

State of Texas
Petroleum Refining and Chemical Products
Cluster Assessment

August 2005

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1 – Executive Summary and Recommendations

1.1 - Overview of the Texas Petrochemical and Refining Cluster Assessment Report

The Texas Refining and Chemicals Industry Initiative Cluster is part of a recently launched intensive effort to identify, bolster and exploit Texas' competitive advantage in six technology areas – each considered to be key to the state future economic growth. Texas is the nation's leading producer of oil and gas, refined products, and chemicals. These industries are closely interrelated. For instance, the Texas chemicals industry is actually one of the largest consumers of Texas petroleum products – both refined products and natural gas. Chemical plants not only use oil and gas products as feedstock; they are substantial consumers of natural gas and electricity to power their operations.

Texas is home to 26 operating refineries (ironically, this is the same number of refineries it had in the late 1930's). Overall refinery capacity is approximately 4.3 million barrels per day, accounting for over 26 percent of total US production, and approximately 5.3 percent of worldwide capacity. The value of the refinery shipments in 2002 was about \$59.8 billion, representing 27.3 percent of total US refinery shipments. Texas' Gulf Coast refineries account for 86.7 percent of the state's capacity.¹

In recent years, Texas' refinery business has become far more complex. Environmental mandates have required a tremendous amount of new investment to reduce refinery emissions and to produce a variety of differing grades of lower-emitting fuels. Over the past decade, The U.S. Energy Information Administration's Impact of Environmental Compliance Costs, 1995 – 2001, environmental mandates have accounted for from 10 to 50 percent of the industry's overall capital investment costs.²

Texas is the nation's largest chemicals producer, manufacturing 14 percent of the nation's value of chemical output. The Gulf Coast complex of chemical plants and refineries is the largest petrochemical complex in the world, home to over 200 chemical plants. While the state's largest complex of chemical plants is along the Gulf Coast, the industry itself is much more extensive. At least 124 of Texas' 254 counties have some amount of chemical manufactured output.³

Refining and petrochemicals are typically dependent on natural gas and other hydrocarbon derivative products as both feedstocks and fuels. As natural gas prices have risen in recent years, margins for these commodity products have been constrained. At the same time, international markets have drawn competitors to Asia, Europe, and Latin America. Global pricing mechanisms now are at work for both crude oil and natural gas. This shift to a fundamentally global market has had a tightening effect on North American supply, where competition is based on economies in production, and processing is moving increasingly close to supply.⁴

At the same time that supply is constrained in Texas, the “gas bubble” is apparently drawing to a close with the advent of facilities to handle large quantities of liquefied natural gas on the Texas Gulf Coast. Increasing plant automation and “product lifecycle management” DCS applications are displacing workers but increasing product margins, if only slightly. Co-locations of subsidiary production, and other supply chain partnerships, are creating new business models.

1.2 – Recommendations

The Refining and Petrochemicals team, along with industry stakeholders across the state, met in a series of cluster meetings and regional forums, to discuss sector-specific issues and initiatives. In the context of regional and state strengths and weaknesses in the industry, the groups were asked to develop opportunities that would impact both the industry and the region. These results were then reported back to the cluster team, were compared and prioritized. Three of these priorities, collaboration, workforce, and education, were identified as cross-cluster opportunities. In addition, three other priorities were identified as sector-specific.

1. Collaboration

Advanced Industry Collaborative Council – Create an Advanced Industry Advisory Council funded by both state agencies and private sector companies across the industry spectrum (plant operators, vendors, contractors, etc) who will select and direct technology projects to be undertaken, and select the resources (state, federal, private, local) to be utilized in the pursuit of those projects.

Economic Development and Expansion Opportunities – Refining and chemicals companies screen expansion opportunities much like venture capital; state, regional and local governments must work in concert with industry to define what makes particular regions attractive, and help plant managers promote Texas locations.

Outsourcing of Applicant Screening – In some regions, plant managers perform screening of potential candidates to build a “pipeline” of work-ready applicants. There is a strong opportunity for industry to develop a pilot project for regional screening in collaboration with the Texas Workforce Commission and local workforce boards, in which the state and regional agencies could coordinate, administer, capture, and interview applicants, making the information available to all plant managers.

2. Workforce

Skills Training – Breakthrough initiatives in the industry will require new skills. Industry must work with the Texas Workforce Commission and higher education community to define the skills needed, the curricula to develop these skills, the timetable for deployment, and the screening and certification criteria to develop this new workforce, including Federal Energy Regulatory Commission Certification for Liquefied Natural Gas (LNG) operators.

Industry Image

Texas graduates from community colleges and universities are not entering this industry; what hiring has been going on in the industry has become dependant on international graduates and immigrants, but this pipeline has dried up since 9/11.

- There must be a joint industry – education program to educate students, especially in the community colleges and universities, of the opportunities in this industry sector.
- Industry must work with the state, federal agencies, and Texas’ universities to establish a process by which companies can sponsor foreign students’ education at Texas universities.

3. Education

In all regions surveyed, there is a strong relationship between the industry and the local community colleges.

Industry Demographic Study – Perform a joint study with the Texas Chemical Council and the higher education community in Texas to identify high performance programs in the delivery of “Work Ready” programs for the refining and chemicals industry.

- Identify and propose replication of “best practice” programs within the community college system to meet the emerging needs of the industry. Jointly monitor and manage the development of these “best practice” programs across the state.
- Work with the higher education community in Texas to streamline regulatory processes for the development and deployment of curricula leading to specialized certification in areas identified as priority requirements by industry

“Just In Time Workforce” – Breakthrough technology initiatives will require new people with new skills and competencies

- Partner industry with community colleges and technical schools to strengthen a “workforce pipeline” of technical skills and craft talent by strengthening curriculum development and establishing certification standards along emerging industry requirements
- Develop and implement a “Youth to Energy” program in concert with state and local educational resources to re-brand the industry and connect with future talent

1.3 – Sector-Specific Recommendations

1. ***Tax Policy*** – Millions have to be spent to improve a process or remain compliant with the many regulations that affect the refining and petrochemicals industry. These funds do not create jobs, but are a cost of staying in business. Without some new alternatives, state and local tax structures will continue to be a damper on new development and expansion plans.

Industry must work with state, regional, and local governments to institute economic incentives for expansion and job creation that mitigate the current tax structure.

Alternatives should include incentives for job creation in existing plants, as well as new facilities, based on salary structure. In lieu of tax abatements, industry should be offered assistance with capital investments and land purchases. Relocation grants should be used to attract employers and should apply not only to key personnel but costs for relocation of equipment.

2. ***Workforce Displacement and Re-training*** – Trends in plant automation must necessarily continue to keep Texas refining and petrochemicals plants competitive in a global market. The implications for workforce displacement is clear, and the opportunity cost of losing a highly skilled workforce is also clear, both in terms of local economic impact and in terms of the ability to remain competitive globally. Given the continuation of these trends in

automation and employee dislocation, it is important for industry, local and regional workforce agencies, and the state of Texas to address this problem.

State agencies must be proactive in working with industry to develop workforce intervention strategies and plans for re-training displaced workers, so that these skill sets are not lost to the industry and region.

3. **Regulatory Agency Permitting Process** – Permitting of facilities and projects was identified as one of the highest capital costs for the sector.

The state should coordinate the permitting process among agencies, based on common requirements, for facilities improvement and expansion.

Opportunities and Recommendations Summary	
Collaboration	<ul style="list-style-type: none"> ● Advanced Industry Collaborative Alliance ● Economic Development and Facilities Expansion ● Applicant Screening
Workforce	<ul style="list-style-type: none"> ● LNG Skills Training ● Industry Image
Education	<ul style="list-style-type: none"> ● Industry Demographic Study ● “Just In Time” Workforce for emerging skills and technologies
Tax Policy & Incentives	<ul style="list-style-type: none"> ● Institute non-traditional economic incentives for expansion and jobs creation that mitigate the current tax structure
Workforce Displacement & Re-Training	<ul style="list-style-type: none"> ● Develop workforce intervention strategies and plans for re-training displaced workers
Permitting Process Rationalization & Coordination	<ul style="list-style-type: none"> ● Coordinate the permitting process among agencies, based on common requirements

2 – Assessment Methodology and Approach

The Cluster Initiative teams 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 three 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, Schoenfeld & Associates database on private sector research and development, the 1790 Analytics patent database. Also included are 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 – Electronic Survey

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
Commitment of state and regional leaders to improving the environment for growing a business	71%	27%
Access to new markets	60%	31%
Attracting well-trained technicians	58%	33%
Retaining industry-based managers	56%	42%
Retaining well-trained technicians	56%	36%
Product innovation	53%	31%

Figure 2. Survey Key Results

Commitment of State and Regional Leaders

As with many of the comments in both the core team meetings and regional forums, “business climate” issues topped the list of challenges. Industry sees the commitment of state and regional leaders as two-fold. The first way that state leadership demonstrates its commitment to the industry is by dealing with taxation and educational reform. Taxation, especially property taxation, is seen as burdensome on an industry that has such a high concentration of fixed assets. Education, as an extension of the commitment question, relates to the lack of qualified workers entering the industry. Educational reform is close behind tax reform in the priorities of this industry group.

The second way the industry sees commitment coming from state and regional leadership is through the fostering of new technologies, for the development of new or improved products, and for the development of new plant processes. Plant processes are seen as everything from a new catalysis process to innovative and less expensive ways to generate and delivery energy to the plants.

Access to New Markets

A “market” was once defined as an event that occurred in a particular place at a particular time. This is still true of some markets. The refining and petrochemicals market, though, define a truly global market, where customers are free, if not always able, to buy in any geographic location they choose, and prices are equalized worldwide.

The ability of Texas plants to reach new markets is of high concern. True commodity products are undifferentiated, so competition is based on economies of scale, margins, and volume. Given that margins should improve through process improvement and other cost containment initiatives, as well as improved fuel and feedstock costs with the development of LNG facilities in Texas, new markets should improve revenue, profitability, and jobs.

On average, a \$1 increase in orders from a Texas petrochemical plant generates \$2.33 of business in the state economy, and increases personal income by \$0.45. Every new job in these industries creates a total of 6.6 new jobs in Texas. The Lone Star State has a vested interest in helping the industry market itself and its products to this increasingly global and expanding market, leveraging not only the plants and products across the state, but also the world-class infrastructure that facilitates trade.

Attracting and Retaining Technical Professionals

“Workforce” concerns reinforce 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.

Product Innovation

The Texas refining and petrochemicals industry is looking at product innovation in two ways. The first is in the improvement of current products. Current industry focus in the chemicals industry is on the production of basic chemicals that are used in industrial processes and as

feedstock for further refinement. Among the top chemicals that Texas manufactures is ethylene, a basic chemical building block used in plastics, fire retardants, dyes, cosmetics, and explosives, among others.

Texas’ ethylene cracker plants have an efficiency advantage over other types of crackers, and the importation of liquefied natural gas with high “heavy gas” content may improve the competitive position by increasing availability and lowering cost. The focus of state and regional officials on facilitating the permitting and construction of LNG plants along the Texas Gulf Coast is a primary concern.

New product development through research and development is also a high impact area for the industry. The commitment on the part of the state to foster collaboration, among companies, and between industry and the university systems, can help these players develop new and higher margin “niche” products, and develop robust entries into new markets.

Research and Development

The survey responses (below) from this industry group point to a perceived lack of correlation between academic and research institutions and innovation in the petrochemical industry. If future collaboration is to take place in this arena, this perception will have to change dramatically.

“How important are the following sources of innovation in your organization? ‘Innovation’ is described as the creativity process sparking new products and services, and leading to accelerated growth in revenues, sales, and/or recognition.”

Universities and research organizations	
Very Important	7%
Important	21%
Neither Important nor Unimportant	43%
Unimportant	11%
Very Unimportant	11%
Not Applicable	7%

Government laboratories	
Very Important	4%
Important	14%
Neither Important nor Unimportant	32%
Unimportant	21%
Very Unimportant	11%
Not Applicable	18%

Sources of innovation are not seen as coming from outside of the industry, but are seen as the product of either company (private) research and development effort, or of service-company level (plant) innovation.

3.2 – Perryman Plant Managers’ Survey

The Perryman Group (TPG) is an economic research and analysis firm located in Waco, Texas. TPG has decades of experience in evaluating industries, economic impacts, and business conditions. In particular, the firm has been actively involved in forecasting and analyzing the energy sector on an ongoing basis for the past 25 years.

Through the course of the Plant Managers’ Survey, TPG analyzed results of a survey of refining and petrochemicals firms located in Texas, and reviewed other information related to the refining and petrochemicals cluster. TPG then quantified the economic impact of the cluster on counties with a significant presence in the industry as well as the state as a whole; and studied potential policy directions to

- (1) help ensure the future viability of the cluster in the state and
- (2) enhance Texas’ chances of being chosen as the site for future expansion.

The Refining and Petrochemical Cluster has exceptionally high “multipliers” due to high value added and the capacity to provide many needed inputs throughout the production process.

On the whole, the cluster is responsible for more than \$260 billion in annual total Expenditures, \$82 billion in Gross State Product, almost 870,000 total jobs, and \$3.6 billion in annual state revenues. Some of this activity is disbursed around the state, but it is concentrated in several key areas (primarily along the Texas Gulf Coast).

Although employment within the cluster peaked in the early 1980s and has declined in recent years, output and income have continued to expand. Future employment is expected to expand modestly.

Global demand and production factors will drive much of future industry expansion, but current capacity constraints will likely create ongoing opportunities for domestic expansion. Industry participants see the overall tax base and regulatory environment as the primary sources of concern regarding future success in Texas. Job training and other facets are also important, although to a lesser degree. The Texas business climate is seen by members of the cluster as losing ground with regard to crucial factors (tax burden and regulation).

Survey respondents have identified more than \$3.2 billion in near-term (2005-2008) investments. The industry total is much higher. In order to be successful in expanding the cluster, it is imperative that Texas

- (1) revamp its tax system (particularly the reliance on property taxes and the capital component of the franchise tax) so as not to overly penalize capital-intensive firms, and
- (2) work to reduce environmental and other regulatory compliance costs in an enlightened and competitive manner.

Other key initiatives include more focused training, adequate infrastructure investment, and incentives to offset key disadvantages. Because of the high multipliers and substantial market potential, this cluster is extremely desirable for ongoing expansion.

In summary, the current shortage of global capacity and increasing demand for petroleum products will generate future development of new facilities. Texas has a long history of leadership in this cluster and enjoys substantial capacity to support expanded activity. To be successful, however, the state must pursue an aggressive policy agenda on multiple fronts.

3.3 – 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?	There are 3 LNG terminals in development in our region, being installed as partnerships. Gas plant goes on chemical company land, and the chemical company gets cheap gas, while gas is also sold to the market.
	Communications and transportation is the most promising. Technology has changed the way the industry does business, i.e.; communications all along supply chain, and the movement of materials. Logistical information and “Just-in-time” systems/process management have changed the environment. The product hasn’t changed significantly.
	Partnership with the pharmaceutical industry, finding ways to tweak existing processes to make new products for the pharmaceutical industry.
How would you measure success for your firm, given the potential generated by greater collaboration on innovation?	1. Commercialization of new products and technologies 2. Percentage of new products patented and released, and 3. Changes in profitability
	1. Health and strength of companies 2. Ability to grow jobs 3. Value-added products
What 2-3 specific scientific and technological areas within and in support of the Petrochemicals cluster do you consider makes Texas a competitive region?	1. University of Houston 2. A&M Engineering program – one of three universities that BASF draws from 3. Nuclear power plant 4. High tech chemical plants 5. Strong expertise in medicine
	1. Bayport container terminal 2. Primary and secondary processing of petrochemicals 3. The Houston ship channel give us plentiful natural resources, and proactive zoning 4. Strong, diverse, pipeline infrastructure 5. Homeland security - Air force and national guard minutes away 6. Consortia, good communication between companies and counties

Figure 3. Interview Results Summary

Question	Response
	<ol style="list-style-type: none"> 1. Petrochemicals – two-thirds supply nation and world, dominance in the field 2. Current workforce and education programs – our program in process technology is the only one that exists. 3. A majority of petrochemical sector workers are getting ready to retire; ‘baby boomers’ make up 75 % of work force. The process experts running the plant complexes will not longer be in the workforce 4. Need to educate a new workforce – promoting a new degree out of the community college 5. Protect current Texas industries 6. National Association of Manufacturers is working to promote manufacturing as a career
	<ol style="list-style-type: none"> 1. Biotech is a key area that impacts the petrochemical industry, and in which Texas has a strength 2. Aerospace-NASA also relates to petrochemicals 3. Computer science and new technologies impact the productivity of industry in general, and Texas has this asset.

Figure 3. (continued) Interview Results Summary

3.4 – Qualitative Data – Regional Forums

Three 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 refining and petrochemicals industry. The meetings were held in Beaumont, to represent the Southeast Texas region, in Houston, to represent the Houston and Bay Area regions, and Corpus Christi, to represent the South Texas region.

Attendees included operations managers from local plants and refineries, academics, community colleges, economic development professionals from local and regional and local agencies, and infrastructure managers, such as directors of the ports of Houston and Corpus Christi. Primary industry input came from Corpus Christi, where the majority of attendees came from industry, and from Houston, where the group included industry senior management and industry consultants. Universities represented included Texas A&M University, University of Houston, Lamar University, San Jacinto College, and Texas A&M – Corpus Christi.

The venture capital and commercial banking firms were not in attendance due to scheduling conflicts in Houston (seen as a center in industry-specialized lending), and the major service companies, such as Kellogg and Bechtel were invited but unable to attend. Also missing were members of ancillary clusters, especially the information technology and advanced manufacturing industries.

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		
Beaumont	Houston	Corpus Christi
<p>Strength A existing, highly skilled workforce is supported by extensive infrastructure.</p>	<p>Strength The national perception of engineers educated in Texas universities is that they are the best qualified to come out of school and go directly into a job site position.</p>	<p>Strength Infrastructure – a critical mass of plants and support services, combined with transportation assets such as sea, air, highway connections, etc. are a major strength of South Texas and create an environment of collaboration among stakeholders.</p>
<p>Weakness As regional plants automate to try to remain competitive in a global market, worker displacement will continue and workforce skills are lost to other industries and regions.</p>	<p>Weakness The refining and chemicals industry is not seen as an attractive industry for college graduates because of its cyclical and image. Graduates do not see the high technology content in these jobs.</p>	<p>Weakness Millions have to be spent to improve a process or remain compliant; this does not create jobs, but is a cost of staying in business. At the same time, the permitting process slows these major capital projects, especially by environmental regulators. This only raises costs.</p>
<p>Opportunity At Lamar University, there is an emerging center of excellence built on composite materials development.</p>	<p>Opportunity There is a significant opportunity to create a “research triangle” around petrochemicals in the Houston region, based on the combination of plants, universities and supporting services that are available. An example of such a paradigm-shifting project would be in low sulfur regulations, which necessitate the development of new catalysis processes, providing a competitive advantage.</p>	<p>Opportunity LNG is one of the keys to the future of the region. It will lower costs, create jobs and guarantee feedstock availability. At the same time, LNG plants will require new skillsets, which the industry can define and develop in concert with state and regional workforce authorities.</p>
<p>Threat The industry is looking for increasingly higher education attainment levels for entry positions. High school graduates no longer qualify for “technician” positions. Entry level positions require more math and chemistry skills than are being pursued in local schools.</p>	<p>Threat The ramifications of the Clean Air Act and Houston’s position as being at non-attainment make it very difficult to add to or build new refining capacity in the region.</p>	<p>Threat Current state and local tax structures will continue to be a damper on new development and expansion plans unless new types of incentives are created to reduce cost of location, expansion and operation.</p>

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 (only three plant managers attended the first forum in Beaumont). 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 “wins” of the process was to build interest in and credibility for the state’s initiative; given this increase in interest, attendance and participation by these groups 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 VP and CXO level executives, who will bring a different perspective to the discussion.

3.5 – Quantitative Data

3.5.1 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, petrochemical related patents are mature, and newer areas of energy research and related intellectual property is occurring outside of Texas. From 1997 to 2003, there were some 73,200 patents issued to companies or individuals in Texas. Some 5,150 of these patents were related to the petrochemical industry. The vast majority of this activity took place in Houston, which is the headquarters for many large petrochemical 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.

Figure 5

Petrochemical Patents in Texas by Subcategory, 1997 - 2004 ⁵	
Subcategory	Number of Patents
Composites and Films	200
Dyes/Paints/Coatings	568
Other Chemical Processes	727
Other Chemistry	624
Other Organic Compounds	1390
Resins/Polymers/Rubber	1641
Total	5150

The majority of sector patents (3,031 out of 5,150) were issued for innovation for resins, polymers, and “other organic compounds”. Dyes, paints, and coatings lagged at 568. Chemical processes numbered 727 and composites and films, identified as a sector opportunity, numbered only 200 out of the total of over 5,000. Over 80% of the patents were issued to entities in either the Houston or Dallas / Fort Worth region.

Figure 6

Petrochemical Patents in Texas by Region, 1997 – 2004⁶	
Region	Number of Patents
Houston-Galveston	2826
Dallas-Fort Worth	1057
Austin	422
Other Regions	292
South Texas	138
San Antonio	123
Beaumont-Port Arthur	107
College Station	102
Midland-Odessa	26
Lubbock	18
Tyler	16
Amarillo	13
El Paso	10
Total	5150

3.5.2 Venture Capital

Venture capital information is based on data from the MoneyTree Survey, a quarterly study of venture capital investment activity in the United States produced through a collaboration between PricewaterhouseCoopers, Thomson Venture Economics and the National Venture Capital Association. The MoneyTree Survey is the definitive source of information on emerging companies that receive financing and the venture capital firms that provide it.

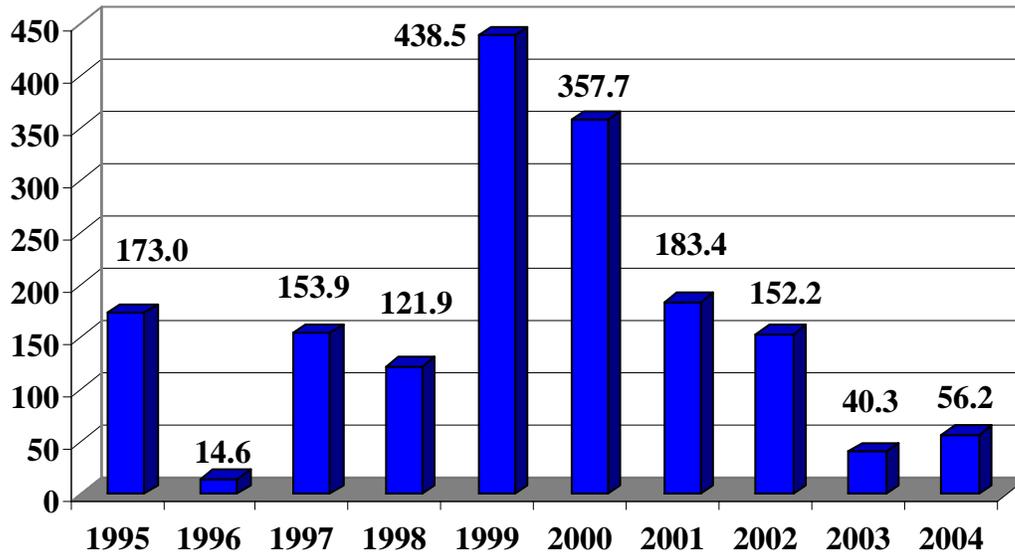
Because the MoneyTree Survey classifies and defines industries in a way which does not correspond directly to the cluster definition provided in the Texas Cluster Initiative legislation, the results shown here are not exact – it is possible that they include some funding which is irrelevant to the cluster, and exclude some funding which is relevant. For instance, the MoneyTree Survey does not classify the petrochemical and refining cluster as a distinct industry. Instead, they include it in the data set they call “Industrial/Energy,” which they define as including “producers and suppliers of energy, chemicals, and materials, industrial automation companies and oil and gas exploration companies. Also included are environmental, agricultural, transportation, manufacturing, construction and utility-related products and services.”¹ Despite

¹ PricewaterhouseCoopers, Thomson Venture Economics, the National Venture Capital Association

its limitations, however, the overall accuracy of the data is sufficient to provide a reliable and compelling snapshot of venture capital activity in Texas.

Figure 7

VC Activity in Industrial/Energy in Texas, 1995 - 2004 (millions of \$)



4 – Cluster Mapping

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

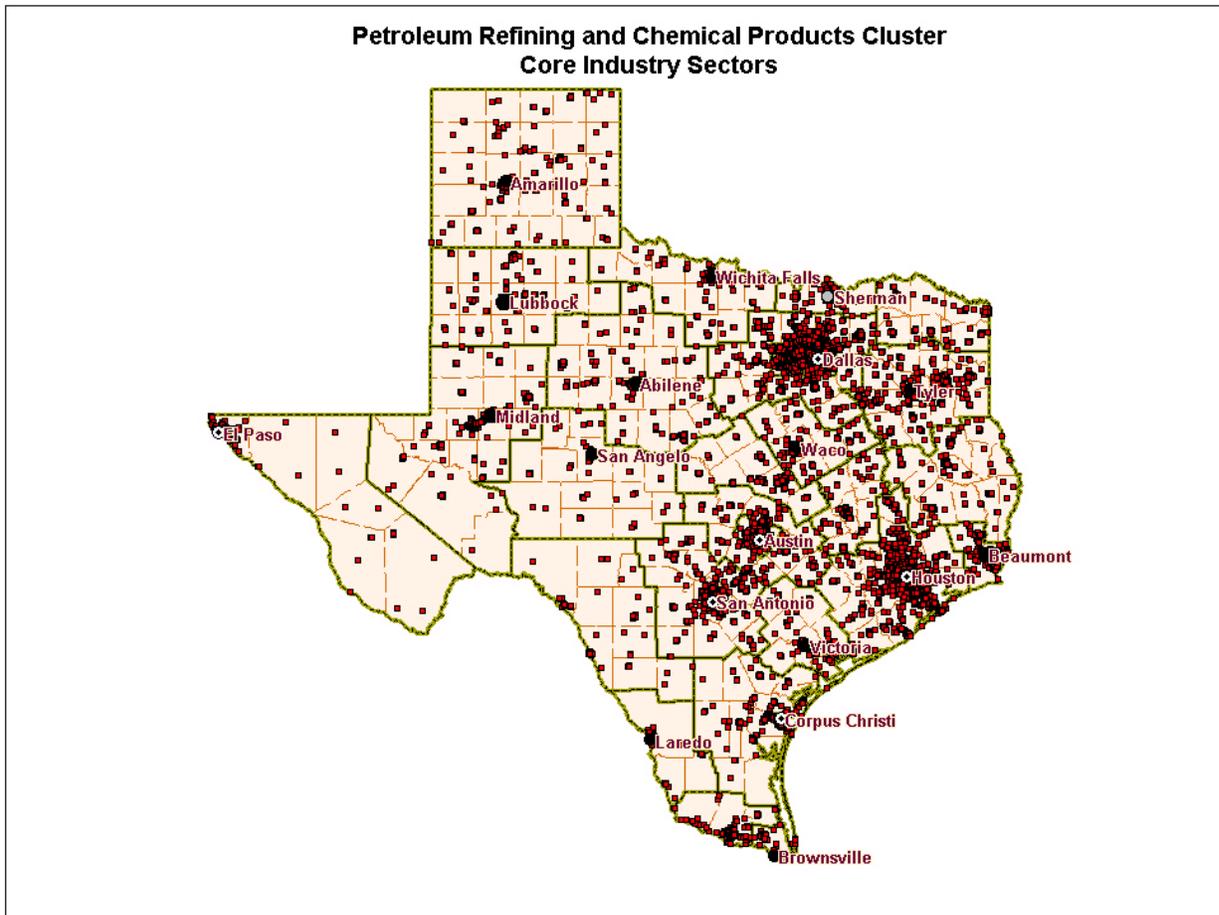


Figure 8. Core Employment in the Petrochemical and Refining Cluster

5 – The Competitive Landscape

The late 80's and 90's witnessed four distinct periods, with the Texas industry's positioning driven largely by the PC cycle. Gas-rich regions occupied the low end of the cost curve. The Texas industry was able to remain competitive in an often-difficult environment.

Period	Petrochemical Markets	Cost of Crude Oil (\$/bbl)	Cost of US Gulf Coast Natural Gas (\$/MCF)	Competitiveness of US Gulf Coast Ethane Crackers
Late 1980's	Globally tight – Asian driven import growth	\$12 - \$20	\$1.50 - \$2.50	Export – Competitive
Early 1990's	Global surpluses	\$18-\$35	\$1.50 - \$2.50	Advantaged
Mid 1990's	Recovery and Price Fly-Up	\$15-20	\$2.00- \$2.50	Strong Position
Late 1990's	Asian driven surpluses	Falling until 1999	\$2.00 - \$4.00	Losing advantage

Figure 9. Texas Competitive Position 1988 - 1999

Since 2000, Texas' refining and chemicals competitiveness has deteriorated. Recent record high crude and gas prices have started a reversal in this trend.

Period	Petrochemical Markets	Cost of Crude Oil (\$/bbl)	Cost of US Natural Gas (\$/MCF)	Competitive Position
2000-2003	Weak	\$20 - \$35	\$2.50 - \$7.00	Advantage Lost
2004-2005	Tight	\$35 - \$55	\$5.00 - \$7.00	Improving Position

Figure 10. Texas Competitive Position 2000 - 2005

Global pricing mechanisms now are at work for both crude oil and natural gas. Given the rising global demand for crude oil and refined products, OPEC is not able to keep up its production. The continued strong demand for incremental barrels of crude is being funneled into energy-thirsty Asian customers, especially China and India. Production constraints and higher cost supplies, especially heavy crudes, from non-OPEC sources are re-setting the pricing base, but even these outlets are limited by refining capacity.

The demand scenario for natural gas is similar. There is a fundamental shift from a continental market to an increasingly global market. The market in North America is increasingly tight, and ultimately is reliant on imported natural gas in various forms, including liquefied natural gas (LNG). Only the Middle East and Eastern European countries, along with several other gas-rich regions (Siberia, Indonesia, etc) have a substantive and persistent cost advantage in production.

Rising crude oil prices bring parity to energy costs, on a million BTU basis. As the energy potential of crude oil and natural gas reach this equilibrium point on the world market, the

operational efficiencies of Texas plants will finally deliver a slender marginal competitive advantage.

Texas currently has six liquefied natural gas facilities under permit by the Federal Energy Regulatory Commission, with a total send-out capacity of some 15.5 BCF per day. Two additional projects, with a potential send-out capacity of an additional 2.2 BCF/day, have been announced but are not yet approved.

Proposed Terminal	Location	Send-out Capacity	Proposed Markets	Project Status
Freeport LNG Development, L.P. (ConocoPhillips; Chenierre)	Sabine Pass, Texas	1.5 Bcf/day proposed expansion would increase s/o to 4.0 Bcf/d	Terminal to serve intrastate market	FERC issued authorization on 6/18/04 In construction In-service goal: 2007 winter heading season
Corpus Christi LNG, L.P. (Cheniere)	Corpus Christi, Texas	2.6 Bcf/day	Terminal to serve both interstate and intrastate market	Application pending at FERC In-service goal: 2008
Vista del Sol LNG Terminal, L.P. (ExxonMobil)	San Patricio County, Texas	I. 1.1 Bcf/day II. 2.0 Bcf/day	Terminal to serve both interstate and intrastate market	Application pending at FERC; In-service goal: 2nd qtr, 2008
Golden Pass LNG Terminal LP (ExxonMobil)	Sabine Pass, Texas	I. 1.0 Bcf/day II. 2.0 Bcf/day	Terminal to serve both interstate and intrastate market	Application pending at FERC; In-service goal: 2nd qtr, 2008
Port Arthur LNG Terminal and Pipeline Project (Sempra Energy)	Port Arthur, Texas	I. 1.5 Bcf/day II. 3.0 Bcf/day	Terminal to serve both interstate and intrastate market	Application pending at FERC; In-service goal: 2009
Ingleside Energy Center LLC (Occidental Energy)	San Patricio County, Texas	1.0 Bcf/day	Terminal to serve both interstate and intrastate market	Application pending at FERC; In-service goal: 2008

Figure 11. Status of Texas Liquefied Natural Gas Facilities

What does this increase in LNG capacity mean for the Texas refining and petrochemicals industry? These 6 proposed facilities have a combined send-out capacity of over 4 trillion cubic feet per day, more than 3 times the current US capacity (including planned expansions), and over 2 ½ times the *total* European capacity for handling LNG imports.

As these LNG facilities come on line over the next three to five years, natural gas prices are expected to plateau, and eventually recede, approaching the \$4.00/MCF level. The combination of increased supply, lower feedstock and fuel prices, and delivery infrastructure along the Texas Gulf Coast should result in an improved competitive position for Texas plants.

Many Middle Eastern exporters of LNG are shipping “wet” gasses, due to the lack of facilities in that region. This may present an additional benefit to Texas plants, as it may be an opportunity to strip “heavy” gasses from the LNG mix. These “heavies” can be used in a variety of products, from plastics to fertilizers, and could provide both a lower price feedstock and an opportunity to develop higher-margin “niche” products in existing facilities.

5.1 – Implications of Industry Trends for Texas

Future Trends	
Industry	<ul style="list-style-type: none"> North American expansion will be limited. Capacity should grow about 0.5% per year through 2008. As a result, operating rates should climb to near full capacity towards the end of the decade, and any additional demand growth is expected to be filled by reduced exports and increased imports. At the same time, European expansion will be modest, and primarily located in Eastern Europe. The chemicals sector customer base will continue to grow in developing countries, especially China, and manufacturing capacity will follow. Health and safety will continue to be a driving issue, both in workforce development and technology. Increasing importance of cutting-edge technology as a cost of staying competitive. Environmental regulations will continue to impact the economic feasibility of domestic expansion. Homeland security concerns are higher in this sector than in other energy-related sectors, due to the concentration of assets. Consolidation among larger firms will continue. Many small firms, lacking the resources to expand abroad, invest in expensive R&D and equipment, and weather severe price swings, will fail.
Technology	<ul style="list-style-type: none"> Methane activation SCORE Technology CD Hydro Technology LNG receipt, transportation, and processing Natural gas conversion Clean coal technologies CO2 Sequestration Low sulfur regulations will drive research and development in advanced catalysis systems and processes Advanced system controls and monitoring
Globalization	<ul style="list-style-type: none"> The critical mass of Texas’ operating plants, pipelines, supply, and transportation will continue to generate economies of scope and scale to the industry; however, capacity will need to be upgraded to retain a global leadership position. Labor costs will grow in developing countries, but will remain dramatically lower than US domestic costs. Globalization of “downstream” customers of the chemicals industry will threaten the chemicals industry in Texas and the US, as industrial consumers source intermediate product from less expensive regional providers Low-cost feedstocks will continue to favor the Middle East and Far East; LNG capacities and the importation of “wetter” gas may be the equalizer.

Figure 12. Petrochemical and Refining Cluster Trends

Impacts of Future Trends

- Domestic expansion will be driven by opportunities to exploit margins on select products and on “niche” products and services.
- Competition with developing nations, and China in particular, will be driven by
 - Low cost of construction, driven by lower labor costs,
 - Low cost of operating labor,
 - Synergies built on the rapidly growing industrial customer base, and
 - Rapidly growing domestic demand in the region.
- There are many competing trends in the international arena, including
 - There is a tremendous base of under-utilized educated workforce in China. How will this workforce supply balance with future demand for skills? How will this trend move labor costs?
 - There is currently a very low labor cost, but it is rising rapidly. At what point does the cost of labor become a dis-incentive to plant relocation?
- In China particularly, there is a rapid increase in domestic consumption of chemical products, and a commensurate increase in manufacturing capacity. How much of the Chinese manufacturing capacity will be dedicated to domestic consumption? At what point will excess capacity be exported?

6 – Assessment Acknowledgements

Special acknowledgement is hereby given to the Texas Petroleum Refining and Chemical Products Industry Cluster Team chaired by Mr. Phil Anastasio, Plant Manager, Oxy Vinyls of Deer Park, Texas. Cluster Team members include the following:

Cluster Team Members	Organization
Phil Anastasio, Chair	Oxy Vinyls
Steve Ames	Gulf Coast Process Technology Alliance
Michael Barnhill	Entergy
Erik Bliss	State Strategy on Advanced Technology
David Cocke	Lamar University
Art Colwell	BASF
Andy Cunningham	Flint Hills Resources
Tom Curlee	Port of Corpus Christi
Ron Dipprey	Texas Chemicals Council
Bart Gliatta	Dow Chemical
Judy Hawley	Port of Corpus Christi
Chris Hext	Lubrizol
Flavius Killebrew	Texas A&M University - Corpus Christi
Tom Kornegay	Port of Houston
John Larue	Port of Corpus Christi
Jan Lawler	Economic Alliance, Houston Port Region
Bill Lindemann	San Jacinto College District
Julie Moore	OxyChem State Government Affairs
Greg Norgard	Seadrift Coke, LLP
Lori Ryerkirk	ExxonMobil
Millicent Valek	Brazosport College
Jack Wu	Formosa Plastics
Industry and Stakeholder Observers	Organization
Renee Miller	Texas Workforce Commission
Denny Gunia	Centerpoint Energy
Mike Shields	Baytown/West Chambers County EDF
Don Gartman	Galveston County Economic Development
Ron Dipprey	Assoc. Chemical Industries of Texas (ACIT)
Paul Chavez	Bay Area Houston Economic Partnership
Sara Tays	ExxonMobil
Charlie Jenkins	Port of Houston
Allison Benton	Deloitte Tax LLP
Larry Buehler	Alliance Economic Dev. For Brazoria County
Clarissa Davaney	North Lake College, Dallas County District
Linda Burns	Greater Dallas Chamber
Kent Fuller	Greater Houston Partnership
Bob Glover	Ray Marshall Ctr LBJ School of Public Affairs
Adrian Ocegueda	City of El Paso, Joe Wardy Mayor
Mike Acosta	UTEP Policy & Economic Development

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Contributor	Organization
Jack Burns	Air Liquide America Corporation
Ron Arcenau	Arcenau & Gates Consulting Engineers
Frank Tobia	Arch Chemicals
Paul M. Chavez	Bay Area Houston Economic Partnership
Mike Shields	Baytown/West Chambers County EDF
Bob Shaw	Bob Shaw Consulting Engineers, Inc.
Dave Maneman	Calabrian Chemical
Dick Cuneo	Chevron Phillips Chemicals
Randy Carbo	CITGO
Kyle Hayes	City of Beaumont
Andy Green	Composite Tech, Inc.
Ralph Coker	Corpus Christi Chamber of Commerce
Alison Benton	Deloitte Tax LLP
David Smith	ENGlobal Engineering, Inc.
Tom Odenthal	Entergy Gulf States - Sabine Plant
Richard Faust	Faust Engineering & Surveying, Inc.
Terry Shipman	Fittz & Shipman, Inc.
George Gardner	G.A.J. Investments & Associates, Inc.
Brad Ioerger	Goodyear Tire & Rubber Company
Bert Black	Great Lakes Carbon
James Rich	Greater Beaumont Chamber of Commerce
Linda Burns	Greater Dallas Chamber
Betty Harmon	Greater Orange Chamber of Commerce
Al Cutrone	Honeywell Speciality Additives
Cavin Clark	HR Manager, Huntsman
Mike Burrow	Huntsman Chemical
Brian Henderson	Huntsman Surface Science
Robert Turner	J K Chevrolet Isuzu
Jerry Bradley	Lamar University
T.C. Ho	Lamar University
Jack Hopper	Lamar University
Kuyen Li	Lamar University
Hollis Lowery-Moore	Lamar University
Harley Myler	Lamar University
Brenda Nichols	Lamar University
Russ Schultz	Lamar University
Jimmy Simmons	Lamar University

Kevin Smith	Lamar University
George Talbert	Lamar University
Enrique Venta	Lamar University
Russ Waddill	Lamar University
Stuart Wright	Lamar University
Robert Yuan	Lamar University
Butch Wilson	Leap Engineers LLP
Chris Hext	Lubrizol - Member of TCC and EHCMA
Clarissa Davanay	North Lake College, Dallas Co. District
Terry Burke	Oxy Chem
Steve Buser	Partnership of Southeast Texas
Tom Curlee	POCC
Verna Rutherford	Port Arthur Chamber of Commerce
John LaRue	Port of Corpus Christi
Judy Hawley	Commissioner, Port of Corpus Christi
Charlie Jenkins	Port of Houston
Clyde Howard	Praxair, Inc.
Joe Domino	President, Energy-Texas
Terry Simpson	San Patricio County
Arnold Pierce	Schaumberg & Polk, Inc.
Sina Nejad	Sigma Engineers, Inc.
Ron Dipprey	South TX – AIChE
Gretchen Arnold	TAMU – CC
Ted Poe	United States Congressman
Mike Acosta	UT EP Policy and Economic Development
Bob Grimes	Valero
Adrian Cannady	Victoria EDC
Jay Eisen	VP, Sampson Steel Corp
Deborah Arnold	Work-Force 1
Linda White	Work-Force 1

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¹ Texas Chemical Council

² U.S. Energy Information Administration

³ TTARA Research Foundation

⁴ American Petroleum Institute

⁵ 1790 Analytics, LLC

⁶ 1790 Analytics, LLC