

While this worker pipeline issue is not new to the energy industry, until recently the number of engineers and scientists needed by industry was augmented by foreign students and graduates, who made up a growing percentage of industry professionals. Since the implementation of new immigration rules in the post-9/11 United States, though, these students and post-graduate professionals have found it increasingly difficult to enter the country.

Business climate concerns complete the top three concerns of industry. Again, this reinforces comments collected in the regional forums and Energy Cluster team meetings, where each sector had its own distinct concern. For instance, the renewable and sustainable sector is concerned that the state must increase the Renewable Portfolio Standard – the amount of energy generated from emerging sources – that utilities are required to offer to the public. The oil and gas sector is looking for a way to encourage the use of new technologies and at the same time reduce the risk of failure, so that smaller operators can adopt new exploration, development and enhanced recovery technologies. Utility companies want "regulatory certainty" to get them through the new world of de-regulation. All industries identified the need for simplified permitting and reporting processes to the multitude of state regulatory agencies as a critical business climate issue.

Finally, it is of interest that, while collaboration was identified as having the potential for making the greatest impact on the energy industry in general, it was identified as only the fifth highest issue for the industry at large. Additionally, little more than half of the respondents ranked interaction among stakeholders as "very important."

Respondents were asked how important different sources of innovation were for their organizations, and to identify those high impact sources. They overwhelmingly pointed to the importance of universities, research organizations, and government laboratories (innovation was described as the creativity process sparking new products and services leading to accelerate growth in revenues, sales, and/or recognition).

3.2 – Qualitative Data - Stakeholder Perspectives from Telephone Interviews

In a survey of core team members concerning innovation and technology, the following responses were collected

Question	Response
If you had one 'chip' on which to bet Texas' current or emerging science and technology opportunities, where would you place your bet?	Automated equipment – computer electromechanical technologies, have infrastructure in Texas to build it
	Hydrogen Technologies • The area leverages existing infrastructure. There is a lot of knowledge and equipment on an industrial scale. • Hydrogen as an emerging area: Texas should realize that Hydrogen is a developing, fast growing sector and that we are fast finding new applications for it in the private sector (retail ex: distribution power generation for fuel cells)
	Within energy – wind power! Texas has the second largest installed capacity in the country for wind-generated energy generation. Job growth potential is very large. Design codes for wind turbines are based on Europe, and not specific to the great plains. Unusual weather could hamper deployment and increase costs.
How would you measure success for your firm, given the potential generated by greater collaboration on innovation?	Metrics to look at include: o Consumption o Targets for growth o Societal Benefit o Environmental impact o Ability to keep the economy healthy
	Number 1 measure is return to shareholders. Involves growing asset base, maintaining healthy ROI.
What 2-3 specific scientific and technological areas within and in support of the energy cluster do you consider makes Texas a competitive region?	Wind industry. Problem is that none of the parts are located in TX – parts are made in Finland, or Sweden, or CA, or Pueblo CO. Caution against becoming too heavily dependent on wind power. Economic development perspective on growth, instead of contractual agreements Texas has a lot of aging technology in the older gas-powered generators. Texas still has a tremendous amount of lignite coal, but no one has built a coal generator in 20 years. The state's population growth has put a strain on energy, and puts Texas at a disadvantage vis-à-vis other states.
	Advanced electrical training – more equipment is becoming automated – people will have to increase skills in engineering, transportation and transmission of energy – low level is no longer 'low level' must be technically adept Shift management culture – different type of person, different motivators, new generation, huge challenge in the future, management needs to understand differences and be able to motivate – make Texas a better place to work, agility in management, management culture needs to respect and understand where this next generation came from and how they were raised

Figure 3. Interview Results Summary

3.3 – Qualitative Data - Regional Forum Perspectives

Four regional forums were held to solicit industry and stakeholder input into the current "state of the industry," and to build a collaborative vision of the economic development opportunities and threats for the Texas energy industry. The meetings were held in Midland, to solicit input from the west Texas region; in Houston, to survey the Houston and Gulf Coast region; Arlington, to gather information from the North Texas region; and San Antonio, to represent the South Texas region.

Attendees included independent oil and gas operators, operations managers from local plants and refineries, academics, community colleges, economic development professionals from local and regional and local agencies, and managers of major service firms. Primary industry input came from Arlington and San Antonio for the renewable and sustainable energy sector, and from Houston and Midland, for the oil and gas and utilities sectors. Universities represented included Texas A&M University, University of Houston, Lamar University, San Jacinto College, the University of Texas at San Antonio, and Texas A&M – Corpus Christi.

Each regional forum was introduced as a "town hall" meeting for the discussion of regional issues and resources. Attendees were introduced to the work done by the core team, and standard facilitation techniques were used to collect input and validation of the strengths, weaknesses, opportunities, and threats for the region.

In every meeting, the major topics that emerged included education, workforce requirements, industry image, plant expansion, and technology transfer / commercialization. There were also key regional differences in viewpoint and resource.

An Overview of Regional Strengths, Weaknesses, Opportunities and Threats			
Midland **West Texas**	**Dallas** **North Texas**	**Houston** **Gulf Coast**	**San Antonio** **South Texas**
Strength This region is rich in the resources that enable the Energy sector, including oil and gas reserves, wind, solar, and geothermal energy sources.	**Strength** North Texas is one of two major financial hubs in Texas that include commercial and investment banking for energy, and the convergence of industries is supported by a thriving IT infrastructure	**Strength** Houston is recognized as the oil and gas capital of the world, with a strong and diverse labor force with energy related skills, world-class port facilities and other infrastructure, and is the home of many technology providers	**Strength** San Antonio in particular sees itself as a center for training and workforce development, in an environment where LNG infrastructure will promote industry growth in the region
Weakness While there is plenty of capital for oil and gas development, there is little local venture capital for new technologies	**Weakness** Environmental and air quality concerns about the development of conventional energy, contributing to a stigma and lack of understanding at high school and college levels of the opportunities presented in the energy industry	**Weakness** The perception is that Houston is an oil and gas town, not an "energy" center	**Weakness** San Antonio and Corpus Christi are homes to several energy related firms, but there are few actual operations in the area

An Overview of Regional Strengths, Weaknesses, Opportunities and Threats			
Midland **West Texas**	**Dallas** **North Texas**	**Houston** **Gulf Coast**	**San Antonio** **South Texas**
Opportunity The Permian Basin is a world-class "living laboratory" for reservoir-based R&D, and there are "home grown" software and service companies that can grow to meet regional needs	**Opportunity** There need to be new and innovative "collaboration networks" among companies involved in the development of energy technologies	**Opportunity** Technology transfer is a real opportunity; however the opportunity to identify, modify, and market technology from other industries must be accompanied by local capital opportunities	**Opportunity** There is significant training and development infrastructure throughout the South Texas region, and cross-border cooperation with Mexico is a strong opportunity for all energy sectors
Threat The major oil companies have left the Permian Basin, and were the only source of significant R&D funding for the region	**Threat** The lack of a national energy policy makes it hard to forecast resource allocation for R&D at the same time that other nations are ramping up research in science and engineering.	**Threat** Economic cycles in oil and gas are seen as transferable to other energy sectors, discouraging investment and employment	**Threat** In states where there is more of a regulatory paradigm, utilities do more community education and economic development activities. The Texas public Utilities Commission doesn't have power to direct these activities

Figure 4. Summary Regional SWOT Analysis

Regional Forum Evaluation

As a process, the regional forums were successful. The process generated some significant insights into regional issues and opportunities, and built credibility for the Cluster Initiative as a whole. In every case, the forums ran over the 3 hours allotted, and could easily have filled twice that time. In each case, the attendees requested copies of the findings, and asked the presenters to return with the state implementation plan. Buy-in on the part of all attendees was very high, as was the enthusiasm level in the meetings.

It would have been helpful to have more industry input earlier in the process. Since the service companies, who compete on levels of service, were seen as the "centers of innovation", it would also have been helpful to have more of the major service companies in attendance. As stated previously, one of the goals of the process was to build interest in and credibility for the state's initiative; given this increase in interest, attendance and participation by the service sector at any future meetings should not be a problem.

If the regional forum process is to be repeated or replicated for other industries, or if regional planning groups undertake similar initiatives, it would be important to bring these un-represented or under-represented stakeholder groups to the table. Additionally, any review of the findings should include upper level executives, who will bring a different perspective to the discussion.

3.4 – Quantitative Data

3.4.1 Patents and Energy-Related Research and Development in Texas

Growth in patenting in Texas generally outpaced the U.S. average from 1990 to 2003. However, energy related patents are mature, and newer areas of energy research and related intellectual property is occurring outside of Texas. If this issue is not addressed, Texas stands to lose its current leadership position in the development of intellectual capital in the energy space. From 1990 to 2003, there were some 73,200 patents issued to companies or individuals in Texas. Some 5,944 of these patents were related to the energy industry. The vast majority of this activity took place in Houston, which is the headquarters for many large oil and gas companies and service companies. Patenting is a proxy for research and development, and is usually carried out in the private (non-university or national laboratory) sector.

The majority of energy patents (74.5%) were issued for innovation in the oil and gas drilling and exploration area. A related set of patents (9.5%) were in petroleum / gas / coke, or refining area, followed by patented innovations in power systems, including turbines, generators, batteries, transformers, etc., at 15.9%. Over 80% of the patents were issued to entities in either the Houston or Dallas / Fort Worth region.[3]

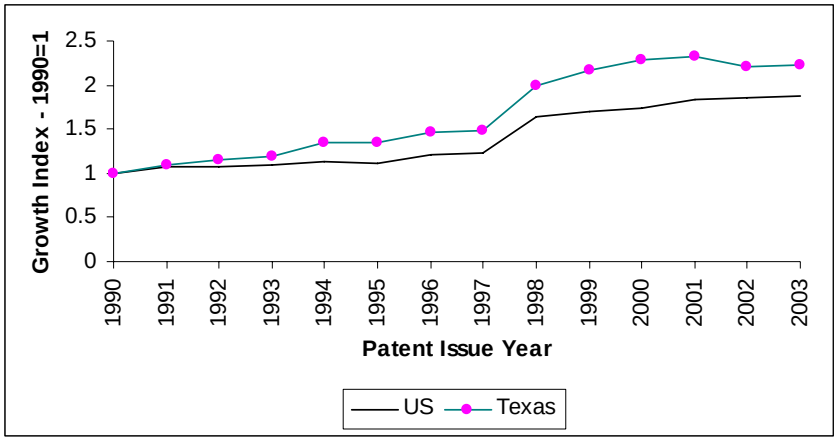


Figure 5. Patent Growth in Texas and U.S.

Private expenditures in research and development have increased somewhat from 2002 to 2004, from $ 687 million to $ 816.5 million. In each of those years, well over 80% of expenditures were in oil and gas field equipment and machinery or field services, and were centered in the Houston region. Contributions in other regions and industry sectors were either negligible or not represented at all.

3.4.2 Venture Capital in the Texas Energy Industry

Energy related venture capital is a relatively small percentage of the total venture investing activity in Texas. This illustrates the lack of funding for emerging energy technologies at both early and later stages of product technology development. Energy-related venture capital is focused primarily on establishing new oil and gas production firms to capitalize on the opportunities presented by the recent property divestitures by the major oil companies. There is

also a component of current funding that is committed to developmental drilling projects, though this amount is not quantified, and is normally a function of partners and mezzanine lenders.

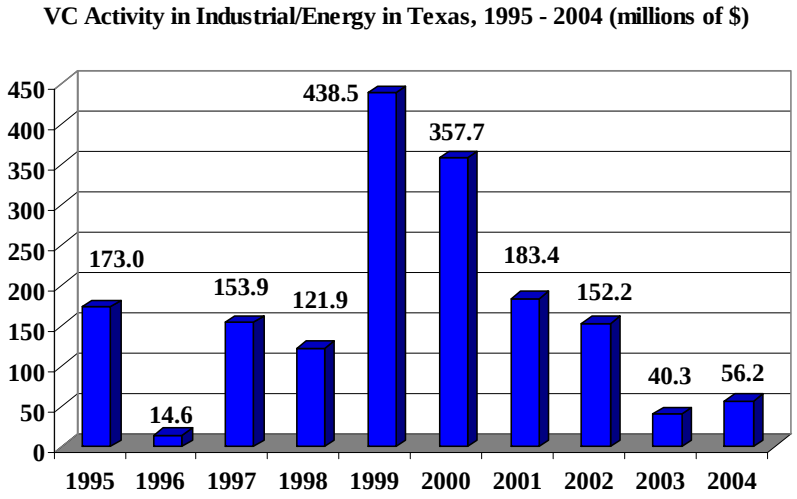
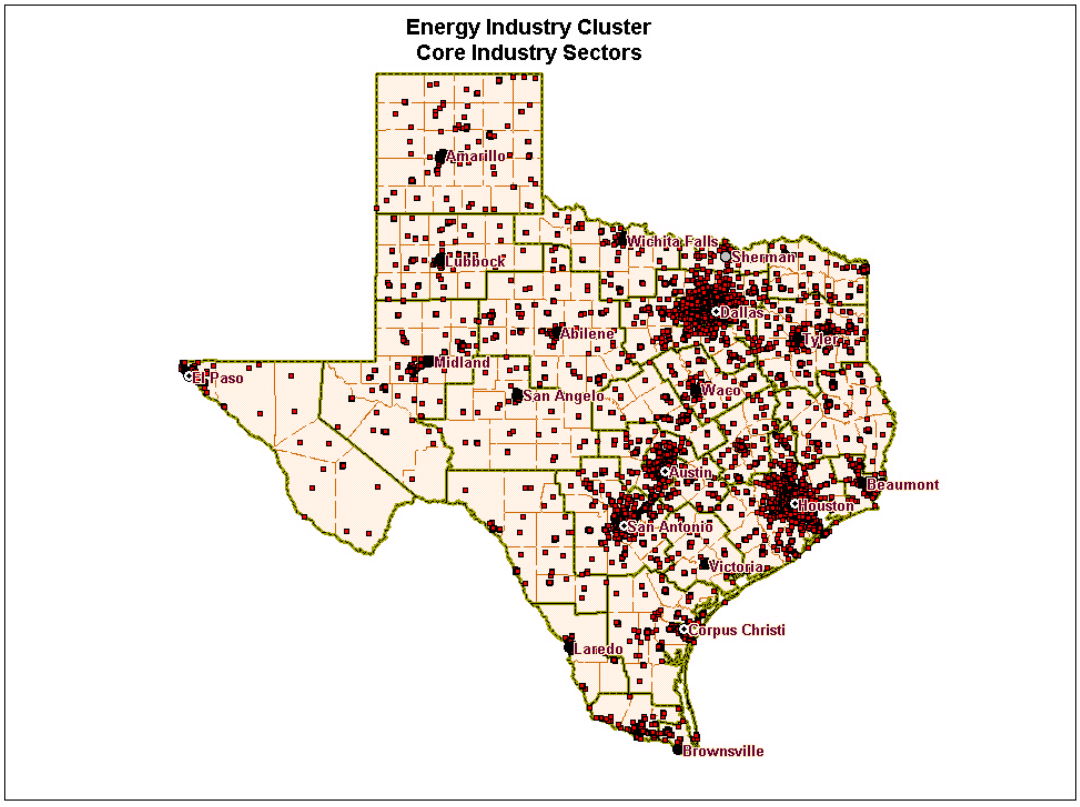


Figure 6. Venture Capital Activity in Industrial/Energy in Texas

4 – Cluster Mapping

The Energy Cluster assessment focused on regions in Texas with the greatest concentration of core employment in the Energy Cluster. Mapping those employment concentrations reveals some distinct regional attributes and opportunities to connect regions across Texas.



As part of the assessment, a new premise was introduced to evaluate employment categories in this highly diverse cluster. An extensive review of several hundred Standard Occupational Codes (SOC) narrowed to 20 the positions in the Energy Cluster. These were grouped in the categories depicted below:

SOC Core	SOC Title
17-2161	Nuclear Engineers
17-2171	Petroleum Engineers
17-3026	Industrial Eng. Tech
17-3027	Mech. Eng. Tech
19-2042	Geoscientists
19-4041	Geol. / Petro. Tech.
19-4051	Nuclear Tech.
19-4091	Environmental Science
SOC Support	
11-3071	Transport, Storage, Distribution
25-1032	Eng. Teachers, Post-secondary
25-1052	Chem. Teachers, Post-secondary
47-5011	Derrick Operators, Oil and Gas
47-5013	Rotary Drill Operators, Oil & Gas
47-5071	Service Unit Operators, Oil & Gas
47-5099	Roustabouts, Oil & Gas
51-4121	Extraction Workers, Other
51-8011	Welders, Cutters, Solderers
SOC Transformative	
17-2081	Environmental Engineers
19-2043	Hydrologists
25-1053	Environmental Science Teachers

Embedded in this dataset are the critical ingredient – people with skills and competencies that are key to these industries. Some people are core to the success of the industry, others provide supportive roles. And there are those individuals that could be transformed into serving the industry based on their skills shifting to new opportunities.

5 – Competitive Landscape for Texas Energy

5.1 – Oil and Gas Exploration and Production

The oil and gas exploration and production segment is one of Texas' most established industries. New oil and gas reservoirs are being discovered on an ongoing basis (e.g. 82 new oil reservoirs and 174 new natural gas discoveries in 2003 alone). These new discoveries, however, are relatively small, and the conventional geologic wisdom holds that the largest increment of oil yet to be produced will likely be found in existing reservoirs.

The decline in oil production has been dramatic. In 2003, preliminary production data indicated that the state produced just under an estimated 360 million barrels, or about 0.98 million barrels per day. In 1972, the state produced some 1.2 billion barrels, or about 3.3 million barrels per day.

The number of businesses involved in the exploration, production and distribution industry has varied substantially over the years. Currently, however, there are over 6,000 operators actively registered with the Texas Railroad Commission, operating over 142,000 active oil and 63,000 active natural gas wells.

After a century of sustained production, it is true that Texas' oil production and reserves are declining, but natural gas resource potential remains significant, with steady production in recent years and modest gains in reserves as development programs continue. In both crude oil and natural gas, Texas still leads the United States in both production and reserves as well, underscoring the continued importance of the industry to the state and to the nation.[4]

Texas also leads the nation in EOR (Enhanced Oil Recovery) potential, which ties closely to the team's recommendations for the *future*Gen project. CO_2 injection and / or sequestration is essential for *future*Gen to achieve its emissions targets. One way to make sequestration economically viable is to link captured CO_2 with oil reserves, producing increased recovery efficiencies of those petroleum resources, as well as creating jobs.

The 50 CO_2 enhanced oil recovery projects active in west Texas represent about 50% of the total CO_2 flooding activity worldwide, so the experience base, from both the operations and regulation viewpoints, is deeper in Texas than anywhere else. The Lone Star state has more than 40 years' experience in CO_2 EOR, with more than 11,000 wells permitted for CO_2 injection, and the University of Texas' Bureau of Economic Geology has estimated that at least 31 billion barrels of oil in Texas may be recoverable using CO_2-driven EOR. Based on 50% recovery rates and $25 per barrel oil, the Texas Comptroller's Office has estimated:

- 15.5 billion barrels of crude oil,
- with a wellhead value of $338 billion,
- generating franchise taxes of $2 billion, and
- sales taxes of $23 billion

5.2 – Electric / Coal / Nuclear Power Generation

The electric power industry in Texas is composed of traditional electric utilities and nontraditional participants, including energy service providers, power marketers, independent power producers, and combined heat and power plants. Electric utilities include investor-owned electric utilities, municipal utilities, rural electric cooperatives, and energy service providers. In total, there are 185 electric power producing entities in Texas, providing the highest generating capacity in the nation.[5]

Historically, most of the largest electric utilities have been vertically integrated investor-owned utility service companies that provided generation, transmission, distribution, and retail energy services for all customers in a designated service territory. The industry, however, has evolved to a more diverse structure, including a competitive market for power generation. As a result, there was one active service provider without distribution facilities at the end of 2002. This energy service provider generated 2,000 megawatt hours in 2002 retail sales.

Texas restructured its $20 billion electricity industry in 2002, allowing for the option of both individuals and corporations in most cities to choose their power supplier. ERCOT, the Electric Reliability Council of Texas, Inc., oversees the transactions resulting from restructuring, while maintaining the overall reliability of the electric power grid.

Texas also has approximately 4,800 megawatts of installed nuclear power capacity being generated at two plants. The Comanche Peak project is located in Somervell County, and the South Texas Project is on the Gulf Coast in Matagorda County. Nuclear energy supplies 9.2% of the electricity generated in Texas.

Texas ranks fifth nationally among states with coal production, and is the largest producer of lignite. Lignite coal constitutes approximately 97% of the near-surface coal resources in Texas, and is most commonly used in electric generation plants. The most significant bituminous resources are in the north-central and southern parts of the state. Cannel coal, used by the cement, lime, and aggregate industries, and exported to Europe for fireplace coal, is also produced in the state.

In a state as resource-rich as Texas, non-renewable energy resources have traditionally provided the basis for the state's energy supply. During the 1990's, renewable energy sources other than hydroelectricity had provided only 0.3% of electric generation capacity for the state, as the relative abundance of non-renewable natural resources and the economics of adopting renewable resource technologies had not encouraged use of renewable energy sources. Now, however, tightening conventional resource supplies and the associated cost increases in their use has led to recent expansions in the use of renewable energy. By the end of 2002, renewable energy – primarily wind power – had grown to providing 1.3% of total electric generating capacity for the state, with considerable potential for expansion.

5.3 – Renewable and Sustainable Energy Generation

The Lone Star State is better known for its oil wells than its wind turbines; nonetheless, the state is second in the country (behind California) in the amount of energy generated by wind power. Texas' electricity restructuring legislation, intended to open the state's market to competition, includes a "Renewables Portfolio Standard" – a requirement that at least 2,000 megawatts of new renewable energy capacity, generating approximately 3% of the state's power, be developed by 2009. Eligible technologies include wind, solar, geothermal, wave or tidal energy, biomass and methane gas, and hydropower (tallied in a separate category).

Transmission issues pose impediments to the development of new wind power plants, because existing transmission policies tend (1) to penalize wind generation because of its intermittent nature, (2) impose multiple charges along transmission lines ("pancaking"), and (3) impose burdensome requirements on wind plants wishing to connect to transmission lines. ERCOT has adopted several policies that do not penalize new wind plants, including a market-based subzonal congestion management scheme that allocates congested lines fairly among generators.

5.4 – Energy Industry Trends and Implications for Texas

Future Trends	
Industry	• Increasing importance of cutting-edge technology in all sectors of the energy industry. • Despite the growth in renewable energy, fossil fuels will continue to dominate the energy sector for the near future. • Because of an unfortunate industry image, undergraduate and graduate students will continue to be attracted to areas of higher investment in technology, migrating away from energy curricula. • As US graduate and undergraduate enrollment declines, fewer foreign undergrad and graduate candidates will be able to enter Texas universities to fill the gap because of post-9/11 immigration policies. • Oil companies will use fossil fuel operations to support increasing investment into renewable energy. • Future investments in energy development will be highly influenced by government policy (gasoline tax vs. support for increased drilling, environmental policy, investment in emerging technologies, and movement towards hedging US dependence on foreign oil). • Major oil companies will continue to divest holdings in the mature basins of North America to finance their migration to larger, newer, less expensive overseas production. • The migration of large oil and gas producers out of the Texas oilfields will have a significant effect on the profile of the average operator in Texas. Operators will continue to invest in smaller property acquisitions nearer their bases of operations, where they can manage production operations at lower costs, matching costs closely to the decline of production. • Environmental regulations will continue to impact the economic feasibility of domestic expansion, driving some segments and constraining others. • Homeland Security concerns, both real and perceived, will continue to be of concern in the midstream and downstream segments, especially where these assets are geographically concentrated.
Technology	• Hydrogen and hydrogen-powered fuel cells • Increasing cost-effectiveness of solar, wind, and geothermal power. • Research into viable, large-scale electricity production from nuclear fusion. • New facilities and processes for Gas-to-Liquids (GTL) products and services. • New extraction techniques (ex: extreme deepwater drilling and production, heavy oil production and transportation, CO_2-based enhanced recovery, oil sands extraction, more efficient transmission, storage, and distribution media for electricity, composite materials manufacture, etc) • Energy industry applications of micro-eletronics and nano--technology
Globalization	• Traditional large US energy firms will increasingly abandon the domestic exploration and production market in search of opportunities abroad. • Growth in demand will be strongest in developing countries (non-OECD).

Figure 8. Energy Cluster Trends

Impact of Global and National Trends

- Texas is known for its leadership in both its hydrocarbon reserves and the intellectual assets to develop and manage oil and gas assets. As oil and gas production in Texas and the US in general continues to decline, how does Texas remain preeminent in a market where growth is shifting to other global regions?
- As regional trade agreements continue to evolve, especially in the Americas, how do Texas companies take advantage of the oil and gas reserves potential in Mexico? How can Texas energy producers enter the Mexican electricity market? What impact will these trade agreements have on development and import opportunities in other Latin American countries?
- As Texas continues its aggressive recruitment of industry through its economic development activities, how do Texas energy companies partner with research and development leaders to develop increasingly efficient sources of power?
- How do national security and post-9/11 concerns regarding energy independence impact Texas and the production of U.S. energy?
- How can Texas capitalize on outsourcing, offshoring, and homesourcing trends in the industry? Are there locations within Texas with assets and capabilities that could be attractive to energy-related companies across the United States? Are there opportunities for concentrating research and development in the Texas cluster of community colleges, university systems, and energy services firms?
- Traditional economic development practices focus on attracting and retaining large companies. There is a concentration of these companies already resident in the Texas energy cluster; should Texas place a greater emphasis on entrepreneurial ventures and growth companies?
- Many large oil and gas companies have divested themselves of mature assets in Texas in favor of overseas ventures. What effect will this have on the Texas oil and gas operator? How can these smaller companies assume the risk of adopting new technologies? How can they develop the leverage, financial and political, to make their needs known? Is there real clarity on long term outcomes of these changes?
- The chasm between workforce skills and industry needs will continue to grow if left unattended. The solution can only come from new forms of collaboration among all stakeholders – government, education and business – and must be sustained over time. Is the gravity of the problem for Texas clear enough to coalesce leaders in these sectors to unite in action to address it?

6 – Acknowledgement of Assessment Participants

Special acknowledgement is hereby given to the Texas Energy Industry Cluster Team chaired by Mr. Grant Billingsley, Manager of Public Affairs, Wagner & Brown, Ltd., Midland, Texas. Cluster Team members include the following:

Cluster Team Members	Organization
Grant Billingsley, Chair	Wagner & Brown, Ltd.
Richard Amato	University of Texas at Austin
David Blackmon	Burlington Resources
Erik Bliss	Texas Technology Initiative
Bud Brigham	Brigham Exploration Company
Eileen Campbell	Marathon Oil Company
John Duncan	Apache Corporation
John Fainter	Assoc. of Electric Companies in Texas
Tom Foreman	Lower Colorado River Authority
Denny Gunia	CenterPoint Energy
Paula Harris	Schlumberger
Dr. Homer Hayes	College of the Mainland
Walter Hornaday	Cielo Wind Power
Anne Marie Johnson	Public Citizen
Rebecca Jones	University of Texas – Austin BEG
Mladen Kezunovic	Texas A&M University
Rebecca Klein	Loeffler & Associates
Jerry Langdon	Reliant Energy
Rob Looney	Texas Oil and Gas Association
Mike McKinney	TXU Electric Delivery
Dr. Richard Rhodes	El Paso Community College
Nancy Sauer	Unocal Corporation
Steve Smith	Texas Mining and Reclamation Assoc.
Stephanie Sparkman	West Texas Energy Technology Initiative
Dr. Andrew Swift	Texas Tech University
Sara Tays	ExxonMobil
Dr. Scott Tinker	University of Texas Bureau of Econ. Geol.
Joel Truart	Northwestern Resources
Chip Wolfe	Meridian Energy Systems

The Energy Cluster Team was assisted by the Texas Workforce Commission, the Office of the Governor, the Texas Workforce Investment Council and New Economy Strategies.

Additional Acknowledgement

This assessment process sought to engage and solicit input from a broad set of stakeholders statewide through team and industry group meetings, electronic surveys, regional forums and personal interviews by telephone and meetings. In addition to the Energy Cluster Team, acknowledgement is given to all that contributed to this process including thirty-two survey participants and the following interview and forum participants:

Contributor	Organization
Bud Abbott	Abbott Consulting
Isabel Chacon	Alamo Area COG – Clean Cities
Peter Bella	Alamo Area COG – Natural Resources
DeeDee Wallace	Andrews Industrial Fund
John Duncan	Apache Corporation
Bud Brigham	Brigham Exploration Company
Millicent Valek	Brazosport College
Rebecca Jones	Bureau of Economic Geology, UT Austin
Roger Hite	Business Fundamentals Group
Scott Davis	Capataz Operating Company
Richard Erdlac	CEED, UT Permian Basin
Susan Primeaux	CEED, UT Permian Basin
Bob Trentham	CEED, UT Permian Basin
Denny Gunia	Centerpoint Energy
Allison Thompson	City of Burleson
Adrian Ocegueda	City of El Paso
Jose Luis Garcia	City of San Antonio International Affairs
Steve Castle	Cowboy Resources
Raymond Flumerfelt	College of Engineering, University of Houston
Mike Krenek	Deloitte Consulting
Alison Benton	Deloitte Tax LLP
Yolanda Castillo-Crosley	DFW/Arlington MBDC
Amy Callender	Flowserve Corporation
Brian Weeks	Gas Technology Institute
Lane Sloan	Global Energy Management Institute, University of Houston
Sharon Venable	Greater Dallas Chamber
Linda Burns	Greater Dallas Chamber
Kent Fuller	Greater Houston Partnership
Jennifer Kolbe	Guadelupe Valley Electric Cooperative
Prentice Creel	Halliburton – SPE
John Galiotos	Houston Community College
Stuart Schaaf	InterSyn Technologies
Lou Pugliaresi	Key Energy Services
Craig Dutton	Mechanical and Aerospace Engineering, UT Arlington

Linda Stone	Metropolitan Partnership for Energy
Ronnie Rivera	Middle Rio Grande Development Council
Barry Zimmerman	Middle Rio Grande Development Council
Barry Horseman	Midland College
Janie Pierce	Midland College
Hoxie Smith	Midland College
Larry Dunaway	Midland Development Corporation
Blake Wallace	Midland Development Corporation
Mike Gregory	North American Coal Corporation
Susan Au	North Central Workforce Development
Kelly Barraza	North Central Workforce Development
Neil McDonald	Odessa Chamber of Commerce
Frank Wright	Omega Risk Group
Terry Dudley	Pape - Dawson Engineers
Walt Rosenbusch	Petris Technology
Dale Steffes	Planning and Forecasting Consultants
Anne Johnson	Public Citizen
Bob Glover	Ray Marshall Center, LBJ School of Public Affairs
Chuck Russell	SAIC Oil and Gas Consulting Services
Dan Titerle	San Antonio Water System
Louise Glenn	Santos USA
Anita Crawford	Santos USA
Sean Murphy	Sematech
Anita de Rijk	Solar San Antonio
Adrienne Shabazz	Tarrant County College
Mladen Kezunovic	Texas A&M University
Alex Mills	Texas Alliance of Energy Producers
Margaret Rabbitt	Texas Homeland Security Alliance
Dixon Bailey	Texas State Technical College
Homer Taylor	Texas State Technical College
Jamie Chapman	Texas Tech University
Mario Garcia	Texas Workforce Center - Del Rio
Larry Buehler	The Alliance Economic Development, Brazoria County
Lloyd Brink	Trilateral Technology Summit
Tom Rose	TXU Electric Delivery
Susan Villanueva	TXU Electric Delivery
Burke Froehlich	Unique Digital
Michael Massey	University of Houston
Mike Acosta	UTEP Policy and Economic Development
Jack Ladd	UT Permian Basin
John Isom	Waller Economic Development Corporation
Ruth Fosdick	Workforce Network

Virginia Belew	Workforce Network
Lupe Villanueva	Workforce Network
Judy Bell	Workforce Solutions

[1] Texas Coal Council, Railroad Commission of Texas
[2] Bureau of Economic Geology, University of Texas
[3] CHI Patent Database
[4] Bureau of Economic Geology, University of Texas
[5] Texas Public Utility Commission