OPPORTUNITIES FOR

THE PITTSBURGH REGION

IN THE OIL AND GAS TECHNOLOGY CHAIN

for the

PITTSBURGH REGIONAL ALLIANCE

from

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EXECUTIVE SUMMARY

The oil and gas supply chain has invested significant resources in commercial R&D. Unlike other technologies, US domestic companies continue to dominate the field. The Top-10 companies in the supply chain, many of which have facilities in the Pittsburgh region, produce nearly 60 percent of the patented inventions in the mining cluster. In terms of academic institutions, only the University of California and the University of Texas appear in the Top-100 patent holders. The leading companies in oil and gas services produce as many patents per billion dollars of sales as IBM, Intel, General Electric, Boeing and DuPont.

R&D in the oil and gas supply chain is still highly concentrated in a handful of oil and gas centers. The patent classes with the most inventions in the supply chain are in Wells (Class #166) and in Boring the Earth (Class #175) but the industry also does significant research in data processing, electronic communication, measuring and testing and inorganic chemistry.

Pittsburgh is one of the nation’s largest and oldest centers for industrial and academic R&D. Pittsburgh has maintained strength in coatings and organic chemistry over the last 20 years but has seen a declining number of patents in electronics, mining and inorganic chemistry.

Patent production in the Pittsburgh region, as nationally, is dominated by a small number of assignees. The top assignees include PPG Industries, Eaton Corporation, University of Pittsburgh, Seagate, Chimimage Corporation, Carnegie-Mellon, Kennametal, RIC Investments, Alcoa and MEDRAD, Inc. Seagate has since closed its facility in the region. The National Energy Technology Lab, the Department of Energy’s fossil fuel lab, is among the top 15 patent assignees in the region, and the only national lab on the list of top assignees. Few of the patents in the region are in the mining cluster, however.

The Pittsburgh region has little research that is directly tied to well drilling. The best R&D opportunities for the region to explore consist of new techniques for supplying, handling and treating frac water and a better understanding of the geology and geo-mechanics of shale formations. R&D facilities that meet the supply chain’s needs for new technologies in these fields could be a significant economic opportunity for the region that would enhance the competitiveness of supply chain companies with ties to Pennsylvania. A university research consortium similar in design to the Center for Excellence in Formation Evaluation at the University of Texas is a model to consider in launching these initiatives.

INTRODUCTION

The Pittsburgh region is witnessing an economic boom from shale gas exploration and production. The Pittsburgh region, with 36 universities and several of the nation's major research universities, has a major presence in industrial research and development. This report identifies those companies and opportunities that Pittsburgh should pursue in oil and gas technology.

The analysis in this report is built around a technology classification published in 2003 by Taimerica Management Company.[1] That system compressed the 800+ classifications used by the US Patent and Trademark Office into 8 technology clusters that were linked geographically using principal components analysis. The advantage of the Taimerica classification is that it allows economic developers to understand their competitive strengths for technology development.

The eight clusters are:

- Electronics
- Entertainment and Fashion
- Medical
- Mechanical Inventions
- Mining Inventions
- Organic Chemistry
- Inorganic Chemistry
- Coatings

About 68 percent of the patents in the US cluster geographically within these 8 categories. The balance, called Footloose, are widely dispersed and do not cluster geographically. Additional information on the types of inventions in each of the clusters is shown in Table #1 referenced in the report shown in Footnote #1.

The mining category consists principally of patents assigned to oil and gas companies with some patents in earthworking and material handling technologies. The vast majority of the patents in this category are issued to companies that provide oil and gas equipment, supplies and services, which is the heart of the shale gas supply chain.

[1] Ed Bee, "Knowledge Networks and Technical Invention in America's Metro Areas: A Paradigm for High Technology Economic Development", Economic Development Quarterly, 2003 17(2) 115-131, available at www.taimerica.com/previous/Tech_Net_4.pdf

INNOVATION IN THE OIL AND GAS SUPPLY CHAIN

While the US has lost market share in many sectors of global manufacturing, domestic companies dominate in oil and gas technologies and equipment. Over half of the rotary drilling rigs in use in the world today are in North America. Although the Middle East is the largest region in terms of oil reserves, it has few wells and hence doesn't have the demand for equipment that would shift plant locations.

About 93 percent of patents in the oil and gas sector are issued to US companies versus just half of all patents (see Figure 1 for a comparison of mining and total patents). Most of the oil and gas patents issued to foreign assignees are in fact issued to the foreign subsidiaries of US companies like Halliburton and Weatherford International.

Figure 1

Source: Taimerica database of US PTO patents

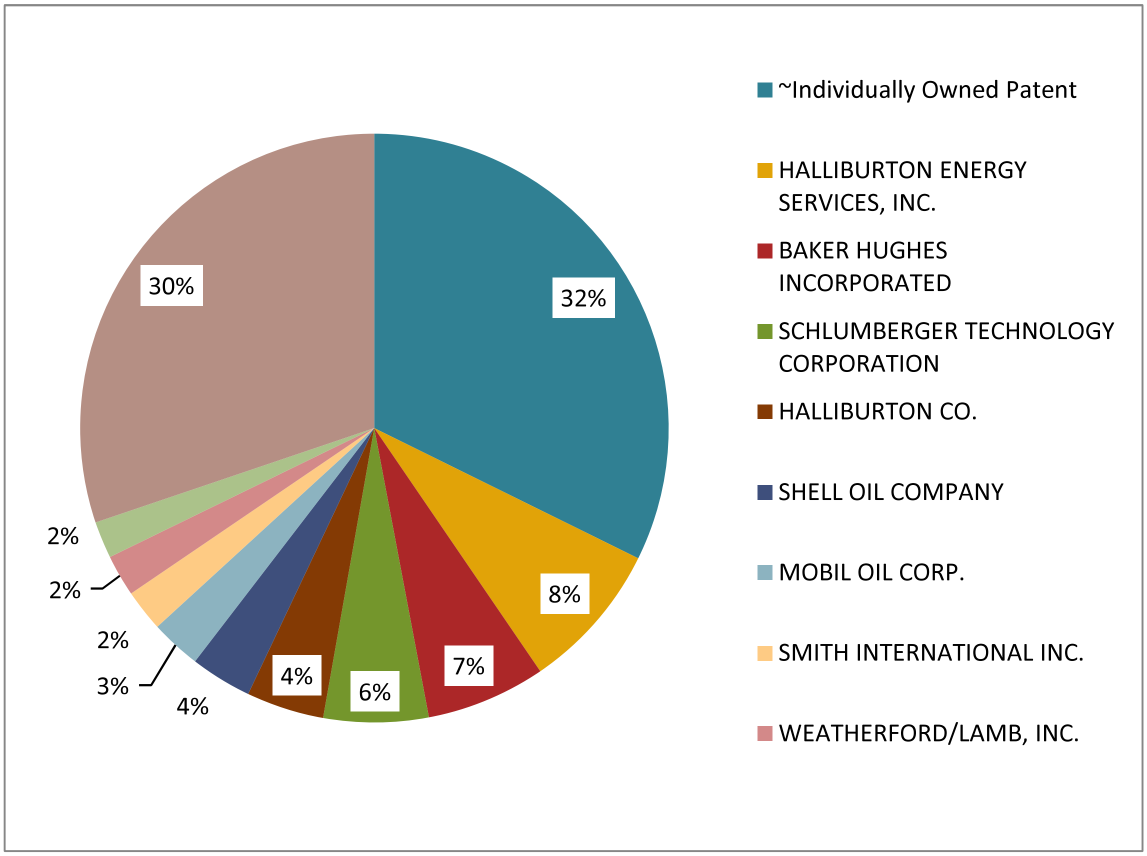
Patented inventions in mining are different from other technology clusters in the share of patents issued to individuals as well as in the concentration of patents among a handful of companies (see Figure 2). The percent of patents issued to individuals between 2006-2010 was 32 percent in the mining cluster versus 9 percent for all classes of patents.

The top 10 companies account for 58 percent of the patents assigned to all 2700 companies in the cluster and the top-20 account for 82 percent (this calculation excludes the 32% of patents held by individuals). Just a handful of companies generate most of the inventions in the industry. In terms of academic institutions, only the University of California system and the University of Texas system rank within the top-100 assignees in the mining cluster. Almost all of the patents in the mining cluster are assigned to private companies.

Invention, as measured by patent indices, is as important to companies in oil and gas cluster as to other types of technology companies (see Table 1). Companies like Baker Hughes, Dresser

Industries and Halliburton, on an index of patents per billion of sales, exceed technology companies like IBM, Boeing, Dupont and General Electric.

Figure 2. Patents in Oil and Gas by Assignee (2006-2010)



Source: Taimerica database of US PTO patents

Table 1. Index of Innovation in Leading Oil Services Companies and in Leading Companies in other Technologies

Company	Patents/$ of Sales in Billions
Baker Hughes*	49.8
BJ Services*	9.0
Schlumberger*	21.1
Dresser Industries*	67.0
FMC Corporation*	71.8
Halliburton*	39.7
Ingersoll Rand*	8.9
Smith International*	15.7
Varco I/P*	1.9
Weatherford/Lamb*	12.5
Cameron International*	2.1
IBM	39.6
Intel	45.6
General Electric	5.6
Boeing	6.8
Dupont	12.8

Source: US PTO, S&P
*Oil Field Services

TYPES OF INNOVATION IN THE OIL AND GAS SUPPLY CHAIN

Oil and gas supply chain companies focus their inventions in a handful of patent classes. Of the more than 800 technology classifications in the US system, nearly half of oil and gas patents fall within 10 classes (see Table 2). A third of the total involves well drilling activities while the remainder involve data processing or electronic signal capturing or measuring and testing processes.

Table 2. Oil and Gas Inventions by Patent Class 2006-2010

CLASS	Description	Percent	# Patents
166	Wells	25%	4634
175	Boring or penetrating the earth	8%	1504
324	Electricity: measuring and testing	4%	686
73	Measuring and testing	3%	640
250	Radiant energy	3%	567
507	Earth boring	3%	531
702	Data processing	3%	474
367	Electric comm: acoustic wave systems	2%	367
376	Induced nuclear reactions	2%	286
423	Chemistry of inorganic compounds	1%	253
	All Other Classes (n=387 classes)	47%	8871

Source: Taimerica database of US PTO patents

GEOGRAPHIC LOCATION OF OIL AND GAS INVENTIONS

Just as oil and gas inventions are concentrated among a handful of companies, the patents issued in this cluster are concentrated in a handful of metro areas (see Map 1). Seventy-seven percent of all patents in this cluster are issued to inventors in seven metro areas: Houston, Duncan, OK, Dallas-Ft. Worth, Lafayette, LA, Provo, UT, Oklahoma City and Tulsa, OK.

INNOVATION IN PITTSBURGH

Pittsburgh is one of the nation's largest and oldest centers for manufacturing and academic R&D. It is headquarters for the National Energy Technology Lab, which is the Department of Energy's research leader for fossil fuels. Pittsburgh historically was strong in coatings, inorganic and organic chemistry and mining patents (see Figure 3). It has maintained its strength in coatings and organic chemistry over the last 20 years while losing some of its strength in electronics, mining and inorganic chemistry since 1990.

BASIC RESEARCH IN ENERGY AT NETL

The National Energy Technology Lab is one of the major resources for basic energy research in the region. Basic research consists of the scientific R&D that precedes commercial application. It typically does not result in patented inventions. Some of NETL's work is performed by the research universities in the Pittsburgh region while other work is done at NETL's labs in Pittsburgh and Morgantown, WV. As a national lab, NETL solicits research proposals throughout the nation and a significant amount of their sponsored research is performed outside of the ten-county PRA region. NETL is an important resource for advancing the understanding of shale gas reservoirs and drilling practices. They performed basic research in the 1970's and 1980's that allowed exploration companies to understand the geological and geophysical characteristics of the Marcellus formation. They also introduced the use of nitrogen foam fracs in shale formations and were pioneers in horizontal drilling in shale.

NETL has identified several technical challenges in the development of the Marcellus formation. These are issues that NETL is addressing through research grants and in-house research:

- Water management for hydraulic fracturing. Well operators need better means of supplying, handling and treating water used in fracturing operations. This is arguably the biggest issue facing operators and production companies in shale gas.

- Development of processing and gathering pipelines.

- Environmental, health and safety issues involved with intense development of gas resource in rural communities, and;

- Risk Reduction and improved efficiency in shale exploration and production operations. The basic science to efficiently fracture shale formations is still evolving. Most of the drilling and fracturing techniques used in the industry stem from trial and error experimentation rather than through a scientific understanding of the Marcellus' natural fractures and physical characteristics.

These issues are of utmost importance to the upstream companies in the shale gas supply chain. The resources that NETL have for oil and gas research is dropping as the focus of the Department of Energy shifts to renewable energy and clean coal. The lab's budget for oil and gas research is under 5 percent of the $1 billion it spends. The amount of research dollars for oil and gas dropped from $50 million in 2009 to a proposed $20 million in the 2011-12 fiscal year. NETL is not currently issuing solicitations for research projects owing to a lack of funding for new projects. While the NETL and the university research consortium it organized could prove valuable to improving the economics of shale gas production while minimizing its environmental consequences, the lack of funds, if not addressed, could limit its future impact of the shale gas supply chain.

APPLIED RESEARCH IN THE PITTSBURGH REGION

Commercial research typically results in the filing of patent applications. Patents tend to gradually evolve from basic research over long periods. Shale gas production techniques, for instance, evolved over twenty years from basic research at NETL.

Patent production in the Pittsburgh region peaked in 1998 and has declined since (see Figure 4). While patent production accelerated nationwide during the last decade, it tapered significantly in the Pittsburgh region owing to a decline in patents in the electronics and inorganic chemistry clusters.

Patent production in the Pittsburgh region, as nationally, is dominated by a handful of assignees (see Figure 5). Individual inventors plus fourteen companies and two research universities in the region account for 57 percent of all patents. Individual inventors in Pittsburgh, at 8% of inventions, account for about the average share of patents. (Seagate Technology, which is among the top patent assignees in the region during the five year period of analysis, has closed their R&D center in the region). The remaining 444 companies in the region with new patents between 2006-2010 account for the remaining 43 percent of patents.

Most of the patents in the region are in fields outside of mining (See Figure 4). Individual inventors and Jennmar Corporation (not shown on the figure because they rank #31 in the region in patent awards) are the only sources of patents in the mining fields in the region (see Figure 6). Almost all of the commercial research now underway in the region is of limited direct application in drilling and fracturing wells.

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CONCLUSIONS ABOUT R&D OPPORTUNITIES IN THE OIL AND GAS SUPPLY CHAIN

Our recommendations are based on interviews we conducted with operating and service companies nationally, as well as our patent research and our review of industry literature. The best research opportunities for Pittsburgh, in our view, consist of finding solutions to the technical problems that are unique to shale gas development, such as 1). frac water supply, reuse and treatment; 2). better understanding of the geology and geo-mechanics of shale development.

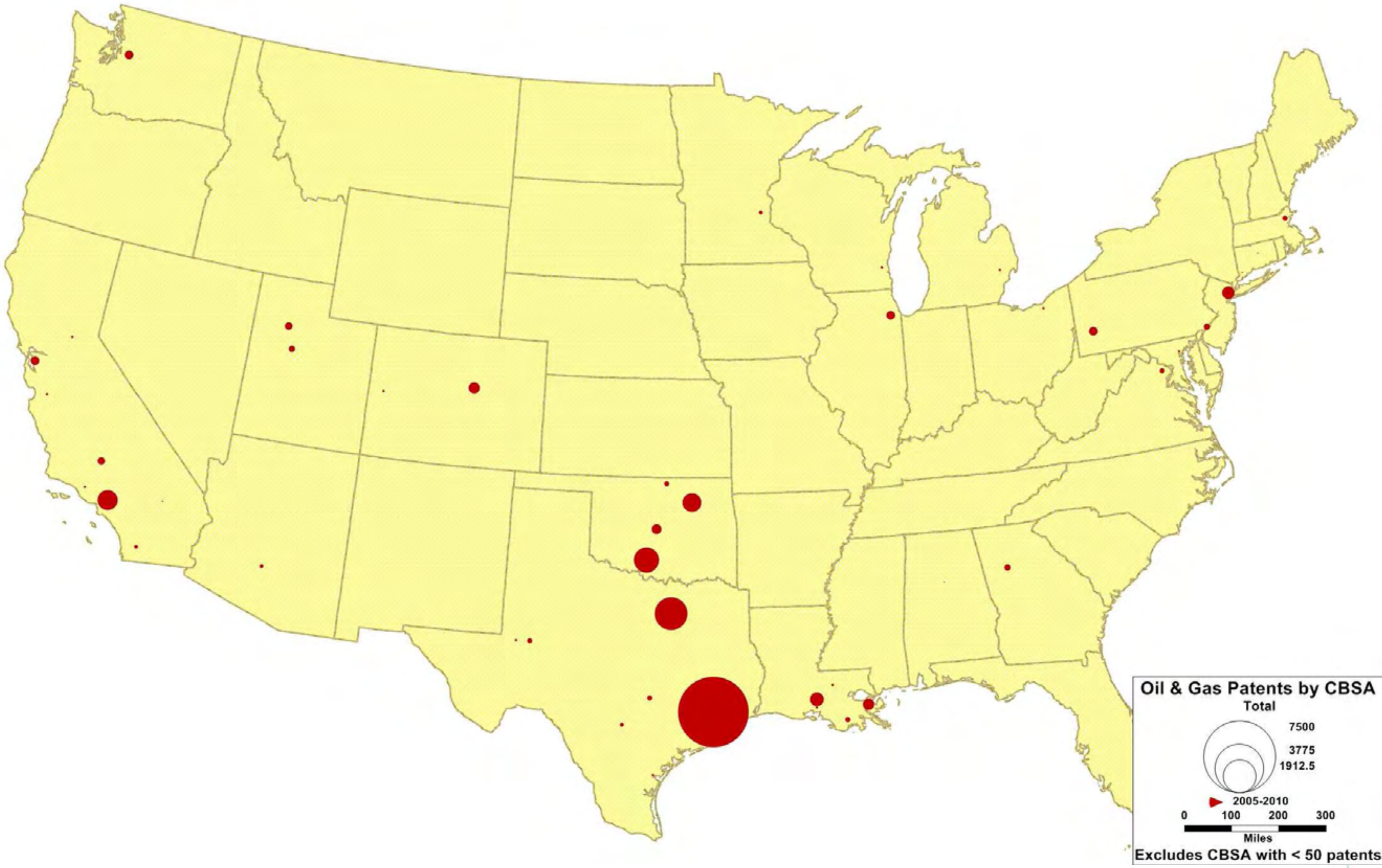
The amount of water used in fracturing can be reduced with a better scientific understanding of fracturing in shale plus a better understanding of how to treat frac water for reuse. These issues have been of less importance in the Haynesville and Barnett shales than they have become in the Marcellus region. They are likely to be even more important to the industry in drilling programs in Europe and Asia. Frac water treatment is an important issue in shale gas production that has not been the focus of the R&D leaders in the industry.

The second of these research issues involves a better understanding of shale geo-mechanics. The scientific problem with shale, unlike conventional formations of sandstone and salt domes, is that operating companies have a limited understanding of the reservoir properties of shale. Basic and applied research in rock mechanics is needed to optimize production while minimizing the amount of fracing and the volume of frac water needed to optimize well production. The technical issues involved with shale gas production are more akin to civil engineering than to petroleum engineering. The leading service companies and operators would be interested in working with university engineering and geology faculty to solve these problems. Service companies that are active in applying new science to gas exploration and production are likely to underwrite some of the cost of these kinds of initiatives if performed at a regional university or at a regional university consortium. Pittsburgh's proximity to the Marcellus is a competitive advantage for labs involved with this research. The Formation Evaluation Consortium at the University of Texas in an example of this kind of collaborative industry-university research (see http://uts.cc.utexas.edu/~cefe/res/Background.htm)

R&D programs that meet the supply chain's needs for technologies in these fields could offer a significant economic opportunity for the region that would enhance the competitiveness of supply chain companies with ties to Pennsylvania. Moreover, these collaborations have the added advantage of preparing technical talent for shale gas supply chain companies. Companies often join research consortiums because they offer a competitive advantage in recruiting students with cutting edge tools and techniques for shale gas exploration.

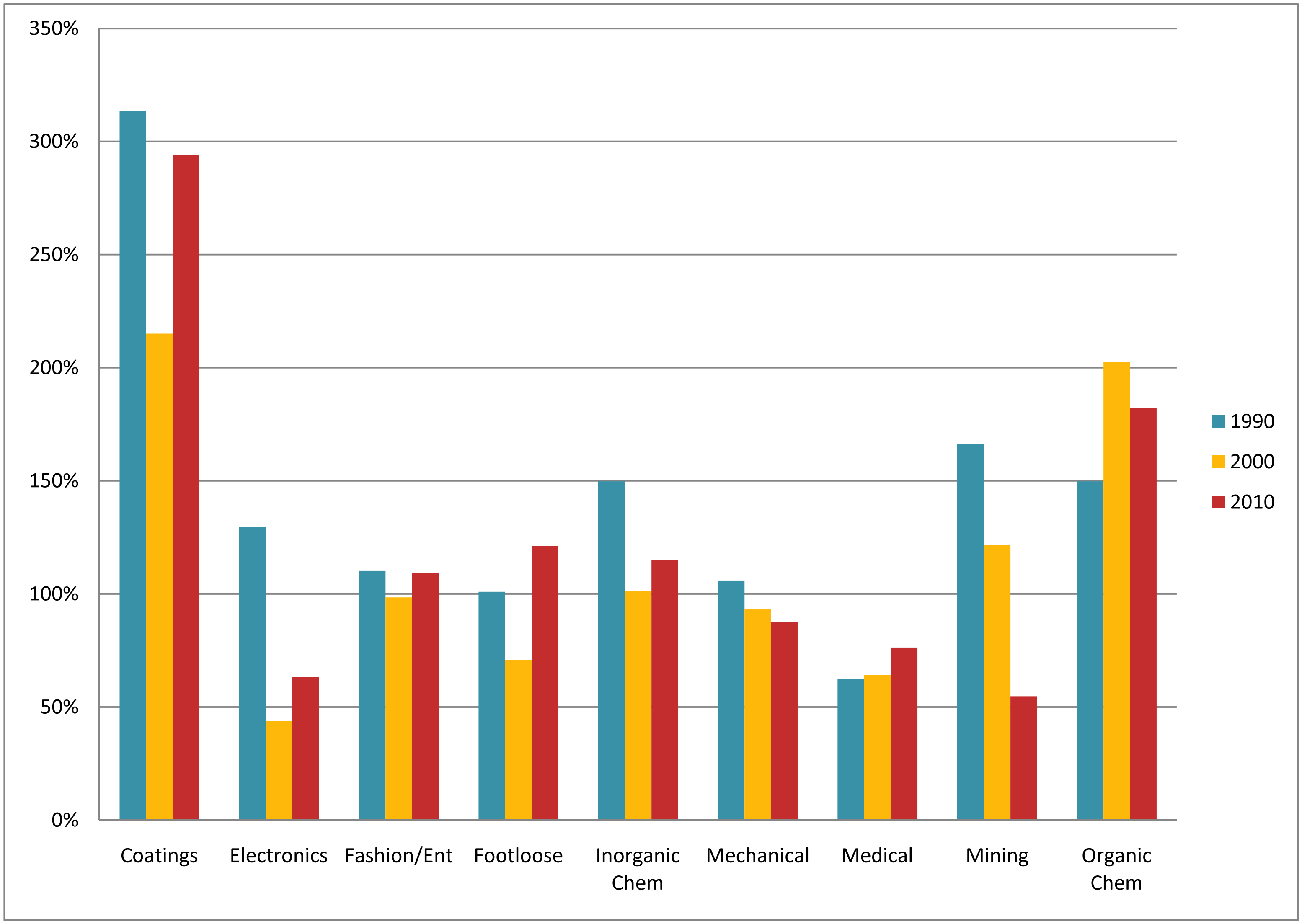
While the region has other research skills to offer in data processing, sensors and electronic communication and testing, the leading R&D companies in the oil and gas supply chain really have not established a research infrastructure for addressing these two issues. We believe these are the two areas for R&D focus where the Pittsburgh region can gain international prominence in shale gas R&D.

Map 1. Oil and Gas Patents issued from 2006-2010 by CBSA



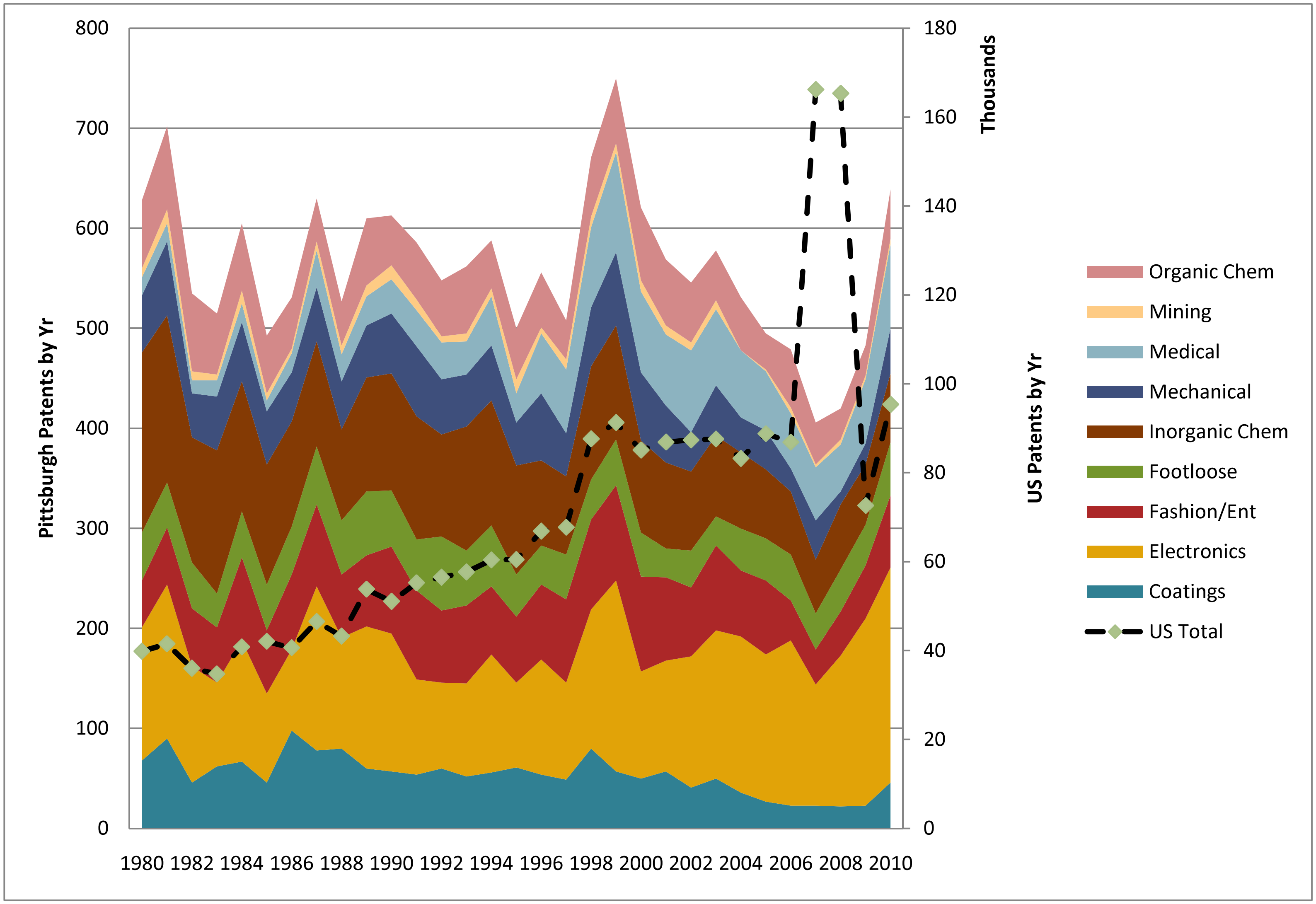
Source: Taimerica database of US PTO patents

Figure 3. Patents in Pittsburgh CBSA as Percent of US Average



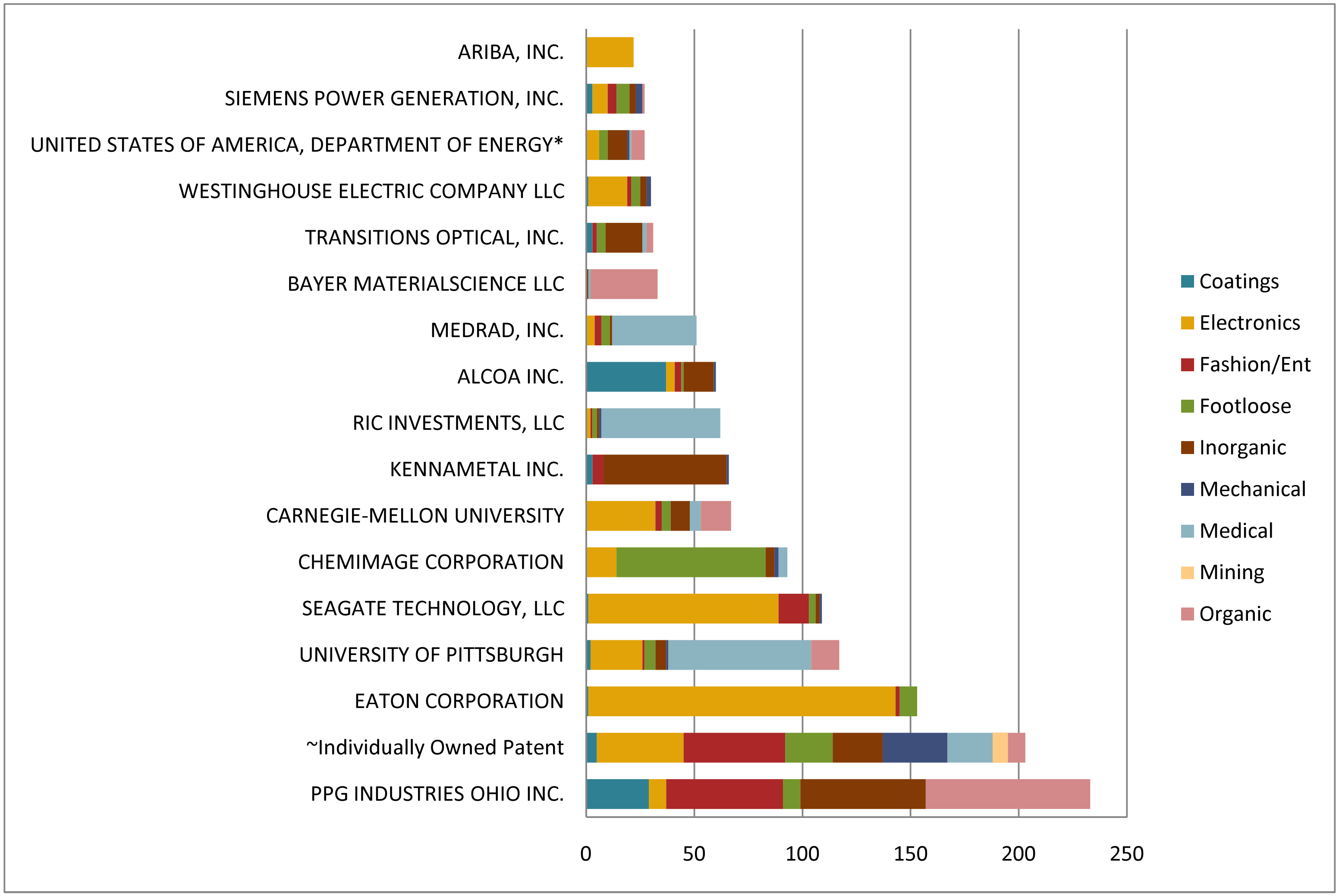
Source: Taimerica database of US PTO patents

Figure 4. Patents in Pittsburgh by Type of Technology



Source: Taimerica database of US PTO patents

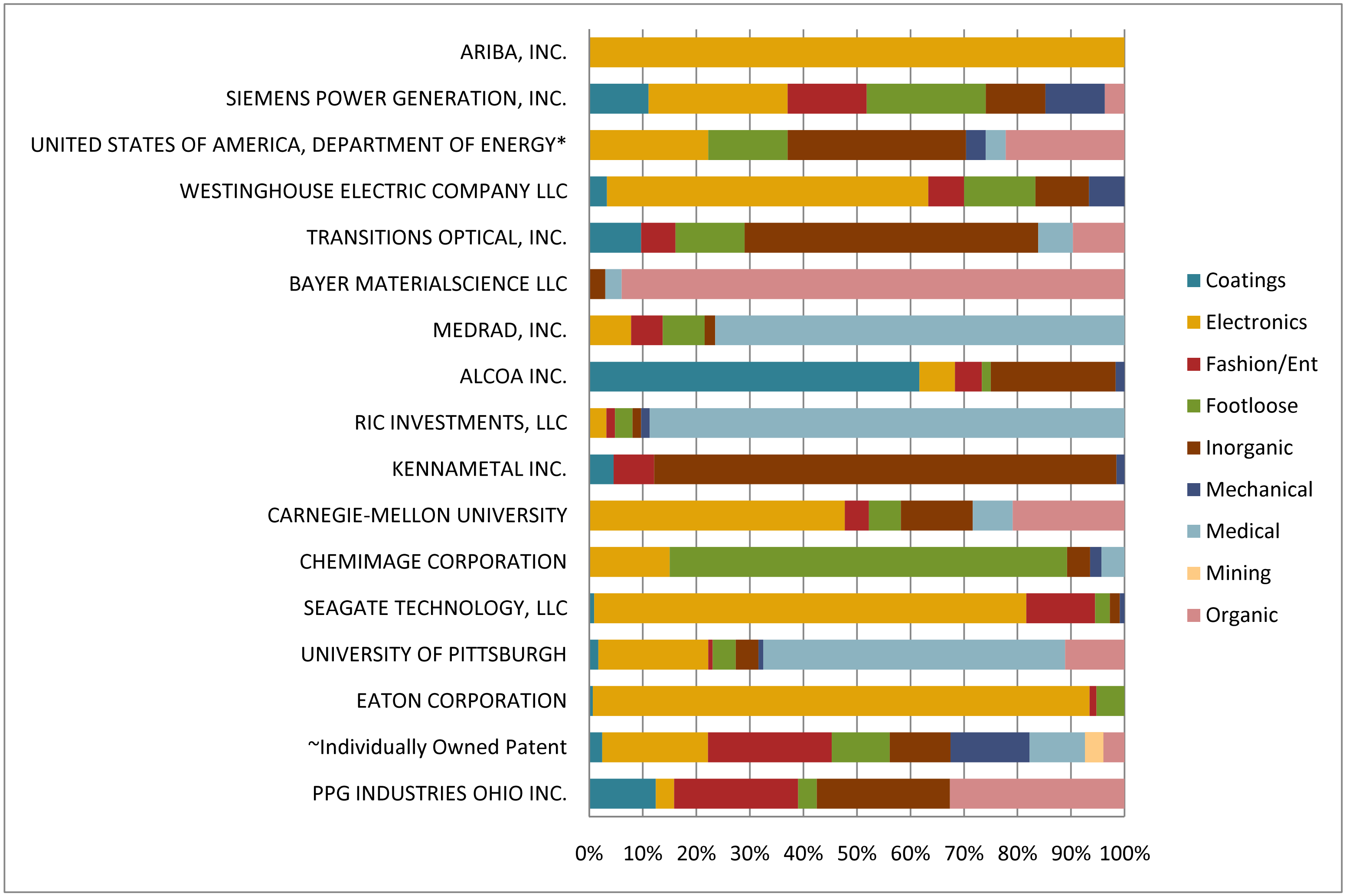
Figure 5. Pittsburgh Region Patents 2006-10 by Assignee by Taimerica Class



*US Dept. of Energy includes patents produced at both Pittsburgh and Morgantown, WV labs of NETL

Source: Taimerica database of US PTO patents

Figure 6. Share of Pittsburgh Region Patents 2006-2010 by Taimerica Class by Assignee



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