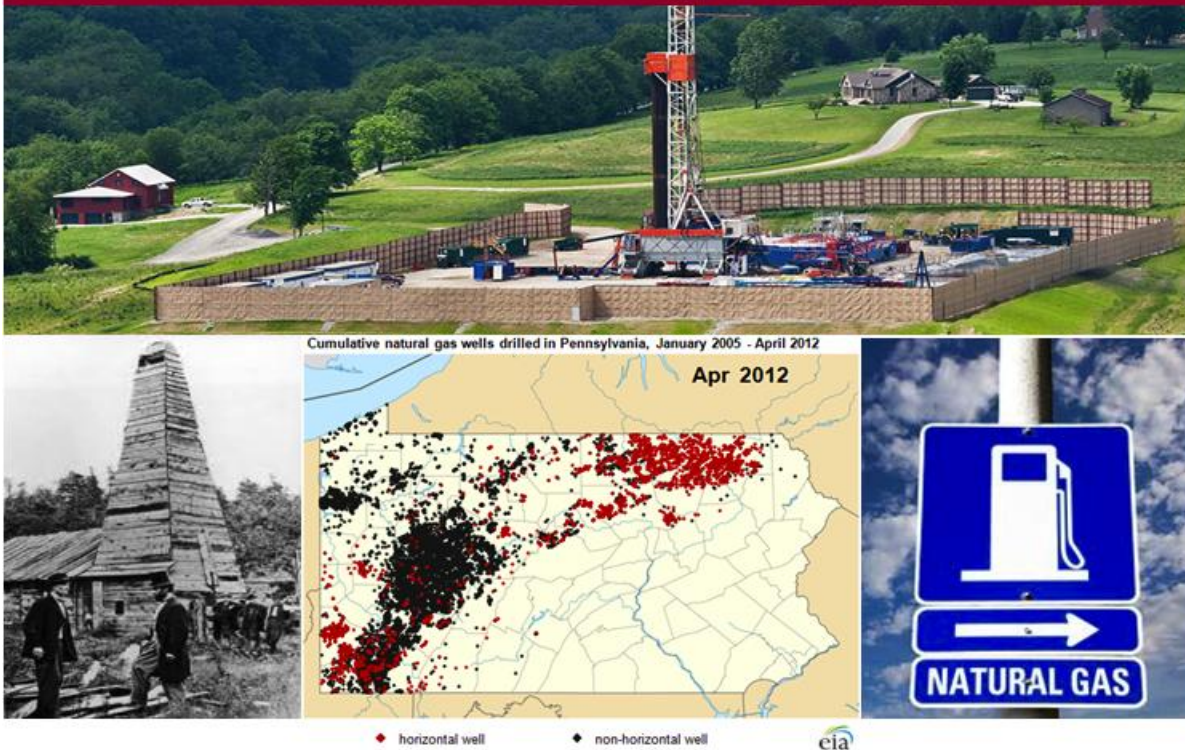




HARVARD  
BUSINESS  
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## Microeconomics of Competitiveness

# The Pennsylvania Gas Cluster



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## Executive Summary

- The state of the U.S. economy is still overshadowed by the latest financial crisis. This crisis had not only tremendous cyclical impact in terms of high unemployment and declining growth rates; it also amplified structural fiscal problems of the U.S. economy due to bank bailouts and lost tax revenues. The U.S. government and its companies and citizens borrowed from the rest of the world to pay for their consumption and investment before the crisis, and they do so today.
- In order to tackle these imbalances the U.S. has to strengthen its competitive position. Recent exploration of shale gas fields in the U.S. and technological developments making these fields exploitable can play a crucial role in this process. This is especially true as shale gas caters to the U.S. economy's strong and growing demand for cheap fossil fuel. Furthermore, shale gas is now pushing the US towards energy independence, an objective that all Presidents since Richard Nixon have been trying to meet.
- In Pennsylvania a set of industries and state institutions seized the opportunity capitalizing on the current macroeconomic situation and on the Marcellus Shale Gas Field. Focusing on this endowment they developed a cluster providing higher-than-average wages to their employees and constituents. This way they upgraded the whole region economically leveraging all parts of the diamond.
- In order to not to lose their competitive advantage and to further deepen and upgrade the cluster, companies and state officials now have to collaborate. They should especially abandon trade barriers and increase the efficiency of investment processes by reducing bureaucracy and increasing transparency with respect to information about buyers and sellers.

# 1. Introduction

A couple of years ago, fossil energy sources were hardly expected to have any kind of bright future. The future was expected to be green with solar power and wind energy taking the lead. But now, the future turns out to remain dominated by fossil fuels. The “shale gas revolution” not only pushes energy costs for the U.S.’ domestic industries to all-time lows, unthinkable a couple of years ago; it also turns some long held beliefs about geopolitical certainties upside down. Suddenly, energy self-sufficiency does not seem to be utopian anymore but a realistic scenario for decades to come. Shale gas exploration in Pennsylvania has put the U.S. to the forefront of this development. Applying the diamond model this report explores the reasons behind this success story in Pennsylvania. Based on these findings it lays out recommendations to further upgrade the maturing cluster in order to strengthen the region’s competitiveness and to maintain the cluster’s frontrunner position.

We begin with 1) an analysis of the U.S. economy and 2) its competitive position as compared to the rest of the world with a special focus on the role of energy. We do so in order to put the natural gas bonanza in Pennsylvania in a broader macroeconomic context. Then we 3) zoom in to the state level focusing on the Pennsylvania economy that is the Marcellus Shale gas field’s major regional beneficiary. Building on these macroeconomic analyses we describe 4) the Pennsylvania Natural Gas cluster’s key drivers applying a detailed diamond analysis. Finally, building on this analysis we 5) lay out our recommendations.

## 2. Overview of the U.S.

Before turning to current developments in Pennsylvania’s energy sector we offer an overview of U.S. history and contemporary economic conditions to establish a macroeconomic context for our regional analysis. In this chapter we basically argue that the shale gas revolution marks a historic shift, as it not only renders the U.S. potentially self-sufficient in terms of energy but that it is also capable to alleviate some of the countries very economic and fiscal problems.

## 2.1. The rise to the Global Economic Super Power - A Brief History of the U.S.

Starting in the 19<sup>th</sup> century the United States experienced an industrial revolution and economic expansion that by 1903 left it with the world's largest economy by GDP and the largest GDP per capita.<sup>1</sup>

Victories by US-led coalitions in the First and Second World Wars resulted in a massive expansion of U.S. military power and in a shift of its foreign policy toward internationalism. The Cold War period, which was defined by diplomatic and military tensions with the Soviet Union, the People's Republic of China, and other Soviet-allied nations, witnessed the United States exercise hegemonic neoliberal international economic leadership and proliferate military commitments across the globe. Domestically, the United States experienced significant socio-cultural change as various social reform movements achieved political empowerment.

### **US Demographics and social development:**

- US resident population: 315.4 million (3rd largest population among nations in the world)
- Non-Hispanic whites 64%, Hispanics 16%, blacks 13%, Asians 5%
- > 50% Christian Protestants, 24% with Christian Catholicism, 2% with Judaism, 16% unaffiliated
- UN Human Development Index: 4th
- Average life expectancy: 78.5 years
- Average amount of schooling: 12.4 years
- UN Human Development Index: 4th

Sources: Pew Forum on Religion and Public Life, United States Census Bureau

After the end of the Cold War and into the early 21st century of our days, the United States finds itself regarded as the world's sole superpower, but the country's dominance is challenged economically due to the ascendancy of the European Union and China and militarily from the rise of asymmetric threats such as global terrorism networks. Furthermore, the country's economy suffers from the recent financial crisis that exacerbated existing structural problems in its economy and political sphere.

## 2.2. A Diverse Geography Provides Rich Endowments

The Pacific and Atlantic Oceans bound the contiguous 48 states of the US on the West and East, and the countries of Canada and Mexico bound them to the North and South. The state of Alaska, the largest American state by total area, is a part of the North American continent and shares a border with Canada.

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<sup>1</sup> Maddison 2010; JEC 1999

The state of Hawaii is an island chain in the Pacific Ocean. The United States occupies a total area of more than 9.8 million square kilometers making it the third largest country in the world by total area.<sup>2</sup>

Despite the large territory, the U.S.' regions are well connected within the country and with the outside world due to their well-developed infrastructure. It has a 100% electrification rate, a 65% broadband internet adoption rate, and it is ranked 13th in average internet connection speeds.<sup>3</sup> It has the largest number of airports (over 15,000), the most extensive railway and roadway networks (225 thousand kilometers; 6.5 million kilometers) and the ports of Los Angeles, Long Beach, and New York/New Jersey that are the 16th, 21st, and 25th busiest in the world by container volume.<sup>4</sup> These hubs are facilitate the export of the U.S.' abundant endowment of natural resources including the world's largest coal reserves (491 billion short tons), the 3rd largest reserves of rare earth minerals (13 million metric tons), the 4th largest copper reserves (39 million metric tons), and the 5th largest proven reserves of natural gas.<sup>5</sup>

### 2.3. The U.S. System of Government is Highly Developed, but is in a Gridlock

The United States has a constitutional federal republican form of democratic government. Government in the U.S. divides power among executive, legislative, and judicial branches at the national, state, and local levels.

For most of the post-World War II era, a politically divided government has led the U.S., with left-of-center Democrats and right-of-center Republicans controlling different branches of the federal government simultaneously. Democrats and Republicans have repeatedly traded control of the US Presidency and of the two houses of the US Congress over the last twenty years. The current U.S. President is Barack Obama, a Democrat. He is the nation's first US president to be a member of a racial or ethnic minority. Obama began his term of office in January 2009, at the peak of the global financial crisis, with high approval ratings and strong Democratic control of Congress. Obama successfully enacted through major parts of his domestic reform agenda, including a large economic stimulus

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<sup>2</sup> CIA 2013

<sup>3</sup> UNDP 2012; Pew Internet 2012; Byford 2012

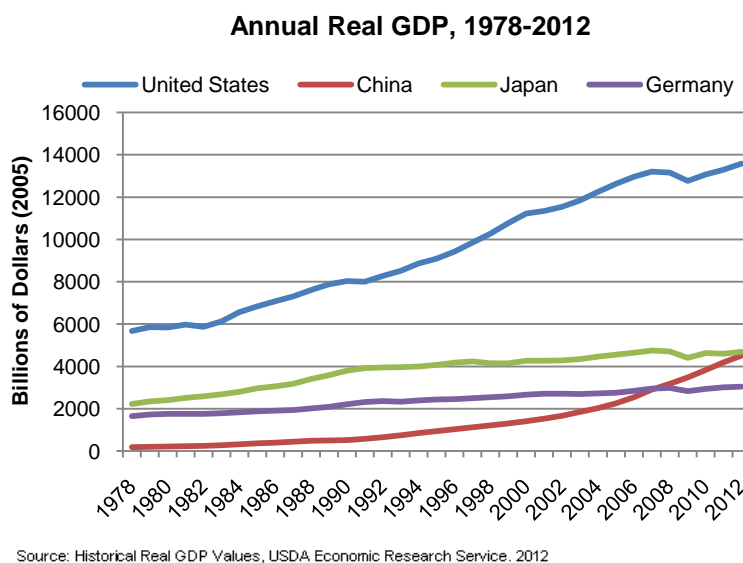
<sup>4</sup> CIA 2013; World Shipping Council 2013;

<sup>5</sup> *ibid*

package to fight economic downturn, as well as an expensive universal health insurance coverage law. Sweeping electoral defeat of the Democratic Party in the 2010 Congressional elections empowered congressional Republicans whose combative relations with President Obama culminated in an August 2011 political standoff over the raising of the US debt ceiling, which led rating agencies to downgrade the US credit rating below the AAA level for the first time in history. Obama was reelected to a second four-year term in November 2012.

## 2.4. The Recent Crisis has Worsened the U.S.' Fiscal Position

The U.S. has the world's largest economy with a gross domestic product (at purchasing power parity) of \$15.66 trillion and a real GDP growth rate of 2.2 percent in 2012 which was an improvement on the slight 1.8% real GDP growth from 2010 to 2011. By super-sector, its GDP was comprised of 79.7% services, 19.1% industry, and 1.2% agriculture.



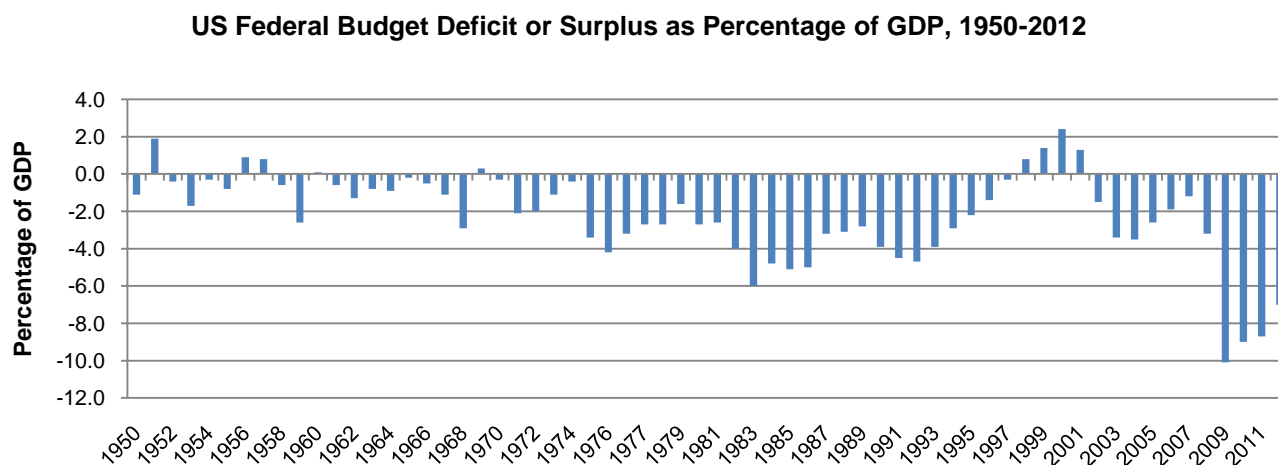
The estimated GDP per capita (at PPP) in the United States in 2012 is \$49,800, which ranks 12<sup>th</sup>. US exports totaled \$1.612 trillion (2<sup>nd</sup> largest globally) and its imports totaled \$2.357 trillion (world's largest). Additionally, as of 2012, the United States ranked second in the world in patent filings, both in terms of the total number filed in US patent offices (503,582) and global patent filing originating in the US (432,298).

Despite signs of recovery and growth the US has not returned to pre-crisis labor-market performance. Despite rising employment growth and falling unemployment, the US, whose labor force of 154.9 million is the world's third largest behind China and India, is still estimated to have a 7.5%

unemployment rate as of May 2013.<sup>6</sup> In April 2013, the US labor participation rate reached a 34-year low of 63.3%.<sup>7</sup> A similar trend is observable in the housing market: Despite residential properties prices going up again, many unsold and foreclosed properties remain what helps to depress housing prices.

In summary, the American post-recession economic recovery has shown signs of acceleration since 2012 but is still struggling with the consequences of the recent financial crisis.<sup>8</sup> Since crises go along with less revenue from taxes and higher government expenditures for stimulus packages, bailouts, and social security fiscal implications of the recent crisis worsened structural problems of the U.S.' fiscal position. U.S. budget deficits remain large although they start to decline from their 2009 peak.<sup>9</sup>

These deficits contribute to high debt levels from pre-crisis times. The Congressional Budget Office projects that the US budget deficit will be \$845B in 2013, which will be 5.3% of GDP, the lowest percentage since 2008, but still historically high.<sup>10</sup> The largest contributing factor to the budget deficit is federal entitlement spending under the Social Security and Medicare programs.<sup>11</sup> Due to the ongoing increase of public debt, the CBO projects that total federal debt will reach 76% of GDP by the end of 2013.



Source: White House Office of Management and Budget:

<sup>6</sup> BLS 2013; Unemployment figure cited is the BLS's U-3 rate. The U-6 rate of total labor unemployment, discouragement, and underutilization is 13.9%.

<sup>7</sup> Davidson 2013

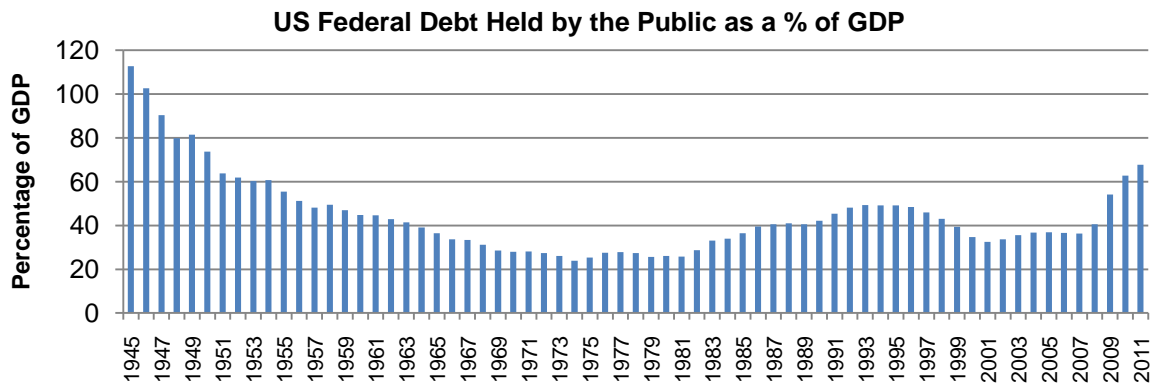
<sup>8</sup> "OECD Economic Surveys: United States," Organization of Economic Co-operation and Development, June 2012.

<sup>9</sup> "OECD Economic Surveys: United States," Organization of Economic Co-operation and Development, June 2012.

<sup>10</sup> <http://www.cbo.gov/publication/43907>

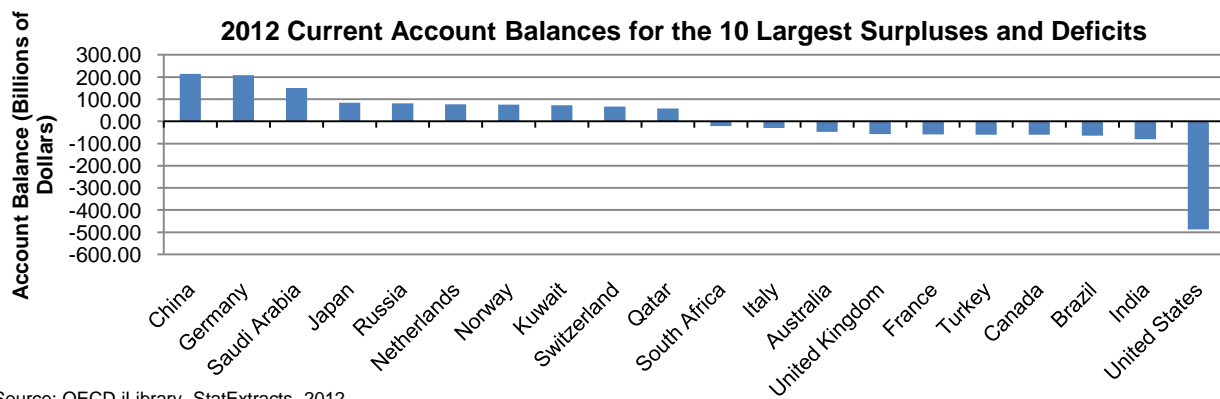
<sup>11</sup> Social Security Administration 2012





Source: US Government Accountability Office

The U.S. has financed these deficits through borrowing from the rest of the world as reflected in huge balance of trade deficits that amounted to \$539.5 billion dollars in 2012.<sup>12</sup> Since the enactment of the North American Free Trade Agreement in 1993, the average annual growth rate of the US trade deficit has been nearly 13%. This way the U.S. became the country with the by far largest BOP-deficit as opposed to surplus-economies like China and Germany. In 2012, the largest NAICS sub-sectors, by percentage, for exports was “transportation equipment” at 16% of total exports, “computer and electronic products” (13.2%), “chemicals” (12.8%), non-electrical “machinery” (10.7%), and “petroleum and coal products” (7.2%).<sup>13</sup> As of 2010, the top five US exported goods and services clusters, by dollar value, were hospitality and tourism (\$134.8 billion), automotive (\$101.8 billion), business services (\$98.5 billion), agricultural products (\$95.5 billion), and financial services (\$81.0 billion).<sup>14</sup>



Source: OECD iLibrary, StatExtracts, 2012

<sup>12</sup> US Census Bureau 2013

<sup>13</sup> US Census Bureau 2012

<sup>14</sup> Porter and Bryden 2012

## 2.5. Competitiveness Analysis of the U.S.

In this chapter we apply the diamond framework analysis to evaluate the competitive conditions in the U.S. economy and to illustrate its strengths and weaknesses. The diamond framework decomposes national economic circumstances into “factor conditions,” “demand conditions,” “context for strategy and rivalry,” and “related and supporting industries.

### **The U.S. Diamond**

*(See Appendix I for an image of the US Diamond diagram)*

The United States has many positive factor conditions. There is a very large and well-educated labor force that is highly skills-diverse and that in 2010 had the 3<sup>rd</sup> largest labor productivity as measured by output and the 5<sup>th</sup> highest labor productivity per hour.<sup>15</sup> Additionally, financial capital is easily available, borrowing rates are low due to Federal Reserve zero-interest rate policies and there are many sources of venture capital. In addition, the U.S. has very highly-developed capital markets. The New York Stock Exchange, the NASDAQ, and the NYMEX – all based in the US – are among the largest stock and commodity exchanges in the world.<sup>16</sup> Extensive physical infrastructure systems in the United States are another important positive factor condition. In particular, transportation, water and sewage management, electricity, and information and communications infrastructure systems provide support for diverse business needs virtually everywhere in the country. However, U.S. factor conditions also feature some negative points. Infrastructure, although positive in its extensiveness, is aging and declining in reliability and quality of use. The American Society of Civil Engineers’ annual report card awarded the U.S. an overall “D+” grade for the quality of its infrastructure. Another negative factor condition is the highly fractured and complex administrative and regulatory system for businesses. They often must traverse overly-long and byzantine regulatory processes at multiple levels of government in

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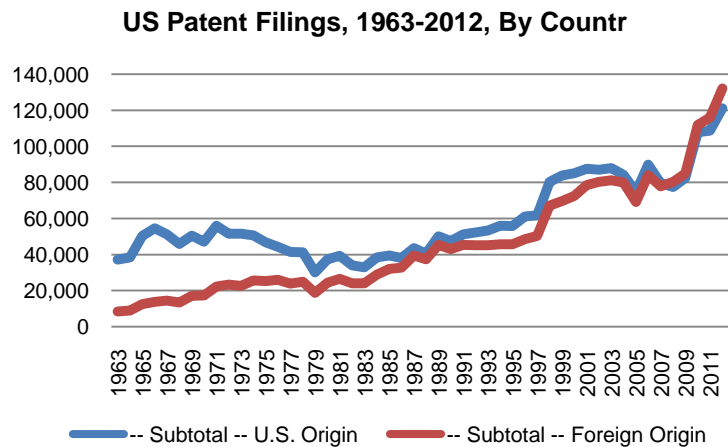
<sup>15</sup> “2011 International Comparison of Labor Productivity,” Japan Productivity Center, February 16, 2012. Available at: [http://www.jpc-net.jp/eng/research/2012\\_02.html](http://www.jpc-net.jp/eng/research/2012_02.html)

<sup>16</sup> “2012 WFE Market Highlights,” World Federation of Exchanges, January 2013. Available at: <http://www.world-exchanges.org/files/statistics/pdf/2012%20WFE%20Market%20Highlights.pdf>; “The World’s Commodity Exchanges: Past, Present, and Future,” UNCTAD and the Swiss Futures and Options Association, 2006. Available at: [http://r0.unctad.org/infocomm/comm\\_docs/docs/meetings/burg/enTheWor835rtl.pdf](http://r0.unctad.org/infocomm/comm_docs/docs/meetings/burg/enTheWor835rtl.pdf)

order to implement projects.

The demand conditions picture is also mixed. The US is home to the world's largest consumer market with \$9.43 trillion of household final consumption expenditures in 2011.<sup>17</sup> The US also has very high levels of public sector demand. In 2011, government final expenditures in the US totaled \$2.14 trillion.<sup>18</sup> Additionally, regulations that

enforce high standards for product quality, safety, and environmental impact trigger sophisticated demand. Also, due to the fact that many multinational companies are located in the U.S., domestic supplier relationships impose higher product quality and product innovation requirements. On the negative side due to



a long-term decline in real GDP growth since the 1990s household final consumption expenditure in the US is stagnating. Moreover, economic pessimism due to the financial crisis and ensuing recession has driven an increase in household savings behavior limiting consumption.<sup>19</sup>

The massive scale of inter-firm competition defines the US context for strategy and rivalry. The huge U.S. GDP is an indicator of the highly productive U.S. private sector. The country is also home to a larger percentage of the world's largest companies than other nations. For example, as of 2012, the U.S. is the location of the corporate headquarters for 132 of the Fortune Global 500.<sup>20</sup> This is reinforced by a vigorous entrepreneurial culture, with 6.75 percent of existing businesses being new businesses.<sup>21</sup>

<sup>17</sup> National Accounts Main Aggregates Database, United Nations Statistics Division. Available at: [unstats.un.org/unsd/snaama/introduction.asp](http://unstats.un.org/unsd/snaama/introduction.asp)

<sup>18</sup> National Accounts Main Aggregates Database, United Nations Statistics Division. Available at: [unstats.un.org/unsd/snaama/introduction.asp](http://unstats.un.org/unsd/snaama/introduction.asp)

<sup>19</sup> "Personal Savings Rate" chart, Federal Reserve Bank of St. Louis, March 2013. Available at: <http://research.stlouisfed.org/fred2/series/PSAVERT/>

<sup>20</sup> Chua, Jean, "China Overtakes Japan in Fortune Global 500 Companies for First Time," CNBC.com, July 9, 2012. Available at: <http://www.cnbc.com/id/48128996>

<sup>21</sup> "Entrepreneurship at a Glance, 2012" OECD, 2012. Available at: [http://www.oecd-ilibrary.org/sites/entrepreneur\\_aag-2012-en/02/02/01/index.html?jsessionid=dc9s1oc18pjh.x-oecd-live-](http://www.oecd-ilibrary.org/sites/entrepreneur_aag-2012-en/02/02/01/index.html?jsessionid=dc9s1oc18pjh.x-oecd-live-)

The World Bank's "Doing Business" index ranks the US 4<sup>th</sup> for its business environment. It is also ranked 7<sup>th</sup> for competition in the World Economic Forum's Global Competitiveness Index. Additionally, the U.S. is a highly open economy with most sectors exposed to foreign competition. Inter alia for these reasons the Heritage Foundation ranks the US 10<sup>th</sup> in terms of economic freedom.<sup>22</sup> Additionally, the U.S.' intellectual property protection institutions are highly developed and well enforced. The US also shines as an example of flexible labor markets with a ranking of 6 in that category in the Global Competitiveness Index. The major negative aspect within the context of strategy and rivalry in the U.S. is taxation, with corporate tax rates exceeding those of most peer nations.

In the U.S., conditions pertaining to related and supporting industries for business activity have multiple positives. One positive is that economic cluster development exists for multiple traded sectors and industries and in many different regions and metropolitan areas. In addition, innovation and R&D continue to be strong. The U.S. benefits from comparatively high-levels of public and private research and development investment much of which is channeled through US research universities. The US also continues to be a global leader in patent filings. US-based suppliers often compete globally, meaning that they tend to be reliable and capable of supporting their industrial partners through competition in global markets. Negatively, institutions for collaboration in the United States are relatively weak in fostering inter-firm collaboration on common technological research and factor development.

## 2.6. The U.S. Economy will Depend on Fossil Fuels for Decades to Come

We finish the U.S. economy's analysis with a brief overview over the structure of its energy consumption. This structure shows that despite some decent growth of renewable energy sources fossil fuels are still by far the major sources of energy. This underlines the current shale gas boom's significance, the more so that gas is the only fossil fuel that is forecast to grow and the more so that the U.S. is the world's second largest energy consumer in absolute terms (only China consumes more) and

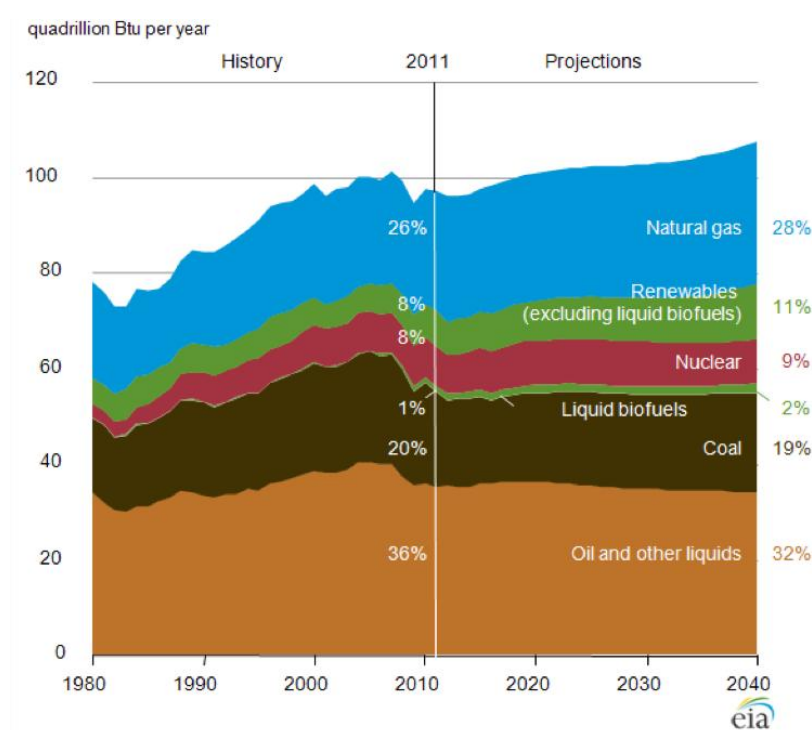
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<sup>22</sup> "United States: Economic Freedom Score," 2013 Index of Economic Freedom, Washington, DC: Heritage Foundation. 2013. p. 451

the seventh largest on a per capita basis. These developments are expected to happen in a similar way all over the world driven by three reasons: Natural gas is available on a large scale since current resources are projected to be sufficient for 250 years;<sup>23</sup> it is affordable as compared to other sources of energy; and it is widely accepted with respect to environmental considerations since gas emits 50% less CO<sub>2</sub> than coal.

### US Primary Energy consumption by fuel



## 3. The rise of Natural Gas in Pennsylvania

The emergence of the natural gas cluster in Pennsylvania is based on natural endowments and new technologies that allowed for their exploitation, but it has also to be seen in the context of the state's competitive environment. This chapter analyses these factors and their interplay.

### 3.1. A brief overview profile of Pennsylvania

Pennsylvania is located in the Northeastern section of the United States and is bordered by the

<sup>23</sup> <http://www.shell.com/global/future-energy/meeting-demand/natural-gas/shell-natural-gas.html>

states of New York, New Jersey, Delaware, Maryland, West Virginia, and Ohio. The US Census Bureau estimates that Pennsylvania has a population of 12.76 million residents as of 2012 which makes it the fifth-largest state. The largest city in Pennsylvania is the City of Philadelphia, which is the 5<sup>th</sup> largest city in the United States largest city by population, and whose metropolitan statistical area (MSA) has the 7<sup>th</sup> largest regional GDP as of 2011.<sup>24</sup> It is followed by the City of Pittsburgh, which is the 61<sup>st</sup> in the US by population, and whose MSA is ranked 22<sup>nd</sup> in the US for regional GDP. Politically, Pennsylvania is a divided state with the governorship, both houses of the state legislature and 13 of 18 Congressional seats under Republican control, but the state's voters have supported Democratic presidential nominees in every national election since 1992.

In 2011, the Pennsylvania economy was the 6<sup>th</sup> largest in America by GDP, but it ranked 28<sup>th</sup> in real GDP per capita. Real GDP growth in Pennsylvania in 2011 was a modest 1.2%. As of March 2013, the unemployment rate was 7.9%, which is slightly above the national unemployment rate. By sector, the Pennsylvania economy is led by education and health services, which is 20% of state nonfarm employment, the trade, transportation, and utilities sector that is 19%, and business and professional services that is 13%.<sup>25</sup> Between 1998 and 2009, the traded clusters with the highest rates of employment growth relative to the national economy included among others lighting and electrical equipment, sporting and recreational goods, medical devices, biopharmaceuticals, tobacco, power generation and transmission, and transportation and logistics. Analysis from the Harvard Business School's Institute for Strategy and Competitiveness indicates that, relative to the U.S. mean, Pennsylvania has fallen behind with below-average values for GDP per capita, labor force participation rate, output per labor force participant and employed worker, and for its growth rate in patented innovations.

The public sector in Pennsylvania is struggling to manage a high level of public sector debt.

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<sup>24</sup> "Economic growth continues across metropolitan areas in 2011,  
[http://www.bea.gov/newsreleases/regional/gdp\\_metro/2013/pdf/gdp\\_metro0213.pdf](http://www.bea.gov/newsreleases/regional/gdp_metro/2013/pdf/gdp_metro0213.pdf)

<sup>25</sup> <http://www.bls.gov/eag/eag.pa.htm>

Whereas the Pennsylvania state budget for fiscal year 2013 was \$27.65 billion, the state government currently has a total outstanding debt of \$142 billion which is \$11,168 per capita. This debt includes unfunded state employees pension liabilities of \$41 billion.<sup>26</sup> The ratings agency Moody's cited the scale of the pension liabilities when it lowered Pennsylvania's bond rating in 2012.

### 3.2. Competitiveness analysis of Pennsylvania's Natural Gas Industry

*(See Appendix II for an image of the Pennsylvania Diamond diagram)*

While economic confidence in Pennsylvania according to Gallup is below US average<sup>27</sup> the natural gas boom is inspiring consumer confidence with 81% of Pennsylvanians surveyed feeling that the gas development makes them feel more optimistic about the future of their communities.<sup>28</sup> This can be considered as an indicator that the shale gas boom is actually improving demand conditions. Especially the chemical industry in Pennsylvania is benefiting from cheap energy supplied by natural gas resources since plastic resins respond well to lower plastic gas feedstock costs.<sup>29</sup> While capital markets in the natural gas industry in Pennsylvania work well focusing on M&A and JV activity with some foreign investors,<sup>30</sup> problems for doing business stem more from political gridlock. This is especially the case for state and local governments arguing over jurisdiction issues with respect to drilling when conflicts arise about control and rights in complex permitting processes.<sup>31</sup> Despite these bureaucratic problems, Pennsylvania can score with a tax code that is more favorable to the code in other states as reflected in Pennsylvania ranking 19<sup>th</sup> in the US state business tax climate index.<sup>32</sup> However, this does not seem to translate into high-end natural gas equipment and knowledge industries emerging in Pennsylvania since much natural gas equipment and knowledge still comes from states like Texas. This implies a weakness

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<sup>26</sup> [http://sunshinereview.org/index.php/Pennsylvania\\_state\\_budget](http://sunshinereview.org/index.php/Pennsylvania_state_budget)

<sup>27</sup> <http://www.gallup.com/poll/160232/states-gains-economic-confidence-2012.aspx>

<sup>28</sup> Willits, Filteau and McLaughlin

<sup>29</sup> American Chemistry, Bokowy, Hatcher and Fritzy Pryor

<sup>30</sup> Futrell

<sup>31</sup> Ruff

<sup>32</sup> Center for Federal Tax Policy

in the Pennsylvania based technical and equipment-manufacturing suppliers.<sup>33</sup> There is also no institute for collaboration (IFC) focusing on cluster building that could lobby for some suppliers relocating to Pennsylvania since industries merely seem to lobby for their own narrow interests.

### 3.3. PA's Long History of Energy Production with Gas Being the New Big Thing

Pennsylvania is one of the major energy producing states in the U.S., ranking 5<sup>th</sup> in total energy production, 2<sup>nd</sup> in electricity, 4<sup>th</sup> in coal and 6<sup>th</sup> in gas production. The state is popularly credited with the world's first commercially successful oil well, drilled in 1859. This success touched off the state's first oil rush and the Petroleum Age. However, Pennsylvania hasn't been considered a primary focus of the oil and gas industry for a long time. Natural gas exploration and development activity in Pennsylvania was relatively steady, with operators drilling a few thousand conventional (vertical) wells annually. This changed dramatically as a shift towards new production technology allows gas resources to be developed from shale reservoirs that previously were out of reach – leading the transition to the Age of Gas. With the shift to horizontal wells, Pennsylvania's natural gas production has risen almost exponentially since 2008.

### 3.4. New technologies allowed the exploitation of shale gas

Shales are fine-grained sedimentary rocks that can be rich resources of petroleum and natural gas. Shale gas refers to natural gas that is trapped within these formations. Over the recent decade, the combination of horizontal drilling and hydraulic fracturing has allowed access to large volumes of shale gas that were previously uneconomical to produce.

An enormous amount and variety of inputs from various sources come together for one drill site. The value chain begins with the site preparation and continues all the way through postproduction. Before drilling, transport and power infrastructure as well as security

#### **Historical facts:**

The new technologies became possible due to Federal Government R&D-investments in the 1970s. They led to the development of horizontal drilling, micro seismic imaging, and hydraulic fracturing methods.

#### **Business facts:**

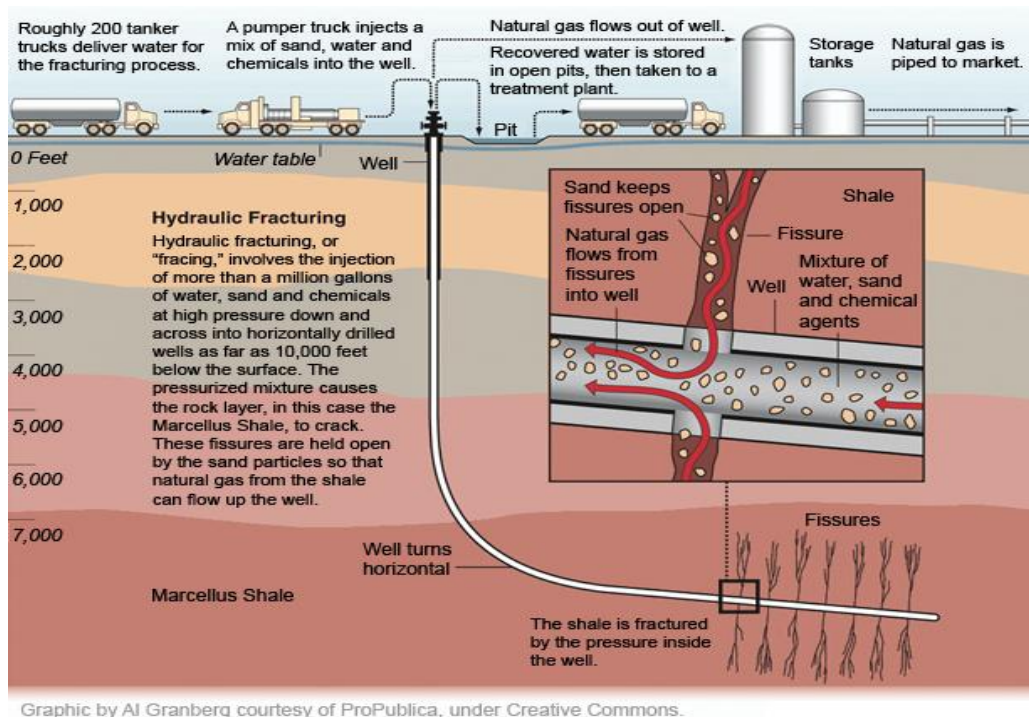
- Minimum land required by law: 640 acres per production unit (well)
- Signing bonus: \$1.7M to \$3.2M/unit
- Average royalty: 12.5% (in 2011 landowners in PA were paid \$400M)
- Total estimated cost per well: \$7.7M
- One mile of gathering pipeline: \$1M

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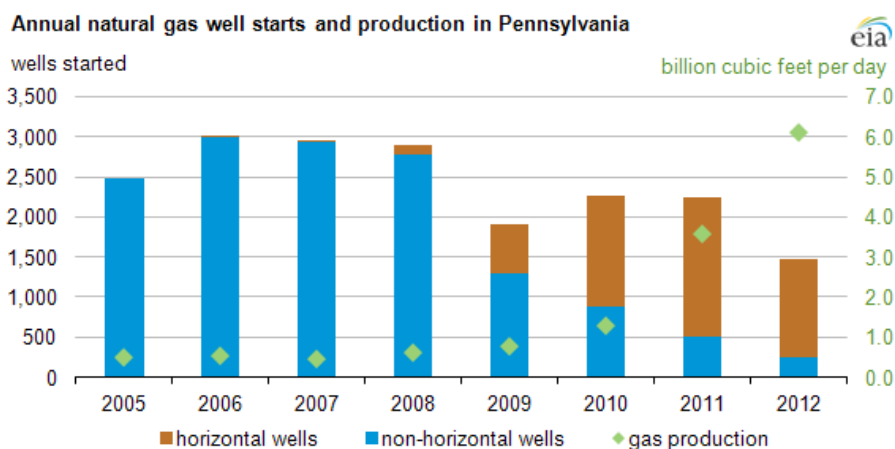
<sup>33</sup> Fehling



measures need to be put in place. All water used throughout the process either needs to be piped or trucked on-site. After vertical drilling is complete, concrete filler is put in place to maintain the integrity of the hole, protecting both the well itself and the environment that it traverses. Then the horizontal drilling process starts and completes with the concrete. Next is the shale fracturing process in which a fracturing fluid is pumped down the well bore to crack open the reservoir and allow for gas to flow out of the well. The graphic below shows the vertical and horizontal drilling as well as fracturing and production processes.



In Pennsylvania this new technology set off a boom in drilling and exploitation with horizontal drilling becoming the industry's major growth engine.

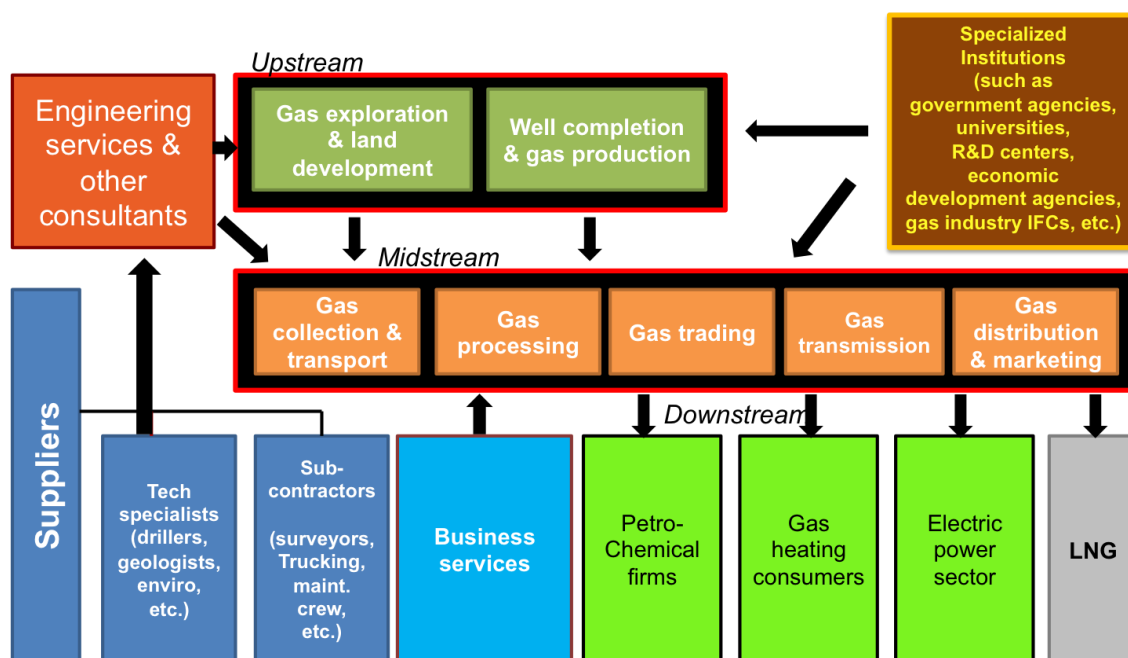


## 4. The Natural Gas Cluster in Pennsylvania

In this chapter we analyze the Marcellus shale gas basin that is mainly located in Pennsylvania. This endowment is the largest shale gas basin within the US accounting for 30% of total reserves. Reserves estimates are still not very accurate because the understanding of shale gas reservoirs has not developed fully. Many leading research firms believe that the government estimates are too conservative and expect the real number to be higher. After mapping the cluster we apply the diamond model in order to analyze strengths and weaknesses of the cluster.

### 4.1. Mapping the cluster – and how its industries work together

Pennsylvania has developed a Natural Gas Cluster integrating a broad and deep range of industries that contribute to the clusters growth.



The gas industry in Pennsylvania flows into 3 distinct areas of activity: 1) Upstream that includes gas exploration, obtaining legal rights to minerals, drilling the well, and preparing the well for long term release of the gas from the well to the collection pipeline. 2) The Midstream portion includes collection from multiple gas wells to gas processing, gas trading, long distance gas transmission, distribution and

marketing to end users. 3) The Downstream activity is mainly gas consumers made up of electric power plants, residential and commercial heating and processes, and petro-chemicals.

Specialized institutions such as government agencies, universities, R&D centers, institutions for collaboration (IFCs), engineering services and constructors support these streams. Other support comes from suppliers such as technology experts and specialists, subcontractors for trucking, surveying, maintenance, and business services, such as legal and IT suppliers.

#### 4.2. The Diamond – Sophisticated Demand is a Major Driver

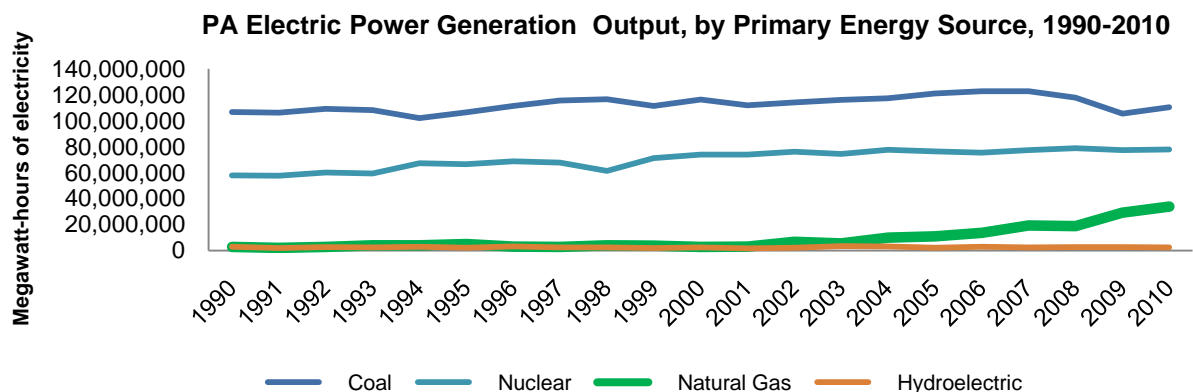
Primary natural gas demand in Pennsylvania comes from five basic categories of end-use: electric power generation, residential, commercial, industrial, and transportation. According to the Energy Information Administration (EIA), in 2012, the electric power producers in Pennsylvania were responsible for 43% of in-state natural gas demand.<sup>34</sup> The electric power industry generated 33.72 million megawatt-hours of electricity from natural gas in 2010, which constituted 14.7% of all the electricity produced by in-state facilities. This is a large increase in comparison to the past given that in 2000 natural gas-fired electricity comprised only 1.3% of the total electricity generated. Residential consumption of natural gas, which includes the use of natural gas for home heating and cooking fuel, was 22% of in-state natural gas consumption. Industrial use of natural gas, largely for manufacturing purposes, was 21% of in-state demand. Approximately 14% went toward commercial demand uses such as heating commercial office space and providing fuel for restaurants. Lastly, less than 1% was directed toward use as transportation fuel.

Natural gas use is expected to grow as it is substituted for coal, heating oil, and gasoline. Pennsylvania has a large in-state underground storage capacity, which allows it to be a supplier of natural gas at times of peak demand. Sophisticated demand is coming from petrochemical companies that are planning to use natural gas as a feedstock for chemical production processes. Also, large vehicle

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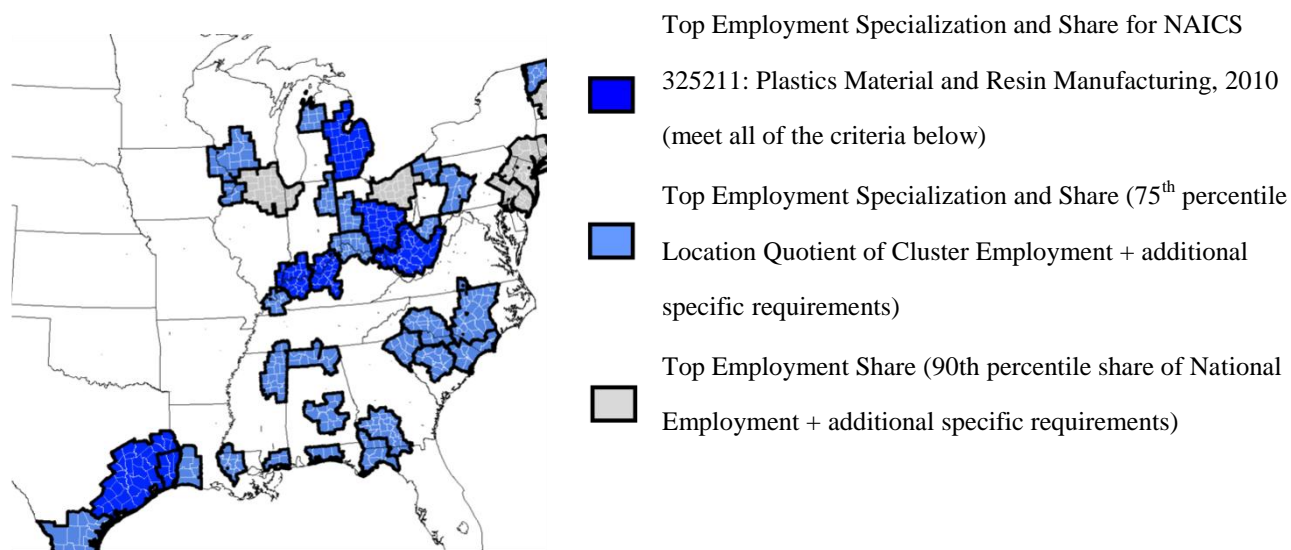
<sup>34</sup> The Energy Information Administration notes that its total consumption figures include, in addition to natural gas “delivered to consumers,” natural gas used as “lease and plant fuel” and consumed in pipelines and other forms of distribution. In 2011, natural gas “delivered to consumers” was 89% of total Pennsylvania natural gas consumption.

fleet owners in Pennsylvania are starting to convert to compressed natural gas combustion engines in order to exploit local natural gas availability as well as federal and state tax incentives.



Source: Energy Information Agency

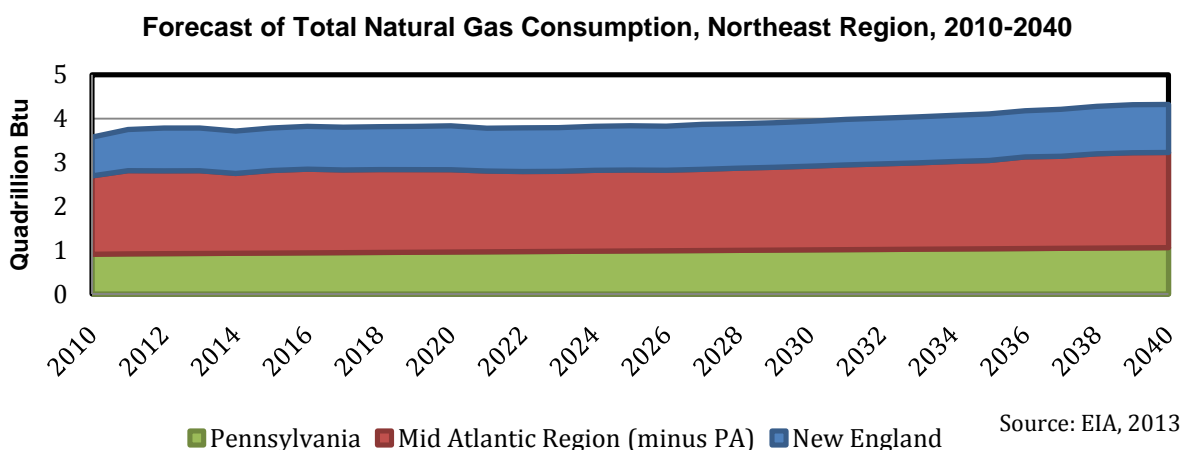
Plastics material and resin manufacturers concentrated in Pennsylvania and surrounding states are major drivers of sophisticated demand for shale gas since cheap gas enables them to lower their production cost as compared to traditional procedures to obtain ethylene, the major plastic feedstock. Traditionally, they obtained ethylene from crude oil. Another possibility is to obtain ethylene from natural gas. Since there has been an up to 800% rise in the crude oil to natural gas price ratio in 3 years the crude-oil option is much costlier now. The existing rule of thumb of 70/30% crude-oil to gas-based feed stocks is forecast to move to 95/5%.<sup>35</sup>



Sources: Institute for Strategy and Competitiveness, Bryden, Rich; Direct. I.S., Harvard Business School;

<sup>35</sup> Bokowy, Hatcher and Frtiz

After a long hiatus, major petrochemical cracker capacity additions have been announced that will crack natural gas ethane to ethylene, the most common petrochemical building block, leading to increased low cost plastics supply.<sup>36</sup> The plastics industry has leveraged the cost advantage enabled through shale gas exploitation to boost America's trade prospects by increasing exports from 12% of plastic resins produced in America a few years ago to 22% - a share that is expected to grow to 33%.<sup>37</sup> We expect that these developments will also increase employment in these industries.



Regional sources of natural gas demand also play a very important role defining the potential scale of demand for Pennsylvania's natural gas resources. Data for the EIA's Annual Energy Outlook for 2013 indicate that while 889.2 trillion Btu were consumed in Pennsylvania in 2012, an additional 1,149.9 trillion Btu were consumed in three states that share borders with Pennsylvania including Ohio, Maryland, and West Virginia. On top of that, 2,847.4 trillion Btu of natural gas were consumed in states to the north and east of Pennsylvania including bordering states like New York, New Jersey, and Delaware, as well as all of New England. There is reason to believe that Pennsylvania is uniquely positioned to be the primary provider to Northeastern natural gas demand that constitutes 20% of all US natural gas demand. Primarily, this has to do with the fact that Pennsylvania has the 5th largest outflow natural gas pipeline capacity in the US, and the largest capacity of any state in the Northeast, at 15.8 million cubic feet per day. It is closer to major Northeastern natural gas demand centers such as New

<sup>36</sup> Pryor; Shell Chemicals; Bokowy; Hatcher and Frtiz

<sup>37</sup> American Chemistry

York City, Baltimore, Newark, Hartford, and Boston than any other state. EIA projections indicate that natural gas consumption is expected to grow through 2040.

#### 4.3. The Diamond – Competition and Rivalry Push the Cluster Forward

Competition and rivalry can be analyzed both within the cluster and in a broader context seeing the cluster itself competing on a global energy market.

##### **Competition and Rivalry on the regional level**

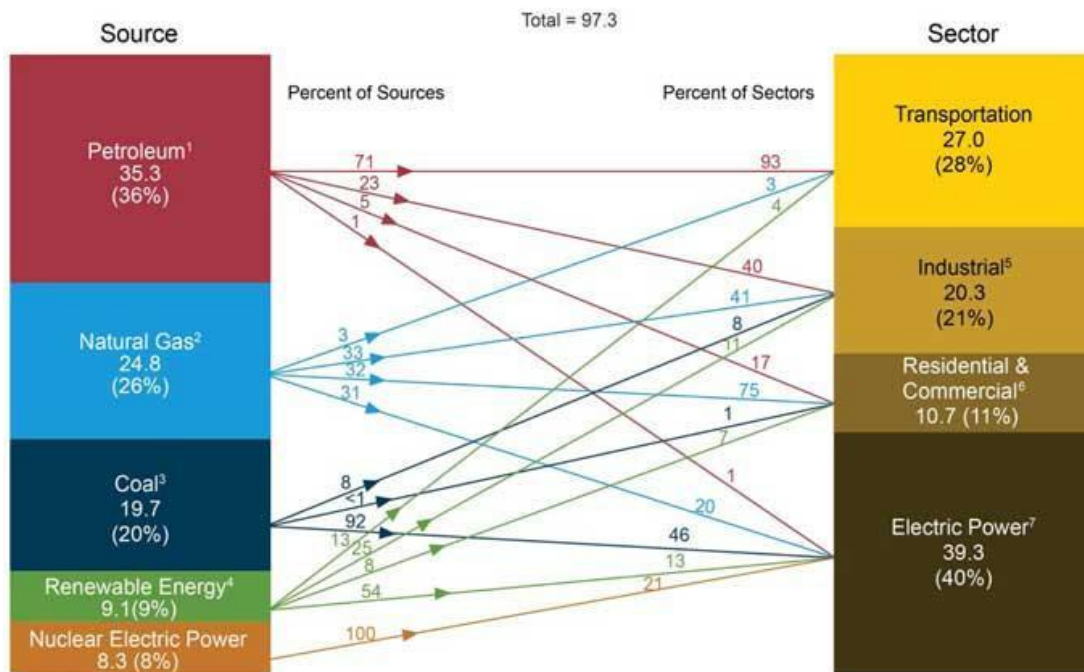
Within the cluster the sheer number of players indicate how strong rivalry and competition are: The Pennsylvania Independent Oil and Gas Association is the principal organization in the state and counts over 950 members, including oil and gas producers, drilling contractors, service companies, manufacturers, distributors, professional firms and consultants, royalty owners, and other individuals with an interest in Pennsylvania's oil and gas industry. Around 90 exploration and production companies are present and competing for claims.

Mineral rights belong to the landowners. Leasing agents approach them with extraction contracts to allow for exploration and production. A typical lease agreement includes a bonus payment for the landowner and gives to the gas producer the exclusive right to conduct exploration. When gas production starts the landowner receives royalty payments that are based on the value of the gas sold from the well.

##### **Competition and Rivalry on a global scale**

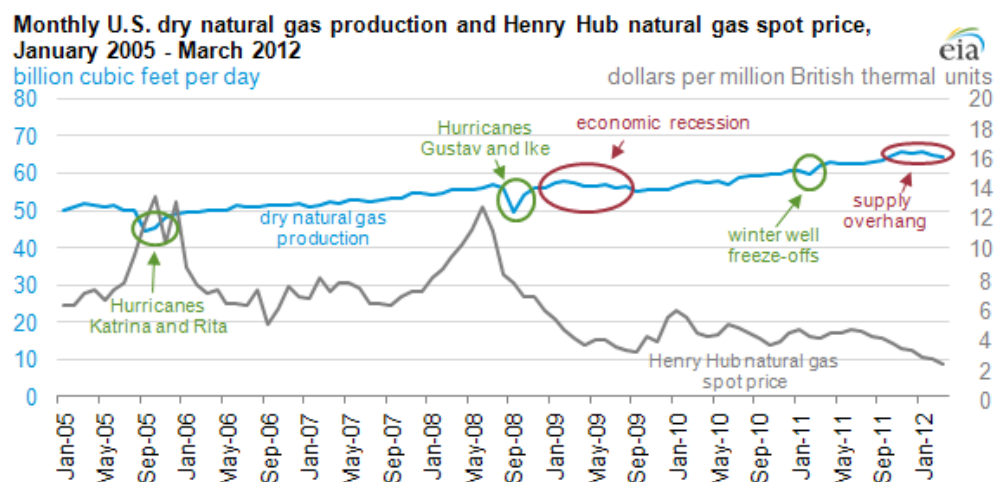
Primary energy sources are competing directly with each other for market share within different market segments. Recent trends show clearly that gas is increasingly displacing other fuels. This is due to the fact that accelerated shale gas production across the US has pushed down gas prices giving it a price advantage over other primary energy fuels. Gas is now even encroaching into the transportation sector, which for long has been the mainstay of petroleum. Since it is a commodity easily tradable on a national and global scale we also need to analyze the effects of global competition and rivalry on Pennsylvania's Natural Gas Cluster.

## Primary energy consumption by source and sector 2011



Source: Energy Information Agency

The high supply side competition has increased the pressure for shale gas producing companies to innovate and reduce their extraction costs. As a result of increasing gas production gas prices started to fall post 2008 making US gas competitive on the global market.



Momentum for natural gas and shale gas development is upheld globally as long as production in other regions is not competitive as compared to U.S. prices. Currently, low levels of U.S. prices make exports to European and Asian gas markets attractive with sales prices in the U.S. at \$4.1/mmbtu, in Europe at \$11/mmbtu and in Asia at US\$16/mmbtu. This huge difference is due to different price setting



mechanisms in the U.S. as compared to Europe and Asia. In the U.S. the price setting mechanism is driven by the supply/demand balance whereas in Europe and Asia the gas price is linked to the oil price. As oil prices have increased over the past few years Europe and Asia have also experienced increased price levels for natural gas.

But the price advantage of US gas cannot be utilized to conquer foreign markets because federal law limits the possibility to export gas. While export applications to countries with a Free Trade Agreement are deemed to be in the ‘public interest’ and quickly authorized by the Department of Energy, applications for export authorization from non-FTA countries will have to be scrutinized by the DoE and require a determination of whether they are in the ‘public interest’.

Opposition to lifting the ban has come from Dow Chemical and Alcoa who have argued that exports will cause domestic gas prices to rise and diminish the cost advantage that US companies were profiting from. However, the Obama administration has recently signaled that it will lift a general ban and support export projects.<sup>38</sup> They can’t hold up the ban anyway, at least not legally because it contradicts free trade obligations that the US has signed up to with the WTO. If the ban remains in place then European chemical companies are likely to sue the US for providing subsidies to its industries. A wide set of economic studies have furthermore shown that gas price increases in the US will be in a range between 2%–11% and not cause a sudden price spike.<sup>39</sup> More broadly, the expansion of energy trade will strengthen the US economic power base, translate into greater political influence globally, and diminish the geopolitical weight of resource exporting countries as compared to the U.S. If current U.S. export restrictions are removed U.S. shale gas will compete on a growing global market with other providers of Liquefied Natural Gas such as Qatar, Indonesia, Malaysia, and Australia. Marcellus basin gas is well positioned to compete globally as it has the lowest extraction costs in the U.S.

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<sup>38</sup> Obama backs rise in US gas exports, <http://www.ft.com/intl/cms/s/0/5af31212-b59e-11e2-a51b-00144feabdc0.html>

<sup>39</sup> Charles K. Ebinger, The Department of Energy’s Strategy for Exporting Liquefied Natural Gas, <http://www.brookings.edu/research/testimony/2013/03/19-liquefied-natural-gas-ebinger>



#### 4.4. The Diamond – Factor Conditions: Workforce

In Pennsylvania more than 88,000 workers hold jobs that oil and gas development projects created directly or indirectly.<sup>40</sup> As operations expand in the Marcellus shale the demand for qualified workforce is growing to meet the needs of the gas cluster. Wages in Pennsylvania's natural gas industry being higher as compared to other industries indicate high demand for qualified workforce. While the average wage of all industries is \$47,922, the average wage in core shale gas industries is \$82,643, and in ancillary industries \$64,559. This also indicates that the Natural Gas Cluster actually upgrades the region in terms of wage levels and in effect the standard of living. Besides the jobs directly related to operating gas drilling rigs, there are opportunities in a number of professional and skilled areas: Engineering and surveying, Construction and earthmoving, equipment manufacturing, service and repair, environmental permitting, water transport/wastewater management, well servicing, legal services, accounting and other professional services. Universities and the state government are directly involved in education efforts to train workers. The Shale Training & Education Center (ShaleTEC) for example is funded by the Pennsylvania Department of Labor and Industry in collaboration with the Pennsylvania College of Technology and Penn State Extension. It offers courses relevant to the shale gas cluster.<sup>41</sup>

#### 4.5. The Diamond – Factor Conditions: Infrastructure and Transportation System

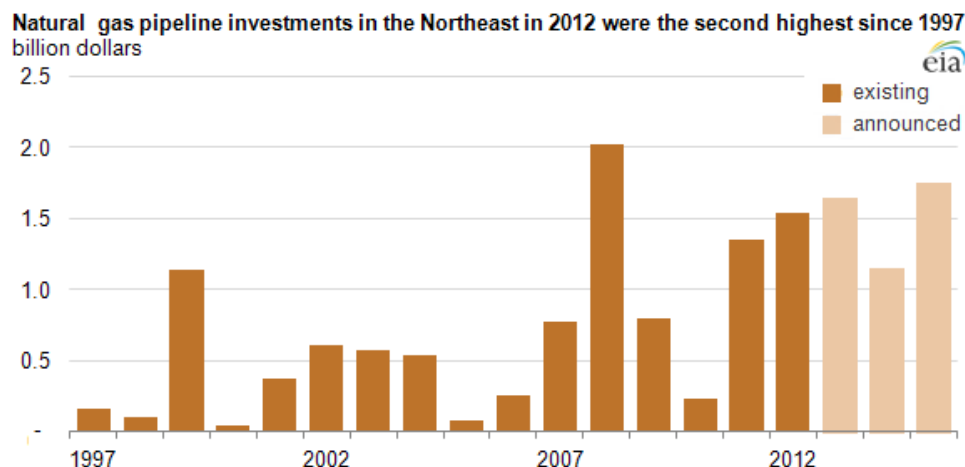
The natural gas pipeline network involves gathering, transportation and local distribution systems. Gathering systems connect the production wells with the mainline transmission grid through small-diameter pipelines. If extracted gas is “wet” (usually in Southwestern Pennsylvania), then it needs to be further refined at a processing plant to remove impurities and liquids (NGLs), such as propane and butane, before entering the transmission systems. Transmission systems carry the processed natural gas, often over long distances, from the producing region to local distribution systems around the country (the transmission systems consist of 29% for intrastate pipelines and 71% for those that are interstate). Local distribution systems, such as a local utility, connect to the interstate pipeline at a “city gate”. The natural gas is then delivered to residential, commercial, industrial, and other end customers.

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<sup>40</sup> Pennsylvania Independent Oil & Gas Association, <http://www.pioga.org/marcellus-shale/>

<sup>41</sup> ShaleTec, <http://www.shaletec.org/>

In the Northeast (and hence in Pennsylvania) pipeline infrastructure grows stronger than in the rest of the U.S. due to the necessity to remove bottlenecks for the fast-growing gas production from the Marcellus basin. In 2012 a total of 245 miles of pipe and 3.2 bcf/d of capacity was added to the Northeast accounting for two-thirds of all new projects within the US. Investments of \$1.5 billion in capital expenditures were necessary. In particular, two projects—the Appalachian Gateway Project and Sunrise Project— cost \$900 million, equaling to about 50% of total US pipeline investment in 2012.<sup>42</sup>

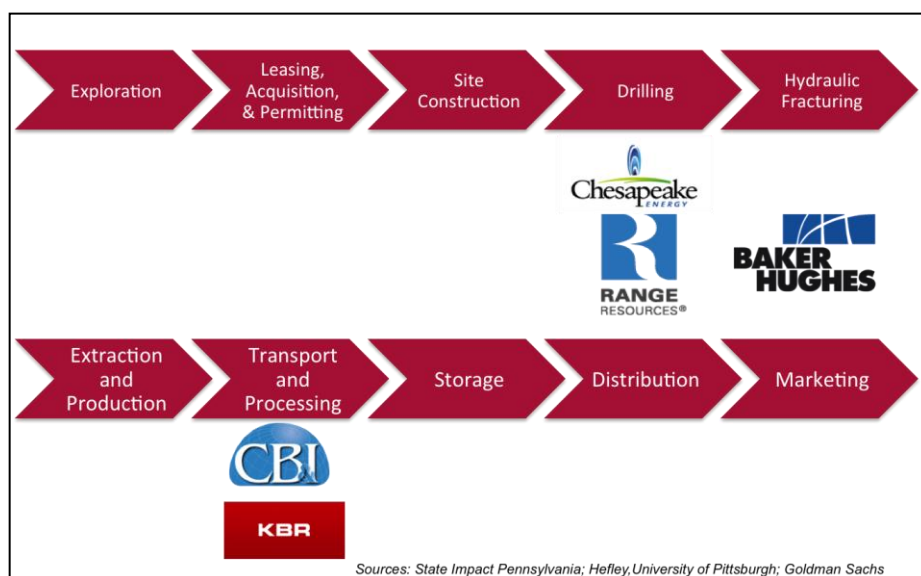


## 5.6. The Diamond – Related and Supporting Industries

During the over 100 year plus history of energy in Pennsylvania, a deep and varied value chain has been developed. Until recently coal has been the principal US energy source, but that is now is being over taken by natural gas – and the related industries supported this development.

Specifically the Marcellus

### Pennsylvania Shale Gas Value Chain



<sup>42</sup> Energy Information Agency, Over half of U.S. natural gas pipeline projects in 2012 were in the Northeast, <http://www.eia.gov/todayinenergy/detail.cfm?id=10511-investment>

Shale value chain has been comprised of many specialized supporting suppliers for upstream, midstream, and downstream goods and services. This includes exploration, land acquisition, construction of the well drilling site, the drilling operation, and the highly technical hydraulic fracking. It also includes extraction and production, transport and processing, storage, distribution, and marketing.<sup>43</sup> Within the value chain are engaged water treatment services for drilling and fracking, technical machinery suppliers, gas institutions for collaboration (IFCs), and consultants for land leasing, engineering, legal services, technology, supply chain, and marketing.

Out of a total of 74 drilling operators in Pennsylvania the recent top 3 are Chesapeake Energy Range Resources, and Talisman Energy.<sup>44</sup> Top Marcellus fracking service companies are Halliburton and Baker Hughes.<sup>45</sup> The Engineering and Construction (E & C) supply and support plants and equipment in the major areas of gas processing, fractionalization, ethylene crackers, derivatives plants, gas power, and LNG export. Some industry observers estimate the opportunity for US Engineering and Construction companies for plant and equipment over the next 5-7 years to be \$57-65 Billion.<sup>46</sup> Forecasts for longer-term capital investments in the shale gas industry are expected to be nearly \$1.9 Trillion between 2010 and 2035, and will additionally support 1.6 million jobs.<sup>47</sup>

#### 4.7. Institutions for Collaboration (IFCs)

There are several general and cluster-specific IFCs, which have been playing an important role in developing the Pennsylvania shale gas cluster. Three will be presented here briefly.



**Marcellus Shale Advisory Commission** was created by Governor Corbett to identify, prioritize and craft recommendations regarding the safe, efficient and environmentally responsible extraction and use of shale gas reserves in PA. In 2011 the commission issued a comprehensive report.

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<sup>43</sup> Hefley and Seydor

<sup>44</sup> Amico, DeBelius and Detrow

<sup>45</sup> Hefley and Seydor

<sup>46</sup> Ritchie, Durbin and Maguire

<sup>47</sup> Bonakdarpour, Flanagan and Holling



**Marcellus Shale Gas Coalition (MSC)** works with exploration and production, midstream, and supply chain partners in the Appalachian Basin to address issues regarding the production of natural gas from the Marcellus and Utica Shale plays. It provides in-depth information to policymakers, regulators, media, and other public stakeholders. MSC has more than 300 members, including: Chesapeake Energy Corporation, Chevron Corporation, Anadarko Petroleum Corporation, and Statoil.



**Marcellus Center for Outreach and Research (MCOR)** is Penn State's education and research initiative on unconventional gas plays. It serves state agencies, officials, communities, landowners, industry, environmental groups, and other stakeholders. MCOR is committed to expanding research capabilities on technical aspects in developing these resources and in providing science-based programming while protecting the Commonwealth's water resources, forests and transportation infrastructure. MCOR is internally funded through the College of Agricultural Sciences, the College of Earth and Mineral Sciences, the Penn State Institutes of Energy, and by the Environment and Penn State Outreach program.

#### 4.8. Strengths and Weaknesses

This section provides an overview of the strengths and weaknesses of the Pennsylvania gas cluster.

	Strengths	Weaknesses
Factor inputs	<ul style="list-style-type: none"> <li>• Largest holder of US shale gas resources, 30% of total</li> <li>• Sufficient water resources.</li> <li>• Well skilled work force, with regional skill education access.</li> <li>• Strong University R&amp;D.</li> <li>• Access to capital resources</li> </ul>	<ul style="list-style-type: none"> <li>• Pipeline infrastructure needs expansion</li> <li>• 4 independent PA state agencies in charge of permissions greatly slow down processes (no one stop shop for permitting)</li> <li>• Takes excessive time and money to acquire sufficiently large areas needed for mineral extraction</li> </ul>
Demand conditions	<ul style="list-style-type: none"> <li>• Strong national and regional energy demand</li> <li>• Strict quality, safety, environmental standards</li> <li>• Consumer protection laws</li> </ul>	<ul style="list-style-type: none"> <li>• Gas exports restricted</li> <li>• Little government procurement of advanced technology</li> <li>• Poor public perception of environmental standards</li> </ul>
Company strategy and rivalry	<ul style="list-style-type: none"> <li>• Strong competition between 100 extracting companies</li> <li>• Strong rule of law</li> <li>• Flexible labor policies</li> </ul>	<ul style="list-style-type: none"> <li>• Gas export ban shelters from global competition</li> <li>• Not transparent land acquisition processes</li> <li>• Complicated U.S. tax system</li> </ul>
Related and supporting industries	<ul style="list-style-type: none"> <li>• Highly specialized contractors and technological services for upstream and downstream activities</li> <li>• IFCs are actively supporting industry growth</li> </ul>	<ul style="list-style-type: none"> <li>• Technical machinery producers are located far away, i.e. Houston</li> </ul>

## 5. Recommendations

In this final chapter we suggest a strategic vision for further developing the Pennsylvania Natural Gas Cluster. Then we translate this strategic vision in concrete recommendations.

### 5.1. Vision for Strategic Positioning based on a clear Value Proposition

The Pennsylvania gas cluster is well positioned to compete. Pennsylvania value proposition is the ability to provide natural gas on a very long-term basis at low price as compared to global competitors on an ultra-reliable, contractual basis. This is because of the natural condition of the

Marcellus shale and since it has the lowest gas extraction cost relative to the rest of the US.<sup>48</sup> Services provided by Pennsylvania gas include pipeline delivery to its customers via an extensive and growing midstream pipeline network. These deliveries occur near one of the largest and wealthiest population centers, the US northeast, along with the mid-west, south-east, and eastern shore areas. Market pricing is

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<sup>48</sup> Lacoursiere

determined typically via the Henry hub market price. The Henry Hub price is based on US supply and demand. The US price is not tied to world oil prices but only to supply and demand and transportation cost.

In order to maintain this value proposition, we recommend for strategic objectives focuses at the diamond dimensions: Factor conditions: Its large resources base and favorable geology allows for low cost and long-term production. Pennsylvania has a well-educated work force which matches growing needs for qualified personnel. Competition Rivalry: Strong competition between extracting and service companies spurs innovation and keeps Marcellus shale gas producers ahead of U.S. and global competition. Demand: Large and low cost supply expands regional demand and gives downstream industries competitive advantage. Gas push into the transportation, power, and plastics sectors makes Pennsylvania a global leader in natural gas utilization. Related and Supporting Industries: The growth of supporting and related industries enhances the innovation growth and strengthens cluster.

## 5.2. Recommendations

We have divided our recommendations by divided by long (green), middle (yellow) and short (red) term priorities, by diamond framework and addressee.

#	Challenge to address	Recommendation	Level
1	Despite the ecological advantage, natural gas is still not widely used as a transportation fuel	Consider corrective tax incentives to speed conversion of vehicles to use natural gas instead of oil as well as reducing negative environmental externalities by shifting demand towards becoming a social optimum	<u>Demand:</u> Federal /State
2	Insufficient supply of natural gas for fueling cars leads to high switching costs for consumers	Support building natural-gas dispensing stations for the transportation sector and/or provide natural gas dispensers at existing stations	<u>Demand:</u> Federal /State
3	Comparatively moderate investments existing in PA industries limit demand for gas as an energy source and raw material  Critical importance of high environmental standards for health and growth of residents, as cost of failure is nearly incalculable and unacceptable	Develop a comprehensive strategy to maximize “downstream” use of natural gas and its by-products, such as in the areas of chemical manufacturing, plastics, etc. Conduct global road shows/conferences attracting energy consumers (big industry) Educate energy intensive industries nationally about opportunities and joint ventures Use outcome based environmental protection standards to increase sophisticated demand	<u>Demand:</u> State IFCs
4	Four independent PA state agencies in charge of permissions greatly slow down processes	Create a one-stop shop for a pipeline permitting process to better coordinate review and ensure thorough oversight	<u>Factor Cond.:</u> State
5	Process is slowed due to excessive time (9 mo-5years) and money currently required toward the negotiating of bonuses and royalties with owners of all adjacent land in the acquisition of other needed areas	Make the land leasing and acquisition procedures more transparent by implementing dealing systems such as auctions Develop a ‘standard’ mineral rights bidding process to protect both seller and buyer while reducing the time it takes to complete a contract Educate landowners about their rights, process and benefits of shale gas clusters; eradicating misinformation	<u>Factor Cond.:</u> State IFCs
6	Shale Gas development will increasingly require more sophisticated workforces, including specialists in engineering, geology, ecology and finance	Invest in developing workforce skills  Ease the immigration process for highly skilled individuals	<u>Factor Cond.:</u> State
7	Water supply used for fracturing is critical from both ecological and economical points of view. Due to environmental concerns with fracturing chemicals, regulations require the usage of only fresh water or water refined to the standards of drinking water. This is relatively costly (up to 30% production expense per well).	Consolidate their efforts and increase R&D investments into innovative technologies, which could revolutionarily change current situations and further provide an effective solution for water cleansing. Such technologies, too, has potential to greatly contribute to other needs in society.  Agree on a federal agency regulatory agency and reporting framework to guide the development of shale gas that balances economic and environmental considerations.	<u>CSR:</u> Federal /State , IFCs and companies
8	Complicated taxation system and regulations in the US hinders process.	Simplify the corporate-tax code and streamline regulations by focusing on outcomes, not reporting and compliance	<u>CSR:</u> Federal
9	Constraints on international gas trade shelters from global competition	Allow companies to export natural gas Support infrastructure for gas shipment (LNG plants)	<u>RSI:</u> Federal/State
10	Limited cooperation across cluster specific IFCs  Clusters suppliers need to have the capacity to supply cluster services	Create a cluster wide IFC Advocate for laws and rules that benefit business as a whole as opposed to lobbying for a firms special interest or industry Actively strive to identify and increase sourcing from local suppliers	<u>RSI:</u> IFCs





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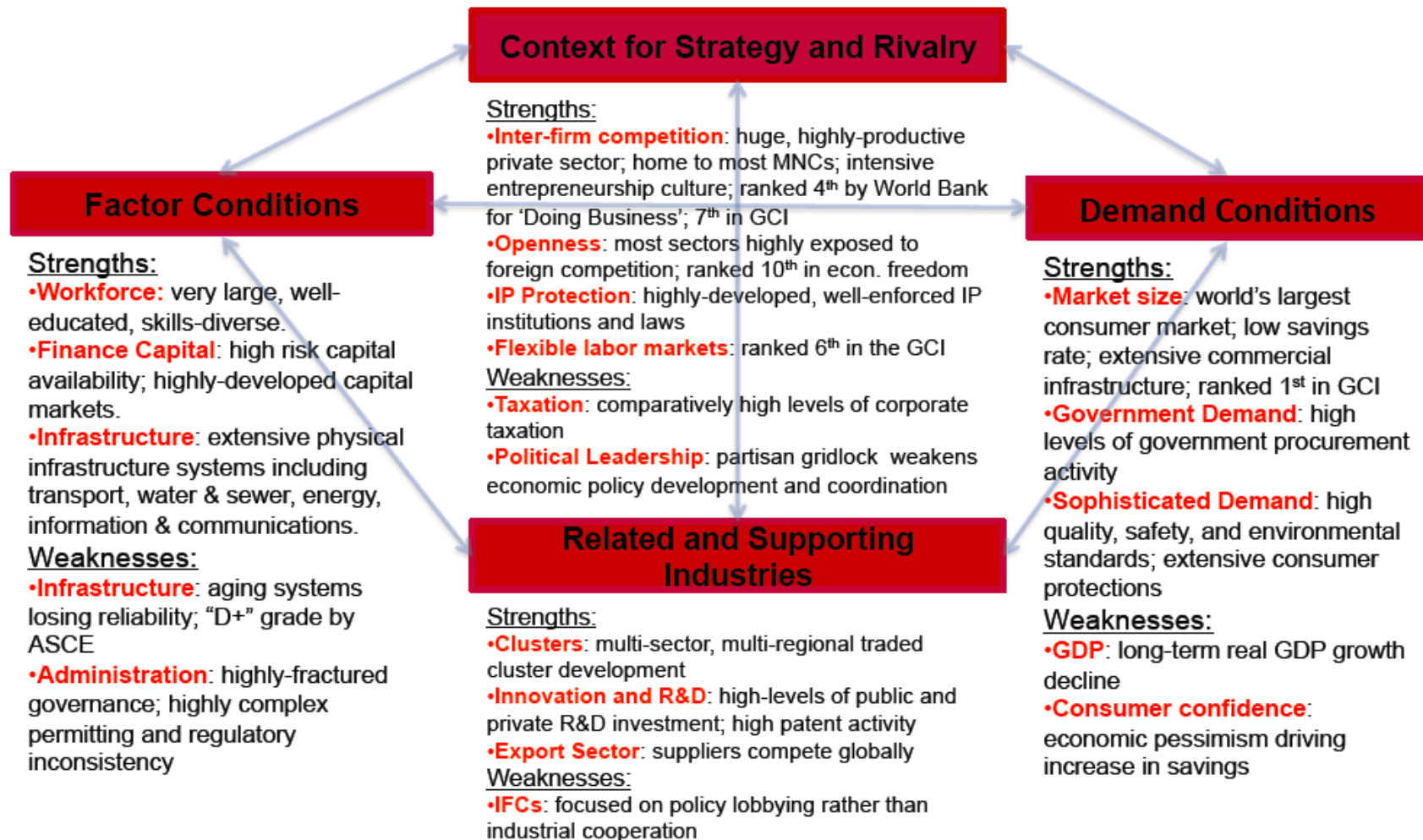
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## 7. Appendix

# UNITED STATES: NATIONAL DIAMOND



HARVARD  
BUSINESS  
SCHOOL



# PENNSYLVANIA: STATE DIAMOND



HARVARD  
BUSINESS  
SCHOOL

