

**Technology Adoption
in the Shale Energy Industry**
+
the Role of SGICC

*An analysis of how small Pennsylvania companies
can be successful in delivering new products and
services to the industry*

September 2015

Prepared for the
Ben Franklin Shale Gas Innovation &
Commercialization Center

Funded by
The PA Department of Community
and Economic Development

Prepared by



About the SGICC

The Ben Franklin Shale Gas Innovation and Commercialization Center (www.sgicc.org), an initiative of Ben Franklin Technology Partners/CNP (<http://www.cnp.benfranklin.org>) is designed to harness innovation and new technologies as a means to maximize the economic return to Pennsylvania's citizens from the various shale formations comprise part of the energy reserves of the Commonwealth. The Center also identifies, supports and helps commercialize technologies and early-stage businesses that enhance responsible stewardship of the environment while properly utilizing this transformative energy asset.

About the Author

The Shale Gas Innovation and Commercialization Center (SGICC) requested that Kathryn Klaber author this report, given her related experience with the oil and gas industry, start-up ventures, economic development and competitiveness in Pennsylvania, and SGICC. Ms. Klaber earned her undergraduate degree in environmental science from Bucknell University and her Masters in Business Administration from Carnegie Mellon University, where she received the Enterprise Award for Entrepreneurship. She launched and led the Marcellus Shale Coalition as its first CEO, growing it to be the premier trade association for the oil and gas industry in the northeastern United States during a high-stakes period. During this period, Ms. Klaber was an advocate for engaging Pennsylvania-based businesses into the industry's rapidly expanding supply chain, and formulated the first technology showcase, creating the early partnership between the industry and the SGICC.

Prior to joining the MSC, Ms. Klaber served as Executive Vice President for Competitiveness at the Allegheny Conference on Community Development and as the Executive Director of the Pennsylvania Economy League – roles that focused on sustainable prosperity for businesses and residents alike. During the first decade of her career, Ms. Klaber worked for the international environmental, health and safety consulting firm Environmental Resources Management, first at the company's headquarters in Philadelphia, then as branch manager in her native Pittsburgh. Kathryn Klaber launched The Klaber Group in November 2013, to provide strategic services to businesses and other institutions as they capitalize on shale development in the United States and abroad. Ms. Klaber's career-long experience in energy, economic and environmental issues at the confluence of the private and public sectors brings new perspectives, strategies and implementation to the clients of The Klaber Group.

SECTION 1 – INTRODUCTION

At the 10-year mark from the first commercial Marcellus shale well, the Ben Franklin Shale Gas Innovation and Commercialization Center (SGICC) approaches its fifth anniversary. This milestone is an appropriate time for the SGICC to take stock of the value it has brought to the shale industry and to the Pennsylvania entrepreneurs that have recognized the business opportunities created by the significant growth of the oil and gas industry in the Commonwealth. To that end, SGICC engaged The Klaber Group to address technology adoption by the oil and gas industry in Pennsylvania, identify hurdles for local companies, and make recommendations for these companies to improve their success rates. In addition, The Klaber Group gauged the awareness of the SGICC and the services it provides among the companies served by the center, and provides associated recommendations. This study has been funded by a grant from the Pennsylvania Department of Community and Economic Development provided to the SGICC.

Whereas a state's policies can have a profound impact on the business climate, and many policies that impact the energy industry are being considered in Harrisburg at this time, this report does not address the broader impacts of pending policy decisions on either the success or failure, growth or stagnation of the Pennsylvania technology companies or their energy industry customers.

The shale energy industry is comprised of various segments, most of which are supported by the SGICC's programming. In particular, this report references the segment of Pennsylvania's natural gas industry involved with the planning and drilling of wells as *upstream* or *E&P*, which stands for exploration and production. The segment of the industry that involves taking the gas from the wellhead to market is referred to as *midstream* or *pipeline*. Finally, the term *downstream* refers to any of the many ways that natural gas is used after it leaves the pipeline, including as a transportation fuel, in manufacturing processes, or for electricity generation. The SGICC also supports companies focused on all aspects of generating through the utilization of natural gas liquids (NGLs) and oil related to the shale energy play in the Commonwealth.

This report presents data in several contexts, generated from a survey administered in spring 2015 by The Klaber Group to companies that have worked with SGICC in some way. Responses from 24 completed surveys are incorporated into the findings of this report.

Section 2 of the report presents information on the current state of the oil and gas industry in Pennsylvania. In short, the sustained low prices of natural gas, natural gas liquids (NGLs), and oil have driven most upstream companies to cut capital spending and operating expenses, which can have a significant impact on how small Pennsylvania-based companies must position themselves for short- and longer-term success. However, there are many growth opportunities for new technology adoption in the midstream/pipeline and the many downstream segments of the business.

Section 3 of the report includes an analysis of technology adoption in both benchmark industries as well as in Pennsylvania's shale industry. This section presents information on some of the biggest challenges faced by technology companies in getting their products and services introduced to and adopted by industry customers.

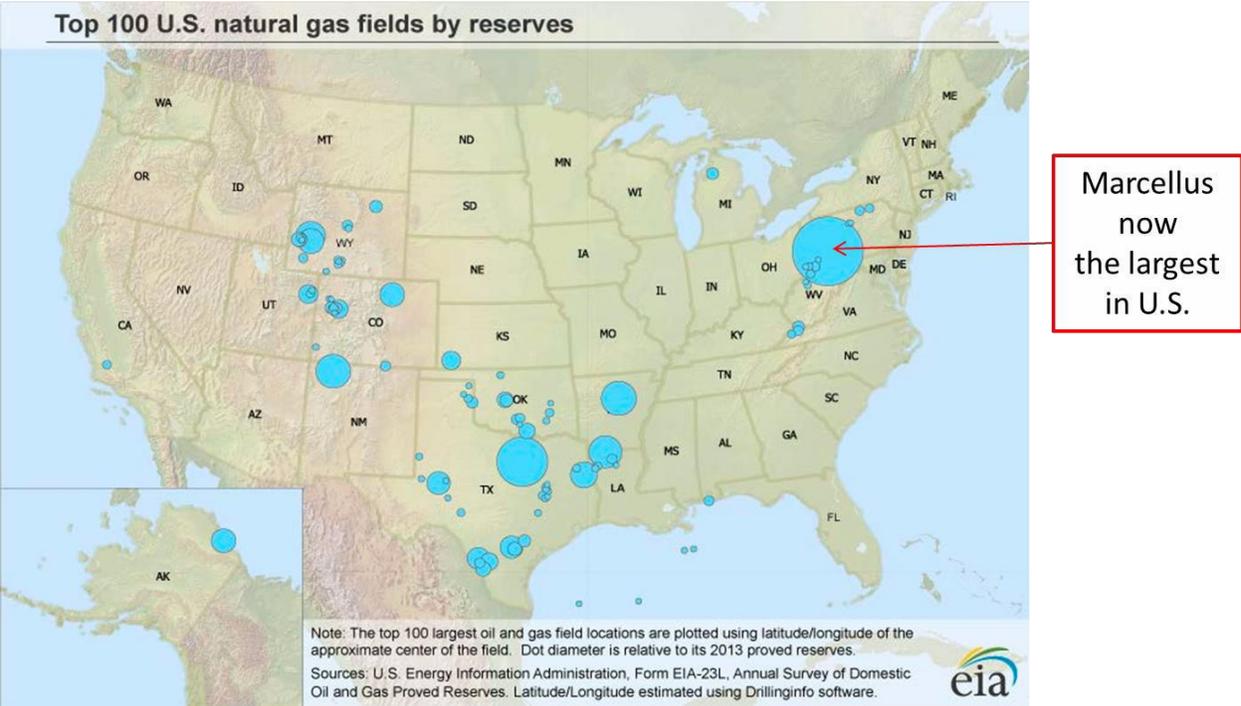
From Section 4, the reader will understand more about the services provided by the SGICC and how they have assisted Pennsylvania companies. Survey respondents identified how they have been able to leverage the SGICC's assistance in ways that are most valuable to their success at growing Pennsylvania-based businesses.

Section 5 summarizes the findings from this project into recommendations for companies who hope to create new products and services for the shale industry. Recommendations are also included for the SGICC to continue to successfully support technology companies serving the industry.

SECTION 2 – STATE OF THE OIL AND GAS INDUSTRY IN PENNSYLVANIA

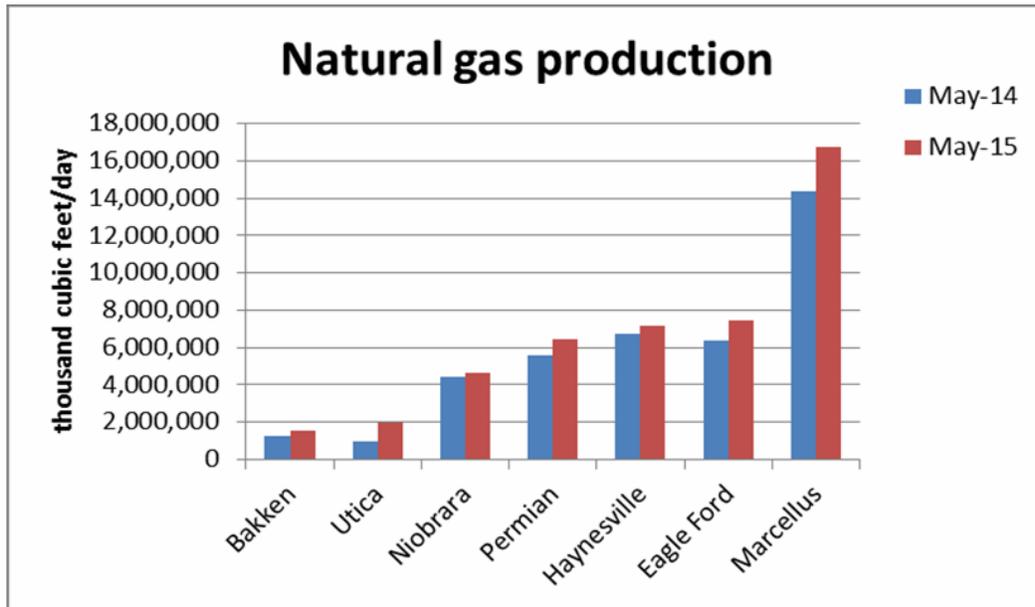
Shale resources are prevalent around the world, yet the United States is developing its shale resources ahead of other nations. Within the U.S., Pennsylvania has been a driver of natural gas and natural gas liquids production growth, now ranking second behind Texas in gas production. The majority of Pennsylvania’s natural gas production comes from the Marcellus shale, which is the largest natural gas field in the United States and producing more natural gas than any other basin, as shown in Figures 1 and 2, respectively.

Figure 1 – The Marcellus is the largest shale reserve in the United States



Source: EIA, April 24, 2015

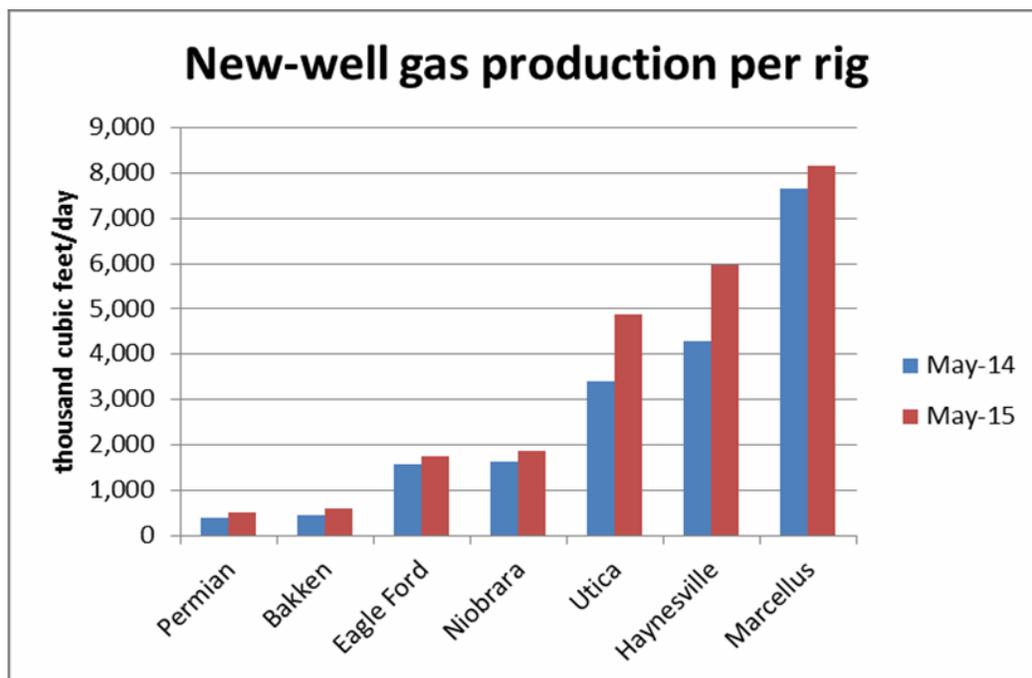
Figure 2 – The Marcellus basin leads the nation’s natural gas production



Source: EIA and Klaber Group

In addition to its large reserves, the Marcellus has been characterized by the largest productivity gains, as show in Figure 3.

Figure 3 - Marcellus production per rig is highest in United States

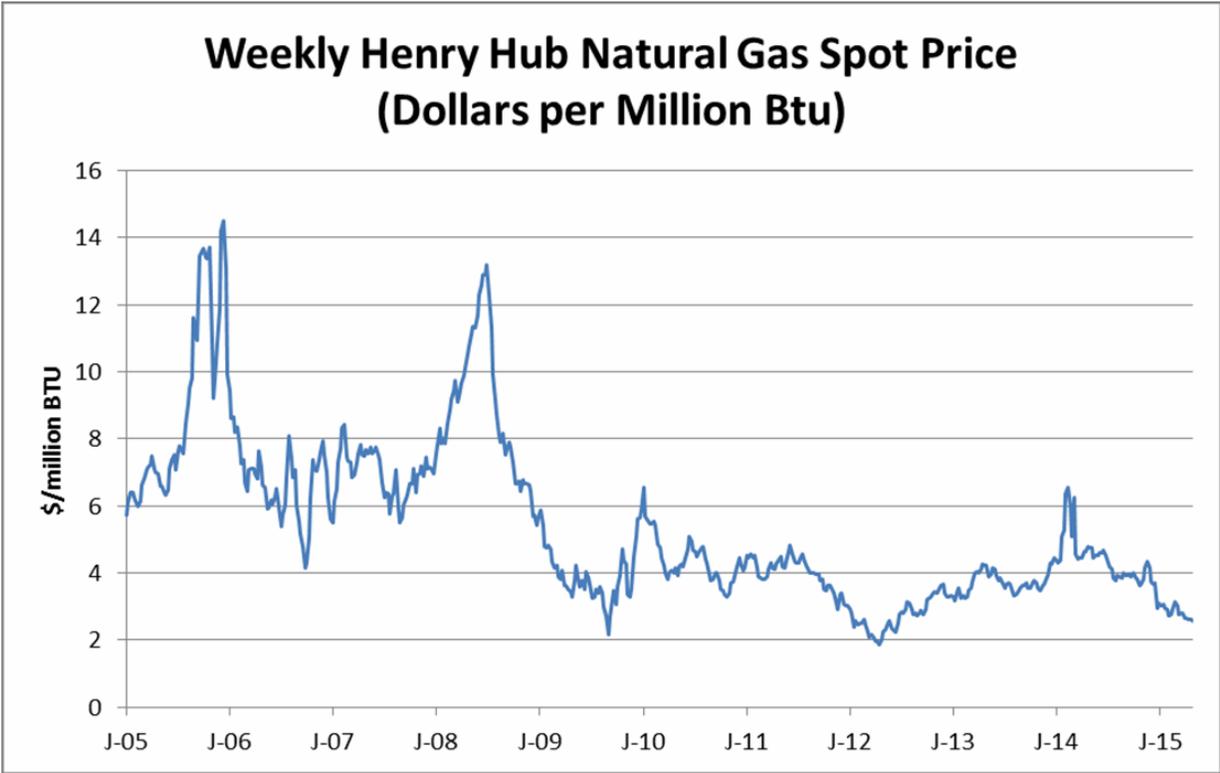


Source: EIA and Klaber Group

The significant natural gas production volumes from the Marcellus and other U.S. basins, coupled with lagging installation of pipeline infrastructure to take gas to underserved markets, and the slow pace of getting natural gas exports through the federal permitting process, have pushed the price of natural gas to historic lows (see Figure 4). Oil prices have also dropped due to global supply dynamics. For example, on August 20, 2015, the following cash prices for natural gas were reported in the Wall Street Journal, demonstrating both the drop from already-low prices one year ago, and the dramatic difference between cash prices in northeastern Pennsylvania and the rest of the nation. As a result, a majority of oil and gas companies and their suppliers have made significant cuts to their capital expenditures and pared back non-essential spending in both personnel and expenses.

	Price (\$/MMBtu)	Year Ago Price (\$/MMBtu)
Natural Gas, Henry Hub	2.730	3.850
Natural Gas, Transco Zone 3	2.730	3.880
Natural Gas, Transco Zone 6 NY	2.730	2.370
Natural Gas, Panhandle East	2.540	3.700
Natural Gas, Opal	2.640	3.790
Natural Gas, Marcellus NE PA	0.800	2.130
Natural Gas, Haynesville N. LA	2.700	3.800

Figure 4 - Historically low natural gas prices create challenges for Marcellus operators



Source: EIA and Klaber Group

At the same time that E&P companies have scaled back, the midstream and pipeline companies are extremely active. Downstream opportunities arise from the expected sustained healthy supply and lower price of natural gas, including new gas-fired power generation, transportation solutions, and a variety of manufacturing applications benefitting from the current economics. The same holds true regarding natural gas liquids, with both midstream build out underway and new technology needs desired in this area and downstream manufacturing applications and associated opportunities for innovation expected.

As a result of these major drivers in the industry, Pennsylvania-based companies may face even more challenges in introducing a new product or service into the upstream markets. This dynamic makes organizations with missions such as the SGICC even more critical, and challenges entrepreneurs to look for more diversified applications of their technologies – ideally resulting in stronger long-term viability.

SECTION 3 – TECHNOLOGY ADOPTION IN THE INDUSTRY

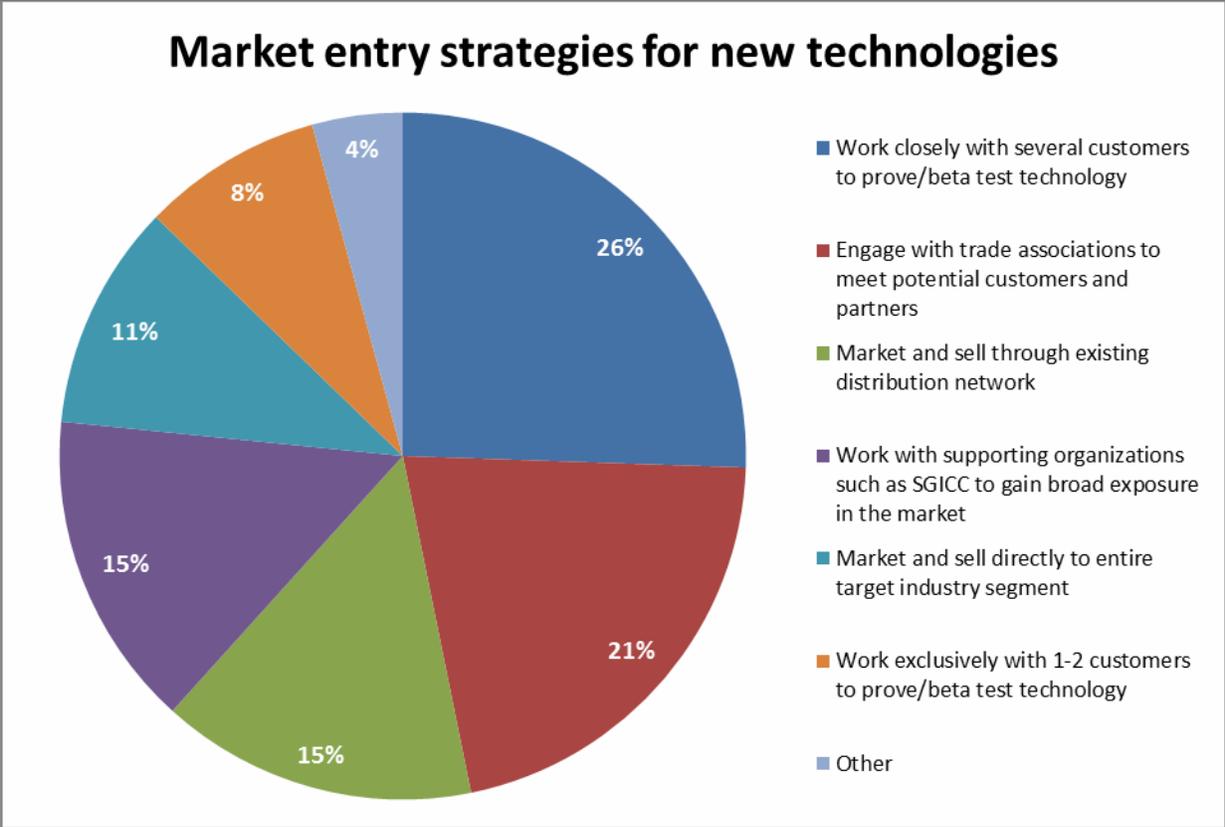
There should be no doubt that innovation and voracious technology adoption has resulted in the historic gains toward North American energy self-sufficiency from the shale revolution of the last decade. The marriage of hydraulic fracturing and horizontal directional drilling set the stage for the energy supply and productivity discussed in Section 2 above. Whereas this innovation is widely acknowledged, there are countless additional opportunities to increase productivity as well as decrease cost and risk across the various segments of the industry.

In the absence of landmark studies on how technology has been adopted within the oil and gas industry, a benchmarking analysis was conducted in other technology-adopting sectors of our economy to identify a set of best practices that could apply to oil and gas. Appendix A includes the detailed results of the literature review. In summary, the key best practices for both the customer and its technology provider to increase the success of technology adoption are summarized as follows.

1. **Justify the benefits** in terms of both cost savings and increase in service quality.
2. **Assess the organizations' readiness** to adopt the technology: The organization needs to have a realistic picture of how the technology can benefit its operations and must be ready to adopt the technology.
3. **Vendor fit**: Choose the right vendor based on the vendor's actual experience, capability, and willingness to provide long-term support.
4. **Task-technology fit**: The technology should align with the task that the organization is trying to accomplish. This fit must be gauged periodically to account for any divergence in the tasks. The organization must choose the appropriate medium to use the technology. For example, a new software technology might only be as effective as the hardware hosting it.
5. **Ease of use**: The capabilities of the end user to learn and use the technology must be taken into account while designing/selecting the new technology.
6. **Top management support**: Top management's support is essential as the engineering department alone may be ineffective in influencing other units which make use of the technology.
7. **Policy compatibility /dynamic impact**: The organization must ensure that the existing policies do not lead to dissatisfaction among employees or other disruption of current processes and procedures.
8. **Formal training**: Formal training, including perhaps an easily comprehensible operating manual is important for quick acceptance by and lower risk to the end users.
9. **Periodic review**: Periodic reviews keep track of improvements in or obstacles to the production process and encourage continuous improvement.
10. **Safety**: New technology must be sourced from vendors who understand how any hazards will impact company operations and be integrated into existing safety programs and protocols. Adequate training to handle the device safely under different operating conditions is essential.

In addition to the many important considerations listed above, each company entering or expanding in the shale industry in Pennsylvania must have a technical, and sales and marketing strategy uniquely designed to its product or service. Figure 5 demonstrates the range of strategies that companies engaged with the SGICC have used to enter new markets.

Figure 5 - Companies use a range of strategies to enter the shale industry in Pennsylvania



When asked what has been the most critical aspect of bringing a new product or service to market, technology companies respond with the following types of responses:

- Gaining customer awareness as a Pennsylvania-based company when many decisions are made in other jurisdictions, like Houston, Texas
- Defining the value proposition in terms that make sense to the customer, educating the customer on the product benefits
- Demonstrating the value proposition
- Getting to the proof of concept stage
- Getting the first customer to test the product
- Proving the technology is more cost-effective and accurate than current methods
- Demonstrating that the product works according to the customer expectations and is cheaper than current methods

- Preparing for and achieving successful field trials
- Strengthening the feedback loop with customers, getting product requirements correct and gaining market acceptance, getting to scale
- Getting an audience with the customer so they can physically experience the product
- Building credibility for the technology
- Engaging closely with key regional customers
- Identifying and talking with decision-makers and closing sales

The biggest challenges to bringing a new product or service to market fall into the following types:

- Regulatory awareness
- Getting sales representatives up to speed
- Building brand awareness and credibility
- Convincing the customer to try and use a new product
- Low commodity prices that temper change or new investments
- Low gas prices and slow production, which leads to customer focus on cost-cutting measures
- Market volatility, including relative price of oil, diesel, natural gas
- Customer resistance to change and long budget cycles
- Finding the first adopter
- Getting in front of decision makers to demonstrate product
- Turnover in personnel at target customers
- Development costs and costs to test at scale
- Raising capital

Making the process even more complex for new technology providers, there is by no means a formula to navigating oil and gas companies. For example, several larger companies operating in the Marcellus basin have systematically made new technology identification and adoption a strategic imperative to the company and attempted to streamline the process within their organizations.

“EQT is always searching for new technologies to improve our operations. The process used by SGICC to uncover innovative products and services is a valuable asset to the industry.”

-- *Karl Coke, Senior Vice President of Innovation at EQT Production*

“I’ve worked with SGICC since its inception, and I really enjoyed the engagement in the Innovation Contest this year. Their process used to uncover innovations is a real value for the industry.”

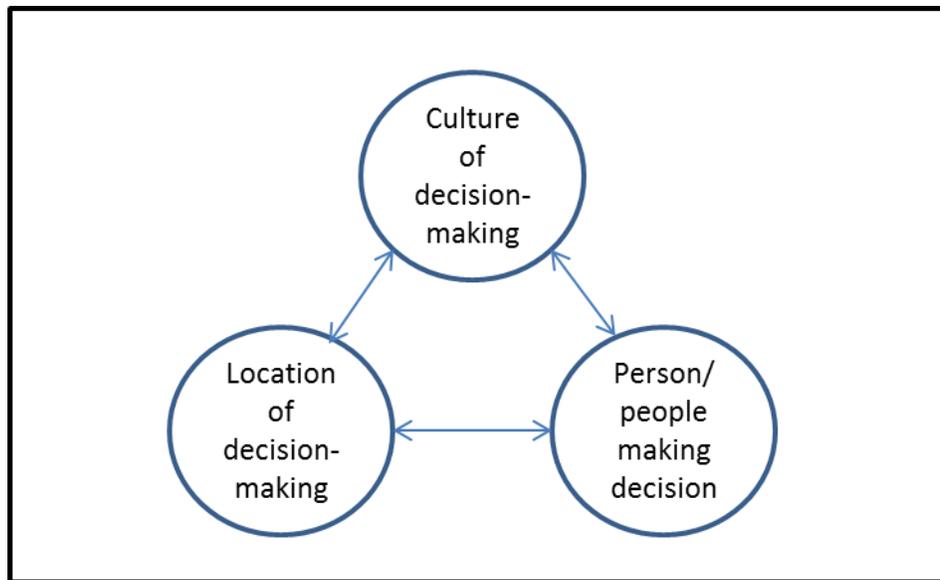
-- *Joe Frantz, Vice President of Engineering Technology for Range Resources, Appalachia*

This approach does not guarantee that a technology company will have an audience for its pitch, but it does help the process move forward more seamlessly if the product or service meets an identified customer need. On the other end of the spectrum, there are many smaller gas companies that simply don't have the staff or longer-term view to consider how novel technologies may help their businesses – they may follow other companies into using the new product or service, but won't likely be early adopters. For the many companies in the middle of these two extremes, there are a myriad of ways that a new technology and its company representatives can find an entrée – from extensive networking in the industry to demonstrations of the product. Furthermore, the decision to integrate a new product or service into the value chain can be made at many different points – by the E&P company, by the midstream/pipeline company, or by one or more critical links in the vast supply chain that serves the industry.

As shown in Figure 6, there are three key factors for understanding a prospective client for the purposes of developing and executing a sales and marketing plan:

- the culture of the company with respect to considering adopting new technologies, as discussed above;
- the decision-making authority of individuals and departments within the company and how broad the buy-in needs to be to move forward;
- the location when decisions get made, whether it is delegated to field personnel, or made at a corporate or regional headquarters that most likely is located outside of Appalachia.

Figure 6 – Key Considerations for Navigating Customers in the Oil & Gas Industry



Breaking into the industry requires persistence and a broader knowledge of the industry, as discussed further in Section 5, and strong partners, such as the SGICC, discussed in Section 4.

SECTION 4 – ROLE OF TECHNOLOGY SUPPORTERS

Throughout the cities, towns and counties of Pennsylvania, as well as within the Commonwealth’s Department of Community and Economic Development, are numerous organizations and professionals with the job of supporting local businesses. Only one organization – The Shale Gas Innovation and Commercialization Center, SGICC - has the express mission to establish a collaborative that will engage a wide range of partners with the intent to accelerate technology break-throughs related to the shale gas resource in Pennsylvania. The shale gas industry has changed continuously since SGICC launched in 2011, yet it has consistently brought Pennsylvania companies to the table with the oil and gas industry, leveraging the Marcellus boom to create even more opportunities for business growth at home.

When the Marcellus Shale Coalition hosted its first major industry conference, Shale Gas Insight¹, in Philadelphia in September 2011, the conference creators wanted to be sure to include, and foster support for, new technologies. Using Pittsburgh’s Three Rivers Venture Fair as a model, the conference incorporated a screening process for companies, a technology showcase, company pitches, and monetary awards. Wanting to partner with Pennsylvania-based organizations with expertise in technology start-ups, the MSC began its long-standing relationship with the Ben Franklin Technology Partners.² Awareness of the Ben Franklin Technology Partners’ SGICC and its mission grew when the SGICC first sponsored its inaugural Innovation Contest in the spring of 2012. That contest continues, with the fourth held in Canonsburg, Pennsylvania in May 2015, with strong industry participation on the judging committee and as sponsors,³ and with roughly a dozen Pennsylvania companies presenting at each contest.

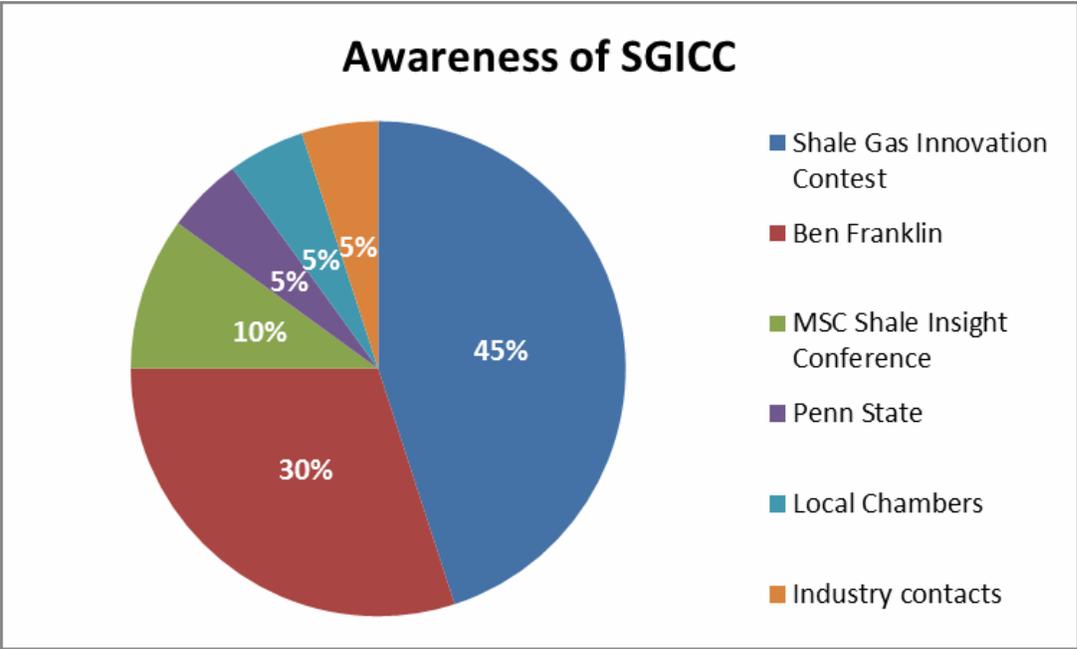
Companies who had participated in SGICC and MSC events were asked to recall how they first learned about the SGICC and the majority referenced the Innovation Contest as the means by which they were introduced to the organization and its services (see Figure 7). Yet there are other channels that also create awareness of the SGICC and its mission, including the Ben Franklin network, the MSC conference, Penn State University, and business groups and chambers throughout the Commonwealth. This information reinforces the importance of a landmark event, like the Innovation Contest, that brings new technologies together with the companies that would benefit from them. But it also highlights the importance of maintaining, and even enhancing, the other channels through which companies can connect with the SGICC.

¹ The name of the conference was subsequently shortened to Shale Insight given that the Appalachian basin was producing valuable products beyond natural gas.

² Bill Hall, SGICC and Katie Klaber, MSC first met in April 2011 in the early planning for the Shale Insight conference’s Technology Showcase, which remains integral to the annual conference.

³ Sponsors from the industry included AquaTech, Chevron Technology Ventures, CONSOL Energy, EQT, GE Oil & Gas, INABATA America Corporation, Little Pine Resources, Marcellus Shale Coalition, PPG Industries, Praxair, Range Resources, Shell, Williams and XTO Energy, in addition to First Nation Bank, Steptoe and Johnson, and Ben Franklin Technology Partners.

Figure 7 - Technology Companies learned about SGICC from many sources, most commonly from the Innovation Contest



Once a technology company is engaged with the SGICC, there are numerous ways for them to benefit, including:

- Exposure to industry decision makers
- Coaching via participation in the Innovation Contest
- Monetary award from the Innovation Contest
- One-on-one advice and counseling from SGICC staff
- Connection to Ben Franklin Technology Partners, Innovation Works, or other investment funding source
- Grant funding when available

Companies that have been engaged with SGICC find all of these services valuable, but mostly the exposure to industry decision-makers – their current and potential future customers (see Figure 8). It will therefore continue to be very important for SGICC to maintain relationships with the companies in a very dynamic industry, including decision-makers located both locally and in out-of-state offices of companies doing work here. In addition, the coaching expertise and access to funding sources will be key components to maintaining the momentum created in the early years of the shale play, through the current upstream industry challenges, and into the long future of the play in Pennsylvania.

Figure 8 - Relative value of services offered by SGICC to Pennsylvania technology companies



Additional comments from respondents regarding services that have been beneficial to their business include:

- Networking in general, and deeper market intelligence from primary sources
- Shale Insight Innovation sessions
- The opportunity to “practice” our pitch
- SGICC-provided connections with experts/scientists in academia
- Responsiveness of SGICC staff and efforts to make connections on the business’ behalf.

The following are examples of the type of feedback that the SGICC receives from small companies that use the center and benefit from its guidance, direction and connections to shale companies to help them advance their product and service offerings:

- “SGICC’s support was the tipping point that transformed our company from a back-office R&D facility to a customer-facing, growing, and profitable business. This isn’t just about grant money; it was SGICC’s enthusiastic introductions to prospective customers that made the difference. Thanks to SGICC, KCF Technologies is hiring people and doubling down on our commitment to building a strong business in Pennsylvania.”
-- *Ben Lawrence, VP of Business Development at KCF Technologies*
- “We were thrilled and honored to be selected as a winner in this year’s competition. The SGICC has been instrumental in accelerating the development of our gas monitoring products. Without the support and guidance of the SGICC and Ben Franklin we might have missed our window of opportunity to present our solution to the shale gas industry. Entrepreneurs are fortunate to have these organizations in the state of Pennsylvania!”
-- *Bill Powers, President/CEO of Pix Controllers*

In addition to positive feedback from small companies the center supports and E&P companies that benefit from interacting with the SGICC, the center also receives positive feedback from large companies that interact with the center through the Innovation Contest who are seeking new technologies to support the shale energy play. The following quote highlights this:

- “Through the Shale Gas Innovation Contest, SGICC brings together a broad range of promising ideas covering production, transportation and utilization. From the technology scouting perspective, there is no better opportunity to see high caliber shale gas related innovations on display at a single event.”
-- *Dante Bonaquist, Senior Corporate Fellow, R&D at Praxair*

SECTION 5 – CONCLUSION AND RECOMMENDATIONS

This section provides straightforward and tangible guidance to Pennsylvania companies looking to enter or expand their offerings to the oil and gas industry. It goes without saying that the product or service offered by a company must perform as it is promised to the customer, and this report does not portend to anticipate the technical aspects of industry offerings. The key recommendations for technology companies are summarized as follows:

1. Clearly define the value proposition
2. Devote the necessary resources and time to marketing and selling
3. Diversify the customer base
4. Stay current on customers' and industry's needs and pressures

Clearly define the value proposition

As evidenced by the amount of business guidance on defining a value proposition, it is not an easy task to get right. This has been true for the companies that apply to and participate in the shale technology forums over the last five years in Pennsylvania. Too often, companies are focusing on the *features* of their technologies and not the *benefits* they bring to the customer. Companies often make references to branded technology or terms that need significant explanation in their literature and pitch, without recognizing that this brings zero value to the customer. The company descriptions are not sufficiently compelling to leave the potential customer yearning for more information and asking for the next meeting to learn more. It would clearly benefit each company with a new technology to spend time and resources to develop and test the high-level description of their company's offering, honing it until it creates excitement and clarity about their product. Every member of the team should be able to successfully deliver an elevator pitch for the company, using similar language. Sounds simple, but rarely given the attention it deserves.

These are some examples of clear value propositions:

- Lower annual operating costs
- Increased productivity per well
- Increased safety performance resulting in lower overhead costs
- Decreased barriers to productivity, thereby increasing profitability

These are some examples of language used in unclear value propositions:

- Model XYZPDQ[™]
- Proprietary technology
- Instrumentation includes “bells and whistles”
- Green technology
- Avoids unwanted consequences
- World's premier developer

Devote the necessary resources and time to marketing and selling

Technology innovations stem from individuals with a passion and talent for applying their talents and experience in a chosen area of technology. However, this laser focus on the technology itself is not enough to get the product into a new market. Therefore, technology companies should develop the sales and marketing of the product or service *in parallel with* technology development instead of as an afterthought to perfecting the technology.

The oil and gas industry is characterized by many complexities and nuances that differ from industries that have long flourished in Pennsylvania. New technology companies should not underestimate the time and effort it will take to penetrate the market. Here are some underlying reasons that should inform any target marketing plan.

- **Industry's geographic footprint.** By the nature of the business, oil and gas companies have operations across many locations, often beyond Appalachia and even outside of North America. It is important to consider where within its operations a potential customer will be using the product and the various technical, regulatory and other constraints this may impose or opportunities this may present.
- **Headquarters location and decision-making authority.** The majority of unconventional upstream and midstream/pipeline companies that are active in Pennsylvania are not headquartered in Pennsylvania. This situation does not dictate the location of decision-makers for a specific new technology, but should be given consideration in approaching each company. Often there are multiple stakeholders within a company for a new technology, and often they can be located in multiple offices. A sales and marketing plan should take into account the need to travel to company headquarters or regional offices, even if they are out-of-state, in order to create sufficient contact with the potential customer.
- **Reassignments within customer companies.** A technology company should make sure its sales and marketing efforts are uniquely targeted to the oil and gas industry, which is fragmented, and relationship-driven. There is rarely a single purchasing department, but instead there are a constantly changing set of decision-makers, often sitting in locations across the US and around the globe. A company must make a commitment to developing and maintaining a good database for companies and individuals, and recognize that change is constant in personnel and planning within the oil and gas industry.
- **Realize it is a small world.** As a result of the frequent job reassignments and company moves within the industry, there are personal relationships that may exist for which a new technology company is unaware. This can result in unpredictable information flow and decision making, and certainly creates the need for discretion and a high level of job performance.

- **Avoid supporting regulatory drivers of the new technology.** Over the last ten years, an ever-increasing number of regulatory requirements have been placed on the oil and gas industry in Pennsylvania. Often, these new requirements benefit vendors with a product or service that helps the industry comply with the new mandates. However, companies have found themselves in difficult positions with their current or potential oil and gas customers when they were found to have pushed new regulations for the purpose of creating a regulatory driver of their business.

Diversify the customer base

The current downturn in upstream industry activity has been a wakeup call to many companies to build in contingencies for such a fluctuating market. Diversification for new technology companies can take many different forms, but should be a part of any comprehensive strategy. For example, companies can diversify across multiple customers within one sector of the industry, diversify across multiple industry segments, and introduce its product in multiple basins (domestic and international) and outside of the oil and gas industry. The exact strategy will differ by product and service, but at the very least, a company should set specific goals for diversification and direct operations and business development efforts to meet those goals.

Stay current on customers' and industry's needs and pressures

There are many forces currently impacting the oil and gas industry, and suppliers to the industry must be attentive to them all. These include commodity prices, regulatory changes, legislative initiatives, shareholder considerations, merger and acquisition activity, human resources challenges, and many others. Many of these issues are raised in customers' investor communications, in local and national media, and other publically accessible documentation. They are often topics of conversation at trade association meetings. Any suppliers to the oil and gas industry should determine a strategy on how at least all customer-facing personnel will stay current on the most important drivers to your part of the business, which can include:

- Executive branch and regulatory actions (state and federal)
- Legislative branch actions (state and federal)
- Local government actions/ordinances (county and municipal)
- Key judicial decisions (various courts within the Commonwealth)
- Public reaction to company activity.

Customers will certainly notice and appreciate the fact that their suppliers fully understand the context in which any new technology will be deployed.

Recommendations for the SGICC

The SGICC has played a leading role in fostering the engagement of Pennsylvania-based technology companies with the dynamic shale industry. In order to maintain the progress made by the organization, especially through the current low commodity price environment, the following recommendations are provided:

- Further expanding the consultation to technology companies in order to improve their presentation capabilities and clarify the value proposition to their oil and gas industry customers;
- Continue the networking services to connect technology companies with sources of capital to accelerate their growth; further expand networking opportunities with sources of private capital;
- Further diversify SGICC's engagement in the industry by increasing the SGICC's outreach and engagement with midstream and pipeline technologies, and with new uses of natural gas in the Commonwealth and beyond; consider creating distinct programs and service offerings for these growing markets;
- Continue to be a critical source of grant funding for demonstration projects.

APPENDIX A - BENCHMARKING

Best Practices for Adoption of New Technologies in Organizations

Abstract:

The adoption methodologies for four technologies in different industries are analyzed and the best practices for adoption are outlined in this document. This document also summarizes the key learnings from the aforementioned technology adoptions. The Shale Oil & Gas industry may consider utilizing these best practices for effective diffusion of new technologies.

Key best practices from the study:

1. **Justify the benefits** in terms of both cost savings and increase in service quality.
2. **Assess the organizations' readiness** to adopt the technology: The organization needs to have a realistic picture of how the technology can benefit its operations and must be ready to adopt the technology.
3. **Vendor fit**: Choose the right vendor based on the vendor's actual experience, capability and willingness to provide long-term support.
4. **Task-technology fit**: The technology should align with the task that the organization is trying to accomplish. This fit must be gauged periodically to account for any divergence in the tasks. The organization must choose the appropriate medium to use the technology. For example, a new software technology might only be as effective as the hardware hosting it.
5. **Ease of use**: The capabilities of the end user to learn and use the technology must be taken into account while designing/selecting the new technology.
6. **Top management support**: Top management's support is essential as the engineering department alone may be ineffective in influencing other units, which make use of the technology.
7. **Policy compatibility /dynamic impact**: The organization must ensure that the existing policies do not lead to dissatisfaction among employees.
8. **Formal training**: Formal training, including perhaps an easily comprehensible operating manual, is important for quick acceptance by end users.
9. **Periodic review**: Periodic reviews keep track of improvements in or obstacles to the production process and encourage continuous improvement.
10. **Safety**: New technology must be sourced from vendors who understand how any hazards will impact company operations and be integrated into existing safety programs and protocols. Adequate training to handle the device safely under different operating conditions is essential.

1.0 Introduction

The methodologies for adoption of RFID in manufacturing industry, mobile devices in the logistics and supply chain industry, cloud computing in manufacturing industry, and big data in retail industry were analyzed with the help of scholarly work and text books (mentioned under references). The key factors influencing the adoption and the best practices followed by successful organizations for adoption are as follows.

2.0 Adoption of RFID in Manufacturing

Significant factors that affect the adoption of RFID by organizations:

1. **Compatibility** (technological, hardware, software): The compatibility factor is important because adopting companies would want to integrate the technology into the existing infrastructure and would further want to use it within their supply chain in cooperation with suppliers and customers.
2. **Costs**: Costs are initial costs of implementation (hardware components, system integration and customization) of a RFID system and running expenses (example: transponders).
3. **Complexity** of the technology and its implementation: A RFID system is much more complex than a barcode system. Many factors do influence the system and there is no one-fits-all solution. So every implementation needs to be customized.
4. **Performance**: No company would like to replace an existing system with a technology that is not able to provide similar or better performance than the existing or an alternative system.
5. **Top management support**: The adoption of a new technology like RFID needs to be supported by the top management because of its cross-functional characteristic. The IT department of a company does not have the authority to convince other units of the benefits of a new technology whose adoption is fundamentally necessary for the company.

BEST PRACTICES:

1. **Vendor selection**: Choose the right technology vendor based on the vendor's actual experience and capability in RFID implementation.
2. **Justify the benefits**: in terms of both cost savings and increase in service quality.
3. **Clear objectives and expectations**: An organization should not have unrealistic expectations from a new system, but should have a good understanding of RFID technology functionalities and investigate how these functionalities could enhance organizational performance.
4. **Obtain users' acceptance**: The creation of business value from new technology depends very much on users' acceptance. If the organization's members are not comfortable with using a new technology such as RFID, then introducing this technology and changing the business process will be more difficult. Keeping the operation simple and **providing adequate training to users**, considering the **capability of potential** users before system's design and delivery are important to obtain users' acceptance. In addition, starting with a **small-scale test run** of the usability and functionality of the new system will help to gain initial user acceptance.
5. **Conduct periodic operational review meetings**: Periodic reviews keep track of

improvements in or obstacles to the production process and encourage continuous improvement.

6. **Obtain top management support:** Securing the support of top management will lead to better access to information and resources, and obtain an organization-level user support.
7. **Adopt appropriate policies:** Some users are more likely to tamper with the systems if they realize that their salaries decrease due to the introduction of RFID. Appropriate policy, which pays the users based on a per piece basis might be a good idea.

3.0 Adoption of Mobile Technologies in Logistics & Supply Chain

Factors affecting the adoption:

1. **Compatibility** (technological, hardware, software): The mobile technology sometimes might not integrate well with the systems already in place.
2. **Costs:** The cost of the software app not only depends on software development but also depends on the hardware needed to host it.
3. **Ease of use:** Many end users might not be well-versed with the usage of a smartphone.
4. **Trainings:** The vendors who build these small apps might not always be equipped to provide formal trainings and long-term support.
5. **Top management support:** The IT department of a company does not have the authority to convince other units of the benefits of a new technology. Top management's influence might be essential in this case.
6. **Safety:** Constant charging, moisture, heat and pressure due to mobility can cause the battery operated mobile device to explode, which may cause severe injuries and in some cases even death.

BEST PRACTICES:

1. **Task-technology fit:** A task effectively supported by mobile technologies should be simple and structured, such as operational tasks.
2. **Ease of use:** A mobile application must emphasize easy information access and notification, and try to avoid inputting and processing data which inhibits a mobile worker from adopting this mobile application.
3. **Appropriate trainings:** Formal operational trainings and an easily understood manual will benefit a user to quickly accept a mobile application.
4. **Manage expectations:** It might take a while before the users start using the technology with comfort.
5. **Choose an appropriate hardware device:** The choices depend on the main functions that a mobile application provides. If the mobile application requires making database calls and inputting data, a mobile device has to be a smart phone with a touch screen and a smart pen.

6. **Safety:** Active components such as batteries must be sourced from reliable vendors. Timely maintenance check and training to handle the device properly, under different operating conditions, are very much essential.

4.0 Adoption of Cloud computing in Manufacturing

Today manufacturing may not survive without the support of Computer-Aided capabilities and Information Technology. Cloud technology can improve the environment of product design, manufacturing process management, enterprise resource planning, and manufacturing resource management by providing a globally optimized solution. Also, cloud technology is easy to learn and use.

Factors affecting the adoption:

1. **Security:** Since the organization does not always own the servers on which the applications are hosted, cloud computing poses security issues.
2. **Cost:** Cloud computing is effective only for small and medium sized applications, but for large projects the costs are simply too high.
3. **Service availability:** Since the cloud is merely a service that the service provider offers many clients and is not owned by the client-organization, availability becomes an issue.
4. **Compliance:** Certain data or applications are confidential to the organization. The legal team might not support the idea of hosting confidential information outside the organization's control.
5. **Perceived usefulness:** The top management may fail to recognize Cloud as a strategic technology that has long-term benefits.
6. **Perceived ease of use:** Certain organizations might perceive cloud computing as a complex technology which is difficult to use.

BEST PRACTICES:

1. **Perform Cloud readiness assessment:** Moving applications to cloud can be complex. An organization needs to assess itself in terms of business alignment with cloud strategy, organizational readiness for change, infrastructure readiness, applications' readiness. The organization needs to identify, screen, and categorize these applications.
2. **Vendor selection:** Choosing the most suitable cloud service provider (CSP) with experience in providing similar services is important. Effectively manage relationship with the CSP.
3. **Top management influence and employee buy-in:** technology adoption's success depends on the knowledge, skills, and participation of the management and employees. It also depends on how the top management perceives the technology (success rate is higher if the management perceives the technology as a strategic partner).
4. **Establish an implementation strategy and allocate a dedicated project team** for rolling out and managing the transition of specific applications to cloud.
5. **Review:** Regularly review both the cloud services by the cloud service provider (CSP) as well as the cloud service requirements since frequent divergence between organizations' realized and intended IT strategies might be possible.

5.0 Adoption of Big Data in Retail

Market Research is generally used to grow the business. Big Data as opposed to Market Research is used to drive operational efficiencies in business. However, Big Data is still in its initial stages and hence there are many challenges for its adoption.

Factors affecting adoption:

1. **Interoperability:** Organizations have already invested in business intelligence to develop solutions. Integrating Big Data solutions with existing systems and BI with precision, is quite difficult.
2. **Manageability:** Managing a big cluster of hundreds of nodes poses problem related to infrastructure management. Though different vendors provide different support for monitoring, management and recovery of big clusters, a complete solution is difficult to find.
3. **Security:** Data, while getting generated and being accessed, need to be controlled properly in enterprise context. Otherwise that can lead to compliance issues, unintentional data loss, exposure of data to non-legitimate users, and accumulation of data without the right quality.
4. **Maturity:** Complexity of the Big Data poses challenges in selecting right solution and vendors. Given multiple technology solutions and vendors mushrooming every month, it is difficult to settle on a technology choice and the partner.
5. **Development Scalability and Maintainability:** Lack of IDEs, Testing, Deployment and Administration tools (which suit the Big Data scale) make the development phase of Big Data slow and also pose challenges in maintenance.
6. **Reusability:** Big Data adoption needs proper data modeling and unified Big Data Architecture across structured and unstructured data elements with huge volumes. Otherwise the reusability of the solution at enterprise level cannot be achieved.

BEST PRACTICES:

1. **Use a continuous monitoring and improvement methodology:** Adopt 3-legged Big Data environment strategy in an agile environment. The first leg is for the Developer community which can be a small scale cluster with very limited data volume. The second environment is for the analyst community which is also a smaller cluster but big enough to prove the use cases with reasonable volume and variety of data. The third one is for the business community which is large scale cluster and will potentially grow over period. The developer builds the use case (with a reasonable set of flexibilities) for research. The researchers try out various options of the use case and decide on the best analytics model and release the same to the business users in the same environment. The business users try the use case/models in research environment and either accepts it or rejects the same. In case of acceptance the use case gets deployed to the business environment. In case of rejection the researchers further tune it either himself with the given flexibility or reaches out to the developer for more flexibilities. This strategy ensures that all key contributors can work in a collaborative way.

2. **Hide the implementation details with an abstraction layer (ease of use):** To run with a 3-legged environments with Big Data next best practice is to build abstraction layer that hides the way in which the technology is implemented. This will help solving the key challenges like Security, Technology Maturity, Interoperability, and developers' skill issues leading to Development Scalability and Maintainability challenges.
3. **Standardize the way you manage the environments (ease of managing):** create an integrated Big Data workbench and the process around the same to manage the 3-legged environments and abstractions. Building the use case in development environment, then passing the same to researcher and eventually deploying the same to production for business users should be seamless and one click affair. This step can help in addressing the challenges like Manageability, Development, Scalability and Maintainability.
4. **Vendor selection:** Selecting a vendor complying with the Open Core model is healthy practice observed by most of the organizations. Also, choosing the vendor with relevant experience and capabilities is important. Constant improvement in Big Data's features by the vendor also contributes to quick adoption.

6.0 Conclusion

Technology adoption is not a linear process. New technologies will not be fully adopted by an industry in all processes at a single point in time. Typically the diffusion of the new technology is gradual. Diffusion rates differ across industries, regions and countries and also across technologies (Stoneman 2002). The best practices mentioned in this document might help industries to effectively adopt a new technology.

REFERENCES:

Rogers, E.M. "Diffusion of Innovations", 2003

Ngai E, Chau D, Poon J, Chan A, Chan B, Wu W. "Implementing an RFID-based manufacturing process management system: Lessons learned and success factors", 2012

Bradfort, M. and Florin, J. "Examining the role of innovation diffusion factors on the implementation success of enterprise resource planning systems", 2003

Matta, V. and Moberg, C. "The development of a research agenda for RFID adoption and effectiveness in supply chains", 2006

Sharma, A.; Citurs, A. and Konsynski, B. "Strategic and institutional perspectives in the adoption and early integration of Radio Frequency Identification (RFID)", 2007

Lu, B.H.; Bateman, R.J. and Cheng, K. "RFID enabled manufacturing: Fundamentals, methodology and applications", 2006

Fichman, R.G. "Going beyond the dominant paradigm for information technology innovation

research: Emerging concepts and methods”, 2004

E.W.T. Ngai, D.C.K. Chau, J.K.L. Poon, A.Y.M. Chan, B.C.M. Chan, W.W.S. Wu, “Implementing an RFID-based manufacturing process management system: Lessons learned and success factors”, 2006

Davis F. “Perceived usefulness, perceived ease of use, and user acceptance of information technology”

Gebauer J, Shaw M J. “Success factors and impacts of mobile business applications: Results from a mobile eprocurement study”

Gribbins M. “Wireless B2B mobile commerce: A study on the usability, acceptance, and process fit”

Venkatesh V, Morris M G. “User acceptance of information technology”, 2003

Van Akkeren J, Harker K. “Mobile data technologies and small business adoption and diffusion”, 2003

Alanen J, Autio E. “Mobile business services: A strategic perspective”, 2003

Weidong Li, Jörn Mehnen, “Cloud Manufacturing: Distributed Computing Technologies for Global and Sustainable Manufacturing”

<http://www.salesforce.com/solutions/manufacturing/>

Christian, B., Boncz, P., Brodie, M.L., and Erling, O. 2011. “The Meaningful Use of Big Data: Four Perspectives – Four Challenges,” 2011

IBM BigInsights. <http://www-03.ibm.com/software/products/en/infobiginteedit>

Cloudera, Cloudera Enterprise Edition Release Notes

<http://www.cloudera.com/content/cloudera/en/documentation/archives/cloudera-manager-4/v4-5-2/Cloudera-Manager-Enterprise-Edition-4.5.x-Release-Notes/Cloudera-Manager-Enterprise-Edition-4.html>

Foley, M. and Shah, H. “Deploying and Managing Hadoop Clusters with Ambari,” 2012

Cynthia M. Saracco, Daniel Kikuchi, and Thomas Friedrich, “Developing, publishing, and deploying your first Big Data application with InfoSphere BigInsights”

<http://www.ibm.com/developerworks/data/library/techarticle/dm-1209bigdatbiginsights/index.html?ca=dat>

John Gantz and David Reinsel, “THE DIGITAL UNIVERSE IN 2020: Big Data, Bigger Digital Shadows, and Biggest Growth in the Far East”

<http://www.emc.com/collateral/analyst-reports/idc-the-digital-universe-in-2020.pdf>

Stonebraker, M., "Big Data, Big Problems," 2011

Liikanen, Jukka & Stoneman, Paul & Toivanen, Otto, "Intergenerational Effects in the Diffusion of New Technology: Case of Mobile Phones," 2002

Casio computer co., ltd.; "electronic device" in patent application approval process. (2015).
Politics & Government Week 1186. Retrieved from
<http://search.proquest.com/docview/1682234435?accountid=13158>

http://www.saftbatteries.com/force_download/CP_52_14_Eng.pdf

<https://www.osha.gov/SLTC/poweredinustrialtrucks/hazmat.html>

https://www.worksafe.vic.gov.au/__data/assets/pdf_file/0018/44343/Alert-Battery-explosionsv3.pdf