This is not a Cluster Study: A New Approach to Regional Competitiveness, Innovation, and Strategy

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***Abstract**: Regions and companies have both struggled maintaining competitiveness and avail themselves of different tools, such as cluster studies and development. This article presents a different approach--technology strategic planning--that provides a framework for assessing extant technological strengths of a given region or industry and for developing a concrete technology strategy that creates and sustains a competitive advantage in the global marketplace. Two illustrations of regional technology strategy planning are discussed.*

Introduction

Our ability to create and commercialize advanced technology products is rapidly eroding. In 2004 the US advanced technology product trade deficit for all technology categories reached nearly $40 billion. Our largest trade deficits are with China, Malaysia, S. Korea, Japan, Ireland and Mexico (National Science Board 2006). Many of the states—including Texas—that have driven science and technology excellence in the United States in the past are experiencing the erosion of their innovation edge and the consequent loss of technology jobs.

Turning the tide at the country, state, and regional levels will depend on our ability to develop and use tools to cooperate and to exploit complimentary assets in order to compete globally. Regions and industries have employed myriad tools to meet the challenge including cluster studies/development, technology roadmapping, regional benchmarking, regional innovation systems studies/development, and triple helix studies/development. Although valuable, each of these approaches suffers from a fragmented perspective that limits the business insight that drives regions and industries forward.

Texas faces the challenge of maintaining and growing its capacity to innovate at a time when global competitors are aggressively pursuing markets that have generated economic success for Texas companies in the recent past. The future success of Texas companies will depend on their ability to improve how they exploit technologies for their products and services to satisfy customer needs better.

What is needed is a framework for assessing the extant regional technological strengths that translates easily into concrete action for creating or sustaining a competitive advantage in a global marketplace. New tools must provide comprehensive, timely, actionable insight to address:

- The large **size and diversity** of the technology sector;
- The high level of **complexity** of the technology sector;
- The significant **number of competitors** pursuing the technology sector; and
- The high level of **aggressiveness of the competitors** pursuing the technology sector.

A New Approach to Regional Competitiveness: Technology Strategic Planning

This article reports on the deployment of a method for technology strategy planning developed in US intelligence agencies and used by some of the largest and most successful US corporations but never before deployed in the service of regional economic development. Due to the confidential nature of the method's origins and subsequent use, there is little public record of the method and no history of empirical research despite its 25-year history. The two projects discussed in this article are the first such opportunity to explore the method publicly.

Technology strategic planning is an established method for assessing and mapping the commercial potential and market positioning of technology, analyzing the movements of extant and potential allies and competitors, and developing responsive and proactive strategies to exact maximum competitive advantage. In contrast to other approaches, which inventory regional assets to pursue supply-side approaches to economic development, technology strategic planning is a demand-side approach to economic development (although the customer might not know to "demand" the product or service until after it is presented to them). The key assumptions of technology strategic planning are:

- For a region to have sustainable economic growth, it must produce products and services that customers want to purchase. In most cases the customers are well beyond the region's borders and often they are global.

- The foundation of all competitive advantage is the ability to satisfy the customers' needs better then the competition. For the customer to want to purchase the product or the service, it must satisfy the customer's needs better then the competitor's product or service, *as defined by the customer*.

- Technology, when defined properly as any application of science to accomplish a function, is the resource that enables an organization, be it a business, university, nonprofit, or government entity, to excel at satisfying the customers' needs. The science can be very leading edge or it can be well established, and the function can be highly visible/critical or it can be significantly more mundane.

- To excel at satisfying the customers' needs, the organization must exploit the technology more effectively then the competition.

- The effectiveness of the exploitation of technology is dictated by four attributes that are inherent in all science and technology. These four attributes make up the four dimension of the science and technology map: technology structure, capability, flow and time. An organization must outmaneuver the competition in one or more of these dimensions to acquire a competitive advantage.

- A technology strategy enables an organization, a region, a state, or a country to outmaneuver the competition in the acquisition and use of technology in order to acquire and maintain the competitive advantage required for sustainable economic growth. It is not a matter of attempting to pick the next "winning" technology or attempting to predict the next "trend" to jump on; rather, it is a matter of positioning and flexibility to

consistently use the technology more effectively than the competition no matter how the world evolves.

The foundation of technology strategic planning is the technology map, which provides the stakeholder with a holistic view of individual organizations, regions, or countries that are pursuing potentially competitive or complementary strategies. The stakeholder may use the map to develop individual and collaborative strategies.

The technology map is created through several related steps:

1. **Definition of Customer Needs** determines all of the customer needs that, if an organization excels at satisfying, provide that organization with a competitive advantage. The method draws heavily upon the full range of market researchers and others close to the customer such as repair and customer service providers as well as entrepreneurs, managers, and technologists who can provide a full understanding of the complete set of customers' needs.
2. **Technology Path Analysis** produces a technology outline or set of outlines that contains all of the technology paths that could be used today or tomorrow to excel at satisfying the various customer needs identified in the first step. The research team draws upon generalist and specialist technologists and researchers to determine all the ways extant and potential technologies in a given sector may meet a customer need.
3. **Technology Status Analysis** assesses the status of all technologies of the technology outlines to determine:
    - Which organizations are active in the technology;
    - The level of technological capability in those organizations; and
    - How technology is flowing among organizations.

Once the map is complete, the stakeholder, with the assistance of the research team, is in a position to identify the present and potential competitors, determine each competitor's technology strategy, and develop technology strategy options.

The authors have applied the technology strategic planning method in two sectors, one in which Texas has enjoyed a recent historical advantage—digital convergence—and another in which Texas has a rising reputation but limited capability—clean energy. The method was employed to answer related but different questions. In the case of digital convergence the central issue is: how can Texas organizations better identify suitable partners in the region to produce superior products and services? In the case of clean energy the central issue is: how can Texas obtain and expand a foothold in the global clean energy marketplace? Due to the global focus of the question the research team focused on one set of clean energy technologies—photovoltaics—to explore global competitive strategy options. The two studies are contrasted below.

	Digital Convergence	**Clean Energy**
Objective	Create platform for digital convergence stakeholders to identify most advantageous regional alliances.	Create platform for expanding competitive position of Texas organizations in sector in which the state has not been strong

		historically.
Technological focus	All digital convergence technologies	Photovoltaic solar cells
Analytical focus	Technology structure and capability	Technology structure, capability, and flow
Geographic focus	The Waco-Austin-San Antonio Texas Technology Corridor	Globe
Number of Organizations Analyzed	1,600	1,000

The results of each study are discussed in the following sections.

Technology Strategies for Regional Collaboration

Digital convergence technologies are increasingly central to the competitive strategies of companies in nearly all sectors. They enable the delivery of fresher food to the grocery, the diversification and personalization on entertainment, the promotion and protection of health, monitoring and management of energy use, and countless other activities that directly and indirectly affect daily life.

The region that effectively supports a thriving digital convergence sector will have the potential to compete in every major industry. There are approximately 1,600 digital convergence organizations in the Texas Technology Corridor that stretches from Waco to San Antonio. The Digital Convergence Initiative (DCI), a university/private/public venture, was established to spur innovation, collaboration, and competitiveness in the region among these organizations. [1] Through technology strategic planning DCI is attempting to dramatically advance the capacity of the region's companies, universities, nonprofits, and public organizations to cooperate by understanding fully the region's real and potential technology assets in the context of market demand and customer needs, and by creating the organizational capacity to facilitate the myriad and complex relationships needed to transform ideas into products. The approach will enable those organizations that choose to participate in DCI to compete through productive partnerships with organizations with compatible objectives through matching of capability, interest, opportunity, and mutual benefit.

1. Define the boundaries of what constitutes digital convergence;
2. Establish the full set of digital convergence technology paths that could be used to excel at satisfying customer needs; and
3. Detail the full range of Texas Technology Corridor capabilities that could be used today or tomorrow to implement the various digital convergence technology paths to excel at satisfying one or more customer needs to generate a competitive advantage.

Digital Convergence Defined

In the broadest sense digital convergence is the coalescence of all the functions for the acquisition, storage, distribution and use of all present and future human knowledge. Whether

[1] To learn more about the Digital Convergence Initiative please visit www.dcitexas.org.

the customer plays digital games, manages complex logistics, uses 3-D representations of geological formations to determine where to drill for oil, or requires real-time integrated battlefield intelligence to make decisions, consumers of digital convergence have related needs: to use the widest range of relevant data as easily, quickly, cheaply, safely and securely as possible to best satisfy the greatest number of beneficial purposes. The customer wants their needs met at the appropriate time, place, and cost at the appropriate level of risk. Digital convergence technologies meet these needs through a number of processes:

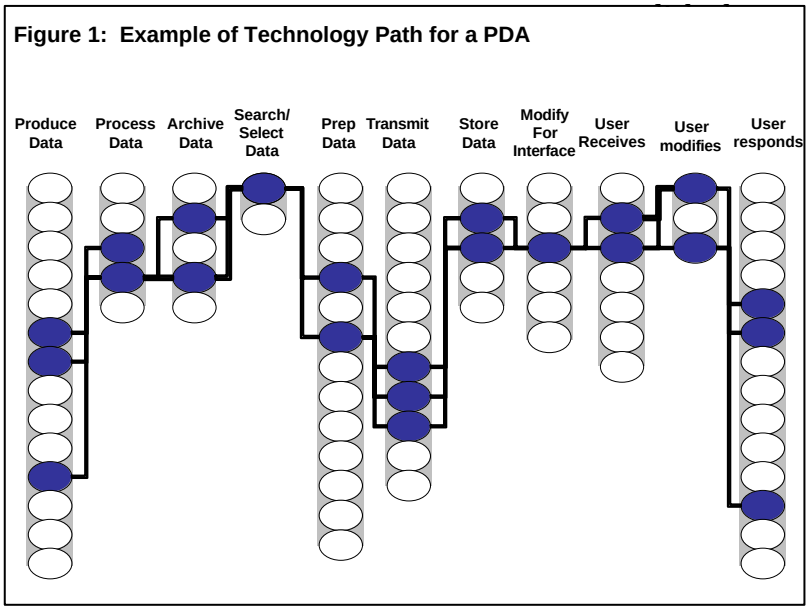
- The **digitization** of the **full range of data**. Data can mean the information to which we have become accustomed such as voice or image information, as well as a host of other information that exists but has not yet been captured, created, or converted to a digital form.
- The **enabling** of the data to be used with **increasing ease**. A key to digital convergence is the customer's ability to satisfy their needs without respect to the source, nature, and complexity of the data.
- The **integration** of an increasing percentage of the **data handling systems**. Data handling systems themselves will continue to become increasingly transparent to the customers as data move seamlessly across software, platforms, and communication pathways.
- The **satisfaction of** an increasing portion of the **customers' present and future needs**. These needs include existing needs as well as those yet to be identified and formed into new markets.

Digital Convergence Technology Map

The above definition of digital convergence bounds the second step in creating the technology map. It establishes the outer boundaries of the full set of specific customer needs that comprise digital convergence. Technology paths for products and services follow all or some portion of a thread of functions that begins with the creation or capture of data and ends with the consumer of the data responding to it, thereby beginning the data creation process all over again.

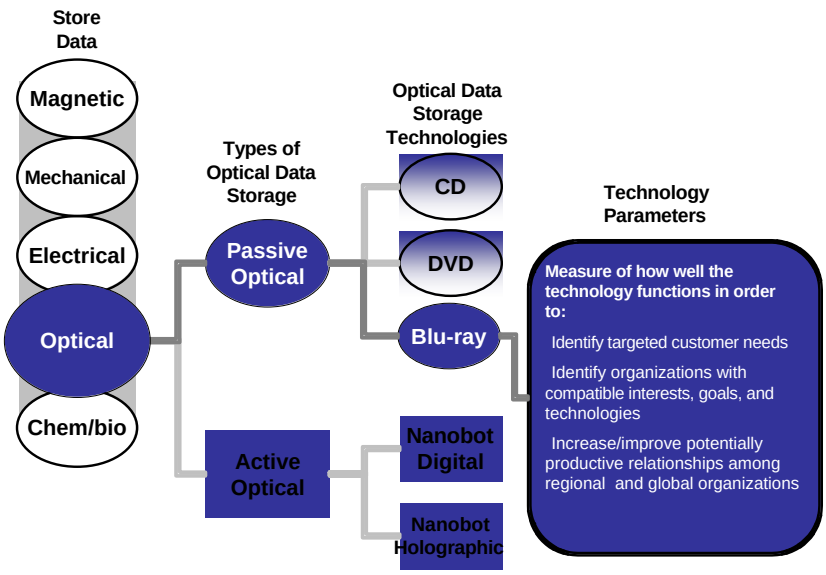
Each of these functions can be through multiple technologies. The mere catalog of the technologies that can used to accomplish a function; rather, as shown in Figure 1, it is a framework for how these technologies relate to each, according to the laws of physics, to accomplish a function. The objective is not to lay out only the present or most feasible technology paths; rather, the objective is to lay out all the technology paths that are feasible at any point in time. By way of example Figure 1 illustrates the technology path for a personal digital assistant.

Figure 1: Example of Technology Path for a PDA



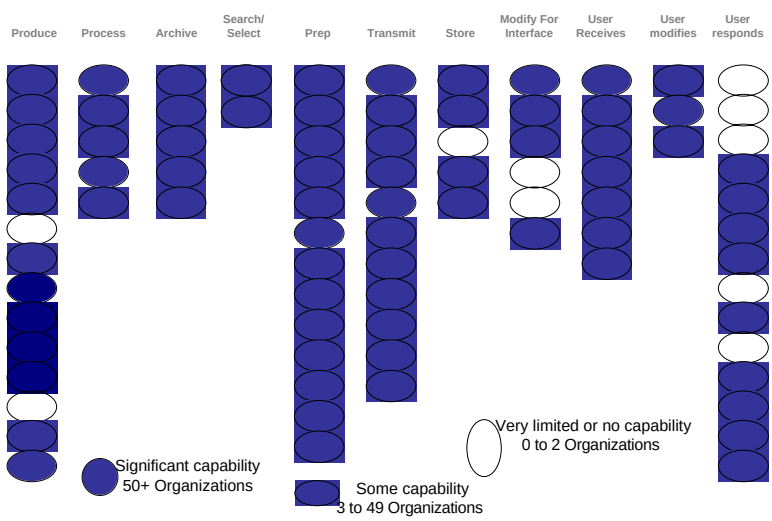
In Figure 2 we drill down into the map framework, using the example of "store data". The map shows there are five physical processes that technologies exploit for data storage. Drilling down further still, the map framework captures the types of data storage and the actual technology commodities for data storage. At the highest level of resolution the map shows the technology parameters for each commodity. These parameters are used to assess an organization's technology capability to meet specific customer needs. In the case of passive optical storage such parameters include measures of data storage density and the speed with which data is stored to and extracted from the medium. These parameters tells us what customer needs are being targeted, such as reliability or portability, and, therefore, which organizations have technologies targeted toward compatible customer needs. This alignment of interest and capability is the foundation for productive alliances in product and service development.

Figure 2: Digital Convergence Technology Map Detail



Once the technology framework is established, we map the Texas Technology Corridor assets. Figure 3 presents the level of capability in the Corridor at the highest level of abstraction. Findings are based upon publicly available sources such as patents, scientific journals, company websites, and trade journals. The technologies assessed may be anywhere in the commercialization continuum from conceptualization, to development, to a product in the marketplace.

Figure 3: Texas Technology Corridor Digital Convergence Assets

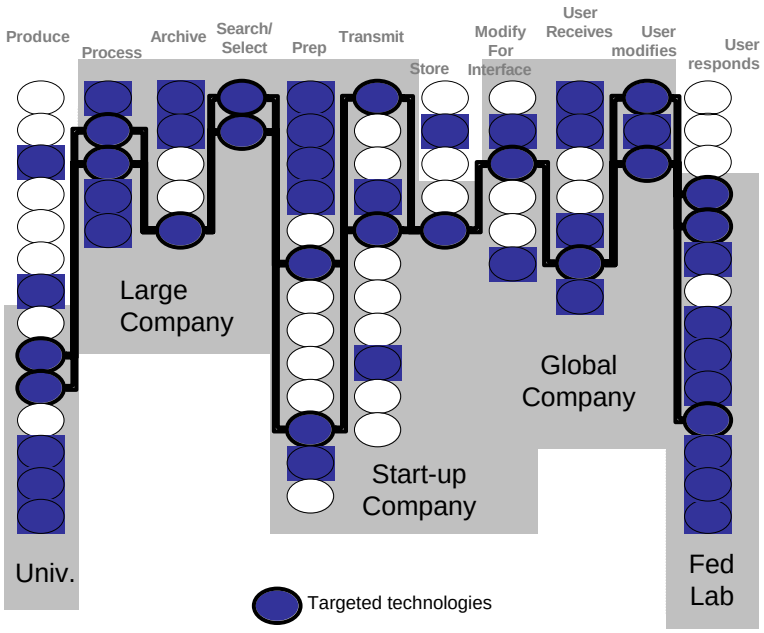


As can be seen in Figure 3, the region has some very specific strengths (darkest) and

weaknesses (white).[2] The economic development strategy is not to dispatch the chambers of commerce to recruit companies to fill in all those areas where the region lacks capability; rather, the challenge is to determine how we can best leverage the resources in the region to the greatest effect. Recruitment may indeed be necessary but only as a component of a larger strategy for amplifying the capability and competitive positioning of the existing organizations.

To illustrate the utility of the map at the organization level we give a highly simplified and hypothetical example based on a real case. Figure 4 shows the technology assets of five organizations and how the assets are being leveraged by an entrepreneur to create a device to monitor high performance athletes as well as patients recovering from illness or injury. It is important to note that few of the organizations identified are in the human performance device business. The entrepreneur, knowing the functionality he wants in his product, is licensing some technologies that are currently used in oil wells. Many of the sensors, gauges, and communication technologies used in downhole electronics are suitable for the equally inhospitable environment of the human body. The map gives the entrepreneur the perspective required for using existing technologies in new contexts. It enables him to see precisely which technologies from which organizations can fit together in new ways to satisfy unmet customer needs.

Figure 4: Creation of State-of-the-Art Human Performance Monitor



The digital convergence technology map is an important milestone in a larger program to assess the Corridor's competitive positioning via a vis the rest of the state, nation, and globe and to develop targeted programs to enhance the competitiveness of the region. The next steps in this project are to:

- Identify and understand the current level of interaction among Corridor digital convergence organizations to facilitate more effective collaborative relationships;
- Assist DCI and participant organizations in the development of individual and collaborative strategies;

[2] A higher resolution map may be found in Evans et al (2005)

- Identify the full set of present and future global digital convergence competitors.
- When complete the digital convergence technology map and technology strategy tools will provide a powerful shared resource for propelling innovation and growth in Texas.

Technology Strategies for Global Competitiveness

Clean energy has gained attention as a technology sector vital to the nation's energy security and to economic growth. The sector has enormous potential and will touch every industry in the world. However, numerous corporations, regions, and states see the potential and are aggressively pursuing it. Texas has the potential to be a leader in the clean energy technology sector, but for this leadership to be realized Texas must be much more efficient, knowledgeable, and purposeful in exploiting regional assets in this sector. A technology strategy enables Texas to exploit its internal, as well as the full range of external, resources more efficiently than any of its competitors.

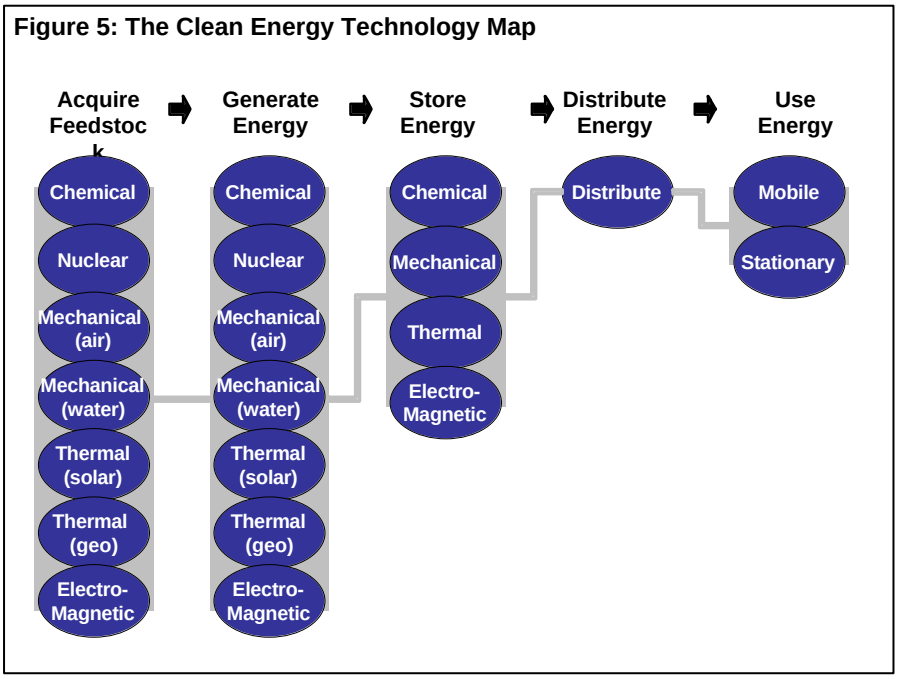
The objective of the clean energy technology strategy project is to investigate the challenge of pursuing clean energy technology, in this case specifically photovoltaic technology, as an economic development goal, and appraise critically and orient the resources the region can bring to bear to become competitive in the clean energy sector.

The Clean Energy Map

Texas requires a precise, detailed, and unbiased map of the ground on which we must compete and have a strategy which enables us to outmaneuver the worldwide competition on this ground.

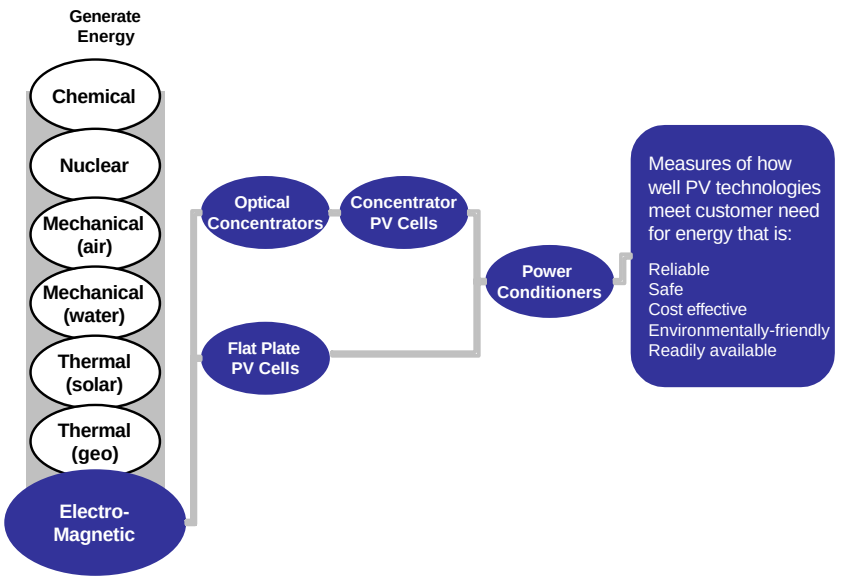
As with digital convergence, clean energy must be defined. Simply put, *energy* is the ability to do work, without applying ones own labor, in a highly reliable, low cost, safe and environmentally sustainable fashion. *Clean energy* is the degree to which a technology meets the customer need for safeguarding human, animal, and environmental health. As such, the clean energy map (see Figure 5) encompasses all technology paths that may be implemented to generate energy regardless of whether they may be considered "clean" by any particular constituency.

Figure 5: The Clean Energy Technology Map



The clean energy technology strategy project focused on a subset of clean energy technology—photovoltaics. The rationale for this focus is that, unlike many digital convergence technologies, photovoltaic technology is well established and neatly bounded, making analysis more straightforward. In addition, there is growing market acceptance at the commercial and residential level and a rising interest across the state in providing photovoltaic technologies, services, and educational/workforce opportunities. Local incentives are also speeding adoption of these products and services. By undertaking an assessment of the global photovoltaic marketplace, we come to a more thorough understanding of Texas' clean energy competitive stance.

Figure 6: Photovoltaic Technology Paths



Photovoltaic technologies convert sunlight into electricity through the use of semiconductor diodes. Although the materials, size, application, and cost vary widely, there are essentially two photovoltaic technology paths as shown in Figure 6: concentrator style photovoltaic cells and flat plat photovoltaic cells. Both technologies must be integrated with a power conditioner to make the direct current generated suitable for application.

Assessment of the Global Photovoltaic Marketplace

The main competitors are those organizations that, through their plans for the exploitation of technology, have the potential of hindering Texas from achieving its targeted competitive advantage. For Texas to achieve its objective, it must know and effectively address its competitors. (Although that is not to say that some of these same organizations might not be effective allies for Texas).

At a minimum, the main competitors' technology strategies must be known in broad strokes. Each competitor's technology strategy is assessed in terms of: the main customer needs they are attempting to excel at satisfying in the near-term; the technologies they are developing and acquiring in order to implement their chosen technology paths; and the technology maneuvers the targeted customer needs, technology paths, and technology acquisitions represent.

The research team identified nearly 1,000 businesses, universities, research centers, and non-profits across the globe that are active in at least one of the four technologies that comprise the two photovoltaic technology paths. Photovoltaic technology capability is widely distributed

across the globe. Although there are concentrations, no region occupies a dominant position. Globally, 70 percent of the organizations analyzed are in the U.S., Germany, Japan, Spain, and Australia. In the U.S., photovoltaic capability is also widely distributed but approximately half of all U.S.-based photovoltaic activity is concentrated in California, New York, and Texas. These organizations were assessed in terms of capability, activity level, and market focus. Technology flow, the sharing of intellectual assets related to photovoltaics through joint ventures, joint research, acquisition, etc., was assessed.

One of the aims of this project is to determine how Texas organizations can take advantage of the photovoltaic marketplace not only as it exists today but how it is likely to evolve in the future. To this end a great deal of attention was given to the state of technology development. Fully two-thirds of the data collected related to photovoltaic technologies not yet available in the marketplace. Assessments were conducted to a detailed parameter level and we have an assessment at this level of granularity for each of the nearly 1,000 photovoltaic organizations.

Photovoltaic Technology Strategy for Texas

The context for the Texas photovoltaic technology strategy is challenging. The technology is structured such that there are only *two* main technology paths. Most technology sectors contain *numerous* technology paths and the limited number of technology paths in photovoltaics constrains maneuverability. There are a large number of organizations attempting to acquire a competitive advantage in these two paths. Technological capability is widely distributed and accessible.

Texas's technology strategy must effectively address two aspects of the photovoltaic marketplace. First, relative to its competitors in photovoltaics, Texas's technology, and other resources, are very limited and therefore must be used in a very efficient manner. Second, because of the large number of competitors, the wide distribution of the technology capabilities and the limited maneuvering room, Texas's technology strategy will have a much higher probability of success if it uses positioning and flexibility rather then outright ownership or control of the technology.

The research team developed a broad stroke photovoltaic technology strategy for Texas that takes into consideration the competitors' technology strategies and the realities of the photovoltaic technology marketplace. The low resolution technology strategy consists of:

1. Establishing a beachhead in power conditioning technology. Most major U.S. photovoltaic organizations are not pursuing power conditioning technologies, but power conditioning technologies are critical to both flat plate photovoltaic cell and concentrator photovoltaic cell systems. In addition, the power conditioning technologies which are required to excel at key customer needs are different for different markets but support all of the markets. Therefore a beachhead can be established within the marketplace that consists of a slice of the photovoltaic system for a particular market, and then expand out to the rest of the markets.

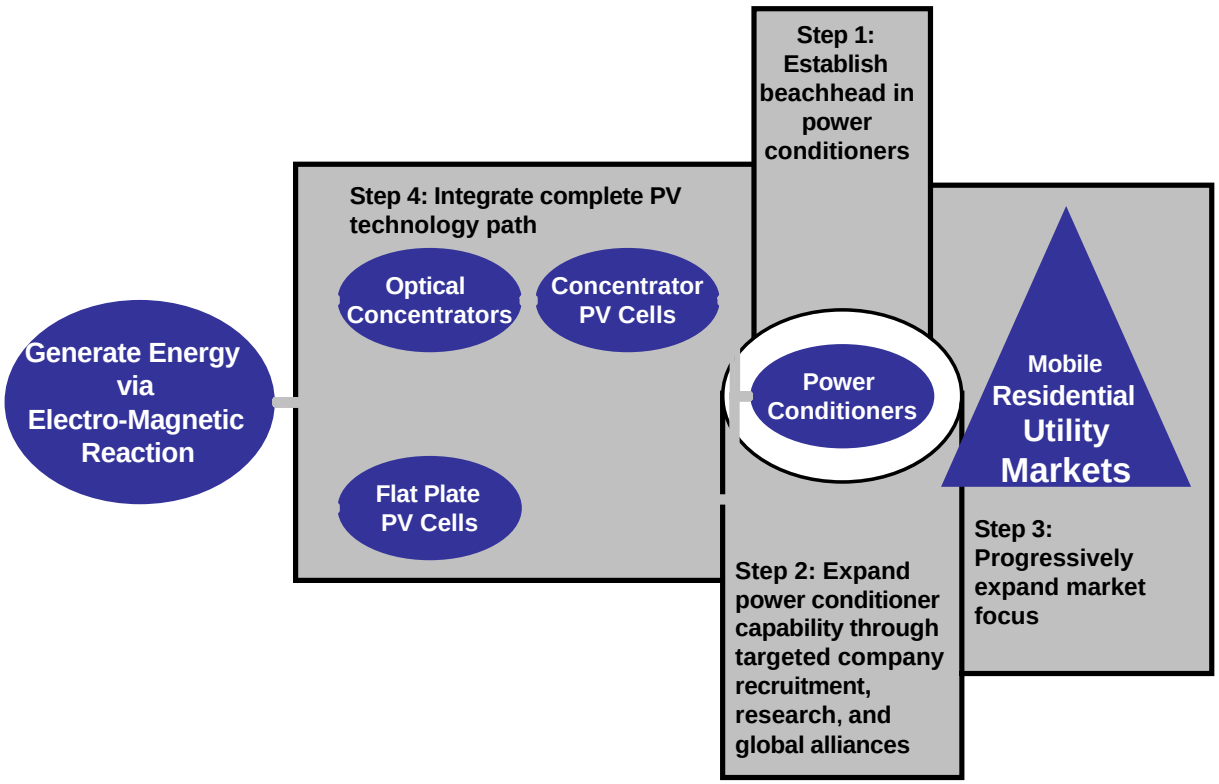
This approach accomplishes three functions: a) it focuses Texas' technology on an area that, due to its size, relative to the amount of resources focused on it, will enable Texas to quickly develop capability in this area; b) it acquires an area that because of its size relative to the technology

available in Texas, will enable the area to be successfully defended; and c) it acquires an area that due to its characteristics will enable Texas to efficiently expand the area.

The team was able to identify organizations with power conditioning technologies—companies and universities—that are best suited to the broadest number of applications in terms of conversion efficiency, unit cost, reliability for mobile and home markets.

2. Expanding power conditioning capabilities through targeted company recruitment, indigenous production of technological assets through targeted research, and target-based

Figure 7: Photovoltaic Technology Strategy Options



alliance development. For example, the strategy identifies which university research programs might be encouraged or funded and which companies are the most suitable recruitment targets for enhancing the overall sustainability of the photovoltaic sector in Texas.

3. Expanding the beachhead to address more customer needs in a greater number of markets. The set of tech alliances will begin establishing the "center of gravity" for power conditioner technology in Texas. The organizations identified for the technology alliances in Texas, and other parts of the U.S., have world-leading power conditioning technologies that are required to meet expanded customer needs and markets.

4. Integrating the complete photovoltaic technology paths with power conditioning beachhead. Create alliances among state organizations to provide a full range of products and

services, thereby creating an opportunity for a technology encirclement offensive. Connect the technologies of the members of the newly established power conditioner technology alliance with the technologies of Texas-based organizations with significant potential capability in flat plate photovoltaic cell technologies in order to provide Texas with a complete photovoltaic system capability that significantly excels at satisfying the customer need of minimum cost and does it by enveloping the competition with the two main technologies of the system (i.e., power conditioners and flat plate photovoltaic cells) for the utility, mobile and home markets. After this encirclement has been realized, Texas will have a significant control over a pivotal area for both types of photovoltaic systems. If this pivotal area is connected with the second technology required for a complete photovoltaic system, and in which Texas can posses a significant capability, Texas can produce a complete photovoltaic system that excels at satisfying a key customer need for all markets.

Conclusion

The authors identify the key challenges to Texas maintaining its competitiveness. Regions and industries have both struggled with this challenge and avail themselves of different tools, such as cluster studies/development, technology roadmapping, and regional benchmarking. This article presents a different approach--technology strategic planning--that provides a framework for assessing the extant technological strengths of a given region or industry and for developing a concrete technology strategy that creates and sustains a competitive advantage in the global marketplace. Digital technology and clean energy show clear examples of how a technology strategy can be used in regional economy strategy planning.

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